NOTES AND MEMORANDA.

Notes on the Senses and Habits of some Crustacea.—In the course of investigations as to the perceptions of fishes, some interesting facts in the natural history of Crustacea have come under my notice. All the Crustacea in the tanks, except *Carcinus mœnas* and *Portunus depurator* are more active by night than by day. Prawns, *Pandalus*, *Stenorhynchus* and *Inachus* generally remain stationary during the day, but will leave their places to hunt for food if any be put in; but *Ebalia*, *Portunus pusillus*, *Porcellana longicornis*, *Galathea andrewsii*, *Virbius varians* and shrimps are rarely visible until night falls, and hardly ever come out by day even to feed. *Eurynome aspera*, though not hidden away like these, being naturally almost indistinguishable from the broken shells, &c., amongst which it lives, seems also never to feed by day. Excepting the shrimps, nearly each individual of the above-mentioned forms has its own place to which it retires when morning comes, and in which it remains during the whole day. One prawn has occupied the same hole for some weeks, and another, which had lived a fortnight in one corner, left it when some mussels were put in, and now sits on the mussels during the day. The distinction then between day and night is of importance to these animals. Such an animal as a shrimp is in fact certain to be caught by keen-sighted fishes if it uncovers itself by day. If shrimps are thrown by day among pollock, they are always eaten unless they reach the bottom of the tank, but there they are safe even if unburied, for the pollock seems unable to see them when on the bottom, and at once gives up the chase. This may or may not be due to their protective colouration. Pollock very rarely take anything off the bottom, and worms and even glistening things like pieces of mackerel are generally left by them if they are not eaten whilst sinking.* Moreover, the bottom of the pollocks' tank is made of yellow gravel brought from the Chesil Beach, which in no wise resembles a shrimp.

Wrasses, however, which are especially fond of shrimps, can not only catch them as they sink in the water, but pursue them on the bottom. The sight of the wrasse is particularly keen, and I have often seen a large wrasse search the sand for shrimps, turning sideways and looking with either eye independently like a chamæleon. Its vision is so good that it can see a shrimp with certainty when the

* This can only be true of small pollock, for large pollock are frequently taken with ground baits.

whole body is buried in grey sand, excepting the antennæ and antenna-plates. It should be borne in mind that if the sand be fine, a shrimp will bury itself absolutely; digging with its swimmerets, kicking the sand forwards with its chelæ, finally raking the sand over its back and gently levelling it with its antennæ, but if the least bit be exposed, the wrasses will find it, in spite of its protective colouration. Shrimps put into the wrasses' tank at night escaped for some days, hence they must retire to the sand before daylight is strong enough for the wrasse to see them. The knowledge of night and day is therefore of paramount importance to a shrimp, as it is not safe for it to hunt until darkness has come. Strangely enough, it seems that this knowledge is not obtained through the eyes, or at all events not entirely through them, for if the eyes be extirpated, the shrimps will bury themselves during the day, getting up in the twilight and careering about at night just like uninjured shrimps. On one occasion (7 p.m., August 4th) I noticed that the blind shrimps in a tub were lifting themselves out of the sand exactly at the same time as the normal shrimps in another vessel were doing so. If, however, food be thrown in by day, the blind shrimps will get up and hunt for it while the normal shrimps very rarely take any notice. Similarly, a blind prawn will remain in his place all day unless food be thrown in, but comes out and wanders at night. It is a singular fact that a prawn, though blind will often find his way back to his proper place, and stay in it.

Both prawns, shrimps, *Stenorhynchus*, &c., find their food almost exclusively by scent, and when blind find pieces of food quite as quickly as uninjured ones. If a piece of worm be put into a small glass sphere with a hole in it, and the sphere is then sunk in the tank, the prawns, &c., will come out of their holes and find it. They do not seem to have any very accurate knowledge of the direction of a scent, but on perceiving it they begin rushing vaguely about, feeling the ground all the way with their chelæ. On finding the glass, the first comer will feel inside, pull out the worm, and skip with it to some high place. I have noticed that those which come after generally find the glass in which the worm has been as easily as the worm itself, and they will continue feeling inside in a puzzled way for some time, showing that the scent remains after the worm is gone. (Conger, soles, and rockling, which all feed by smell and touch, will all do the same thing.)

Shrimps are much quicker at finding food than prawns. They hunt with their faces down on the ground like hounds questing, while the prawn hunts with his head held up as usual. If a piece of worm be just buried in sand, a shrimp will dig it out at once, whether blind or not. I have also seen a prawn, after much hesitation, plunge its two arms resolutely into an anemone (*Anthea*) and pull out a worm which the anemone had closed over. In like manner a blind *Stenorhynchus* or *Inachus* will perceive a piece of worm when it has been in the water a few minutes, and will then set out and find it. I have seen them hunting about when worms have been put into another tank from which water was flowing into their own vessel. There can then be no doubt that these animals find their food by scent, and it becomes difficult to determine what sort of objects they can see. It is not even certain that they can see each other. If a prawn is eating a piece of worm and another prawn finds it and takes it away, the first prawn will again begin to quest wildly as at first, and does not make for the prawn with the worm, though it may be only a few inches off. Nevertheless, it is certain that prawns at all events can perceive more than mere difference between light and darkness, for they notice a hand or even a thin stick placed between them and the light, putting out their antennæ towards it. *Stenorhynchus* also will put up its anterior pair of walking legs when a fish swims close over its head. It would appear that the eyes of these creatures are particularly sensitive to shadows. If a worm is hung by a thread in the water about eight inches from the bottom, the prawns will first hunt on the bottom as usual, and will then begin swimming about in quest, but on coming a few inches below the worm they will rise to it directly.

Though it seems probable that the sense of smell is obtained through the antennules, in shrimps at all events it is not exclusively so derived, for a shrimp with no antennules will hunt if a piece of worm is put very near it. On the other hand, the antennæ, of a prawn at least, appear to have no such power, as prawns when eagerly seeking food may be seen to touch it with their antennæ and still be unable to find it.

As is well known, certain crabs, as *Stenorhynchus*, *Inachus*, *Pisa*, and *Maia*, have the habit of fastening pieces of weed, &c., on their backs and appendages until they are almost indistinguishable from the surrounding weeds if there are any. In the case of *Stenorhynchus* and *Inachus* I have often watched this process. The crab takes a piece of weed in his two chelæ, and neither snatching nor biting it, deliberately tears it across as a man tears paper with his hands. He then puts one end of it into his mouth, and, after chewing it up, presumably to soften it, takes it out in the chelæ and rubs it firmly on his head or legs until it is caught by the peculiar curved hairs which cover them. If the piece of weed is not caught by the hairs, the crab puts it back in his mouth and chews it up again. The whole proceeding is most human and purposeful. Many substances as hydroids, sponges, Polyzoa, and weeds of many kinds and colours are thus used, but these various substances are nearly always symmetrically placed on corresponding parts of the body, and particularly long plume-like pieces are fixed on the head, sticking up from it. It may be supposed that these actions are of use for purposes of concealment, and hence it might be expected that they should be dependent on the power of vision, but not only are all these complicated processes gone through at night as well as by day, but a *Stenorhynchus* if cleaned and deprived of sight will *immediately* begin to clothe itself again with the same care and precision as before. It may be mentioned that there is certainly no disposition on the part of a *Stenorhynchus* dressed in any colour, say green, to take up a position amongst green weed or indeed amongst weed at all, and so on, while some individuals which have taken up their station among weeds do not dress themselves at all.

Sense of Touch in the Rockling (*Motella*).—Both the large three-bearded rockling and the small five-bearded form flourish in the tanks. They are nocturnal in their habits, and lie still all day. If a worm be thrown in by day, the small species will sometimes swim straight up and take it, having to some extent the power of seeing objects, but the large species never does this. Generally, both the animals take no notice of food thrown in until it has lain in the water some minutes, when they start off in search of it. The rockling searches by setting its filamentous pelvic fins at right angles to the body, and then swimming about feeling with them. If the fins touch a piece of fish or other soft body, the rockling turns its head round and snaps it up with great quickness. It will even turn round and examine uneatable substances, as glass, &c., which come in contact with its fins, and which presumably seem to it to require explanation. The rocklings have great powers of scent and will set off in search of meat hidden in a bottle sunk in the water. Moreover, a blind rockling will hunt for its food and find it as easily as an uninjured one.

The barbels of the rocklings bear sense organs having the structure of taste-bulbs, but the sensitive rays of the pelvic fins do not, having an epithelium made of tall, thin cells, somewhat like that upon the fingers of a gurnard.

Sudden Colour Changes in Conger.—During the months of May, June, and July I occasionally saw the conger living in the tanks more or less covered with bright, white spots. These spots come and go suddenly, and their size varies from that of small shot to that of a threepenny-piece. Sometimes the head, both sides of the pectoral and dorsal fins, and anterior end are thus covered, while sometimes it is the posterior end or the middle of the body which is affected. I have seen these spots vanish suddenly, but sometimes they remain for several hours. It does not seem that these appearances are of the nature of secondary sexual characters, for they appear on conger of all sizes. These spots are, of course, caused by contraction of the chromatophores in the skin, but they do not appear to be connected with light, for they not only are occasional in their occurrence but once they appeared on a blind conger also. They do not appear to indicate any special emotion or diseased state, as frequently the animals thus affected are seen to feed like the rest.

Contractility of the Iris in Fishes and Cephalopods.—While in warm-blooded animals the size of the pupil is regulated by the accommodatory mechanism of the iris, this power appears to be wanting amongst Teleostean fishes in general. I have examined the eyes of conger, soles, mullet, wrasse, pollock, &c., and have never seen any alteration in the width of the pupil either by day or night or in twilight, neither do they contract when a strong light is flashed on them by night. On the other hand, all the Elasmobranchs living in the tanks are provided with a means of altering the size of the pupil. In the skate this takes the form of the well-known fern-shaped process from the upper edge of the iris which by day covers the whole pupil. This structure has often been described, but I have found no mention of the fact that it is gradually drawn up in twilight and completely so at night, leaving the pupil clear. If a bull's-eye lantern be turned on to one eye, this process very slowly descends again, and in about fifteen or twenty minutes it will reach down over half the pupil. Probably if the exposure to light were continued it would fall into the position which it occupies by day, but the skate always swam off after about twenty minutes. When the animal turned round, it could be seen that the process of the eye on the dark side had also descended to the same degree as on the light side.

In the dog-fish, nurse and angel-fish, the pupil is almost completely closed during the day by the iris, the edges of which nearly meet along a slit-shaped opening which extends more or less diagonally from the upper posterior edge to the lower anterior one. This slit gradually opens as twilight comes on and in the night the whole of the pupil is exposed. When the light of the lantern was turned into one eye of a dog-fish or nurse, the iris very slowly contracted until the edges met as by day. When the animal turned round the other pupil was seen to be still open widely as before.

The turbot* is the only bony fish in which any great change in size of the pupil was seen. This fish has by day a downward pro-

* I have since seen the same changes in the pupil of the brill.

cess of the iris, which covers the upper half of the pupil but which is drawn up at night. This process gradually returns to its position if an artificial light be shown. I have, however, also seen that the pupil of the gurnard (*Trigla cuculus*) which is almost diamond-shaped by day, enlarges somewhat and becomes circular at night.

It is difficult to correlate this power of contracting the iris among fishes with any special feature in the powers of vision or even with nocturnal habits. The skate and dog-fish in the tanks move very little by day and seem to find find their food entirely by touch and smell, while the angels remain completely buried until night.

On the other hand, in such typically nocturnal fish as conger and soles there is no such mechanism of accommodation. It may be mentioned that the turbot sees very well by day and will rise to catch food falling in the water.

The eyes of the Elasmobranchs glow in the light of the lantern like a cat's eye, but the eyes of the other fishes in the tanks do not.

The iris of Cephalopods (*Eledone* and *Sepiola*) contracts for light like that of a warm-blooded animal, leaving a slit-like pupil. The size of the pupil in *Eledone* varies also with the emotions of the animal. I found that it contracted more for green light than for yellow and least of all for red. In the tanks the Sepiolas sit on the ground with their eyes closed by the lower lids throughout the day.

Modes in which Fish are affected by Artificial Light.—If the fish in the tanks are looked at by night with a lantern several somewhat interesting phenomena may be seen. Fish are differently affected according as they are day or night feeders. Soles and rockling stop swimming if a light is shown, and the former bury themselves almost at once. Bass, pollock, mullet, and bream generally get quickly away at first, but if they can be induced to look steadily at the light with both eyes they gradually sink to the bottom of the tank, and on touching the bottom commonly swim away. Sometimes the fish will lie close to the glass, turning one eye only to the light; in this case the animal never lies horizontally, but always with that side of the head depressed which is turned towards the light. In this connection I may mention that I have seen a whiting which had lost one eye by disease which always swam with the blind side higher than the normal one. In the case of mullet effects apparently of a mesmeric character sometimes occur, for a mullet which has sunk to the bottom as described will sometimes lie there quite still for a considerable time. At other times it will slowly rise in the water until it floats with its dorsal fin out of the water, as though paralysed. I once saw one which remained in this odd position for some minutes after the light had been turned off it. I could not get the mullet to attend to the lamp if the room was generally lit up. The red gurnard and the bass will sometimes swim up to and lie by the light for a time, but they were never seen to take any other notice of it. Turbot, on the contrary, are occasionally greatly affected by the light of a lantern. When the light is first shown they generally take no notice of it, but after about a quarter of an hour I have three times seen a turbot swim up, and lie looking into the lamp steadily. It then seemed to be seized with an irresistible impulse like that of a moth to a candle, and throws itself open-mouthed at the lamp. On one occasion a turbot continued to dash itself with such violence at the lamp that it wore the skin of its chin through till it bled. When the light was moved to another part of the glass the turbot soon followed and began again.

Sound heard by a Lamellibranch (*Anomia*).—In the course of an attempt to find out what class of sounds are generally transmitted to animals living in water I found that Anomia if open can be made to shut its shell by smearing the finger on the glass of the tank so as to make a creaking sound. The animals shut themselves thus when the object on which they were fixed was hung in the water by a thread. It is therefore clear that the action perceived was not communicated merely by the jarring of the solid framework of the tank. The noise made by the finger had to be of a particular pitch, for neither mere rubbing on the glass nor the exceedingly high note made by squeezing the edge of a wet cork along the glass produced any effect. It is remarkable that the Anomia took no apparent notice of the sound made by creaking the antenna of a crayfish under water. Instances of real sounds being perceived by aquatic animals are so rare that this fact seemed worth recording. —W. Bateson.

The Fisheries and Fishing Industries of the United States.—The United States Fish Commission has recently published the third, fourth, and fifth sections of the treatise on the Fisheries and Fishing Industries of the United States which is being jointly produced by them and the United States Census Bureau. The three sections above mentioned comprise four quarto volumes, the first of which contains Sections III and IV, devoted to the Fishing Grounds of North America and the Fishermen of the United States respectively. The section on the History and Methods of the Fisheries extends over two volumes of text and a volume containing two hundred and fifty-five plates illustrating the methods of catching and curing fish and other marine products. It is no disparagement of the excellent works published by private individuals in England to say that no such complete treatise upon the fisheries of a single country has ever yet been attempted or so successfully carried out. Mr. Holdsworth's excellent book upon deep-sea fishing is the most complete work of its kind published on the English Fisheries, but it could not be expected that an individual could include within the compass of a single octavo volume such a varied mass of information as is presented by the United States Commission. The editing of these volumes has been in the hands of Mr. Brown Goode, who has had the help of nineteen associates, many of them well known from their scientific and practical researches.

Members of the Marine Biological Association who would learn how much practical benefit can be conferred on a national fishing industry by such a body as the United States Fish Commission should obtain and read these volumes; they are not only instructive but interesting. It would be difficult to over-estimate the importance of the information given in Section III. Not only are all the areas frequented by United States fishermen described in the text, with an account of the fishes caught in each and the seasons at which they are to be found, but their exact localities are mapped out in a number of excellent charts which embrace the whole of the eastern coast of the North American Continent. No less valuable are the charts showing the annual variations of sea temperatures at various points on the same coast. The fact that the migrations of fish are largely dependent on the temperature of the sea has long been known in a general way, but hitherto no observations have been made of extent and accuracy sufficient to allow a judgment to be formed on the subject. The following paragraph, taken from Mr. Richard Rathbun's report, is instructive:—"During the winter months the water temperatures on the ocean plateau outside of the capes is higher than that of Chesapeake Bay or the Potomac River. The latter part of February or early in March the temperature of the bay waters rises above that of the ocean waters outside. Coincident with this the shad make their appearance in the Chesapeake and are taken in the pounds which are set in salt water along the shores of the bay. About the 1st of April the temperature of the water in the Potomac river rises above the temperature of the water in the bay. Coincident with this is the beginning of the shad fishing in the river."

The section on the fishermen is interesting reading. Some of the American fishermen appear to live as exclusive a life as the fishermen of Europe, and in Maine, for example, they are dependent on the middlemen, and get but small returns for their labour, 175 dollars, little more than £45 per annum. The fishermen of New England, of which the chief port is Gloucester, Massachusetts, are a very different class of men; they are well educated, do not form a class by themselves, and are withal admirable sailors and fishermen. They earn as much as £200 per annum, and a skipper who is part owner of a schooner has been known to make £3000 in a single year.

The section on history and methods may prove rather puzzling to English readers. There is no beam trawling in America, and the flat-fish which are held in so much esteem and command so high a price in this country, the sole, the turbot, and the brill, are unknown on the other side of the Atlantic. On the other hand, many names unfamiliar to us are to be found, such as tautog, menhaden, squeteague, skulpin. The different methods of catching fish are well explained in this section. It is noticeable that the Americans use larger ships than Englishmen, they set their lines in a different manner, they use nets such as the purse seine which are scarcely known and rarely, if ever, used in this country, and they do a great deal of their curing on board ship. Undoubtedly they are ahead of Europeans in their methods of fishing, as in many other things; the fishermen are certainly advanced in this, that they are not prejudiced in favour of old methods, but are one and all ready to try novelties in gear and boats, and to adopt them if successful, to listen to advice and to learn all that they can about marine life and the habits and characteristics of the fish they catch. They assist the Fisheries Commissioners in their researches, and in return receive many benefits from the Commission.

In comparing the work on Fisheries done by the United States Fish Commission with what has been attempted in other countries it must not be forgotten that they possess an income out of all proportion with that bestowed on other fishery departments or commissioners. But when they can produce such a work as this in addition to their scientific and practical researches, no one can assert that the income is not well spent.—G. C. B.

C. Spence Bate, Esq., F.R.S.

The Association has lost one of its ablest and most energetic members in Mr. C. Spence Bate, F.R.S., who died, after a painful illness, at his residence, The Rock, South Brent, Devon, on the 29th of July.

It is hardly necessary here to dwell on Mr. Spence Bate's scientific attainments; as a carcinologist he was distinguished throughout Europe, and his works on the British Amphipoda (in conjunction with Professor Westwood) and the Macrurous Crustacea of the Challenger expedition are testimony to his acute powers of observation and his patience in study.

From the date of its foundation Mr. Spence Bate took the keenest interest in the Marine Biological Association. He was elected a member of Council soon after its formation, and was among those who urged the advantages of Plymouth as a site for a Marine Laboratory. On Plymouth being chosen Mr. Spence Bate took an active part in the early arrangements necessary for acquiring the site and erecting the buildings; his influence was instrumental in securing for the Association that local support which has been so freely given by the authorities and inhabitants of Plymouth, and he personally took a large share in watching the progress of the building and arranging the details of its interior. Lately Mr. Spence Bate was a frequent visitor to the Laboratory, was ever ready to assist younger naturalists with his stores of knowledge on Crustacea, and was most helpful in lending from his own library scientific memoirs not in the possession of the Association.