MARINE BIOLOGICAL ASSOCIATION OF THE UNITED KINGDOM

Report of the Council for 1960–61

The Council have great pleasure in reporting that Prof. C. F. A. Pantin, Sc.D., F.R.S., was elected President of the Association in June in place of Prof. A. V. Hill, C.H., O.B.E., F.R.S., who had served for the previous five years.

The Council wish to record their deep appreciation of the services rendered to the Association by Prof. A. V. Hill during his term of office, a period notable for the increased development of research on the physiology of marine organisms at the Plymouth laboratory. Prof. Hill was re-elected a Vice-President of the Association.

The Council have to report with regret the death of the Earl of Verulam, a Vice-President of the Association since 1953; and of Mr W. H. Searle, B.E.M., who served the Association so faithfully as fisherman collector for a period of 63 years.

The Council and Officers

Four ordinary meetings of the Council were held during the year, two in the rooms of the Royal Society, one in the rooms of the Zoological Society of London and one at Plymouth. At these the average attendance was seventeen.

The Plymouth Laboratory

During the year the outside woodwork and chuting of the south wall of the centre bay of the south building have been repainted.

The small lean-to coal shed on the inner side of the south wall of the yard near the entrance gate has been converted by direct labour to house the motor and compressor for charging aqualung cylinders with air.

As ancillary work to the main laboratory extension, the plunger jar room has been renovated and refurnished for use by the finance office staff.

A new oil-fired furnace has been installed in the basement of the south building and a new flue has been built in place of the existing lift shaft. The chimney pots have been removed from all the flues of the south building.

Laboratory Extension

The Council have signed a contract with Messrs John Garrett and Son (Contractors) Ltd for the building of the new laboratory extension for which

Messrs Easton & Robertson, Cusdin, Preston and Smith, London, are the Association's Architects.

Work on the extension began on 2 May 1960 and the building is well advanced.

Aquarium

A detailed description of the aquarium, reservoirs and outside circulation tanks has been published by Dr Wilson in Vol. 39, No. 3, of the *Journal*.

During the summer months the aquarium has been crowded on most days, often to capacity, and the public have evidently appreciated its general appearance and the animals exhibited. There is no doubt that the new conditions suit the animals well, and the improved servicing facilities have made maintenance much easier.

Two electrically driven Mono Pumps were installed in the basement engine room in February 1961 to replace the two centrifugal pumps now over thirty years old. The new pumps have stainless steel bodies, rubber stators and stainless steel rotors. Each delivers over 4500 gallons an hour, which would appear to be more than twice the amount the old pumps have given for many years. The increased flow of water through the tanks was quickly followed by increased activity of many of their inhabitants, and analyses showed a marked improvement in the oxygen saturation of the water in the tanks. The increased flow is assisting silt removal from the tanks while not interfering with silt deposition in the reservoirs, and the water remains remarkably clean.

Research Ships

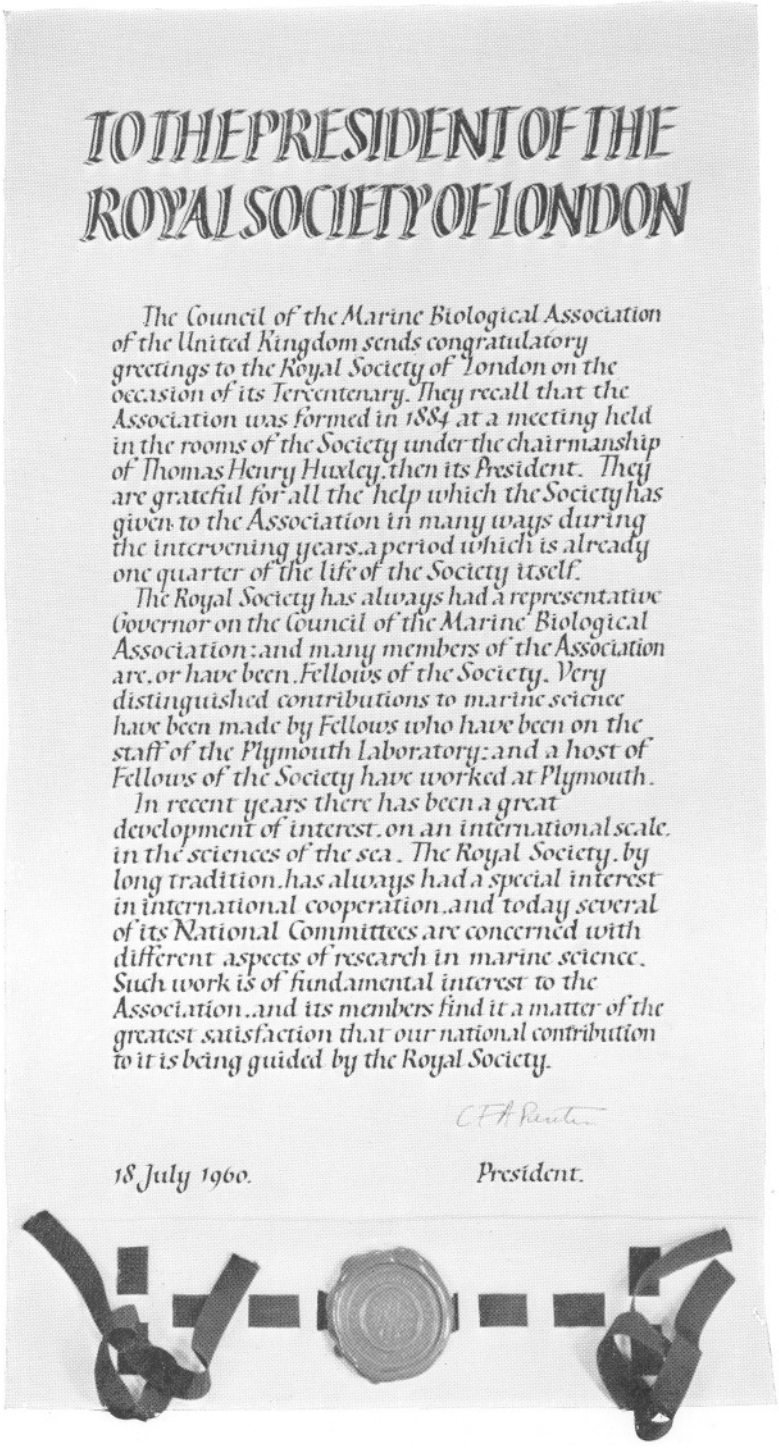
The three research vessels R.V. 'Sarsia', R.V. 'Sula' and M.V. 'Gammarus' have operated regularly throughout the year.

In December 1960 R.V. 'Sula' went into dock for the Lloyds' special survey of the hull. Apart from deterioration round the stern the vessel, which is now 12 years old, was found to be in excellent condition. The sternpost, which was of English elm, has been renewed in oak. At the same time the engine was lifted and completely overhauled.

The vessel is now expected to be fit for many years' service, and her classification continues to be A 1 at Lloyds.

Tercentenary of the Royal Society

On Monday, 18 July 1960, in the Rooms of the Royal Society, Burlington House, London, the Secretary, Dr F. S. Russell, F.R.S., presented a congratulatory address (see opposite) from the Council of the Association to the President of the Royal Society on the occasion of the celebration of the tercentenary of the Society's foundation. This address was inscribed by



TO THE PRESIDENT OF THE ROYAL SOCIETY OF LONDON

The Council of the Marine Biological Association of the United Kingdom sends congratulatory greetings to the Royal Society of London on the occasion of its Tercentenary. They recall that the Association was formed in 1884 at a meeting held in the rooms of the Society under the chairmanship of Thomas Henry Huxley, then its President. They are grateful for all the help which the Society has given to the Association in many ways during the intervening years, a period which is already one quarter of the life of the Society itself.

The Royal Society has always had a representative Governor on the Council of the Marine Biological Association: and many members of the Association are, or have been, Fellows of the Society. Very distinguished contributions to marine science have been made by Fellows who have been on the staff of the Plymouth Laboratory: and a host of Fellows of the Society have worked at Plymouth.

In recent years there has been a great development of interest, on an international scale, in the sciences of the sea. The Royal Society, by long tradition, has always had a special interest in international cooperation, and today several of its National Committees are concerned with different aspects of research in marine science. Such work is of fundamental interest to the Association, and its members find it a matter of the greatest satisfaction that our national contribution to it is being guided by the Royal Society.

C. F. A. Pantin

18 July 1960. President.

(*Facing p.* 838)

Mr A. Forrest, A.R.C.A., A.T.D., Principal of the Plymouth College of Art, and contained in a tooled blue leather scroll case.

Staff

The Honorary Degree of Doctor of Science has been conferred on Dr F. S. Russell, F.R.S., by the University of Exeter.

Mr Q. Bone has been promoted to the grade of Senior Scientific Officer.

Dr D. P. Wilson attended the Congrès International d'Aquariologie at Monaco from 21–26 November and also visited the Marine Laboratory at Villefranche.

Dr L. H. N. Cooper, as Chairman of the Committee on Chemical Oceanography, attended the meeting of the International Association of Physical Oceanography in Helsinki from 25 July to 6 August.

Dr Mary Parke took part in a joint excursion of the British Phycological Society, of which she is President, and the Société Phycologique de France in the Channel Isles in September.

Dr E. J. Denton and Dr T. I. Shaw spent a month during April and May at the marine laboratory at Villefranche studying the buoyancy of plankton animals.

Dr D. B. Carlisle attended the First International Congress of Endocrinology in Copenhagen in July and spent much of that month working at the Kristinebergs Zoologiska Station in Sweden.

Mr N. A. Holme attended a special meeting held under the auspices of the International Council for the Exploration of the Sea at Heligoland in June to review methods of quantitative research on the fauna of the sea-floor.

Mr F. A. J. Armstrong spent a month in May and June on board R.R.S. 'Discovery II' taking part in the International Council for the Exploration of the Sea combined expeditions to investigate the outflow of cold deep northern water over the Iceland–Faroe Ridge. From 25 July to 6 August he attended the meeting of the International Association of Physical Oceanography in Helsinki.

Occupation of Tables

The following one hundred and thirty-eight workers have occupied tables at the Plymouth Laboratory during the year.

Dr A. Acara, Istanbul (Physical Oceanography).
E. Adams, Plymouth (Library).
Dr W. J. Adelman, Bethesda, U.S.A. (Squid axons).
Dr J. S. Alexandrowicz, Plymouth (Nervous system of invertebrates).
D. C. Arnold, Durham (Library).
Dr Daphne Atkins, Plymouth (Brachiopods).
Dr J. R. Baker, F.R.S., Oxford (Cytology of dogfish pancreas).
P. F. Baker, Cambridge (Biochemistry of squid axons).
W. J. Ballantine, D.S.I.R., London (Ecology of limpets).

Dr ANNA BIDDER, Cambridge (*Heligocranchia pfefferi*).
Dr E. J. BINYON, London (Ion exchange in *Asterias rubens*).
Dr G. T. BOALCH, International Paints Research Fellow (Effects of toxic substances on algae).
G. C. BOLSTER, Lowestoft (Mackerel).
Dr A. D. BONEY, Plymouth (Ecology of red algae).
Mrs P. C. BORJA, Philippines (General).
Prof. A. A. BOYDEN, New Jersey (Comparation serology).
Dr ELEANOR M. BROWN, London (Plankton).
Dr P. C. CALDWELL, Alan Johnston, Lawrence and Mosely Research Fellow of the Royal Society (Muscle and nerve physiology).
Mrs P. A. CALDWELL, Plymouth (Library).
R. CALVERT, Surbiton (Testing equipment at sea).
N. L. CHADWICK, Salisbury (Library).
D. M. CHAPMAN, Cambridge (Scyphozoan hydrotuba).
W. CHAPPLE, Syracuse, U.S.A. (Library).
Miss E. CLAY, Brixham (Library).
A. J. COLLINGS, Birmingham (Volatile organic matter in sea water).
J. S. COLMAN, Port Erin (Deep-sea plankton).
R. H. COOK, Cambridge (Library).
Miss A. C. COUPLAND, Birmingham (Library).
Dr J. W. COWIE, Bristol (Submarine geology).
E. CROWTHER, Southampton (Library).
N. CUMMINS, Plymouth (Library).
D. CURRY, Bristol (Submarine geology).
R. J. DANIEL, Torpoint (Library).
J. M. DIAMOND, Cambridge (Sodium ions in bile).
P. S. B. DIGBY, London (Pressure sensitivity in marine animals).
Dr ELIZABETH J. DIMELOW, New Brunswick (Biology of *Antedon*).
Sister MARIE THERESE DIMOND, Washington (Radio-iodine uptake in fish embryos).
L. A. W. DOWNER, Tavistock (Library).
M. EDMUNDS, Oxford (Defence mechanisms in nudibranchs).
Dr MARIA M. FELINSKA, Ashby de la Zouch (Ciliates).
A. E. FISHER, N.I.O., Wormley (Algal culture techniques).
K. A. FLETCHER, Surbiton (Testing equipment at sea).
I. H. FORD, Bristol (Submarine geology).
R. FOWLER, Plymouth (Library).
C. J. FOXWELL, Plymouth (Library).
Dr VERA FRETTER, Reading (Prosobranch molluscs).
Dr KAREN R. GAARDER, Oslo (Systematics of flagellates).
Dr J. B. GILPIN-BROWN, Plymouth (Biology of *Nereis fucata*).
B. GLAIZNER, London (General).
Dr D. R. GLASSON, Plymouth (Library).
J. GOSTAN, Villefranche (Chemical oceanography).
Prof. A. GRAHAM, Reading (Prosobranch molluscs).
Mrs G. GRANT, Chalfont St Peter (*Mytilus* veligers).
J. R. GRINDLEY, Capetown (Library).
E. HARADA, Kyoto (Crustacean larvae).
Dr D. N. HARCOURT, Plymouth (Library).
M. G. HARDY, Reading (Euphausiacea).
Dr H. W. HARVEY, F.R.S., Plymouth (Productivity of sea water).

J. J. HATCH, Ashburton (Library).
J. B. HAWTHORNE, Weymouth (Library).
D. HEDDLE, Oxford (Functional morphology of asteroids).
Dr R. B. HILL, Glasgow (Innervation of *Buccinum* heart).
Dr D. HINES, Plymouth (Library).
Dr J. A. HINKE, London (Squid axons).
Prof. A. L. HODGKIN, F.R.S., Foulerton Research Professor of the Royal Society (Squid axons).
Dr E. P. HODGKIN, Perth, W. Australia (Littoral biology).
D. J. HUME, Teignmouth (Library).
O. D. HUNT, Newton Ferrers (Library).
MISS A. HURST, Reading (*Philine*).
Mrs W. HUSSAIN, London (Algal culture techniques).
Dr W. G. INGLIS, London (Free-living nematodes).
Dr C. H. JELLARD, Plymouth (Library).
Dr F. R. H. JONES, Lowestoft (Labyrinth fluids of elasmobranchs).
P. G. W. JONES, Lowestoft (Chemistry of sea water).
G. C. KEARN, Birmingham (Monogenean parasites of fish).
Sister MARY ST JOHN KEEFE, Boston (Food storage in *Turritella*).
Dr G. Y. KENNEDY, Sheffield (Chlorophyll pigments).
Dr R. D. KEYNES, F.R.S., Cambridge (Physiology of squid giant axons).
Prof. L. H. KLEINHOLZ, Oregon (Crustacean endocrinology).
Prof. E. W. KNIGHT-JONES, Swansea (Library).
Dr JOAN LANCE, Southampton (Behaviour of *Calanus*).
Dr MARIE V. LEBOUR, Plymouth (Decapod larvae).
Miss R. S. LEE, Oxford (Nervous system of tunicates and echinoderms).
D. LESTON, London (Biology of *Aepophilus*).
J. G. E. LEWIS, Bradford (Littoral centipedes).
Dr J. LLEWELLYN, Birmingham (Trematode parasites of fishes).
Prof. O. E. LOWENSTEIN, F.R.S., Birmingham (Central nervous responses in elasmobranchs).
R. MCGREGOR, Parkstone (Library).
Prof. H. MCLENNAN, Vancouver (Physico-chemical properties of nerve tissue extracts).
G. I. MANN, Plymouth (Library).
Miss J. E. MANNING, London (Hydroids).
Prof. IRENE MANTON, F.R.S., Leeds (Flagellates).
Dr A. L. MARTIN, London (Library).
Dr J. J. MILAIRE, Brussels (Cytochemistry of dogfish embryos).
J. MOOREY, N.I.O., Wormley (Measurement of temperature and salinity with portable salinometer).
Miss M. A. MURPHY, Manchester (Maritime Apterygota and dogfish skin).
Dr J. S. C. PARRY, Bristol (Submarine geology).
Dr R. B. PIKE, Millport (Decapod larvae).
W. J. PITMAN, Ohio (Endocrinology).
Dr W. T. W. POTTS, Birmingham (Body fluids of elasmobranchs).
Cdr. C. F. B. POWELL, R.N. (Rtd.), Plymouth (Library).
Dr J. N. PREBBLE, London (Library).
Mrs J. N. PREBBLE, London (Library).
M. QUICK, Bristol (Submarine geology).
Dr W. J. REES, London (*Stygiomedusa*).
Dr J. M. RITCHIE, New York (Heat production in muscle and nerves).

Dr M. B. V. ROBERTS, Marlborough (Annelid histology).
Dr ELAINE ROBSON, Cambridge (Nervous system of *Calliactis* and *Metridium*).
H. ROSA, JR., Rome (Library).
Dr D. M. ROSS, London (*Calliactis* and *Eupagurus*).
Miss H. G. Q. ROWETT, Plymouth (Library).
A. S. M. SALEUDDIN, Reading (*Astarte*).
P. D. V. SAVAGE, Plymouth (Library).
D. J. SCARRATT, D.S.I.R. (Fauna of *Laminaria* holdfasts).
A. SHARPLES, Plymouth (Library).
Miss J. SHEPHARD, London (Polyzoa).
Dr A. J. SMITH, Bristol (Submarine geology).
Prof. J. E. SMITH, F.R.S., Ray Lankester Investigator, London (Nervous system of *Echinus*).
Dr EVE C. SOUTHWARD, Plymouth (Pogonophora; polychaetes).
B. W. P. SPARROW, Newton Ferrers (Library).
Miss F. A. STANBURY, Plymouth (*Cladophora*).
Prof. M. TAMASHIGE, Sapparo (Crustacean stretch-receptor).
Dr W. H. THOMAS, La Jolla (General).
C. H. THORP, Newton Ferrers (Library).
Dr K. K. TIWARI, Calcutta (Crustacean endocrinology and systematics).
D. L. URRY, London (*Pseudocalanus*).
R. C. VERNON, London (Library).
Sister ANNA VOSS, California (Plankton).
Dr R. A. WALL, Oxford (Peptides of *Rhodymenia*).
H. WALLACE, Belfast (Ascidian embryology).
P. R. WALNE, Conway (Library).
G. E. WALSTER, Plymouth (Glycolysis in *Maia*).
Prof. W. F. WHITTARD, F.R.S., Bristol (Submarine geology).
F. W. WILLIAMS, Zanzibar (Pelagic fish).
Dr D. I. WILLIAMSON, Port Erin (Decapod larvae).
P. WOODHEAD, Lowestoft (Elasmobranch thyroids).
Mrs A. D. WOODHEAD, Lowestoft (Elasmobranch thyroids).
Mrs J. A. M. WOOTTON, London (Biosynthesis of sterols).

Among the many other scientists who have visited Plymouth during the year to see the general work of the laboratory and to discuss problems with members of the scientific staff, the following have come from overseas: Mrs C. Wallace (New Zealand), W. D. Oliff (South Africa), G. Boillot (France), Dr J. B. Bateman (U.S.A.), Dr G. L. Clarke (U.S.A.), Mrs C. L. Deeleman (Holland), K. Boss (U.S.A.), Dr T. S. Austin (U.S.A.), Dr M. C. Sargent (U.S.A.), Dr B. Komarovsky (Israel), Dr F. J. Schwarz (U.S.A.), B. Schiefflin (U.S.A.), Prof. J. L. Mohr (U.S.A.), Dr B. C. Abbot (U.S.A.), Prof. S. O. Hörstadius (Sweden), Dr A. Krishnakumarau (India), N. H. Verdonk (Holland), A. O. Simpson (South Africa), Miss A. Berner (Norway), Prof. R. F. Nunnemacher (U.S.A.), Dr G. Camougis (U.S.A.), Prof. M. L. Fott (Czechoslovakia), Dr A. H. Leim (Canada), M. Bashuruddin (Pakistan), Dr V. R. Meenakshi (India), Dr J. C. van de Kamer (Holland), Prof. D. L. Ray (U.S.A.), Dr J. S. Craigie (Canada), Dr W. H. Thomas (U.S.A.),

F. Körte (Germany), Dr M. Neushul (U.S.A.), Dr Eugenie Clarke (U.S.A.), J. E. King (U.S.A.), Prof. C. Kloom (Thailand), Dr M. Yamada (Japan), Dr E. S. Herald (U.S.A.), J. M. Thiemmedh (Thailand), J. L. Pepys-Cockerell (Solomon Islands), Prof. F. J. Trembley (U.S.A.), Prof. and Mrs J. B. Lackey (U.S.A.), Dr G. A. Botros (Egypt).

The Easter Vacation Courses were conducted by Mr G. M. Spooner and Mr P. G. Corbin and were attended by forty-one students from the following Universities: Oxford, Cambridge, Reading, Exeter, Aberystwyth, Southampton, London, Sheffield, Glasgow, Leicester, Edinburgh, and Hull.

Also during the Easter Vacation Dr R. F. Jones and Dr C. T. Prime brought a party of nine boys from Whitgift School and four boys from other schools and Mrs R. M. Goldsmith brought a party of five girls from Harrow County School.

Scientific Work of the Plymouth Laboratory Staff

Sea Water and Plankton

Dr L. H. N. Cooper has continued his revision of the hydrographic observations made in the Celtic Sea in 1950. He has had help from Cdr. A. L. Lawford, R.N. (Rtd.) and Instructor-Cdr. V. F. C. Veley, R.N. in re-examining the current measurements which they had made at the Seven Stones Lightvessel in collaboration with Dr J. N. Carruthers. Conflicting evidence has been harmonized in terms of a narrow, intermittent, well-mixed corner current around Land's End from south to north. The mean direction of the current at the lightvessel had been established as towards 110°. The re-examination has shown that the current tends to deviate to the south of the mean direction at neap tides and in summer and to the north of the mean direction at spring tides and in winter. All the observations now fall into place. The water north of Cornwall tends therefore to be recruited during neap tides in a narrow current around Land's End. The biological and meteorological consequences north of Cornwall of the corner current have been examined.

Much of the Celtic Sea is dominated by wind drift currents. However, the prevailing winds from west and south-west tend to produce a 'prevailing' wind-drift towards south-east and south. Land topography constrains the direction of the wind-drift near coasts where more persistent current regimes may be found. The cyclonic eddy, long recognized, seems to be confined to the north-eastern Celtic Sea. The biological consequences have been examined. Much of this work has been published in Vol. 39, Nos. 2 and 3, of the *Journal*.

In May 1960, earlier evidence for stratification of the deep Atlantic based on oxygen samples obtained from faulty water-bottles was confirmed by samples believed to be free from suspicion. Observations obtained in 1956 suggest that massive upward displacements of all the water between 300 and

4000 m depth may occur. It amounted to 70–200 m. At the meeting of the International Association of Physical Oceanography in Helsinki, Dr Cooper presented a historical account of the overspill over the northern ridges of cold, heavy Arctic water into the North Atlantic. At a symposium there on comparative chemical oceanography, he described the influence that these ridges exert on world chemical oceanography.

Mr F. A. J. Armstrong and Mr E. I. Butler have continued the monthly cruises to the International Hydrographic Station E 1 and have reported the analyses for 1959 in Vol. 39, No. 3, of the *Journal*. Their surveys, started in 1959, of an area of 30 by 45 miles, off Plymouth, which includes the Station E 1, have been repeated bimonthly in 1960. The patterns of water properties have varied considerably and appear to show that Atlantic water may enter the area from the south-east, south, south-west and even north-west. In May an attempt was made to measure water movement at E 1 with cone-type current meters. It failed because of lack of sensitivity in the meters, but direct measurement is still needed to avoid ambiguity in interpreting movement from the hydrographic observations. During the complete tidal period occupied by the current measurements a series of bathythermograph readings were also taken. It showed an irregular oscillation of the thermocline with an amplitude of about 5 m. The record was too short to determine the periodicity.

Mr Armstrong and Dr G. T. Boalch have continued their measurements of the ultra-violet absorption spectra of samples of sea water, and it seems clear that, at least down to a wavelength of 250 mμ, the spectra are continuations of those measured at longer wavelengths by Kalle and others, and that high absorption is associated with the yellowish matter found in coastal water. At shorter wavelengths other constituents may increase the absorption, and it is likely that very high values found in deep North Atlantic water are caused by nitrate ion. The work on ultra-violet absorption and chemistry of distillates from sea water and plant cultures has continued. The seasonal variation of absorption in the 220–250 mμ range was repeated in 1960, maximum values having been found in September. A fairly constant amount of volatile sulphur-containing material has been found throughout the year. For the estimation of carbon in the volatile material a simple combustion method has been developed. The quantities found (which may be a small part of the total because of losses which cannot yet be avoided) have varied from 30–300 μg C/l. and so represent some 5% or so of the dissolved organic carbon in the water. Identification of these volatile constituents is difficult because even in the distillates the concentrations are probably less than 10 mg/l. However, it is hoped that eventually a gas chromatograph may be assembled for this work. Some tests with volatile matter for biological activity in plant cultures and with *Echinus* larvae gave inconclusive results. An account of Mr Armstrong's earlier work on suspended matter appeared in Vol. 17 of the *Journal*

of Marine Research, and he has written a short article on sea-water fertility for the new McGraw-Hill Encyclopaedia of Science and Technology.

Dr T. I. Shaw has continued experimental work upon the state of iodine in sea water. The exchange of ^{131}I between oxidized and reduced forms of iodine in sea water appears to be only of occasional occurrence. A titrimetric apparatus has been prepared for further studies.

During the year Dr Mary Parke and Miss Irene Adams have prepared two papers for the press. The first, for publication in the *Bulletin of the Research Council of Israel*, dealt with a problematic green flagellate, most interesting from the phylogenetic viewpoint. The second paper on the motile (*Crystallolithus hyalinus*) and non-motile phases in the life-history of the coccolithophorid, *Coccolithus pelagicus*, has been published in Vol. 39, No. 2, of the *Journal*. In the same number of the *Journal* the results of the study on the 1–2μ green flagellates, in connexion with the naming of '*Chromulina*' *pusilla* Butcher, have been published by Dr Mary Parke in co-operation with Prof. Irene Manton.

Valuable data are still being accumulated by Dr Parke and Miss Adams on the life-histories of a number of organisms in the Plymouth collection. Although still in its early stages, this work has already shown that a number of the marine algal forms that occur on the shore and have been described as benthic Chrysophyceae are in reality non-motile stages in the life-histories of some inshore coccolithophorids. It is hoped also in this way to elucidate the life-history and find also the correct systematic position for the puzzling planktonic organism *Halosphaera viridis* Schmitz which has now been obtained in culture. Other interesting flagellate forms have also been isolated by Miss Adams, of particular interest being the freshwater *Chrysochromulina* from Lake Windermere which is almost certainly the type species of the genus. Dr Parke is co-operating with Prof. Irene Manton and Dr J. W. G. Lund in the study of this organism.

Dr D. P. Wilson and Mr F. A. J. Armstrong have again turned their attention to problems raised by their previous work on biological differences between sea waters from different localities. There have recently been suggestions by continental workers that the differences they found were due to differing copper concentrations in the waters used. It has been shown by these workers that when copper is added to sea water in which sea-urchin (*Paracentrotus lividus*) larvae are reared the larvae are adversely affected by the copper, even at such relatively low concentrations as are occasionally to be found in natural sea waters. It seemed imperative to test these suggestions with *Echinus esculentus* larvae, using sea water from at least two contrasted localities, as in previous experiments at Plymouth, and not sea water from only one locality as in the continental work just mentioned. Accordingly a number of tests have been carried out with water from E1 and from the Clyde. It was found that these two waters each gave a distinctly different morpho-

logical type of larva, which was clearly recognizable. This was so up to a copper concentration higher than that ever likely to be found in the localities from which sea waters contrasted in earlier experiments had been obtained. It was found that the addition of copper did indeed at higher levels of concentration stunt the growth of the larvae, but even at the highest levels tested the morphological type peculiar to each natural water was recognizable. Water from one source always gave better and different larvae than water from the other source. Moreover, the removal, by chelation, of ionic copper from the two waters did not destroy this clear biological difference although it did result in somewhat poorer larvae in both waters so chelated. Indeed a slight addition of copper to the better of the two waters gave markedly improved larvae without affecting their morphological type. Mixtures of the two waters produced interesting results and in one or two comparisons better larvae were obtained in mixed water than in either alone. Some other tests were also made. The data obtained are now being studied. Larvae from some of the experiments were preserved; these have been mounted and are being examined microscopically for features not so readily comparable while the larvae were alive.

Dr E. D. S. Corner has completed a preliminary investigation of the nutrition of the copepod *Calanus helgolandicus*. Adult females were kept for short periods in a continuous flow of 'outside' Plymouth sea water, and measurements were made of the quantity and type of food they assimilated during the months April–September. It was found that *Calanus* preferentially selected a diet of high organic content from the particulate food available, and the total quantity assimilated was equivalent to a respiration rate which adequately accounted for the highest values reported by previous workers using *C. finmarchicus*. This result provides direct evidence that, during summer months at least, *Calanus* obtains the bulk of its food from insoluble substances present in the sea, dissolved material making no substantial contribution to its diet. An account of this work has been published in Vol. 41, No. 1, of the *Journal*. It is hoped to continue the study during the ensuing year by determining the respiration rate of *C. helgolandicus* under conditions identical with those used in the present feeding experiments.

Dr F. S. Russell, in collaboration with Dr W. J. Rees of the British Museum (Nat. Hist.), has published a detailed account of the viviparous scyphomedusa, *Stygiomedusa fabulosa*, in Vol. 39, No. 2, of the *Journal*. This medusa has an unusual method of asexual reproduction. The young medusae are developed in capsules which project into the cavities of four brood chambers. These capsules result from cysts which develop along a germinal line in the endoderm of the brood pouch and have tubular outgrowths into the stomach cavity. The cyst acts as a chorion passing on nourishment to the medusa which develops within it.

Dr Russell has also examined a collection of deep-water medusae made by R.R.S. 'Discovery II' for the vertical distribution investigations of Dr Talbot

H. Waterman of Yale University. Among these he has found a new trachymedusan of the genus *Colobonema*, a description of which appeared in Vol. 41, No. 1, of the *Journal*.

Dr A. J. Southward has completed the first of two papers on the distribution of zooplankton indicator species in the English Channel and Celtic Sea. This paper, published in Vol. 41, No. 1, of the *Journal*, deals with samples taken with conventional nets in 1955 and 1957; the second, in preparation, describes the results of high-speed sampling in 1958–60. The evidence suggests that changes in distribution of zooplankton since the 1900's, and associated changes in the fisheries, may be related to the general rise in temperature that has taken place during the period. An approximate treatment of some temperature data has been published in Vol. 39, No. 3, of the *Journal*.

Macro-fauna and Flora

The results of Dr A. J. Southward's researches during the past five years on the cirral activity of sessile barnacles are embodied in a paper in association with Dr D. J. Crisp. From cinematographic records, supplemented by direct observation where possible, five different types of activity have been recognized, and their relationship to feeding and respiratory exchange investigated: they are, in order of increasing muscular activity: testing, pumping, normal beat, fast beat, and extension. Pumping appears to be mainly respiratory, microfeeding can occur during pumping and normal beat, while captorial feeding on large organisms takes place during normal beat, fast beat and extension. Fast beat and extension appear to be particularly adapted to captorial feeding, the former in still water, the latter in moving water.

Study has now turned to duration of cirral activity, especially inherent rhythms, in relation to environmental changes, and much time has been spent devising electronic recording gear. This investigation has been delayed by the resumption of building operations at Plymouth, since the animals are very sensitive to mechanical shock. However, excellent results were obtained during a visit to the Marine Biology Station (University College of North Wales) at Menai Bridge. Tidal rhythms seem to be lacking, but shorter period rhythms present in both intertidal and sublittoral species appear to be sensitive to water movement and to oxygen content and hydrogen ion content of the water.

Many herbarium specimens have been added to the Plymouth collection of marine algae this year, in particular material from the Channel Islands collected by Dr Parke, Miss Adams and Miss Hearn during the Phycological field meeting there in September. Amongst the recent additions are specimens of species either occurring rarely or not previously recorded for the British Isles.

Mr G. M. Spooner has continued studies of the interstitial fauna of marine

gravels, particularly with reference to the malacostracan Crustacea. A description of the new *Ingolfiella* has been published in Vol. 39, No. 2, of the *Journal* and that of two new species of bogidiellids (a family of small hypogean species near Gammaridae) is being prepared. These forms (together possibly with an unknown elongate species of the tanaid genus *Strongylura*) appear, as far as the evidence goes, to be distributed sparsely through the body of the gravel and not concentrated close to the surface, as are the greater bulk of malacostracans isolated from the gravel samples. This is in keeping with the striking distribution of known species of Ingolfiellidae and Bogidiellidae, suggesting that these families belong to a special fauna that has developed in and dispersed from the subsurface water held in the pores or joints of the earth's strata. This hypogean fauna must be supposed to spread in the water held in the deposits of the ocean floor as well as in subterranean ground water contained below land surfaces.

For comparison with the Eddystone Rock, a collection of encrusting algae was made from almost the most northerly point of the Isles of Scilly, at low water. The fauna proved rich, including larvae of the little-known marine midge *Psammathiomyia pectinata*, and two isopods new to Great Britain, *Jaeropsis brevicornis* Koehler and *Munna petti* Amar. The latter is known otherwise only from the Mediterranean. *Jaeropsis brevicornis* was originally described from Sark over 70 years ago and has since been recorded in small numbers from a few localities southward to Italy. Though ten other species are now recognized from other parts of the world, very little is known about the genus.

Mr P. G. Corbin has continued to collect data on the Lucernarians, hermit crabs and some of the smaller fishes. At Portwrinkle, in September 1960, Mr R. J. Daniel found a single specimen of the *Lucernariopsis* sp. which hitherto has only been taken plentifully at Wembury. A lot of material has been examined from other localities but so far the species has been found very sparsely outside its Wembury site; at Portwrinkle (1), Looe (1) and Scilly (2). There would appear to be nothing exceptional about the Wembury habitat. In this respect, it parallels the exceptionally restricted distribution of the Connemara Sucker, *Lepadogaster candolli*, at one site near Brixham. The small hermit crab, *Anapagurus chiroacanthus*, has been found to occur in small numbers offshore. It is not recorded in the Fauna List, but is not new to the Plymouth area as Mr D. J. Macdonald previously found it when working on pagurid larvae in 1933 and 1934. Macdonald's manuscript records of the species were received at the laboratory only recently.

Mr N. A. Holme has completed a report on the bottom fauna of the English Channel, based on a series of anchor-dredge hauls along the south coast of England. An additional cruise was made in December 1959 to fill in a gap in the records between Plymouth and Dartmouth, and in all 173 stations have now been worked. A brief outline of trends in distribution

was given in the last *Report*, and additional work has confirmed the previous observations. Temperature appears to be an important factor in the distribution of species near the northern end of their range, but the restriction of certain other forms either to the western end or to the western half of the Channel appears to be related to other factors. While high turbidity in the eastern parts of the Channel may be contributory, no single factor has emerged to explain these distributions, and it seems possible that it is due to the presence of some unknown factor in certain waters.

In February 1960 the dredge survey was extended, a number of transects across the eastern Channel and a series of stations along the Normandy coast being worked. There seems to be some evidence of a greater up-Channel penetration of certain species in mid-Channel and on the French side, but the results have yet to be worked up in detail.

While on holiday in May 1960 Mr Holme visited the Marine Laboratories at Concarneau and Roscoff and toured an oyster farm in the Gulf of Morbihan.

Measurements were made by Mr G. R. Forster of the sample of prawns referred to in last year's report, but the results obtained did not agree with the correlation previously found between the length of the O-group and water temperatures. After a particularly warm summer the length of the prawn was no greater than in some of the previous colder years. Unfortunately, the place from which these samples have been taken on this occasion was heavily fished by some professional prawners. It is felt that growth rate problems could best be resolved by maintaining an experimental population of small prawns in a large tank for a few months.

In July Mr Forster made a short cruise in R.V. 'Sarsia' to try out a deep-sea long line which he has designed. Although the weather curtailed operations the line was shot six times at depths of 500–1000 fm. in the vicinity of La Chapelle bank. A total of thirteen fish were taken. These included three species of deep-water dogfish, *Centroscymnus coelolepis*, *Etmopterus princeps* and *Centrophorus squamosus*; two black scabbard fish *Aphanopus carbo* and five deep-sea eels *Synaphobranchus* sp. were also taken. These results are similar to those obtained by Prince Albert of Monaco who undertook a considerable amount of deep-sea long-line fishing over 50 years ago. It is hoped that by spreading the hooks farther apart larger catches may be obtained. Very little appears to be known both about the abundance of fish and their food on the deeper parts of the continental slope where it is not generally possible to trawl.

Mr Forster has also continued diving near Plymouth though bad weather has frequently interrupted this work. A short survey was made during August on the Lulworth Bank near Weymouth with the co-operation of the marine survey section from the Winfrith Heath Atomic Energy Research Station. In the survey quantitative estimates were made of the abundance of three species: *Polymastia boletiformis* (sponge), *Bispira volutacornis* (polychaete

worm), and *Lepralia foliacea* (bryozoan). A total area of over 600 m² was covered. The results were published in Vol. 41, No. 1, of the *Journal*.

Mr Q. Bone has continued the study of the nervous system of amphioxus: a detailed account of the organization of the central nervous system has been published in the *Journal of Comparative Neurology*, and an account of the innervation of the skin has been published in Vol. 101 of the *Quarterly Journal of Microscopical Science*. The former provides the first identification of the viscero- and somatic-motor cells within the cord, and shows that the system in adult amphioxus is not unlike that found in the early stages of lower craniates. The latter describes a special type of sense-organ from the skin of the ventral region of the body, and considers the implications of the arrangement of the innervation of the skin of the animal with regard to recent theories of the mechanism of skin sensibility. An account of the atrial nervous system of the animal has appeared in the *Philosophical Transactions of the Royal Society*.

Some hauls with a new bottom sampling net designed to collect larvae of amphioxus were carried out late in the season, in collaboration with Mr Forster; it is hoped to use this gear next season and obtain material for a study of the ecology of the larval stages.

The central and peripheral nervous systems of cyclostomes are being studied at present, especial attention being paid to *Myxine*, specimens of which were obtained in Sweden by Dr D. B. Carlisle.

The above researches on primitive chordates are being made as a necessary preliminary leading on to investigations on the organization of the spinal cord in fishes in relation to their swimming behaviour.

Physiology of Marine Organisms

A histological study of the subocular light-organs of stomiatoid fishes, started last year by Dr J. A. C. Nicol, has now been completed, and an account of this work has been published in Vol. 39, No. 3, of the *Journal*. These organs are directly innervated, and it seems that light-production is subject to nervous control. In addition, some method of occluding the light-organ is always present. In the majority of stomiatoids there is a special muscle, arising from the hyomandibular bone, that passes underneath the light-organ to an insertion on the lower and outer face of the latter. Contraction of this muscle pulls the light-organ downwards and hides it from view. In *Idiacanthus* the same muscle is present, but it passes up in front of the light-organ and is inserted on a sheet of black tissue above. Contraction of this muscle pulls a screen down over the light-organ of *Idiacanthus* and screens it from the exterior. This study clarifies certain aspects of the physiology of luminescence in marine fishes.

Dr Nicol has also prepared an account of animal luminescence for the first volume of the *Advances in Comparative Physiology and Biochemistry*.

Continuing investigations begun in 1955, Dr Nicol has been making a comparative and functional study of the tapetum of elasmobranch fishes. In these animals there is a layer of shining platelets in the chorioid, which throw light back upon the retina and cause the fundus of the eye to appear highly reflective. This arrangement confers increased sensitivity on the eye. It is generally believed that the elasmobranch tapetum is occlusible, i.e. that it is covered over by processes of black pigment cells in bright light, and is exposed in darkness. An extensive and exhaustive study has demonstrated that the tapetum is fixed in the dogfish (*Scyliorhinus*) and the rays. In these animals there is always a black patch in the ventral fields, where the eye receives light from above, and a bright retinal surface elsewhere. The tapetum is occlusible in the spur dog (*Squalus acanthias*). Studies are in progress to elucidate the mechanism of pigment-movement in the tapetum of *Squalus* and to determine how it is induced and controlled. This investigation is being extended to other species of elasmobranchs as they become available.

Dr E. J. Denton, in collaboration with Dr J. B. Gilpin-Brown, has continued to study the buoyancy of the cuttlefish. *Sepia officinalis* (L.) is usually active during the night and buries itself during the day. The change of behaviour with light intensity is associated with marked changes in the animal's buoyancy; in the light it becomes less buoyant, in the dark more buoyant. These changes in density, which may amount to 2%, are given by changes in the density of the cuttlebone. After being kept for 2 days in complete darkness a cuttlefish usually becomes so buoyant that it is incapable of staying at the bottom of its tank and can only remain in mid-water with difficulty. The cuttlefish uses its cuttlebone in the same way that a submarine commander uses the buoyancy tanks of his craft; for example, to become less dense the cuttlefish pumps water out of the cuttlebone and increases its gas space. A short account of this work has been published in the *Journal of Physiology*, Vol. 151.

With Mr J. V. Howarth, Dr Denton and Dr Gilpin-Brown have shown that in the first 6 h after cuttlefish are hauled up from about 40 fathoms to the surface of the sea the equivalent osmotic concentration of the liquid inside the cuttlebone moves from about 75% to about 97% of sea water. A small extrapolation back to the time at which hauling began gives a figure for the osmotic concentration in good agreement with their osmotic hypothesis, namely, that when the cuttlefish is at depth in the sea it holds liquid out of the cuttlebone by matching an osmotic difference between cuttlebone liquid and blood against the external hydrostatic pressure. Whilst the concentration of salts in the cuttlebone liquid is rising the liquid deeper inside the cuttlebone is hypotonic to that close to its outer wall. They have explained this quantitatively in terms of the slowness of diffusion along the narrow chambers of the cuttlebone. These chambers are inclined at small angles to the siphuncular surface of the bone so that to reach a depth of about 2 mm from the surface of

the bone the salts have to diffuse along about 8 mm of chamber. The slowness of change of composition is clearly advantageous to the cuttlefish, for it allows transient changes of depth to disturb the salt concentration of the liquid inside the bone very little. The buoyancy of the cuttlefish has been shown to be very insensitive to changes in pressure at least up to six atmospheres. In this it is in marked contrast to a fish with a gas-filled swim-bladder.

They have shown that to go about half way towards an equilibrium between carbon dioxide in the gas space of the cuttlebone and carbon dioxide in the surrounding tissues would take about 1 day. For a given partial pressure difference nitrogen, the gas principally found in the cuttlebone, only diffuses at 1/40th the rate of carbon dioxide and to reach half equilibrium would therefore take about 40 days. This explains why the mass of gas within the cuttlebone remains constant when the cuttlebone density changes.

Dr Denton and Dr T. I. Shaw have studied, in the marine laboratory at Villefranche, the buoyancy of some of the many gelatinous planktonic animals. They found that all the animals studied, including ctenophores, medusae, heteropods and pteropods, were close to neutral buoyancy. The stroma, or structural components of these animals, is always denser than sea water and has a specific gravity of 1·3–1·4, characteristic of protein. Buoyancy is given by the body fluids which are less dense than sea water and supply an upthrust of the order of $\frac{1}{2}$mg/ml. The water soluble material forms over 99·8% of the total body weight.

Some animals (particularly medusae and ctenophores) are less dense than sea water. This is considered to be an arrangement whereby the animals will be kept near the surface of the sea. Even if these animals were entirely inactive, turbulence in the water will tend to hold them below the surface—this has been clearly seen with an experiment using a model animal. When turbulence increases in bad weather the animals will automatically go deeper without effort on their own part.

Whilst at Villefranche Dr Denton and Dr Shaw took the opportunity of visiting Monaco where they examined the visual pigment of the moray eel. They found it to be intermediate in colour between the retinal pigments of the ordinary coastal fish and of the conger eel. The moray eel thus differs from the conger, the silver freshwater and the deep-sea eels, all of which have been shown to have the golden pigment characteristic of deep-sea fish.

Dr Denton gave a communication on 'The design of fish and cephalopod eyes in relation to their environment' in a Symposium at the Zoological Society. An account of this communication is being published in the *Proceedings of the Zoological Society*.

Dr E. D. S. Corner, Dr E. J. Denton and Mr G. R. Forster have studied the buoyancy of the deep-sea shark *Centroscymnus coelolepis*. This animal was found to be slightly less dense than the sea water at the surface of the sea. The low density is entirely attributable to the very large amount of fat stored in

the liver. The liver accounted for about 28% of the animal's weight, and contained about 80% (by volume) fat; without its liver the fish would have been about 4·5% denser than sea water. By allowing for the differences in compressibility and temperature coefficient of expansion between the tissues and sea water, it was shown that the fish would have been almost perfectly neutrally buoyant at the bottom of the sea from which they came. The low density 0·88 of the fat in the liver of this fish is achieved by storing two-thirds of the fat as the hydrocarbon squalene, which with a density of 0·86 is 60% more efficient at giving buoyancy than normal fat with its density of 0·92.

The investigation into the sexual endocrinology of protandric hermaphrodite decapod Crustacea has been continued by Dr D. B. Carlisle, with particular reference to the effects of the vas deferens gland on female characters. He has found as a result of his visit to Kristinebergs Zoologiska Station that there is in fact no such effect in *Pandalus* or *Calocaris*, so that it is possible for the male and female characters to exist simultaneously in the same individual, and an animal in which the testis has disappeared may still possess the secondary male characters. In testing his working hypothesis about the control of the sexual characters in *Pandalus* he has succeeded by appropriate extirpation and injection in bringing about a reversal in the external characters from female to male, i.e. in the direction opposite to that which normally occurs, and in producing animals which have the appendages of both sexes. He found no effect upon the secondary or primary sexual characters of *Palaemon*, when purified sheep follicle-stimulating hormone was injected in a variety of doses. A paper by Dr Carlisle read to a symposium of the Society for Endocrinology on sexual differentiation in Crustacea has been published in the *Memoirs of the Society for Endocrinology*, No. 7, pp. 9–16.

In collaboration with Mr W. J. P. Smyly of the Freshwater Biological Association, and Mr W. J. Pitman a visiting worker from Ohio State University, Dr Carlisle has begun investigations into the endocrinology of copepods. One of the colour change hormones familiar from the study of decapods has been demonstrated in several species, something of the histology of the endocrine system has been revealed and changes in secretory activity correlated with the occurrence of the diapause in overwintering fifth copepodid stages. A preliminary note on some of this work has been submitted for publication in *Nature*.

A gift of a few milligrams of derivatives of the newly synthesized substance 5,6-dihydroxtryptamine from Dr H. Schlossberger of the Max-Planck-Institut, Munich, has enabled him, with assistance from Dr K. K. Tiwari, a visiting worker from the Zoological Survey of India, to confirm that one of the heart-beat hormones of crabs is in fact this compound.

Dr Carlisle has observed that the brief spell of seemingly uncontrolled cell-division that takes place in the epidermis of a prawn shortly before the moult bears superficial resemblances to the similar uncontrolled cell-division

of vertebrate epithelium during carcinogenesis. Preliminary experiments with a series of injections of well-known carcinogenic compounds have proved promising and suggest that this likeness may be more than superficial. Interest centres upon the means by which the prawn may bring this spate of cell-division under control again.

In collaboration with Dr P. E. Ellis of the Anti-locust Research Centre of the Colonial Office, Dr Carlisle has continued the investigation into the comparative endocrinology of moulting in crustaceans and insects. Most of the results which have emerged so far are perhaps more pertinent to insect endocrinology than to crustacean, but it is becoming apparent how similar is the control in the two groups, and that most of the seeming differences which have been advanced by earlier workers in the field derive from the different ways of thinking about hormones which have arisen in the two fields—the differences seem to be largely semantic. In connexion with this work he has developed a method of softening chitin for histology which has been the subject of a recent publication in *Nature*, Vol. 187. He also delivered a paper at the second symposium of the Zoological Society of London on moulting cycles and this has now been published in *Symposium of the Zoological Society of London*, No. 2, pp. 109–20.

Dr E. D. S. Corner, in collaboration with Dr A. D. Boney of Plymouth Technical College, has continued a study of factors affecting the ecological distribution of intertidal red algae. It has been found that when sporelings of *Plumaria elegans* are screened with dilute solutions of the fluorescent dye Eosin Yellow their growth is markedly increased over a wide range of light intensities, including some below and some above the optimum value of 315 lux. An identical result is obtained when the dye in the screening solution is replaced by phycoerythrin extracted from the adult plant. Further experiments have shown that the stimulation of growth is caused neither by shading nor by exclusion of ultra-violet light, but by protection from blue-green light inhibiting growth. It seems from this that the theory of complementary chromatic adaptation does not apply in the case of *Plumaria*, and further studies along similar lines are planned with other red algae. A preliminary account of this work was published in *Nature*, Vol. 188, p. 1042.

Dr Boney and Dr Corner, in collaboration with Dr W. Carruthers of the Carcinogenic Substances Research Unit, University of Exeter, have been studying the effects of certain carcinogens on the growth of red algal sporelings, and initial experiments have shown that growth is greatly increased by such substances as 9:10-dimethyldibenzanthracene and 20-methylcholanthrene. Further work, in collaboration with Dr G. Y. Kennedy of the Cancer Research Unit, University of Sheffield, has been concerned with the effects of various carcinogens on the phospholipide contents of red algae.

Mr G. R. Forster has continued to assist Dr G. Y. Kennedy in experiments on the regeneration in the sponge *Microciona atrasanguinea*. It was found

that a dilute solution of caffeine markedly hindered the initial reaggregation of dissociated cells. The work is now being carried on by Dr Kennedy at the Cancer Research Unit of Sheffield University with sponge material collected at Plymouth generally by diving.

Dr T. I. Shaw has continued investigations relating to the active transport of ions by the giant nerve fibres of *Loligo*. An account of the effects of injecting various phosphate esters upon the active transport of sodium and potassium by these nerve fibres has been published in collaboration with Prof. A. L. Hodgkin, F.R.S., and Dr R. D. Keynes, F.R.S., of Cambridge, and Dr P. C. Caldwell, Alan Johnston, Lawrence and Mosely Research Fellow of the Royal Society. This account, together with another concerning the partial inhibition of active transport, jointly published with the same co-workers, have appeared in the *Journal of Physiology*, Vol. 152. Further work with the same collaborators has been directed towards determining the fate of phosphate esters which affect sodium transport when they are injected into poisoned axons. It has been found that injections of arginine phosphate very rapidly bring about the regeneration of adenosine triphosphate to a level close to that found in unpoisoned axons. Injections of phospho-enol pyruvate bring about regeneration of both adenosine triphosphate and arginine phosphate in poisoned axons. Currently the fate of phosphate esters in poisoned, extruded axoplasms is being investigated in collaboration with Mr P. F. Baker of Cambridge and it has been found that in extruded axoplasm exposed to cyanide the adenosine triphosphate and arginine phosphate are broken down, the rate of inorganic phosphate formation not being very greatly different from that in intact axons in sea water containing cyanide. Both adenosine triphosphate and arginine phosphate persist in unpoisoned extruded axoplasm. Very recently a technique has been devised whereby a giant axon can be perfused with artificial axoplasm; provided the artificial axoplasm has a certain ionic composition the axon will give action potentials.

Dr Shaw is continuing his investigations on the accumulation of iodine by seaweeds. During the year he has published a second paper on respiration and iodide uptake in Vol. 152 of the *Proceedings of the Royal Society*, B.

Mr J. V. Howarth has continued his investigations into the heat production of the anterior byssus retractor muscle of *Mytilus*. The work has been extended to include a study of the thermoelastic properties of the muscle in the 'fused' state. These prove to be analogous to those of striated muscle when the latter is in the 'active' state. This suggests that the molecular architecture is similar in the two states. In the *Mytilus* muscle an actual fall of temperature is observed when the tension increases due to a small, controlled stretch. Such a thermoelastic cooling is an important term in the computation of the energy balance sheet of a muscle, but previously it lacked direct experimental basis and had to be inferred from indirect evidence.

During the summer months Mr Howarth began a study of the heat

production of the limb nerves of *Maia squinado* in collaboration with Dr J. M. Ritchie of the Albert Einstein College of Medicine, New York. They studied the effect of substituting foreign ions for the sodium of the bathing solutions. The substitution of lithium for sodium made no difference to the heat due to a single stimulus at 0° C, but the net heat due to a series of stimuli at higher temperature was diminished. When sodium is replaced by barium both the action potential and the heat production are abolished, but the presence of a trace of sodium results in a greatly enhanced action potential and increased heat production.

Dr G. W. Bryan has continued his work on the accumulation of radioactive caesium by marine invertebrates in relation to potassium balance. In the decapod crustacea studies with ^{134}Cs have been continued in *Carcinus maenas* and extended to *Portunus puber* and *P. depurator*. Work with ^{137}Cs in *Palaemon serratus* was also continued during a 3-week visit to the United Kingdom Atomic Energy Authority Radiobiology Group at Windscale. Experiments with ^{42}K in the above species have shown that K is taken up far more rapidly than Cs (e.g. ten times more quickly in *Carcinus*) and that most of the K in these animals is readily exchangeable. Animals taking up Cs most slowly are those in which ^{42}K uptake is slowest. In marine decapods Cs concentration factors attained at equilibrium by whole animals vary between about 5 and 20 depending on the species and this is increased in diluted sea water. For comparison, experiments with the freshwater crayfish *Astacus fluviatilis* were carried out at Windscale in sea-water dilutions as low as 0·01 %. Under such conditions whole animal concentration factors of more than 100 are reached in about 300 h although the actual attainment of equilibrium is a far slower process than in the marine species.

In order to study the uptake and loss of ^{137}Cs by brackish-water animals the isopod *Sphaeroma hookeri* and the gastropod *Potamopyrgus* (= *Hydrobia*) *jenkinsi* were used. Sodium and potassium balance has been examined in both animals, with the aid of ^{22}Na and ^{42}K, and this related to the rate and extent of ^{137}Cs accumulation. *Sphaeroma* is able to live almost indefinitely in a range of sea-water concentrations between 2·5 and 100 %. Although Cs is taken up more slowly than K the equilibrium concentration factors attained are almost double those for K at all concentrations. Uptake and loss of ^{137}Cs was studied in *Potamopyrgus* in sea-water concentrations varying between 0·1 and 100 % In the more concentrated solutions ^{137}Cs concentration factors at equilibrium are higher than those for K, but in concentrations as low as 0·1 % the factor for K is about 1000 and that for ^{137}Cs about 500 (including shell).

Additional marine invertebrates have been examined under starved conditions. The accumulation of ^{137}Cs and in some cases of ^{42}K has been studied in the anemones *Actinia equina* and *Calliactis parasitica*, the polychaete *Nereis diversicolor*, the gastropods *Littorina littorea*, *Monodonta lineata*, *Ocenebra erinacea*, *Nucella lapillus*, and in the lamellibranch *Mytilus edulis*.

Excluding the weight of the mollusc shells equilibrium concentration factors for ^{137}Cs in these animals are of the order of 10. Concentration factors in tissues are usually rather higher than those for K but appear to be related to them. Cs is not accumulated by any whole animal or organ to a degree which might indicate that it is a necessary element controlled by specific mechanism.

So far all studies have been carried out in unfed animals. Experiments are now in progress on the effects of feeding on ^{134}Cs accumulation in *Carcinus*, and work on other species in collaboration with the Radiobiology Group, Windscale is anticipated.

Dr G. T. Boalch, International Paints Research Fellow, has continued his investigations on the toxic effects of heavy metals on fouling algae. Using bacteria-free cultures of *Ectocarpus* and *Enteromorpha*, the toxic effects of additions of copper and mercury salts to the culture media have been investigated under controlled conditions. The two weeds show marked differences in resistance to these poisons, *Ectocarpus* having a more effective protection against copper whereas *Enteromorpha* is more resistant to mercury. These differences may well be due to differences in the protection afforded by the extracellular products produced by the algae. These extracellular products and their role in reducing toxicity are still under investigation. A few experiments, using copper and mercury salts, have been carried out with a bacteria-free culture of *Phaeodactylum*.

During the past year monthly visits have been made to the River Yealm and a seasonal examination made of the fouling weeds growing on the test rafts of International Paints Biological Research Laboratory, Newton Ferrers. The identification of fouling weeds, often collected in very early stages of development, is sometimes rather troublesome and when in addition the algae are stunted and distorted by poisons certain identification is often impossible.

Library

The thanks of the Association are once more due to many foreign Government Departments, to Universities and to other Institutions at home and abroad for copies of books and current numbers of periodicals either presented to the Library or received in exchange for the *Journal* of the Association.

Thanks are also due to those who have sent books or reprints of their papers, which are much appreciated.

Published Memoirs

Vol. 39, No. 2, of the *Journal* was published in June, and Vol. 39, No. 3, in October 1960.

The following papers, the outcome of work done at the Plymouth laboratory, have been published elsewhere than in the *Journal* of the Association:

Alexandrowicz, J. S., 1960. Innervation of the hearts of *Sepia officinalis*. *Acta zool., Stockh.*, Vol. 41, pp. 65–100.

ARMSTRONG, F. A. J., 1958. Inorganic suspended matter in sea water. *J. mar. Res.*, Vol. 17, pp. 23–34.

ATKINS, D., 1959. The growth stages of the lophophore and loop of the brachiopod *Terebratalia transversa* (Sowerby). *J. Morphol.*, Vol. 105, pp. 401–26.

BATHAM, E. J., PANTIN, C. F. A. & ROBSON, E. A., 1960. The Nerve-net of the sea anemone *Metridium senile*: the mesenteries and the column. *Quart. J. micr. Sci.*, Vol. 101, pp. 487–510.

BONE, Q., 1960. The origin of the chordates. *J. Linn. Soc.* (*Zool.*), Vol. 44, pp. 252–69.

——, 1960. A note on the innervation of the integument in Amphioxus, and its bearing on the mechanism of cutaneous sensibility. *Quart. J. micr. Sci.*, Vol. 101, pp. 371–9.

——, 1960. The central nervous system in Amphioxus. *J. comp. Neurol.*, Vol. 115, pp. 27–64.

——, 1961. The organization of the atrial nervous system of Amphioxus (*Branchiostoma lanceolatum* (Pallas)). *Phil. Trans.*, Ser. B, Vol. 243, pp. 241–69.

BONEY, A. D., 1960. Observations on the spore output of some common red algae. *Brit. Phycol. Bull.*, Vol. 2, pp. 36–7.

——, 1960. The spore output of *Antithamnion plumula* over a number of days. *Brit. Phycol. Bull.*, Vol. 2, pp. 37–8.

——, 1960. Nurture of a fruiting *Antithamnion* tuft and the physiological condition of the liberated spores. *Brit. Phycol. Bull.*, Vol. 2, pp. 38–9.

BONEY, A. D. & CORNER, E. D. S., 1960. A possible function of Phycoerythrin in intertidal red algae. *Nature, Lond.*, Vol. 188, pp. 1042–3.

BOYCOTT, B. B., 1961. The functional organization of the brain of the cuttlefish *Sepia officinalis*. *Proc. roy. Soc.* B, Vol. 153, pp. 503–34.

CALDWELL, P. C., 1960. The phosphorus metabolism of squid axons and its relationship to the active transport of sodium. *J. Physiol.*, Vol. 152, pp. 545–60.

——, 1961. The use of micro-injection techniques and large nerve and muscle fibres in the study of active transport and muscular contraction. *Pflüg. Arch. ges. Physiol.*, Vol. 272, pp. 215–22.

CALDWELL, P. C., HODGKIN, A. L., KEYNES, R. D. & SHAW, T. I., 1960. The effects of injecting 'energy-rich' phosphate compounds on the active transport of ions in the giant axons of *Loligo*. *J. Physiol.*, Vol. 152, pp. 561–90.

—— ——, 1960. Partial inhibition of the active transport of cations in the giant axons of *Loligo*. *J. Physiol.*, Vol. 152, pp. 591–600.

CALDWELL, P. C. & KEYNES, R. D., 1960. The permeability of the squid giant axon to radioactive potassium and chloride ions. *J. Physiol.*, Vol. 154, pp. 177–89.

CARLISLE, D. B., 1960. Sexual differentiation in Crustacea Malacostraca. *Mem. Soc. Endocrinol.*, Vol. 7, pp. 9–15.

——, 1960. Softening chitin for histology. *Nature, Lond.*, Vol. 187, pp. 1132–3.

——, 1960. Moulting cycles in Crustacea. *Symp. zool. Soc. Lond.*, No. 2, pp. 109–20.

——, 1960. Protochordata. *Zool. Rec.*, Vol. 95, Sect. 14, pp. 1–15.

——, 1960. Moulting cycles in Crustacea. *Symp. zool. Soc. Lond.*, No. 2, pp. 109–20.

——, 1961. Locomotory powers of adult Ascidians. *Proc. zool. Soc. Lond.*, Vol. 136, pp. 141–6.

CLARK, R. B. & HADERLIE, E. C., 1960. The distribution of *Nephtys cirrosa* and *N. hombergi* on the south-western coasts of England and Wales. *J. Anim. Ecol.*, Vol. 29, pp. 117–47.

COOPER, L. H. N., 1958. A system for international exchange of samples for trace element analysis of ocean water. *J. mar. Res.*, Vol. 17, pp. 128–32.

CURRY, D., 1960. Eocene limestones to the west of Jersey. *Geol. Mag.*, Vol. 97, pp. 289–98.

DENTON, E., 1960. The buoyancy of marine animals. *Sci. Amer.*, Vol. 203, pp. 119–24, 126, 128.

DENTON, E. J., 1960. The 'design' of fish and cephalopod eyes in relation to their environment. *Symp. zool. Soc. Lond.*, No. 2, pp. 53–5.

DENTON, E. J. & GILPIN-BROWN, J. B., 1960. Daily changes in the buoyancy of the cuttlefish. *Proc. physiol. Soc.*, 19–20 February 1960; *J. Physiol.*, Vol. 151, 36–7*P*.

ENDEAN, R., 1960. The blood-cells of the ascidian, *Phallusia mammillata*. *Quart. J. micr. Sci.*, Vol. 101, pp. 177–97.

HART, T. J. & CURRIE, R. I., 1961. The Benguela Current. *Discovery Rep.*, Vol. 31, pp. 123–298.

HEDLEY, R. H., 1960. The iron-containing shell of *Gromia oviformis* (Rhizopoda). *Quart. J. micr. Sci.*, Vol. 101, pp. 279–93.

HUGHES, G. M., 1960. The mechanism of gill ventilation in the dogfish and skate. *J. exp. Biol.*, Vol. 37, pp. 11–27.

——, 1960. A comparative study of gill ventilation in marine teleosts. *J. exp. Biol.*, Vol. 37, pp. 28–45.

LEBOUR, M. V., 1959. The larval decapod Crustacea of tropical West Africa. *Atlantide Rep.*, Vol. 5, pp. 119–43.

LEON, Y. A., BULBROOK, R. D. & CORNER, E. D. S., 1960. Steroid sulphatase, arylsulphatase and β-glucuronidase in the Mollusca. *Biochem. J.*, Vol. 75, pp. 612–17.

MURRAY, R. W., 1960. The response of the ampullae of Lorenzini of elasmobranchs to mechanical stimulation. *J. exp. Biol.*, Vol. 37, pp. 417–24.

——, 1960. Electrical sensitivity of the ampullae of Lorenzini. *Nature, Lond.*, Vol. 187, p. 957.

——, 1960. Initiation of cutaneous sensory nerve impulses. *Proc. physiol. Soc.*, 22–23 April 1960; *J. Physiol.*, Vol. 152, 53–4*P*.

MURRAY, R. W. & POTTS, W. T. W., 1961. The composition of the endolymph, perilymph and other body fluids of elasmobranchs. *Comp. Biochem. Physiol.*, Vol. 2, pp. 65–75.

NICHOLS, D., 1960. The histology and activities of the tube-feet of *Antedon bifida*. *Quart. J. micr. Sci.*, Vol. 101, pp. 105–17.

RALPH, P. M., 1960. *Tetraplatia*, a coronate scyphomedusan. *Proc. roy. Soc.* B, Vol. 152, pp. 263–81.

ROSS, D. M., 1960. The association between the hermit crab *Eupagurus bernhardus* (L.) and the sea anemone *Calliactis parasitica* (Couch). *Proc. zool. Soc. Lond.*, Vol. 134, pp. 43–57.

——, 1960. The effects of ions and drugs on neuromuscular preparations of sea anemones. I. On preparations of the column of *Calliactis* and *Metridium*. *J. exp. Biol.*, Vol. 37, pp. 732–52.

——, 1960. The effects of ions and drugs on neuromuscular preparations of sea anemones. II. On sphincter preparations of *Calliactis* and *Metridium*. *J. exp. Biol.*, Vol. 37, pp. 753–74.

RUSSELL, F. S., 1960. Mr W. H. Searle, B.E.M. *Nature, Lond.*, Vol. 186, p. 518.

RUSSELL, F. E. & EMERY, J. A., 1960. Venom of the weevers *Trachinus draco* and *T. vipera*. *Ann. N.Y. Acad. Sci.*, Vol. 90, pp. 805–19.

SHAW, T. I., 1960. The mechanism of iodide accumulation by the brown sea weed *Laminaria digitata*. II. Respiration and iodide uptake. *Proc. roy. Soc.* B, Vol. 152, pp. 109–17.

SOUTHWARD, A. J., 1960. Farming the sea. *Discovery*, August 1960, pp. 330–7.

SUTTON, M. F., 1960. The sexual development of *Salpa fusiformis* (Cuvier). Part I. *J. Embryol. exp. Morph.*, Vol. 8, pp. 268–90.

WILLIAMS, H. HARFORD, 1960. A list of parasitic worms, including 22 new records, from marine fishes caught off the British Isles. *Ann. Mag. nat. Hist.*, Ser. 13, Vol. 2, pp. 705–15.

——, 1960. The intestine in members of the genus *Raja* and host specificity in the Tetraphyllidea. *Nature, Lond.*, Vol. 188, pp. 514–16.

MEMBERSHIP OF THE ASSOCIATION

The total number of members on 31 March 1961 was 1182, being 86 more than on 31 March 1960; of these the number of life members was 140 and of annual members 1042. The number of associate members is four.

GRANT FROM ROCKEFELLER FOUNDATION

The thanks of the Council are due to the Trustees of the Rockefeller Foundation for a generous grant of 30,000 dollars to be made available during the 2-year period beginning 1 April 1960 for the purchase of certain selected pieces of apparatus for physiological and biochemical research.

GRANT FROM WELLCOME TRUST

The thanks of the Council are also due to the Trustees of the Wellcome Trust for a generous grant of £5,000 towards the cost of fittings in the chemical and physiological laboratories and constant temperature rooms, in the new laboratory extension.

GRANT FOR AQUARIUM RECONSTRUCTION

The Council wish to record their grateful thanks for the following donation towards the cost of reconstructing the Aquarium: Granada T.V. £105.

FINANCE

General Fund. The thanks of the Council are again due to the Development Commissioners for their continued support of the general work of the laboratory.

Private Income. The Council gratefully acknowledge the following generous grants for the year 1960–61:

Fishmongers' Company (£425), The Royal Society (£100), British Association (£50), Physiological Society (£100), The Cornwall Sea Fisheries Committee (£10), The Universities of London (£210), Cambridge (£125), Oxford (£100), Bristol (£50), Birmingham (£31. 10*s*.), Leeds (£25), Durham (£10. 10*s*.), Manchester (£10. 10*s*.), Sheffield (£10. 10*s*.), Southampton (£15. 15*s*.), Reading (£10. 10*s*.), Nottingham (£10. 10*s*.), Hull (£10. 10*s*.), Exeter (£10. 10*s*.), Leicester (£10. 10*s*.), Gonville and Caius College, Cambridge (£5), and The Zoological Society of London (£10. 10*s*.).

PRESIDENT, VICE-PRESIDENTS, OFFICERS AND COUNCIL:

The following is the list of those proposed by the Council for election for the year 1961–62:

President

Prof. C. F. A. PANTIN, Sc.D., Hon. Dr. Univ., F.R.S.

Vice-Presidents

THE EARL OF IVEAGH, K.G., C.B., C.M.G.
Sir NICHOLAS E. WATERHOUSE, K.B.E.
Col. Sir EDWARD T. PEEL, K.B.E., D.S.O., M.C.
Vice-Admiral Sir JOHN A. EDGELL, K.B.E., C.B., F.R.S.
Prof. A. V. HILL, C.H., O.B.E., Sc.D., LL.D., F.R.S.
Sir EDWARD J. SALISBURY, Kt., C.B.E., D.Sc., F.R.S.
A. T. A. DOBSON, C.B., C.V.O., C.B.E.
Major E. G. CHRISTIE-MILLER
MORLEY H. NEALE, C.B.E.
Prof. Sir JAMES GRAY, Kt., C.B.E., M.C., Sc.D., LL.D., F.R.S.
G. M. GRAHAM, C.M.G., O.B.E.

COUNCIL

To retire in 1962

J. N. CARRUTHERS, D.Sc., F.Inst.P.
Prof. A. L. HODGKIN, F.R.S.
Prof. O. E. LOWENSTEIN, D.Sc., F.R.S.
Prof. G. E. NEWELL, T.D., D.Sc.
Prof. W. F. WHITTARD, D.Sc., F.R.S.

To retire in 1963

G. E. R. DEACON, C.B.E., D.Sc., F.R.S.
F. C. FRASER, D.Sc.
M. N. HILL, Ph.D.
O. D. HUNT, F.R.S.E.
Prof. G. P. WELLS, Sc.D., F.R.S.

To retire in 1964

Prof. A. V. HILL, C.H., O.B.E., Sc.D., LL.D., F.R.S.
J. W. G. LUND, Ph.D., D.Sc.
C. H. MORTIMER, Dr.Phil., D.Sc., F.R.S.
Prof. J. T. RANDALL, D.Sc., F.R.S.
H. G. VEVERS, M.B.E., D.Phil.

Hon. Treasurer

HARRISON S. EDWARDS, Westhumble Lacey, near Dorking, Surrey

Secretary

F. S. RUSSELL, C.B.E., D.S.C., D.F.C., LL.D., F.R.S.

The Laboratory, Citadel Hill, Plymouth

The following Governors are also members of the Council:

B. C. ENGHOLM (Ministry of Agriculture, Fisheries and Food)
The Worshipful Company of Fishmongers:
The Prime Warden
Major E. G. CHRISTIE-MILLER
HARRISON S. EDWARDS
Prof. Sir ALISTER HARDY, Kt., D.Sc., F.R.S. (Oxford University)
S. SMITH, Ph.D. (Cambridge University)
EDWARD HINDLE, Sc.D., F.R.S. (British Association)
N. B. MARSHALL (Zoological Society)
Prof. Sir JAMES GRAY, Kt., C.B.E., M.C., Sc.D., LL.D., F.R.S. (Royal Society)

BALANCE SHEET 1960–61

THE MARINE BIOLOGICAL ASSOCIATION OF THE UNITED KINGDOM

BALANCE SHEET

31 MARCH 1961

	£	£	£
CAPITAL RESERVE ACCOUNT:			
As at 31 March 1960	167,821		
Add: Expenditure on fixed assets recovered	4,779		
	172,600		
Less: Transfer to surplus account being an amount equivalent to the depreciation provided on assets acquired out of Development Fund grants	3,674	168,926	
SURPLUS ACCOUNT:			
As at 31 March 1960	12,261		
Add: Transfer from Capital Reserve Account	3,674		
Stock adjustment in respect of prior year	1,455		
	17,390		
Deduct:			
Increase in provision for diminution in value of General Fund investments	100		
Excess of expenditure over income for the year	5,891		
	5,991	11,399	
		180,325	
BALANCES ON SPECIAL FUNDS (see annexed statement)		4,574	
CURRENT LIABILITIES:			
Sundry creditors and accrued expenses	6,045		
Subscriptions and grant received in advance	363		
		6,408	
Note: Capital commitments outstanding amount to approximately £74,500 (1960 £2,730) of which £73,900 (1960 £1,500) is recoverable			
		£191,307	

J. E. HARRIS
O. D. HUNT
Members of the Council

	£	£	£
FIXED ASSETS:	Cost or Valuation	Depreciation	
Boats and equipment:			
At cost:			
R.V. 'Sarsia'	137,761	13,077	124,684
M.F.V. 'Sula'	12,500	1,605	10,895
R.L. 'Gammarus'	200	40	160
	150,461	14,722	135,739
Laboratory apparatus, equipment and machinery:			
At cost	22,868	8,186	14,682
Library at valuation in 1941 plus additions as valued by the Director	25,290	—	25,290
	£198,619	£22,908	
			175,711
INVESTMENTS AT MARKET VALUE:			
General Fund (including Composition Fees) at book amount (Market value £1,472; last year £1,368)		2,019	
E. T. Browne Bequest Funds at cost (Market value £3,264; last year £3,400)		4,915	
		6,934	
Less: Provision for diminution in value of investments		2,198	
			4,736
CURRENT ASSETS:			
Stocks on hand at the lower of cost and estimated realizable value		5,776	
Sundry debtors and prepayments		2,628	
Balances at bankers and cash in hand		2,456	
			10,860
			£191,307

AUDITORS' REPORT TO THE MEMBERS OF THE MARINE BIOLOGICAL ASSOCIATION OF THE UNITED KINGDOM:

Capital expenditure on the erection of buildings on land held on lease from the War Department is excluded. Subject to the foregoing, in our opinion the above balance sheet and annexed income and expenditure account give a true and fair view of the state of the Association's affairs as at 31 March 1961 and of its excess of expenditure over income for the year ended on that date.

We have obtained all the information and explanations which we considered necessary. In our opinion the Association has kept proper books and the said accounts which are in agreement with them and with the said information and explanations, give in the prescribed manner the information required by the Companies Act 1948.

Norwich Union House
2 St Andrew's Cross
Plymouth
19 May 1961

PRICE WATERHOUSE & CO.
Chartered Accountants

INCOME AND EXPENDITURE ACCOUNT

FOR THE YEAR ENDED 31 MARCH 1961

	£	£
SALARIES (including £6,722 for previous years) NATIONAL INSURANCE, SUPERANNUATION SCHEME CONTRIBUTIONS AND SUPPLEMENTARY PENSIONS		54,993
LABORATORY'S AND BOATS' CREWS' WAGES (including £308 for previous years), NATIONAL INSURANCE, SUPERANNUATION SCHEME CONTRIBUTIONS, PENSIONS AND EMPLOYERS' LIABILITY INSURANCE		38,147
UPKEEP OF LIBRARY		858
SCIENTIFIC PUBLICATIONS, *less* SALES		1,849
UPKEEP OF LABORATORIES:		
Buildings and machinery	595	
Electricity, gas, coal and water	1,335	
Chemicals and apparatus	2,835	
Depreciation of laboratory apparatus, equipment and machinery	1,631	
Rates (including £1,038 for previous year)	2,221	
Rents and insurance	431	
Travelling expenses	1,013	
Audit fee	179	
Stationery, postage, telephone and sundries	1,739	
Specimens	96	
Collecting expenses and upkeep of truck	328	
		12,403
MAINTENANCE AND OPERATION OF BOATS:		
Petrol, oil, paraffin, etc.	1,811	
Maintenance and repairs	10,641	
Depreciation	3,674	
Insurances	2,413	
Hire of Decca Navigator—R.V. 'Sarsia'	395	
		18,934
ENTERTAINMENT EXPENSES		63
		£127,247

	£	£
GRANTS AND TABLE RENTS:		
Ministry of Agriculture, Fisheries and Food—Grant from Development Fund (including £7,030 for previous years)	111,332	
Fishmongers' Company	400	
Miscellaneous (including Royal Society £100, British Association £50, Physiological Society £100, Universities of London £210, Cambridge £125, Oxford £100, Bristol £50, Birmingham £31. 10*s*., Leeds £25, Southampton £15. 15*s*., Durham £10. 10*s*., Exeter £10. 10*s*., Leicester £10. 10*s*., Manchester £10. 10*s*., Nottingham £10. 10*s*., Hull £10. 10*s*., Reading £10. 10*s*., and Sheffield £10. 10*s*., Zoological Society of London £10. 10*s*., Ministry of Works £104, Imperial Chemical Industries Ltd., £52. 10*s*., International Paints Ltd., £52. 10*s*., Gonville and Caius College, Cambridge £5)	1,533	
		113,265
SUBSCRIPTIONS		1,156
SALES:		
Specimens	3,426	
Fish	546	
	£	
Nets, gear and hydrographical equipment	1,597	
Less: Cost of materials	1,179	
	418	
		4,390
INTEREST ON BANK DEPOSITS, LESS CHARGES		56
INCOME FROM INVESTMENTS		64
AQUARIUM:		
Admission fees	3,235	
Sale of guides	104	
	3,339	
Less: Maintenance, printing and advertising	914	
		2,425
BALANCE being excess of expenditure over income for the year		5,891
		£127,247

MOVEMENTS ON SPECIAL FUNDS DURING THE YEAR TO 31 MARCH 1961

	E. T. Browne Bequest									
	Library	Special Apparatus	Scientific Publications	Library Reserve Fund	Rockefeller Foundation Fund	Aquarium Reconstruction Fund	Reservoir and Sea Water Tanks Fund	Main Laboratory Extension Fund	Research Funds*	TOTAL
	£	£	£	£	£	£	£	£	£	£
BALANCES AT 31 MARCH 1960 (after providing £1,417 for diminution in value of investments)	1,059	1,936	753	232	—	1,240	(193)	—	338	5,365
Add: Income during year										
Grants	—	—	—	—	1,587	—	193	36,280	3,839	41,899
Amounts paid direct to contractors and suppliers by:										
Nuffield Foundation	—	—	—	—	—	1,500	—	—	—	1,500
Rockefeller Foundation	—	—	—	—	3,961	—	—	—	—	3,961
Income from investments	40	84	36	—	—	—	—	—	—	160
Bank deposit interest	—	—	—	—	—	43	—	—	—	43
Other income	—	—	69	—	—	132	—	—	—	201
	1,099	2,020	858	232	5,548	2,915	—	36,280	4,177	53,129
Deduct: Expenditure during year	61	—	—	—	5,878	2,118	—	36,280	3,983	48,320
Increase in provision for diminution in value of investments	60	125	50	—	—	—	—	—	—	235
BALANCES AT 31 MARCH 1961	£978	£1895	£808	£232	£(330)	£797	—	—	£194	£4,574

* Including International Paints Limited Research Fellowship.