The case is that in which Provost Charles Duncan was fined £6 by the Sheriff for assaulting Mr Comrie, one of the Town Councillors, at a Council Meeting by *pulling his nose.*

In justice to the memory of Provost Duncan and also of Mr Comrie, it is only fair to say that afterwards they were both good friends.

PLANKTON.

(ABSTRACT OF A LECTURE DELIVERED AT THE BUTE MUSEUM ON APRIL 3, 1914.)

BY J. GRAHAM KERR.

The animal organisms which inhabit the sea may be divided into two sets—(1) those which live on the solid substratum either at the bottom or round the coasts, and (2) those which lead a pelagic existence independent of the substratum. It is customary again to divide the pelagic fauna into the swimming fauna or *necton*, including those animals which are strong swimmers and which consequently can travel about at their own free will, and the drifting fauna or *plankton* including those forms which from their relatively slow independent movements drift hither and thither the sport of tidal and other currents.

Various subdivisions of the Plankton are in use, *e.g.* Holoplankton and Meroplankton, the latter including animals which belong to the Plankton during only a part of their life history as is the case with those very numerous marine animals which possess a planktonic larva and conversely with those other forms such as Hydromedusæ where the adult sexual phase of the life history belongs to the plankton, while earlier phases lead an attached existence. The only subdivision of the plankton that we need use in this lecture is the rough one which divides off the relatively large-sized animals that constitute the *macroplankton* from the small ones which constitute the *microplankton.* The microplankton is of special interest and a word or two may be said as to the methods employed in its investigation.

travels far out into the Central Atlantic to spawn. The larva which develops far out to sea from these eggs is the extraordinary *Leptocephalus*, a creature with but little resemblance to the young eel or elver into which it later metamorphoses but typically pelagic in its clear glassy transparency, even the red Haemoglobin of the blood being actually suppressed.

In those animals which do not show this tranparency but possess a general scheme of colouring, such as for example the majority of pelagic fishes, we notice certain characteristics. In those living near the surface we see usually an ordinary protective coloration (*e.g.* mackerel), the upper side being dark so as to harmonize with the dark waters as seen from above, the lower white or silvery to harmonize with the brilliantly illuminated surface as seen from below. This type of coloration disappears at some distance from the surface and when we examine pelagic fishes or prawns from a depth of say 250 fathoms downwards, the fishes are seen to be uniformly dark in colour while the prawns are uniformly red. It seems natural enough that the fishes should be dark in harmony with the gloomy depths in which they live, but the red colour of the crustacea seems at first sight rather puzzling until it is realized that an object cannot be "red" unless red rays of light are falling upon it and that consequently as no red rays of day-light penetrate through the upper 50 fathoms, these prawns are simply dark in their natural environment and it is merely "chance" that they happen to look red when brought to the surface and seen by ordinary daylight containing red rays.

Many of the pelagic fishes of the upper 250 fathoms in the warmer seas possess photogenic or light producing organs. These are special developments of the glands of the skin, the secretion of which oxydizes rapidly, producing a phosphorescent light, and there is usually present a special lens—a minute bulls-eye condenser—developed also from the skin which serves to concentrate the rays of light so produced. These light-producing organs show considerable variety in their minute structure and also in their arrangement in the body, in different species. Within a single species the arrangement is pretty uniform and

this has led to the interesting suggestion by Brauer that the specific arrangement of these little lamps on the surface of the body serves the same purpose as the scheme of coloration in ordinary terrestrial vertebrates, making it recognizable at a distance by creatures of its own kind.

The animals of the macroplankton possess as a general rule well developed sense organs, more especially eyes and otocysts or simple ears. The latter serve as a rule not so much as organs of hearing as for detecting changes of position this being the primitive function of the ears which is to be found still persisting in the case of man and the higher animals in the use of the inner ear in the perception of rotary movements.

Plankton animals having to remain for considerable periods at about the same depth in order to keep in touch with the organisms which serve as their food, it is necessary that they should possess some means of maintaining themselves at the proper level. In many cases this means consists simply of the musculature of the body, the animal keeping itself up by muscular movement. This is well seen in the medusæ and in the salps and their allies where the body is kept up by rhythmic pulsation. Again in most of the Molluscs which live a pelagic existence, active swimming movements are depended upon to keep the creature from sinking. It is obvious that muscular movement is an extravagant method of keeping at one level and we find that in many of the animals most perfectly adapted to a pelagic existence, the same end is reached in a far less expensive as well as more efficient manner by the action of floats filled with gas or other substance lighter than sea water. The ordinary cuttlefish affords a good example of this type of mechanism, the shell having become subdivided up into an immense number of little chambers filled with gas secreted by the animal and serving to keep the body of the creature at about the same specific gravity as the sea water in which it is swimming. Still more interesting is the case of the majority of ordinary fishes (Teleostei) in which one of the lungs, which according to modern researches seem to have been present as breathing organs in the ancestors of these fishes, has become shut off from its communication with the outer world and now functions merely as a float or swim-bladder. The older naturalists believed that the fish used its swim bladder for altering its level in the water. When it wished to sink it compressed the swim bladder with its contained gas; when it wanted to rise, it expanded it. It is now known that this is not at all the way in which the swim bladder functions. It really serves not to make the fish lighter or heavier than the water in which it swims, but rather to keep its specific gravity precisely the same as that of the surrounding medium so that it floats at one level without any effort. In connection with this it has evolved a beautiful compensating mechanism. Part of the lining of the swim bladder has become converted into a gland which secretes gas—as a rule nearly pure oxygen—and by setting this to work the fish is able to force additional gas into its swim bladder and in this way compensate for increased pressure in the water due to swimming down to a greater depth. Conversely if the fish swims upwards into regions of less pressure, another part of the swim bladder lining comes into play and reduces the amount of gas present by a process of absorption, counteracting in this way the distention and balloon effect which would otherwise carry the fish helplessly upward to the surface.

II. Microplankton.—In the microplankton we find adaptive arrangements equally characteristic to those met with in the larger animals. Here again we find the production of phosphorescent light very usual. There has been much speculation as to the manner in which this is of use to microplantonic animals. It seems probable however that the giving off of a certain amount of energy in the form of light is to be looked upon not as a phenomenon of use in itself but rather as a simple physical accompaniment of the general processes of metabolism—part of the energy set free in the process of oxidation happening to take this form rather than the more usual one of heat.

The problems connected with flotation are rather different in the minute animals of the microplankton from what they are in the case of larger forms. When the body of the animal is of very minute size its natural rate of sinking becomes so slow as for practical purposes to approach very near to flotation. There now comes into play a conditioning factor which was of relatively minor importance in the case of the larger animals, viz. the viscosity of the sea-water—this viscosity being greatly affected by temperature, diminishing with rise of temperature. Correlated with this we find in the animals of the microplankton two different types of arrangement connected with flotation—(1) arrangements for diminishing the specific gravity and (2) arrangements for giving increased effect to the viscosity of the water. Under the first category comes the accummulation amongst the tissues of a large proportion of water as in Medusae or the secretion within the body of jelly or fatty material of less specific gravity than the sea-water (*e.g.* Radiolarians). Under the second category come various arrangements for bringing about increase of the body surface as compared with its bulk. This may be brought about merely by diminution in the size of the creature, the ratio surface-volume increasing with diminution of bulk, or by the development of spiny or feathery outgrowths from the surface (Foramintfera, Radiolaria, and Copepoda). In accordance with what has been said regarding the diminution of viscosity with rise of temperature the second type of arrangements just alluded to is found especially well marked in the plankton of the warmer seas.

[Locomotor arrangements in Plankton animals.

Plankton and Evolution.]*

Plankton and Economics.—The study of Plankton is of interest in relation to economics both directly and indirectly. Directly, because the plankton constitutes a hitherto untapped source of food supply. Copepod plankton in particular, which sometimes forms enormous masses off our coasts, is composed of highly nutritious food-material and no doubt in time

* These sections are not given in abstract here, being of less general interest.

arrangements will be made to extract it, *e.g.*, by centrifugalizing the plankton-laden water, and preserve it for human consumption. Now and in the immediate future, however, it is the indirect relations of the plankton to economics that are of practical importance. They depend upon the relations of the plankton to the marine population of food-fishes. Each particular species of fish as of other animals has its favorite food organisms (*e.g.*, Pilchard is particularly fond of the copepod *calanus*). It may reasonably be assumed therefore that a particular species of food-fish will tend to congregate in these waters where at the particular moment these favorite food organisms happen to be; but the same applies to the food-organism itself, it also has its own favorite food organism, the abundance of which affects its own abundance in a particular spot at a particular time. And so on, until eventually we come to small creatures which find their food in minute protozoa and microscopic plants which depend for their abundance no longer upon still smaller organisms but upon simple physical conditions such as light, temperature, degree of salinity.

Each food-fish is thus dependent upon what we may call a *food chain*; the organisms forming any link of the chain supporting those of the next link and being themselves dependent upon the next link in the other direction while the chain ends in the physical conditions of the sea-water.

Now the importance of the plankton in this connection is that the final links of the chain—those coming next the end constituted by physical conditions—are those minute members of the microplankton which possess chlorophyll or one of the allied substances by which they are able to build up living substances out of inorganic materials. Amongst such organisms the most important are the flagellates and the diatoms. These exist in enormous numbers in the upper layers of sea-water where sunlight penetrates and they form the main ultimate food supply of the larger marine organisms. They also play an immensely important part—far more important than that played by ordinary sea-weeds—in supplying to the sea-water the oxygen necessary for the respiration of its animal inhabitants.

From what has been said it will be readily understood how important it is that these food-chains should be made the subject of prolonged investigation by highly trained observers. For each of our important food fishes we want accurate knowledge of the individual links of its food-chain and of the particular set of physical conditions which are most favourable to its ultimate link. The Clyde Estuary is, as I have urged for ten years past, a magnificient field for carrying out investigations along such lines. All that is needed is a small committee with moderate funds at its disposal to enable it to secure the services of able young men to tackle particular pieces of the problem, and to provide for small laboratory and boat expenses. It has been urged that such work should be undertaken by government, but I do not think that one can fairly expect a government department to undertake this type of work which would have to be carried on for, it might be, a prolonged period before results emerged of sufficient practical importance to serve as justification in the eyes of an unsympathetic Treasury. The *immediate* results would be of purely scientific value as detailed studies of the biology of particular organisms. Eventually when all the various links of a particular chain had been worked out, then we should have for the particular food-fish concerned a body of knowledge which would be of the greatest possible practical value to the particular fishery. When that knowledge is in our possession we shall be able, when confronted with a serious diminution in the numbers of the fish in a given locality, to diagnose whether it is a natural fluctuation dependent upon the weakening of some particular link in the food-chain or whether it is merely a case of migration away from accustomed haunts in company with shifting of the physical conditions suitable to one or other link—and in the latter case it will be possible for the expert to track out the movements of the body of water suitable to the food links and to point the direction in which the fish is to be looked for. When that time comes we shall probably hear a great deal less than we do at present, of mere over-fishing as a cause of the diminution in the quantity of fish.