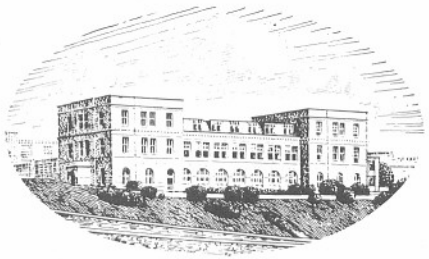
MARINE BIOLOGICAL ASSOCIATION
OF THE UNITED KINGDOM



THE MARINE BIOLOGICAL ASSOCIATION 1884–1984: ONE HUNDRED YEARS OF MARINE RESEARCH

by

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(Figures 1 and 2)

Origins and Foundation

"There is the sea—who shall exhaust the sea"
Aeschylus, *The Oresteia*

THE second half of the nineteenth century was a period of rapid change in the natural sciences in Britain, reflecting changes in social conditions and improvements in education.[1,2] A growing number of naturalists were becoming socially conscious and aware of the need for a proper study of the sea and its products, following the success of the *Challenger* expedition of 1872–1876.[3] In 1866 the Royal Commission on the Sea Fisheries,[4] which included among its officers Professor T. H. Huxley, one of the new breed of professional scientists,[1,5] had reported that fears of over-exploitation of the sea-fisheries were unfounded, and had recommended doing away with existing laws regulating fishing grounds and closed seasons. Nevertheless, the rising trade in fresh fish carried to towns by rail or by fast boats (fleeting), and the consequent increase in size and number of registered fishing vessels, was causing

widespread concern, and there were reports from all round the coasts about the scarcity of particular fish, especially soles. This concern was expressed at the International Fisheries Exhibition in London in 1883, a conference called to discuss the commercial and scientific aspects of the fishing industry, attended by many active and first rank scientists. However, in his opening address, Professor Huxley discounted reports of scarcity of fish, and repeated the views of the Royal Commission of 1866: that, with existing methods of fishing, it was inconceivable that the great sea fisheries, such as those for cod, herring and mackerel, could ever be exhausted.[6]

It is evident from the conference reports that many of the representatives of science and commerce present ventured to differ with Professor Huxley. Their views were put forward by Professor E. Ray Lankester, who summed up the scientific contributions in a brilliant essay on what we would now call ecology. He pointed out that "it is a mistake to suppose that the place of fish removed on a particular fishing ground is immediately taken by some of the grand total of fish, which are so numerous in comparison with man's depredations as to make his operations in this respect insignificant . . . there is on the contrary evidence that shoal fish, like herrings, mackerel and pilchard, and ground-fish, such as soles and other flat-fishes, are really localised. If man removes a large proportion of these fish from the areas which they inhabit, the natural balance is upset and chiefly in so far as the production of young fish is concerned".[7] He went on to develop this theme and concluded with an appeal for the formation of a society to foster the study of marine life, both for its scientific interest and because of the need to know more about the life-histories and habits of food fishes. As Professor Lankester saw it, such a society would construct a laboratory close to the coast, on the shore somewhere not too distant from London. There would be a jetty with steam-launch and other boats, and adjacent ponds for cultivation of shellfish. The building would contain tank rooms and apparatus for the circulation of sea-water, and, most importantly, laboratory accommodation for up to ten temporary visitors as well as a resident Director and assistant. "Bit by bit a new and thorough knowledge of fishery-animals would be built up, and come into use as the basis of new legislative enactments, and of new methods of capture and culture".

The appeal was answered by a group of eminent scientists (Table I), who resolved to form a society and build a laboratory on the British Coast;[8] many of the signatories to this resolution were members of the newly-founded Physiological Society.[1] However, as Michael Graham[9] has noted, Professor Huxley did not sign the resolution although he was active at the meeting, and it has to be assumed that he disagreed with

TABLE I

The Committee formed at the International Fisheries Exhibition 1883

The scientists who resolved to take action to establish a British Marine Laboratory

Sir John Lubbock, M.P. (afterwards Lord Avebury)
P. L. Sclater, F.R.S., Secretary of the Zoological Society
F. Jeffrey Bell, Professor of Zoology at King's College London
Michael Foster, Sec. R.S., Professor of Physiology at Cambridge
J. Burdon Sanderson, F.R.S., Professor of Physiology at Oxford
W. H. Flower, F.R.S., Hunterian Professor, Royal College of Surgeons
G. J. Romanes, F.R.S., Secretary of the Linnean Society
A. Sedgwick, Trinity College, Cambridge
H. N. Moseley, Linacre Professor of Anatomy at Oxford
A. Milnes Marshall, Professor of Zoology at Manchester
W. T. Thistleton Dyer, F.R.S., Assistant Director, Royal Gardens, Kew
W. B. Carpenter, F.R.S.
G. J. Allman, F.R.S., Emeritus Professor of Natural History, Edinburgh
John Murray, Director of the Challenger Expedition Reports

Professor Lankester's summary. Nevertheless, two of the signatories, Michael Foster and W. T. Thistleton Dyer, together with Ray Lankester, had taught in Huxley's department at the Royal College of Science (now Imperial College), London, and, with him, had helped to devise courses to educate a new generation of scientists.[1] At the head of the list was Sir John Lubbock (later Lord Avebury), a well-known educator and populariser of science, and an enthusiast for the Victorian principles of hard work and self-help. The next, P. L. Sclater, had been actively involved in the formation of the Zoological Station at Naples in 1872–74.[10]

There were other examples of the value of marine stations in addition to the evidence from Naples. In 1871 the U.S. Federal Government had set up a Commission on Fisheries[11] that later established permanent marine stations, and France could show a number of coastal biological laboratories attached to the Universities, as for example at Roscoff in Brittany.[12] The call for action in 1883 stimulated other groups of British scientists who had been considering the establishment of marine laboratories. In 1884 a floating laboratory was set-up in the Firth of Forth, later being moved to the Clyde to become the nucleus of the famous Millport Marine Station,[13] and steps were taken to start marine biological studies at St Andrews and Liverpool.[10]

1884–1895 A PRECARIOUS EXISTENCE

"Money speaks sense in a language all nations understand"
Mrs Aphra Benn

The Marine Biological Association was formed at a meeting held in the rooms of the Royal Society in London on 30 March 1884. All but two of

the signatories of the resolution of 1883 were present, together with some other scientists. By this time Professor Huxley had been persuaded to give his support and was elected President of the Association, with Ray Lankester as Honorary Secretary. The aims of the Association were to be very much as stated by Lankester in his 1883 essay, but with greater emphasis given to the study of the physiology of invertebrate animals. There have been a few changes to the articles of the Marine Biological Association since the founding meeting 100 years ago, but basically it still consists of a body of fee-paying members who receive the published *Journal of the Marine Biological Association*, have access to the library, and free use of laboratory space for one week each year. The governing Council of the Association includes representatives elected by the members for a fixed term and a number of Vice-Presidents and Founders who have contributed substantially to the funds of the Association or represent learned institutions and other bodies who have so contributed. The President is elected by Council, which also appoints the Director and the permanent staff.

At the first meeting of the newly formed Association in May 1884 several places were discussed as possible sites for a laboratory, including Plymouth, Weymouth and Bangor.[15] At the second meeting the same year a proposal was received from Plymouth, including the offer of a site on the Hoe by the Town Council and generous financial assistance by local benefactors.[15] The site was inspected by members of the Council of the Association, and it was resolved to build at Plymouth subject to confirmation of the financial assistance offered.[15] There was a problem over the freehold of the land, which was claimed by the War Department (now Ministry of Defence). Transfer of the freehold would have involved an expensive Act of Parliament, but through the good offices of the Earl of Morley and the Inspector General of Fortifications, Sir Andrew Clarke, permission was received to build on the site without cession of the freehold.[15] After a legal readjustment in which the Town Council resigned their lease of the lower part of the slope below the Citadel (Figure 1), the site was leased from October 1885.[15]

During the negotiations for the site and the years of planning and putting out to tender afterwards the Officers and Council of the Association were actively raising funds to build and operate the laboratory. Donations to the building fund were obtained from many private benefactors, of whom the most notable were John and Robert Bayly, prominent Plymouth merchants who were concerned also with the operation of Sutton Harbour, the ancient port of Plymouth and base for the fishing fleet.[16] The interests of the Baylys were secured in 1884 by C. Spence Bate FRS, the famous local expert on the Crustacea,[17] who was invited to join the Council of the Marine

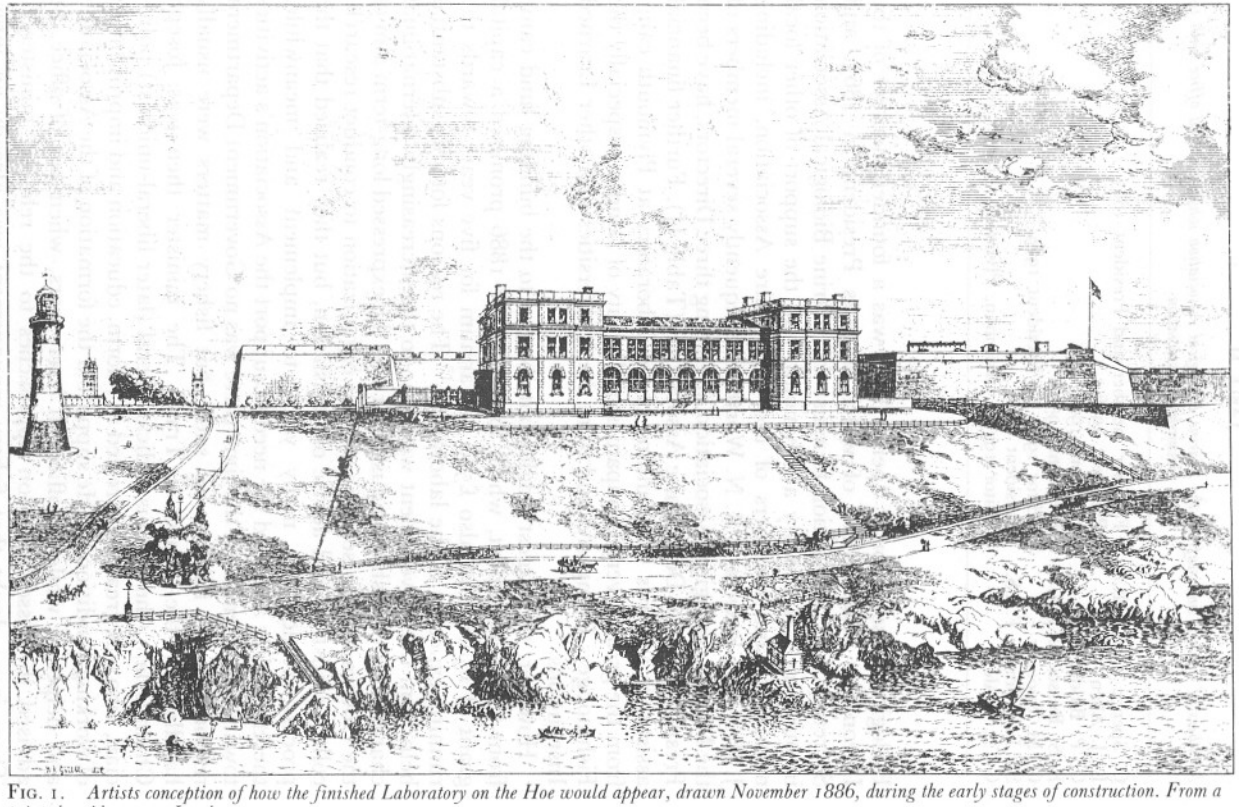

FIG. 1. *Artists conception of how the finished Laboratory on the Hoe would appear, drawn November 1886, during the early stages of construction. From a print by Akerman, London.*

TABLE II

Members of Council and staff of the Marine Biological Association who have held office with the Devonshire Association

C. Spence Bate, F.R.S.	Founder member and President 1863
E. J. Allen, F.R.S.	President 1916
G. P. Bidder	President 1929
F. S. Russell, F.R.S.	President 1953
G. M. Spooner	Editor 1967–72, President 1979
Sir Eric Smith, F.R.S.	President 1980
G. T. Boalch	Editor 1973–, Chairman, Plymouth Branch 1974–

Biological Association.[15] Spence Bate was a founder member of the Devonshire Association, of which he was President in 1863, and Secretary later. His action to assist the Marine Biological Association in building a laboratory at Plymouth had the support of other local naturalists and members of the Devonshire Association, including J. Brooking Rowe and R. N. Worth. Subsequently several members of the Marine Biological Association, including three Directors, have been Presidents of the Devonshire Association (Table II). Further financial assistance towards the building of the laboratory at Plymouth came from the great Livery Companies of the City of London, especially the Fishmongers Company, and from the Universities and other Learned Institutions.

However, the largest single contribution to the building fund came from the Government, which in December 1886 promised a capital grant of £5000 and also £500 per annum for five years towards the running expenses of the laboratory.[15] The reasons for this substantial help from the Government were due to the increasingly international character of the fishing industry. It was the expressed long-term aim of the Government to set up a central organization to conduct research, collect statistics, and advise on legislation, but they realized that the process would take many years to implement and meanwhile, therefore, they accepted the need to support the Association's activities towards these ends. At the time there was no Government Department responsible for fisheries as such, but fishery matters were usually handled by the Board of Trade. The minister then was Joseph Chamberlain, the famous radical-liberal (later liberal-unionist) politician, who was greatly interested in reform, education and improvement of working conditions.[18] He supported the formation of the Association and helped it while in office; in later years, when out of office, he advised the Association on approaches to the relevant ministers.[19] There is no doubt that fishery management was already an inter-

national problem, where scientific facts were seen as the only basis for judgment between nations,[20] and we should note that in 1886 Chamberlain led a delegation to Washington and healed a dispute between USA and Canada about the east coast fisheries.

The help from the Government was crucial to the success of the Association, and allowed building to start. With the financial position thus secured for the time being the Association was now able to appoint a Resident Superintendent, Mr Walter Heape of Manchester, in 1886, and to begin actual building work in February 1887.[15] During the excavations signs of a very much earlier human occupation of the site emerged in the form of flint implements, fragments of coarse pottery and teeth of ox and boar.[21,22] In July 1887 Mr Heape was joined at Plymouth by the first Fishery Naturalist appointed to the staff, Mr J. T. Cunningham. Scientific work was carried out from a small room near the fish quay in the Barbican and included much of fisheries interest.[23] In spite of the Government's financial interest in the Association and the concentration of early research on fishery matters, there was much doubt in official circles about the value of research, and the President of the Board of Trade who followed Chamberlain was not as co-operative.[15] The records hint at other sources of stress in the Association, and Mr Heape resigned early in 1888. He later took up the Balfour studentship at Cambridge and was elected a Fellow of the Royal Society for important researches on the breeding of mammals.[24] The Council appointed Mr G. C. Bourne as Director of the Laboratory in March 1888, by which time the building was virtually complete. The Association did not agree with a suggestion from the Town Council that the opening ceremony should be included among the local celebrations of the tercentenary of the Spanish Armada,[15] and the official opening took place earlier, on 30 June 1888. Among those present, in addition to the Officers and Council of the Association, were the Earl of Morley, the Prime Warden of the Fishmongers Company (Sir James Lawrence), the Mayors of Plymouth and Devonport, the Chairman of the Stonehouse Board, Archdeacon Wilkinson, Rear Admiral Grant, the Editor of the Western Daily Mercury, Mr C. Spence Bate, Mr J. Brooking Rowe and other members of the Devonshire Association, as well as the contractor, Mr J. P. Berry.[25,26] In his opening speech, Professor W. H. Flower thanked the leading citizens for the liberality with which they welcomed the Association to Plymouth, and assured them that although the Laboratory stood between the Citadel and the sea, thus neutralizing part of the old defences, none of the science-loving nations of Europe would wish to march in over the ruins of the Laboratory.[25] It is evident that the learned Professor of Anatomy was not familiar with the tradition in

Plymouth that most of the guns of the Citadel were originally emplaced to subdue the Town, should the enthusiasm of the citizens for the Parliamentary cause once again inflame them against the King! We must also note that the Laboratory was in fact severely damaged in the 1939–45 war.

The building opened in 1888, was designed by the Council of the Association in conjunction with H. J. Snell of Plymouth,[26] but incorporates modifications suggested by the War Department's architect.[15] It is constructed appropriately enough of Devonian limestone containing marine fossils, and has always been regarded as a notable feature of the Plymouth waterfront. The original two-storey central block was raised by addition of a Mansard roof in 1939, but still stands substantially unaltered, though today forming the south wing of a much enlarged Laboratory (Figure 2). The ground floor, as originally proposed by Professor Lankester in 1883, contains the tank room, now the public aquarium, with research accommodation on the floors above. The original underground reservoirs for seawater (maximum 100,000 gallons), which were constructed with additional financial help from John Bayly.[15] are still in use, although the water is now circulated to the tanks by electric pumps instead of the original, more impressive, Otto Cycle engines working from the Town gas supply.[15] The water returns from the large tanks and the scientific tanks by gravity to the reservoirs where it sheds any sediment picked up in its passage before being pumped around again. In the early years the tank room was available for public inspection, free 'on application', but later, when the facilities for viewing were improved and expanded, a small fee was charged, and the Aquarium, as it was renamed later, was open to the public on week-days and bank-holidays.[15]

Many features of the seawater system and tanks were based on advice from Professor Anton Dohrn of the Zoological Station at Naples,[27] and were essentially the same as those employed by W. Lloyd for the public aquarium at the Crystal Palace and copied for the Brighton Aquarium.[19] The plan for Plymouth was to follow a similar 'closed' system, and to fill the reservoirs only occasionally at high tides when the sea-water in Plymouth Sound was especially clear and of normal high salt content. The pumphouse for this purpose is placed close to high water mark on rocks below the Laboratory. At other states of the tide and during rainy periods, the sea in front of the Laboratory can be mixed with fresh water from the rivers Plym and Tamar, and is often contaminated with suspended mud and sewage, as well as oily matter from the Town and docks. This lack of consistent quality of the sea-water supply is one of the major drawbacks of building the Laboratory at the mouth of an estuary complex rather than on a fully

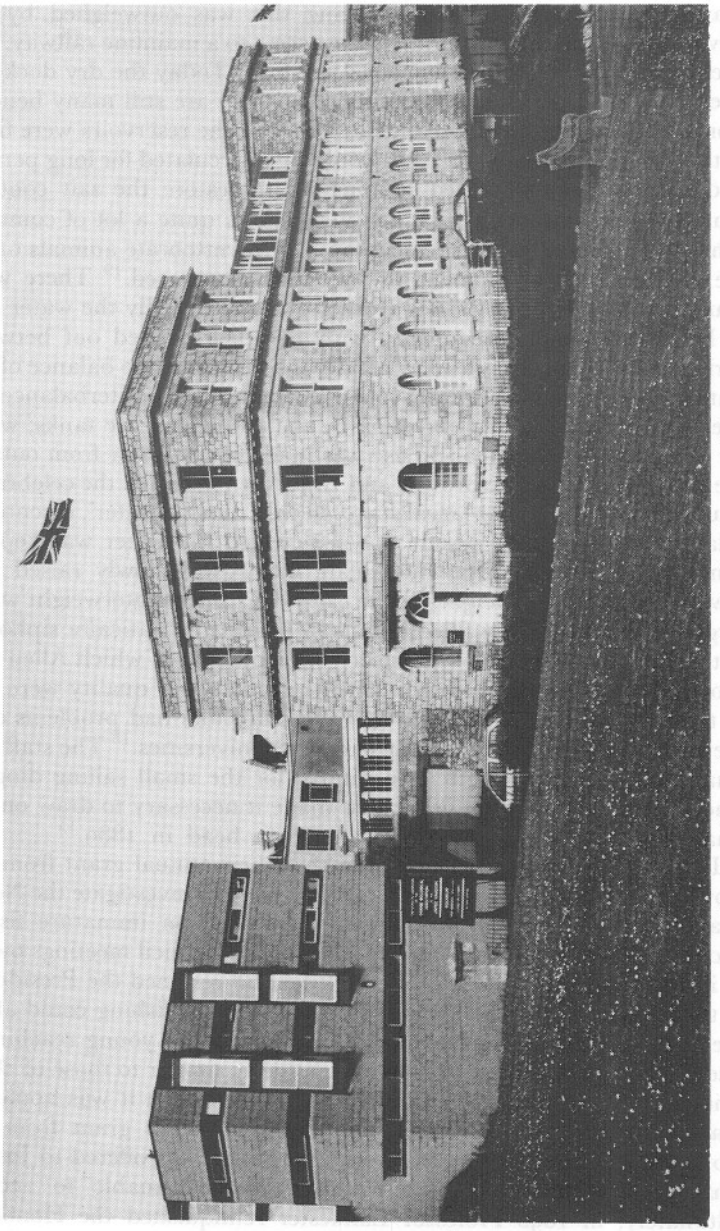

FIG. 2. *The Laboratory in 1984, showing the new library extension.*

marine bay. At the time of building this was outweighed by the advantages of the site, including close access to a mainline railway, two sheltered harbours, and a dry dock for ships. Today the dry dock has been converted into a ferry terminal, but there are still many benefits from the town site. It was planned that, once the reservoirs were filled with high quality sea-water, this would be recirculated for long periods and only occasionally need topping up to restore the salt content. Unfortunately, although such a system allows quite a lot of common fishes to be kept alive, it is less suitable for invertebrate animals or for the young stages of animals, as was soon discovered.[19] There were many complaints from visiting workers, and eventually the water had to be changed more frequently, with pumping carried out between spring tides whenever possible.[15] Later the acid-alkaline balance of the water was adjusted chemically (often by liming) to counterbalance the effects of respiration and excretion by the animals in the tanks; while for delicate species increasing use was made of sea-water from outside the Breakwater.[19] E. T. Browne and E. J. Allen invented the celebrated 'plunger jar' to help rear larval stages in this 'outside water', essentially a large bell-jar turned upside down in which the water was kept in gentle motion by a large glass plate which was slowly raised and lowered by a counterweight. In the early days the counterweight was a large treacle-tin, slowly filled with water and automatically siphoned out at intervals, an economical piece of equipment of which Allen was proud.[19] However, these improvements in sea-water quality were still in the future, and in addition, the early Directors had problems over the supply of specimens to visitors and the Universities.[15] The staff was small and the weather often unsuitable for the small sailing dinghy. There were also financial crises that made it necessary to draw on the small capital reserves. Matters came to a head in 1889.[15]

In 1889 the Association proposed that their annual grant from the Government should be increased to allow them to investigate the North Sea fisheries, especially the effects of trawling on immature fish.[15] Professor Huxley, who had missed some of the Council meetings owing to ill-health, disagreed with this proposal and resigned the Presidency of the Association. Thus the dispute over whether fishing could affect the stock of fish, in this instance by preventing the young reaching a size big enough to breed, arose again in terms similar to those of 1883. The Council supported Ray Lankester, even though it was apparent that there would be no immediate increase in the grant from the Government. The Presidency of the Association was offered to Joseph Chamberlain, then out of office, but he was unable to accept. Ultimately, in 1890 Professor Lankester relinquished the Honorary Secretaryship to Professor H. G. Fowler,[15] and took over as President

himself. He was now better placed to pursue an active fisheries policy, and a study of trawling in the North Sea was begun, with funds from private sources, including the Livery Companies, from a base at Grimsby. However desirable this programme might be, it did not solve the financial problems at Plymouth, and there was consequent pressure on the Director to keep up income from the sale of specimens and from rental of laboratory accommodation. The need to attend to these matters prevented a Director from pursuing his own researches, and there was a fairly rapid succession of Directors. Mr Bourne (later Professor G. C. Bourne FRS) resigned in 1890 to return to Oxford University,[28] and was replaced by W. L. Calderwood. Mr Calderwood resigned in 1892 and returned to Scotland to become Inspector of Salmon Fisheries.[15,29] He was replaced by Mr E. J. Bles who in turn resigned in 1894 to return to University life, and to make important researches into the biology of the amphibia, including a study of the midwife toad, *Xenopus*.[30] At this period there were only two other scientists on the staff, in addition to the Director: a naturalist who dealt with fishery matters, and an assistant to the Director who also helped with administration.[15] There were also an engineer/caretaker to work the sea-water pumps and maintain the pipes, a fisherman to operate the sailing boat and collect specimens, and a young laboratory attendant.[15] The rest of the building was available to visitors from the Universities and other institutions who paid a fee for the privilege, and who were supplied with living or preserved specimens for their researches. Most of the visitors arrived during the summer vacation or at Easter, and the staff might then be crowded together or forced to move into the basement. At other times the space on the first floor was empty but for the naturalist and assistant.[19] Occasionally, with the aid of special grants, it was possible to pay visitors a small emolument for work on specific subjects related to fisheries, as for example the rearing of young fish or shellfish and a search for substitutes for live bait.[15,31]

It was realised from the start of the Marine Biological Association that good research would demand good library facilities, and the decision to build at Plymouth, farther away from other centres of learning than originally envisaged, increased the need. A public appeal was made in 1887 for gifts of books and periodicals, and a small library committee was formed to deal with the generous response and authorize some purchases.[15] A successful application was made to the Government for a set of the *Challenger Reports*, and exchange agreements were entered into with foreign governments. The *Journal of the Marine Biological Association*, begun in August 1887, soon became one of the leading scientific journals published in Britain. For the Association it formed an important article of exchange by which other publications

were obtained for the library, and it remains so to this day. By the time of the official opening in 1888, a respectable collection of books and periodicals was in place in the library, which was situated in a large room on the top floor of the west end of the building, where most of the books were kept until 1931.[15,32] The original library committe seems to have lapsed at this time, and the Director acted as librarian in addition to his other administrative duties. Routine recording was carried out by the Director's clerical assistant, and an accessions register was begun in 1891.[26] A nominal £100 p.a. allotted for purchases was not always available in practice, but the stock grew rapidly, especially of journals obtained by exchange, and as gifts. When C. Spence Bate died in 1893, his collection of books and pamphlets on Crustacea was given to the Association by his son, and another notable specialist collection on Hydrozoa and Polyzoa was purchased from the estate of the Rev. T. Hincks.

From the opening days the staff and visitors actively pursued the two main aims of the Association, as stated by the founders; the study of living marine animals and their physiology, and investigations on food fish and shellfish. The successive naturalists made pioneer researches into fisheries problems. J. T. Cunningham (who later moved to East London College, now Queen Mary College) studied the life-history of many species of fish, painstakingly identifying the floating eggs and newly-hatched young stages collected at sea;[33] W. Garstang (later Professor at Leeds) investigated general marine biological matters as well as fishery subjects, and made one of the earliest studies of races in mackerel at the instigation of the Irish Fisheries Branch;[35] E. W. L. Holt (later scientific adviser, then Chief Inspector of Irish Fisheries), who worked from Grimsby on local trawlers, published a classic account of the effect of trawling on survival of immature fish.[36] Visiting workers were interested in many aspects of marine science, including physics, chemistry, geology and botany, as well as zoology and animal physiology.

1895–1917: Consolidation and Expansion

"Growth is the only evidence of life"

J. H. Newman

A period of much-needed consolidation of the Plymouth Laboratory began with the appointment of E. J. Allen (later Dr E. J. Allen, F.R.S.) as Director at the end of 1894.[15] His success in the role was confirmed in 1902 when he became Secretary to the Association's Council, and the post of Honorary Secretary was abolished. The dual position has

been held by all Directors since Allen, and is regarded as one of the main reasons for the smoother progress compared with the early years, when the Honorary Secretary retained too much responsibility for the day to day running of the laboratory, as in the years from 1884 to 1890 when Ray Lankester was Honorary Secretary.[15,19] Under Allen the sea water system was gradually improved, as already noted, and as an innovation, courses in marine biology for undergraduates and others were begun by Garstang.[15] The number of visitors began to increase, although the 'cavernous laboratory', as the first floor accommodation was sometimes called, was often empty for 10 months in the year. Sometimes, when the fishery naturalist was away working on the North Sea, visiting workers from the universities had to be pressed into service as 'our fishery expert' to show round parties of laymen or journalists.[19] A generation later, a very junior member of staff, who later became Director, remembers showing round two important lay visitors, George Bernard Shaw and Aircraftman T. E. Shaw ('Lawrence of Arabia').

The first fully-decked and reliable steamboat owned by the Association, the 60 ft long *Busy Bee*, was purchased in 1896 and used for the courses as well as research.[15,19] Among those attending the first Plymouth courses were J. Barcroft (later Sir Joseph Barcroft, P.R.S.) and H. H. Dale (later Sir Henry Dale, P.R.S.), while visiting scientists included Professor C. A. MacMunn, F.R.S., G. P. Bidder and E. T. Browne. The latter two became welcome habitués of the Laboratory, and contributed substantially to the building and library funds.[37] An enthusiastic account of a visit to the Laboratory and description of the atmosphere there in the first few years of Allen's directorship was written by William Crossing,[38] a local journalist and expert on Dartmoor.

Library affairs also prospered under Allen's direction. The accessions register from 1895 to 1905 is kept in the handwriting of his laboratory attendant, A. J. Smith, who had moved to Plymouth from Cambridge University. Mr Smith, who kept other laboratory registers and also helped to run the small boats, was a man of many talents who made significant additions to the marine fauna list, and greatly assisted the functioning of the Laboratory until his retirement in 1931.[26] An appeal for named periodicals and monographs was made in the *Journal* in 1897, and the following year's acknowledgement of gifts shows the success of the appeal. The practice of begging gradually became a principal means of enlarging the number of publications in the library. Members of the Association and their friends were pressed to help, and visiting workers asked to donate reprints of their published work. Throughout the 1890s and well into the present century the *Journal* regularly carried lists of gifted items as well as appeals for more. By the

turn of the century the coverage of fisheries literature, both British and foreign, was felt to be fairly complete; most of the monographs on marine organisms were available; and all the chief zoological journals were on the shelves, although back numbers were still needed. The emphasis was still mainly biological, but the scope of the library was not restricted to any particular branch of marine science, and the collection gradually began to reflect the interdisciplinary nature of much of the research carried out at Plymouth from the earliest days.[15]

During this period of gradual improvement in the affairs of the Association Allen received much advice and business assistance from G. P. Bidder, as well as donations to the funds. George Parker Bidder was the third in succession to carry these names, the grandson of the celebrated 'calculating boy' who was born in Moretonhampstead in 1806 and died at Stoke Fleming.[39] This earlier G. P. Bidder pursued a successful career as civil engineer in partnership with George Stephenson, and later in 1868–72 designed and operated the first steam-trawlers in the south-west. With this background it is not perhaps surprising that the third G. P. Bidder was of especial help to Allen over the sea-going facilities. Part of the story is told in his very interesting obituary notice of Allen.[19]

It soon became evident to Allen and Garstang that the hydrography and biological communities of the Channel were influenced by events in the open waters of the continental shelf and ocean to the west of Plymouth. With support from Ray Lankester and other members of the Council, funds were secured from the British Association for the Advancement of Science, and in 1899–1900 a steam tug was chartered for quarterly voyages across the Channel and out to the south and west, to take plankton samples and make hydrographical investigations.[15] This was a bold concept for the time, deploying many new techniques, and the results, which have never been published completely, were enough to justify obtaining a larger vessel for the Association. Early in 1901, with Bidder's help, *Busy Bee* was sold and the sea-going steam yacht *Oithona* (83ft long) acquired. After modifications to improve the sea-keeping properties,[19] this vessel was used to continue the cruises to deep water, initiating a period of regular investigation of the physics, chemistry and biology of the Western Channel and Approaches which ended in 1909, and provided a forerunner to the later studies after 1921[15,37]

When in 1899 the British Government, acting in concert with other European countries, began negotiations towards a policy of control and investigation of the North Sea and English Channel fisheries, the Association was not at first consulted.[15] After representations by the Council of the Association, and when it became certain that extensive

scientific researches would be expected, the Marine Biological Association was requested by the Government to undertake the English share of the investigations of the North Sea and Channel, under the auspices of the International Council for the Exploration of the Sea.[37] This request confirmed the status of the Association as an experienced organization for the study of the sea, and brought immediate improvement to the financial position.[15,37] The annual income from the Treasury for these investigations was several times greater than the original grant to the Laboratory, and the funds made provision for the operation of a larger vessel than *Oithona*. Once again Dr Bidder's help was of fundamental importance: when the arrangements for private hire of the steam-trawler *Khedive* proved unsatisfactory he purchased the vessel and leased it to the Association on favourable terms.[19,37] This 116 ft trawler was named *Huxley* in honour of the first President of the Association, and was based at Lowestoft where another laboratory was set up in rented accommodation in 1902. Garstang took charge at Lowestoft, and several more naturalists were appointed to the staff, including the first woman scientist, Rosa Lee, who worked on fishery statistics. The scale of the operations carried out in the North Sea and English Channel by this devoted group of sea-going scientists, working from commercial vessels and the smaller *Oithona* as well as the more comfortable *Huxley,* is difficult to appreciate in these days of diesel-power, automation and electronics. The hydrographic work by D. J. Matthews (later with the Naval Scientific Service) was not bettered for 30 years.[40]

In 1902 the contents of the Association's library were already overflowing onto shelves erected for the purpose in the corridor outside. Cataloguing was now carried out by S. Pace, appointed Scientific Assistant to the Director in succession to R. A. Todd who moved to Lowestoft to help with the new Fishery Investigations. A small collection of books was purchased for Lowestoft, but from the sums involved (£75 then £25 p.a.), it was obviously not intended to duplicate the stock at Plymouth. Some of these books appear to have formed the nucleus of the later library at Lowestoft when the laboratory there was re-opened in new premises in 1919 by the Board of Agriculture and Fisheries.[41] In 1905 Mr Pace left to become Director of the Millport Marine Station, and in the same year Miss Amy R. Clark was appointed as clerical assistant to E. J. Allen. This lady, experienced in book-keeping, typing and shorthand, took over some of the library clerical work and eventually was put in charge of the library, which remained her responsibility until her death in 1939. The library stock continued to grow, and in 1914 it was reported[15] that further space would have to be provided since the room contained as many books as

could be safely stored there. However, the outbreak of war stopped plans for expansion of the library.

The foundation of the North Sea investigations had already been laid. Work from a temporary laboratory at Grimsby by Holt, Cunningham and Garstang in the late 1890s had been funded by small grants from the Livery Companies and the Government, and the lines of work already initiated were continued under Garstang's direction until 1907.[15,37] By this time it had become clear that government officials wanted direct control of the North Sea operations, now that a Fisheries Department had at last been set up, and Garstang, who valued independence, resigned to take up a new chair of Zoology at Leeds.[15,19,42,43] To help the negotiations at this time, first with the Board of Trade, then with the Board of Agriculture, to which the Fisheries Branch was transferred, Dr Bidder sold *Huxley* to the Association on a favourable mortgage.[42] A deputation from the Association, led by Professor A. C. Shipley (chairman of Council, later Sir Arthur Shipley) went to see Mr Lloyd George. However, after another three years of annual renewal of the grant, responsibility for the International Investigations passed to the Board of Agriculture, although a body called the Development Commission was set up to fund additional fisheries work.[44] It is evident that Dr Bidder was not impressed by the negotiations,[42] and in later years, when serving as an important member of the Council of the Association, he seems to have advised that any future expansion of the Laboratory should be devoted to pure science.[15,19] In 1910 most of the Association's staff remaining at Lowestoft accepted transfer to the Civil Service, but the laboratory was closed, and facilities were not provided again until after the 1914–18. war[9] The use of *Huxley* was discontinued at the end of 1909, and the vessel was sold early in 1910. To the profits from the sale Dr Bidder generously added his nominal profits from the earlir years of leasing,[19,42] and a trust fund was set up to help support scientists who wished to work as visitors at Plymouth; the fund was named after Ray Lankester, effectively the real founder of the Association.[15,37]

In 1910, the Association found itself reduced to the same Government grant as received 20 years before.[15] It was hoped that additional support would be forthcoming from the Development Commission, but this did not materialize until 1912. Meanwhile research into fishery problems at Plymouth was suspended and *Oithona* had to be laid-up for nine months in the year.[15] The services of the hydrographic chemist, D. J. Matthews, were retained on a part-time basis, and two new naturalists were recruited, J. H. Orton (later Professor J. H. Orton, F.R.S.) and E. Ford (later Director of the Millport Laboratory), to replace those retained by the government.[37] In 1911 the physiological

laboratory was refurbished and new experimental courses initiated by Dr Cresswell Shearer from Cambridge.[15] Among those attending these first courses in the physiology of marine animals were H. M. Fuchs (later Professor H. Munro Fox, F.R.S.) and F. M. Davies (later in charge of fishing gear research at the Lowestoft Laboratory when it was reopened).

The Association was involved in three famous Antarctic expeditions of the period 1901–15. T. V. Hodgson, a temporary member of staff (later Curator of the Plymouth City Museum), was biologist with the *Discovery* Expedition of 1901–4;[45] E. W. Nelson (later Scientific Superintendent of the Scottish Fishery Board) accompanied the *Terra Nova* Expedition in 1910–13;[46] and R. S. Clark was with the *Endurance* when she was crushed in the ice-pack. Clark was one of the party marooned on Elephant Island and rescued after Shackleton's heroic small boat journey to South Georgia.[47] Other members of the staff undertook educational work in the south-west, and lectured on fisheries and marine life as far afield as Truro and Bridport.[15]

In 1913, with the benefit of a small grant from the Development Commission, fisheries work was begun again with a renewed investigation of the problem of races in fish, this time with herring.[48] When this work was resumed after the war it became a survey of the local stock of herring, and provided a foundation for the study of long term changes in the biology of the Western Channel. E. J. Allen was himself interested in the possibility of changes in the productivity of the sea, though his earlier publications had been descriptive or faunistic surveys.[50] In 1910 in association with E. W. Nelson he developed a simple method for culturing phytoplankton, the tiny plants in the sea that form the base of the food chain.[51] Using this culture method he was able to show that previous estimations, even by the supposedly superior centrifuge technique,[52] seriously underestimated the abundance of the smallest microscopic algae.[53] These pioneer studies opened the way to present day research into the role of phytoplankton. By 1915 most of the staff at Plymouth were away on war service, and *Oithona* was laid-up awaiting requisition by the Admiralty.[15] However, before he too left Plymouth, D. J. Matthews was able to demonstrate the important link between growth of large phytoplankton organisms (diatoms) in the spring and consumption of inorganic nutrients dissolved in the water,[54] thus laying a foundation for post-war studies by Atkins and Harvey.

The events and activities of these formative years of the Marine Biological Association have been discussed in some detail since the lines of research originating then, later became important projects at many other marine laboratories and fishery institutes. As Professor Sir

Alister Hardy has noted[43] these research lines were founded by outstanding scientists, working "ahead of their time". For example the fact that as long ago as 1899 the sea-going naturalists at Plymouth were venturing far from the land and taking samples by such 'modern' methods as armoured hosepipes and pumps, and nets that could be opened and closed at selected depths underwater, illustrates the forward-looking character of the work and the excellence of the scientific direction.[55] The fisheries work was equally innovative. The demonstration of the destructive effects of trawling on immature fish,[35] and the possibility of increasing the growth of the young by moving them to better grounds,[56] could soon have provided the basis for fishery control. However, the problem could not be dealt with in the absence of effective international legislation,[9] a prospect still unattained.

Even as late as 1921 there were influential British scientists who denied that the sea's bounty could be exhausted by man's activities.[9,57] When the Marine Biological Association was founded in 1884 the Plymouth fishing fleet was almost entirely under sail,[23] although steam trawling was beginning at other ports;[9] and most Plymouth fishing vessels were still under sail well into the twentieth century.[58] If, as Ray Lankester and Garstang then believed, the stocks of fish were capable of being depleted by such a fleet, it was likely that increasing use of steam and motor power could only accelerate the process, and there could be a sharp deterioration after the respite incidentally provided by the 1914–18 war. It is fortunate therefore that, as noted in the next section, there was a group of far-sighted scientists and administrators who were preparing to take action to revive research on fisheries and related marine sciences after the war.

1918–1944 Growth and Development of New Ideas

"It is the customary fate of new truths to begin as heresies and end as superstitions"
T. H. Huxley

The period from the end of the war in Western Europe in 1918, to the start of the second World War was a very happy period for the Plymouth Laboratory, looked back upon by those fortunate to work there as a 'golden age'. The laboratory buildings and staff were enlarged, there was still plenty of room for visiting workers who usually outnumbered the residents, and there was much interchange with scientists of other countries. There were many new ideas for study of life in the sea, how it was produced and distributed, and the Plymouth staff were at the forefront of a new wave of investigation. However, this was not apparent in 1918, when the immediate problem was financial. Allen had kept the Laboratory open during the war with help from temporary assistants, the most notable being Marie Lebour, who was

seconded to Plymouth from Leeds University, where she had worked with Walter Garstang. Dr Lebour was eventually appointed to the Plymouth staff.[59] Her enthusiasm and splendid drawings of the plankton organisms she was investigating, ranging from dinoflagellates to young fish, were an inspiration to others. There were now seven scientists on the staff, including L. R. Crawshay, E. W. Nelson, J. H. Orton and E. Ford who had returned safely from war service. In spite of this increase in staff the basic income of the Association, including the annual grant from the Government, had increased only slightly from the turn of the century, and it was necessary to lay-up the steamboat *Oithona* for most of the year. Nevertheless, even in this period of difficulty the Association helped to support an appeal addressed to the Board of Education for funds to extend university education to the south-west of England.[15] The result of this appeal was the founding of the University College (now University) at Exeter, and for some years a member of the Council of the Association, or one of the scientific staff, served on the governing body of the new College.[15]

There had been plans to extend the Laboratory by building along the north side of the site, but the war had prevented this. Now in the spring of 1919 Dr Bidder urged for a start of the proposed north building, and he and E. T. Browne offered generous financial assistance to this end. The first section was completed in 1921, and known as the Allen Building, although this name was lost in the later stages of expansion. At about the same time as Bidder was pressing for expansion of the laboratories another fund was started for installation of electric power, which was especially needed for the physiological work, and advice was sought from the noted physiologists A. V. Hill and W. M. Bayliss.[15] Up to this time the Laboratory had been lit by gas, which also served to power the engines driving the sea-water pumps. During periods of financial stringency it was necessary to exercise the strictest economy in the use of the gas, and there was a period of near disaster at the turn of the century when a replacement gas engine was found to be consuming several times more fuel than the old one.[15] An illustration of the economy measures can be seen in a photograph taken in the library in 1897;[58] the builders had installed two double gas jets in this room, but only one of the four was fitted with mantle and reflector to allow it to be used! By the 1920s there were sufficient funds to permit all four gas jets to be used, as later photographs show.

The year 1919 proved a major turning point in the fortunes of the Laboratory. As noted in the previous section the Government had already proposed a re-examination of the whole question of funding of Fisheries Research. The Development Commission formed by Lloyd George in 1909 and entrusted with the support of fisheries among other

topics, was given the task of reorganizing fisheries research and related scientific matters. An Advisory Committee of eminent scientists and administrators was set up,[61] with the noted biochemist, Professor W. B. Hardy, F.R.S. (later Sir William Hardy) as chairman. The Marine Biological Association was asked by this Committee about the proposed division of research between Government Departments on the one hand and the Universities and Marine Laboratories on the other. The Council of the Association held a special meeting to discuss "whether it was possible and would be advantageous to discriminate between two kinds of fishery researches: 1) fundamental researches whose aim is the advancement of accurate knowledge of the life-histories of fishes, of the animals and plants with which they are associated, and of the whole physical and biological conditions under which they live; and 2) those researches which are throughout purposely directed to definite industrial ends".[15] The President of the Association, Sir Ray Lankester, emphasized that "researches of either class are both practical and scientific" and deprecated the attempt to separate them in those terms. The Council of the Association adopted the view that basic researches should be entrusted to the Marine Laboratories and the Universities, to be supported by public grants, whilst industrially motivated researches should be undertaken by the Government Departments. However, it was felt that too strict a division should not be insisted upon: the Government Departments might well refer particular questions to the Biological Stations, while the staff of the Departments should not be precluded from basic researches.[15]

The views of the Association were adopted by the Advisory Committee, and the Association was asked to prepare plans and estimates for their own future activities. These plans, including an expansion of investigations into the physiology of marine organisms, and the acquisition of a steam-drifter or motor-trawler to replace *Oithona* were approved, and the Treasury agreed to increased expenditure for the purpose, including an improvement in the salaries of the existing staff, who until then had been paid a 'pittance'.[15] The salaries of the temporary assistant naturalists, what we would call postdoctoral fellows these days, were even lower, and G. P. Bidder recalled that E. J. Allen, who had found the money to employ some of these young men in the early days of the Association, came to him in some distress saying "Bidder, what on earth am I to do, they are marrying on it".[26] The new arrangment meant that the days of such extreme sacrifice were over, but in future the Treasury would have more say in the day-to-day matters, and it would be necessary to keep the accounts in accordance with civil service rules.

The plan of 1919 called for the formation of a new 'Department of General Physiology', staffed by two physiologists and a biochemist: the latter post was not filled at the time, and the first biochemist on the staff was not appointed until after the second World War. By 1920 replacement of *Oithona* was urgent since the boiler was worn out,[15] and arrangements were made to survey the ex-Admiralty steam-drifter *Nadir,* 88 ft long. This rather fateful name was changed to *Salpa* on purchase and after being equipped for trawling, she entered service in July 1921. *Salpa* was called a "powerful sea-boat" at the time, and the passing of *Oithona* was regretted only by Dr. Bidder, who called her a "kindly ship" and remarked that *Salpa* was "wished upon them by the Government".[15,19,37] As Dr L. H. N. Cooper had occasion to remark many years later about *Salpa*[62] "powerful for her time she may have been, but uncomfortable she certainly was, to an extent which those who work our present vessels may find it hard to understand". Nevertheless, it was with *Salpa,* at first lacking even a deck laboratory, that work was resumed on the plankton and hydrography of the Western Channel after the long interval since 1909.

The new work was initiated by W. R. G. Atkins, appointed head of the Department of General Physiology, a plant physiologist with leanings towards physical chemistry, and H. W. Harvey, an ex-naval officer with training in several branches of science including mathematics and botany, who was appointed hydrographer in place of D. J. Matthews who remained with the Hydrographic Office of the Navy. The cruises undertaken by this pair were by no means as ambitious as those of the 1899–1909 series, being essentially a line of stations from Plymouth to Ushant, but the chemical work and treatment of the samples was more sophisticated, and it was the need to bring the samples back for analysis, as much as the discomforts of the vessel, that dictated the station line. Atkins began an attempt to gauge the extent of plant production in the sea by measuring changes in the acid/alkaline balance with colorimetric pH indicators, a method with which he was already familiar, and for which he had acknowledged powers of visual acuity for colour change. The change in pH should indicate how much carbon dioxide has been taken up by the photosynthetic plants of the plankton and converted into organic matter, compared with the amount liberated by respiration of animals and bacteria. Soon, however, he found it more convenient to use the amount of inorganic phosphorus dissolved in the water as a more sensitive indicator of plant growth.[62,63] In contrast Harvey at first used classical temperature and salinity observations to show seasonal changes in water movements in the Channel, but later applied his considerable mathematical talents, without benefit of mechanical or electronic computers, to calculate

theoretical potential current flow from the distribution of water densities.[64]

The improved trawling capacity of *Salpa* enabled R. S. Clark to survey the inshore fishing grounds off Plymouth in the years 1921 and 1922, and the detailed records of fish catches and sizes taken then have provided us with an accurate baseline against which to compare more recent changes in fish populations due to climatic fluctuations and overfishing.[15,37]

The increased laboratory space and improved financial situation now enabled the Association to redeem the early promises made during the foundation years to foster the study of invertebrate physiology. In 1921 C. F. A. Pantin was appointed assistant physiologist, and leading physiologists, including A. V. Hill and L. T. Hogben, began to use the new facilities. In 1924 Pantin began summer courses in physiology, and A. V. Hill, already a Nobel Prizewinner, attended one of them to familiarize himself with marine animals. So successful was the Laboratory in these years in attracting vacation workers that plans had to be drawn up to continue the north building. The next phase of the extension was finished in 1926, G. P. Bidder and E. T. Browne once again leading the list of private subscribers to the fund.[15]

E. W. Nelson had left Plymouth in 1921 to supervise Fishery Research in Scotland, but when he died suddenly in 1923 R. S. Clark moved from Plymouth to Scotland and later took charge of the Aberdeen fisheries laboratory.[47] Clark was replaced by F. S. Russell, whom he had trained at Plymouth in 1922 for a fisheries post in Egypt. On Allen's advice Russell took on the fishery aspects of zooplankton work, improved the quantitative nature of the nets in use, and in a series of researches that attracted world renown, investigated the day and night differences in vertical distribution of fish eggs, young fish and their associated zooplankton.[67] At about the same time Marie Lebour was using the famous plunger-jars to follow the development of crustacean larvae, and observing the feeding habits of different zooplankton animals.[59]

The Advisory Committee on Fishery Research regarded the student classes at Plymouth as an important training for potential fishery naturalists, and encouraged their resumption in 1920. There was some difficulty over rental of the premises used for the classes in earlier years (e.g. the Corinthian Yacht Club), and a new classroom was built behind the south building to solve this problem, and permit two larger classes to be held at Easter. The Easter vacation courses had been popular since their inception by Garstang in 1896; when Garstang left the M.B.A. for Leeds the classes were continued by G. H. Grosvenor, L. Doncaster, and L. R. Crawshay, but in 1914 J. H. Orton took them

over. Orton was never happier than when out 'collecting' as field work was termed then, and his classes were well attended. We have been left a legacy of some of them in the form of doggerel rhymes concocted by each set of students, illustrative of some knotty point in zoology, many of them obviously based on Garstang's verses about larval evolution,[69] or social ethics and staff and student idiosyncrasies. It was each student's task to recite one of these verses at a tea-party, and then, back home at College, one of them had to make a fair copy with illustrations. The surviving text and figures provide us with a welcome insight into some of the personalities who developed into the leading marine biologists of later years.

A majority of professional marine biologists and zoologists who graduated in 1920–1939 were trained by J. H. Orton at Plymouth or by D. P. Wilson and G. A. Steven who took over the courses when in 1930, Orton moved to the chair of Zoology at Liverpool. The courses were so popular that Orton returned each summer after 1930 to run a second set to supplement those at Easter. The student classes and visiting research workers of their period relied greatly on the laboratory collector/fisherman Bill Searle for supplies of specimens or advice where to search.[70] Bill had joined the Laboratory as a boy in 1895 and served as deckhand on *Busy Bee* and *Oithona* as well as managing the sailing dinghy *Anton Dohrn*. His encyclopædic knowledge of the Plymouth Fauna was already a legend. Another 'character' of the Plymouth sea-going staff of these days was Captain Lord, who took command of *Oithona* in 1913, and then *Salpa* from 1921 to 1939.[62]

By 1929 the manifold success of the zoological and physiological research at Plymouth moved the Council of the Association to consider further expansion of laboratory space and sea-going facilities. The succession of sailing dinghies named after Anton Dohrn of Naples had at last, in 1922, been replaced by a specially designed inshore motor-launch named *Gammarus*, skippered by Bill Searle. However, it was becoming clear that *Salpa* was patently incapable of extending other sea-going work far from Plymouth. As Harvey pointed out,[26] the vessel was not only uncomfortable, but with a single watch crew it was impossible to sustain cruises demanding sampling of water and plankton at 2 hour intervals. These deficiencies of *Salpa* were brought sharply into focus by increasing evidence that much of the chemical and biological processes going on in the Channel were dependent on events in deeper water to the west, confirming what the previous generation of marine biologists had found in 1899.[55] The Association also had to consider a reminder from the Development Commission on the need to obtain more private funding, for it was regarded as undesirable that the Government should supply more than two thirds

of the annual expenditure.[15] A proposal was therefore placed before the Rockefeller Foundation for enlargement of the Laboratory and provision of an ocean-going vessel ("similar to *Discovery II*"), for work in the North-east Atlantic.[15] The full extent of this scheme could not be realised then, but the next extension of the North Building in 1931 was helped by a substantial grant from the Rockefeller Trust. It was this phase of expansion that provided large chemical and physiological laboratories for prosecution of important basic scientific studies in the years that followed.

Other aspects of production in the sea were being studied at Plymouth in the 1920s and 1930s, as well as plankton. Investigations in progress in these years include studies by J. H. Orton on the growth of seashore and benthic animals, and surveys of the distribution and abundance of animals living in the sea bed (E. Ford, O. D. Hunt, J. E. Smith)[15,37]. The basic studies by Orton were interrupted by a spell of applied work on oysters and their diseases, originally begun at Government request, but completed out of funds for basic research.[15,37] Other investigations on oysters were made by C. M. Yonge, who took over as physiologist at Plymouth when Pantin returned to Cambridge in 1929. Yonge was leader of the Great Barrier Reef Expedition to Australia in 1927–29, and another member of the Plymouth staff, F. S. Russell, also took part.[15,37] In addition to field surveys of the coral reefs, this expedition set up a temporary marine laboratory, and applied methods developed at Plymouth and the Millport Marine Station to studies of the biology of tropical plankton and bottom-living organisms.[71]

One of the features of the Plymouth Laboratory in the 1920s and 1930s was the ability to appoint recent graduates as temporary research-workers, and thus train them for subsequent employment at Plymouth or elsewhere, including the Fishery Laboratories.[15,37] In addition to the Ray Lankester Fund already mentioned, there was a more formal appointment called Student Probationer, funded by the Development Commission, and carrying some superannuation benefits. In some years, there were two such posts, in others only one, according to financial circumstances. Among those Student Probationers who eventually joined the Plymouth staff was G. M. Spooner, who later became executive editor of the *Journal of the Marine Biological Association* and editor of the *Transactions* of the Devonshire Association; another was J. E. Smith, who later became Director of the Plymouth Laboratory, and was one of the several members of the staff to hold office with the Devonshire Association (Table II). One of the earliest of the Student Probationers was V. C. Wynne-Edwards, who was later Professor of Natural Philosophy at Aberdeen, and was for a time

Chairman of the Natural Environment Research Council.

The death in 1929 of Sir Ray Lankester, closed another chapter in the affairs of the Marine Biological Association. Ray Lankester was the driving force behind the formation of the Association and the construction of the Laboratory. His biographers make it plain that he was unable to suffer fools and would not put up with those he considered to be rogues and poseurs,[72] and his conduct of the Association's affairs, first as Honorary Secretary then as President, was marked by some bitter quarrels, but after his 40 years service the Laboratory emerged secure and confident, ranking high among European and World Institutions. Much of the consolidation and expansion effected by Lankester and Allen after 1895 was due to private benefactions which they organized and put to effective use, and when after 1918, the Government, through the Development Commission, became the major source of funds, they continued their administration with great skill. The next President of the Marine Biological Association after Lankester was Walter Guinness, M.P. (later Lord Moyne, assassinated in Palestine), and he continued the tradition of private benefaction by helping the fund for expansion of the Association's library.[37]

The library was by now rather crowded, although it had been possible to occupy the whole of the top floor of the west end of the South Building in 1921 when some research activities were moved from the old building to the newly-completed first phase of expansion to the north of the site: the original library room was then called the 'main room'.[15,37] Part of the rapid growth of titles was in response to the increasing importance of physiological researches at Plymouth, already referred to. A special library committee, set up in 1928 to review the increase in marine science literature, concluded that it would be imperative to construct a new library building within the next few years.[15] The committee also noted a still very topical complaint about the increasing costs of scientific journals, which meant that even through library expenditure had doubled in the decade since the war, it was still not possible to buy all the desirable new journals. In 1930 an appeal was launched for funds, to which the new President contributed, as noted above, to convert the Allen Building of 1921 into a new library.

The response to the appeal was gratifying, and allowed an immediate start to the construction, including replacement of the sloping roof by a flat one, and consequent insertion of a third storey as a gallery, and the purchase of bookstacks. The new space for books and reading was much appreciated by the staff and the increasing number of visitors. In a library that has depended so heavily for its growth on

gifts from individuals and institutions, the naming of special benefactors runs the risk of appearing to undervalue the rest, but some particular contributions must be mentioned as being of special importance. We have already mentioned the Spence Bate collection of 1890. In 1927 G. P. Bidder presented a full set of reports of the *Valdivia* Expedition, in addition to his contributions to the building fund, and later bequeathed his personal library to the Association. Sir Ray Lankester, who died in 1929, left to the Marine Biological Association forty-three bound volumes of reprints; and E. T. Browne who had generously subscribed to many of the building funds in his lifetime, bequeathed the whole of his own reference collection on Coelenterata, together with many books and journals.[37] During this period of expansion of the library the collection received the devoted care of Miss Clark, for whom it had become a genuine interest, beyond her secretarial duties. On her death in 1939, her assistant Mary Sexton, was appointed full time Librarian, with the Director's Clerk, Doreen Dibben, as Assistant Librarian.[37]

Physiological studies had expanded at Plymouth on completion of the building programme in 1931. When C. M. Yonge moved to the Chair of Zoology at Bristol he was succeeded for a while by L. E. Bayliss, then in 1935 Alec Sand was appointed physiologist. It was Sand, working with a visiting physiologist, O. E. Lowenstein, who initiated the new study of neurophysiology at Plymouth, and important contributions were made by another visitor, A. L. Hodgkin, who was later joined by A. F. Huxley.[73,74] Great advances in techniques for marine studies were made possible by improved thermionic valve amplifiers (balanced input stages and cathode-followers) which enabled measurement of small changes in the electrical potential of nerves, then of single nerve-fibres in fish, crustaceans and molluscs. The changes could be displayed on the then new-fangled cathode-ray tube oscilloscope. Such instruments were becoming easier to obtain or construct as a result of researches into television broadcasting and what was then called R.D.F., later Radar, but the aspirant physiologist still had to build up the units himself from bits and pieces,[73,74] just like the radio amateurs of the time. Few scientists in those days, whether at Plymouth or at the Universities, could rely on the help of more than a single handyman to construct and maintain their gear, and even today only the 'big' sciences such as space research and nuclear physics can call in large teams of technicians.

One of the successes of the new physiology at Plymouth was announced in 1939, just before the outbreak of war.[75] Hodgkin and Huxley obtained the first measurement of the action potential from between the inside and the outside of a single nerve fibre, by means of a

micro-electrode inserted in a 'giant' axon (½ mm diameter) of the squid *Loligo*, a feature of these cephalopod molluscs rediscovered in 1936 by J. Z. Young, another visiting worker at Plymouth.[76] The research by Hodgkin and Huxley at Plymouth before the second world war, and then afterwards, contributed in no small measure to the share of the Nobel Prize for Medicine and Physiology awarded to them in 1963. Table III lists Nobel Prize Winners who have carried out researches into marine animals at the Plymouth Laboratory.

In 1936 came another milestone in our history, the retirement of E. J. Allen after 41 years service as Director of the Laboratory.[19] Allen presided over a period of unparalleled innovation and discovery, carried out with very little money but almost without bureaucratic interference; his gentle but shrewd guidance, and his careful attention to the needs of the visiting workers, contributed greatly to the success of the Laboratory. The quality of the researches, and the facilities available for work on living organisms, brought many visitors from overseas; for example Sven Horstadius the embryologist from Sweden, Th. Mortensen the Danish echinoderm specialist, and Y. Okada from Japan who studied polychaete worms. Perhaps the most remarkable visitors were those from the Soviet Union: V. Bogorov, who worked on zooplankton, E. Kreps who was interested in the chemistry of plankton production, and E. Rutenberg who collaborated with C. F. Hickling (later Director of Overseas Fishery Research) to study pilchard and hake.[77]

Another notable visitor at Plymouth throughout the directorship of E. J. Allen, E. T. Browne, has already been mentioned. Browne was a man of independent means and a skilled amateur photographer whose cherished negatives have helped to flesh out the bare bones of the archives used to compile this account.[78] His greatest love was the coelenterates, the jellyfish and the hydroids, and it was his ambition to write a definitive monograph on the jellyfish, to which end he amassed a great number of records and drawings. Unfortunately, Browne was

TABLE III

Nobel Prize Winners who have carried out researches at the Plymouth laboratory of the Marine Biological Association

	date of award
A. V. Hill	1922
Sir Henry Dale	1936
A. Szent-Gyorgi	1937
S. Ochoa	1959
Sir Alan Hodgkin	1963
Sir Andrew Huxley	1963
Sir Bernard Katz	1970

one of those learned men of whom it has been said (e.g. by Sir Frederick Gowland Hopkins in his obituary notice of E. J. Bles, an early director at Plymouth) that "they would fain allow publication to wait for perfection, and yet realise even better than others that perfection never arrives".[30] In the late 1930s Browne financed work by W. J. Rees, in collaboration with F. S. Russell, for elucidating the relationship between certain jellyfish and the hydroid generation with which they alternate, by ingenious cultivation in the laboratory.[79] When he died in 1937 he left the Marine Biological Association a substantial trust fund to defray the cost of further researches and production of the envisaged monograph. Happily, F. S. Russell was able to complete this *Monograph of the British Medusae* in two volumes after the second World War.[80]

The new Director appointed in 1936 was S. W. Kemp, who came to Plymouth from the 'Discovery Investigations'.[81] The Discovery Investigations began as a series of cruises in the Antarctic, made with the old polar research ship *Discovery* used by Capt. R. F. Scott.[45] A new vessel was built later for this work and shore bases established, the research being motivated by the need to know more about the life-history and habits of the great whales of the southern ocean, which were believed to be in danger of over-exploitation. Under Kemp, a new phase of expansion was started at Plymouth, and in 1939 a third storey was added to the central block of the south building by the insertion of a Mansard roof. This roof, fronted with Delabole slates, preserves the classic lines of the original better than later additions (Fig. 2). Plans were laid to replace *Salpa* with a more modern vessel, but the war postponed this until 1953. *Salpa* had become very unsatisfactory for the sort of work that was now needed, and the original four cruises a year made across the Channel to Ushant and beyond, had, by 1935, become monthly visits to a single station (E1), 10 miles SSW of the Eddystone Reef. F. S. Russell was able to test his hypothesis about distribution of plankton 'indicator' species across the mouth of the Channel only through the generosity of Colonel E. T. Peel, who made available his motor-yacht *St George*. Nevertheless, evidence garnered from E1, and from the more frequent biological sampling at the Eddystone, showed that there had been a serious change in the marine environment off Plymouth after 1930, coinciding with total collapse of the Plymouth herring fishery in 1935.[82,83] The full impact of this discovery and of the chemical and biological changes observed, was just beginning to be appreciated in the years prior to the second World War. However, two other important pieces of sea-going research were accomplished before the war. One was a complete study of seasonal changes in the physics and chemistry of the water, and of the animal and plant plankton in it, at a station half way between the Breakwater and Eddystone (L 4).

This classic series, organized by W. H. Harvey, with co-operation from L. H. N. Cooper, F. S. Russell and Marie Lebour, provided a basis for new assessment of the process of production of living matter in the sea.[84,85] The second piece of sea-going work was a survey of the south-western mackerel fishery, undertaken by G. A. Steven and P. G. Corbin for the International Council for the Exploration of the Sea, and funded by the Development Commission.[86,87] It was possible to charter steam trawlers and drifters for the sampling, and additional help was provided by the research vessel *George Bligh*, belonging to the Lowestoft Laboratory of the Ministry of Agriculture and Fisheries. This survey provided evidence of fish distribution and spawning intensity during a period of lower fishing activity (drift nets and lines only) than today, and forms a baseline for estimating the effects of climatic change and intensive fishing on this important stock of fish.

As the war loomed in 1939 activity at the Plymouth Laboratory was reduced. *Salpa* was taken out of commission, pending requisition by the Navy. The physiologists packed-up their amplifiers and left them in what they regarded as the safety of a laboratory remote from the war, although those members of the staff and long-term visiting workers remaining dutifully practised civil defence precautions. For a while the war affected Plymouth only indirectly, but in the spring of 1941 came a series of devastating air attacks that destroyed the heart of the old town.[88] At first the Laboratory was only shaken by blast, but on the night of 20 March a bomb severed the main freshwater supply near the front gate, and then the south building was hit by a stick of incendiary bombs accompanied by a small high-explosive bomb.[89] The devotion of a fire-watching party of staff and visitors, led by D. P. Wilson and Stanley Kemp, in putting out the fire-bombs saved the main building, but the explosive bomb badly damaged the Director's residence at the east end and caused destruction inside the chemistry and physiology rooms in the north building. A rescue fire-pump party from the Royal Citadel arrived, and by using the large amount of sea-water in the reservoirs, were able to prevent the fire in the director's quarters from spreading. In the process, the east end became a total loss, and Stanley Kemp, who gave priority to rescuing the Laboratory papers from his office, saw most of his worldly goods destroyed.[81] The following night there were more fire-bombs at the west end of the building, the fire at the east end was rekindled, and the fire-party on duty, led by Roy Tozer (specimen supply) and Alf Briggs (crew, later skipper of *Gammarus*), were kept busy.[89]

Miraculously the library survived these nights of terror, with only the glass in the windows and the lantern roof-light shattered. The collection had been valued for insurance purposes under the War

Damage Act in January 1941, at £15,750, but no immediate plans had been made to move it to safety. The Director, who had lost his residence, was negotiating for the lease of Hawkmoor House on the Bedford Estate near Tavistock, and the Council of the Association decided to move the library to the comparative safety of one of the outbuildings of this house. It was necessary first to shore up the floor to sustain the weight of the books, and the removal began in May, with two lorry loads each day for ten days, staff and visiting workers helping to form a human chain to pass the books to and from the transport. For the next three and a half years only a few reference works and recent volumes of periodicals were retained in the cellars of the north building.

With the building damaged and the library removed, little active laboratory-work could be achieved. However, field work was still possible, and gradually, after the air attacks lessened, essential repairs were begun by the Association's own workshop staff. Some parts of the building were brought back into research use quite soon, although the aquarium, which lost some of its plate glass and fish in the bombing, remained closed for the duration of the war. Several members of the staff collaborated in a reinvestigation of the problem of marine fouling of ships, rendered an urgent matter by wartime measures.[90] The war had also made it urgent to find a new source of supply of seaweed products formerly imported from the Far East, particularly agar jelly used for cultivating bacteria and the alginates that formed the base for special camouflage that would not show up under infra-red photography.[91] The team investigating seaweeds at Plymouth included Dr Mary Parke, who had earlier at Port Erin in the Isle of Man, developed new methods for rearing the microscopic algae eaten by larval stages of oysters and other shellfish.[92] Dr Parke was eventually appointed to the staff of the Plymouth Laboratory after the war and resumed work on these algae again. She was only the third female scientist to be employed at Plymouth, and only the fourth woman to be appointed to the Association's scientific staff. The first was Rosa Lee, employed by Garstang at Lowestoft in the 1900s, the second Dr Lebour, and the third was Mrs E. W. Sexton, appointed assistant to E. J. Allen in 1924 after serving 16 years unpaid in the same position. It is probably owing to the upheaval caused by the two World Wars that Marie Lebour and Mary Parke were considered for appointment to the still male dominated world of marine biology and fisheries research.

1945–1965: Reconstruction and Expansion

"When we build let us think that we build for ever"
John Ruskin

At the end of the second World War the Plymouth Laboratory was able

to begin a 20 year programme of rebuilding and expansion, funded by the Development Commission.[26] Continuing emphasis was placed on the individual innovative ability of the scientific staff, and the interdisciplinary attitude of the Laboratory was strengthened by new appointments in chemistry and physiology. The staff who had been away on war service returned safely except for Alec Sand who died in London, and P. Crimp, the last Student Probationer, who died in N. Africa.

The Director, Stanley Kemp, died in the spring of 1945 after a long illness.[81] He was succeeded in the autumn of 1945 by F. S. Russell, who was faced with an immense task. His first priorities were to complete the repairs to the existing buildings and restore sea-going facilities. Restoration of the war-damage was accelerated, and it was possible to reopen the Aquarium to the public in 1946, but full repairs to the laboratory accommodation took until 1949.[37] The third President of the Marine Biological Association, Lord Moyne, had resigned in 1938, under pressure of other duties. His place was taken by G. P. Bidder, who guided the Association through the difficult war years, and introduced the idea of Honorary Membership.[42] When G. P. Bidder retired in 1945, Professor James Gray of Cambridge was elected President. An active experimental zoologist, who had worked at Plymouth and encouraged his students to do the same, Professor Gray's advice was of great help during the period of reconstruction.

An immediate solution to the problem of work at sea was the leasing of an ex-Admiralty motor-fishing vessel. This vessel, previously known only by number, was named *Sabella*, and after equipping for trawling and water sampling, was brought into service in the autumn of 1946, in time for the first post-war visiting physiologists who required supplies of squid.[74] The work at sea soon showed that conditions in the Channel were much as they had been in 1938: inorganic phosphate levels were low, plankton sparse, and little prospect was seen for return of rich fisheries such as that for herring.[37] As had happened twice before, the staff began to cast their eyes farther afield than the Channel in a search for the reasons why biological conditions were so different from those of the 1920s. *Sabella* began investigations off West Cornwall in the hard winter of 1946/47, and in subsequent years sampling of water and plankton was extended across the continental shelf to the west and south-west, the region now called the Celtic Sea. The renewed attack on possible influences of oceanic circulation on the waters of the English Channel was led by L. H. N. Cooper,[94] working with two analytical chemists, who developed improved methods of sampling and analysis. Another approach, developed by D. P. Wilson and F. A. J. Armstrong showed that different water masses could be distinguished

by their suitability to support development of the planktonic larval stages of the sea-urchin, a demonstration of subtle differences not detectable by chemical analysis.

Sabella, lacking radio and radio-aids to navigation, was unsuitable for the precision station-keeping now required, and the lack of an adequate laboratory for handling and analysis of samples was another handicap. Hopes were directed to a new vessel, planned as a replacement for *Salpa*, which had been disposed of in 1946. The preliminary plans for a new ship announced in 1947[37] were for an oil-fired steamboat of 110 ft length, to be backed-up by a 60 ft motor-trawler for inshore work. The acquisition of the 60 ft vessel was the easiest part of this plan; a partly-completed Admiralty-pattern motor fishing vessel was purchased and fitted out, to enter service in 1948 as *Sula*.[37] Use of *Sula* inshore allowed *Sabella* to go on longer voyages, but planning for the new ship continued through 1949 and 1950. By 1951 the new ship was to be a diesel-engined vessel of 115 ft length, and the design was finalised in the autumn of 1952, when construction started at Dartmouth.

The new ship, named *Sarsia*, came into service in late 1953.[95] At 128 ft overall and 118 ft BP, *Sarsia* was the largest vessel actually owned by the Association, though inferior to *Huxley* in depth of keel and sea-keeping properties. A basic feature of the design of *Sarsia* was the ability to operate close inshore and from smaller ports in the south-west, should financial stringency ever call for disposal of the 60 ft inshore vessel. *Sabella* was returned to the Navy in 1953 and *Sarsia* gradually worked up to full operational status through the succession of defects that dog the early days of all research vessels. By 1955/56 *Sarsia* was working all over the Celtic Sea and out to deep water in the Atlantic. In the subsequent years of her 28 year service to the Association she extended the area of MBA operations from the north coast of Spain to the Sognefjord in Norway, and from the entrance to the Baltic out to the ocean far west of Ireland.

F. S. Russell also put into motion the pre-war ideas for improvement of the laboratory accommodation at Plymouth. At first it was possible only to convert existing space, including adaptation of the ruins of the Director's accommodation at the east end, but this allowed expansion of staff without waiting for the proposed extension of the north building. More physiologists were appointed, together with another analytical chemist and several zoologists to expand environmental studies. By 1951 there were 14 scientists, twice the number in 1918, and more than were employed in the heydays of 1903–1909 when the Association also operated the Lowestoft Laboratory under contract to the Government. One of the innovations of the post-war period was a

study of the impact of radio-isotopes in the marine environment, undertaken at Government request, in connection with proposed discharges of nuclear wastes from processing plants. A small laboratory was constructed behind the north building, and later, when work on the more active isotopes was transferred to specially constructed premises elsewhere, this tracer laboratory, as it was termed, was converted to basic studies with milder radioactive isotopes, thus founding a facility that could be expanded to help biochemical and physiological researches.[37]

Important changes were made to the Laboratory sea-water supply at this time. Additional underground reservoirs were excavated between the north and south buildings in 1955/1956, allowing the research circulation to be separated from the aquarium supply connected to the original reservoirs. During the building extensions of 1960/1961 the opportunity was taken to install more sea-water outlets and circulation benches, and a large part of the older sea-water pipes replaced.[37]

The aquarium itself was remodelled internally in 1959/60, with help from the Nuffield Trust. The original plate glass was re-used, but skilful design allowed larger tanks and an illusion of more space for the fish to be created within the existing dimensions. The planned extensions at the east end of the site were carried out in 1960/61. By this time the scientific staff had increased to 18, and the space was urgently needed. The new construction included laboratories for chemistry and physiology in the north building, botanical facilities in the upper floor of a link between the north and south buildings, with a classroom/lecture hall on the ground floor level.[37] The undergraduate classes in marine biology had been resumed in 1945 by D. P. Wilson and G. A. Steven when the class-hut in the yard had been repaired after war-damage. They were continued by G. M. Spooner and N. A. Holme into the 1960s, and held in the new accommodation. A class in experimental zoology and physiology was conducted in 1950 by J. A. C. Nicol, but there was then a gap of some years before further classes were started by E. J. Denton and T. I. Shaw in 1961. In later years J. V. Howarth and Q. Bone were also involved, and from 1967 to 1973, when the last class was held, they were joined by B. L. Roberts.[37]

The library stock had been brought back from its safe store at Hawkmoor House in the autumn of 1944, following repairs and redecoration to the library. Only a few items were found to be damaged by mice and insects after their three and a half year sojourn in a barn. With the end of the European conflict in 1945 contacts were renewed again with other countries and gaps in the journal series filled as far as possible. Pressure on book space began to increase again, and when the Librarian Mary Sexton died in 1951, her successor, Leila Serpell, who

had joined as Assistant Librarian in 1947, faced the start of what was later to be called the 'information explosion', when numbers of publications began to increase exponentially. The library building was extended westwards in 1955/56, doubling the storage capacity.[37] The books were rearranged and recatalogued on a new idiosyncratic system devised to suit the collections, in consultation with the Library of the British Museum (Natural History) and the Association's scientific staff. There had been many gifts to the collections since the war, from Sir Sidney Harmer, Professor A. V. Hill, Mrs E. W. Sexton, and Dr Marie Lebour. Further material came from the estates of Mrs R. A. Todd, E. R. Gunther, G. P. Bidder. The Plymouth library was closely involved in the activities of an international working group on 'Abstracts and Bibliographies of use in the Marine Sciences' which was to lead to active participation in international abstracting services in later years.[96]

The research topics under investigation at Plymouth during the 1960s are too numerous to list the individual scientists involved, and it is too close to the present for selective judgement by a colleague. Grouped together they make an impressive British contribution to the study of the sea, including the physical chemistry of seawater, the influence of inorganic nutrients on marine plant growth and production of fish food, the taxonomy, distribution, breeding and biochemistry of planktonic and benthic organisms, the physiology and behaviour of pelagic animals such as fish and squid, their regulatory processes, buoyancy, vision and other sensory systems.[37]

Ancillary investigations by visitors from the Universities and Colleges covered more basic matters such as nerve conduction, and ion balance in the cell, as well as researches into the geology of the bed of the Channel and Celtic Sea. In the early days of the Association's researches E. J. Allen was greatly assisted by R. N. Worth in analysing the sediments off Plymouth.[50] After *Sarsia* was commissioned the Association was able to offer time at sea to geologists and geophysicists from the Universities who wished to study the structure and stratigraphy of the rock formations of the Channel and Western Approaches. Among those using this facility were the late Professor M. N. Hill, and the late Professor W. F. Whittard, while in more recent years the Coastal Sedimentology Unit at Taunton made extensive use of *Sarsia* to investigate near-shore sediments.

When Sir James Gray retired from the Presidency of the Association in 1955, Professor A. V. Hill succeeded him, the first biophysicist to occupy the position.[66] Then in 1960 Professor C. F. A. Pantin was elected President, the first former member of the scientific staff to be so honoured. The growing interdisciplinary nature of marine science, well

shown by the research topics under investigation at the Plymouth Laboratory and the choice of Presidents of the Association, was recognised by the Government in 1963, when they proposed a reorganization of funding for marine biological and fishery research. The researches had moved a long way from the previous narrow lines in support of fisheries and whaling, and it was now necessary to integrate the marine environmental sciences to allow effective control and rational exploitation of the shallow seas around Britain and the nearby ocean. At the same time it had to be recognised that the need for greater Government funding would be matched by Parliamentary requests for more 'accountability', with, inevitably, increased administration burdens and costs. As a result of the adoption of the proposals for reorganization, responsiblity for marine biological researches other than fishery matters passed, in 1965, from the Development Commission, to the new Natural Environment Research Council, funded like other research councils through the Department of Education and Science.[97] Evidently we have come to the end of another chapter in the history of the Marine Biological Association, and the change was more marked in that 1965 was also the year when F. S. Russell retired after 20 years as Director, his services recognised by conferment of a knighthood.[37] Russell had not only superintended the reconstruction and expansion of the Laboratory, but had continued important researches into plankton organisms. During his term in charge he had built-up a special relationship with the Development Commission and the Treasury, based on mutual trust and respect; the Secretary of the Development Commission from 1934 to 1955, E. H. E. Havelock, is particularly remembered at Plymouth for his help and guidance.[37]

1965–1984 New Frontiers

"The important thing is not to stop questioning"
A. Einstein

"Out of old bookes, in good feith, cometh al this newe science that men lere"
G. Chaucer

The quotations express the two extremes of how research progresses in the marine sciences, by development from existing studies, and by questioning their results. For best progress neither the one extreme nor the other should predominate, and the Plymouth Laboratory has reaped the advantage of being able to apply a mixture of traditional activities and latest methods to study life processes in the sea. It is also important to hold a balance between individual innovative ability, always the strong point of the Association's staff, and the need to work in teams, as urged by the Natural Environment Research Council in

order to make effective use of limited resources such as time at sea and expensive analytical equipment.

For the period of administrative transition in 1965–75, the Association was fortunate to obtain the services of Professor J. E. Smith, F.R.S. as Director. An experienced university administrator and committee chairman as well as a leading marine biologist, Professor Smith was highly regarded for his powers of reconciling opposing views, and the changes were made easier in the first few years by increases in the income provided through the Natural Environment Research Council. Salaries and allowances could be brought into line with those of the other research council laboratories, and for a time it was possible to re-equip the Laboratory with modern analytical equipment and improved light microscopes. The first electron microscope was purchased in 1964 with a grant from the Wellcome Trust, but in later years the facilities were expanded with help from the Natural Environment Research Council, and electron microscopy is now a major feature of several research programmes at the Plymouth Laboratory. To incorporate all this expansion of facilities, minor re-building and extension was carried out within the existing site, including a new section to the tracer laboratory and a block of constant-temperature rooms. Plans were also prepared for another, much larger, extension to the library and for construction of enlarged workshops at the east end of the site. By 1967 the number of leading scientists on the staff had reached 24, while the annual total of visiting workers now averaged 100. Office space and laboratory accommodation were becoming scarce, and discussions were opened between the Association and Plymouth City Council and the Natural Environment Research Council about the use of a vacant site at the west end of the Hoe for expansion of some sections of the Laboratory. The plan had to be postponed during the period of raging inflation that set in after 1972. However, part of the site was developed for a new laboratory operated directly by the Natural Environment Research Council, the Institute for Marine Environmental Research, formed by amalgamation of several small units, some of which had been supported by the Development Commission. This institute carries out research complementary to that studied at Citadel Hill, and the two share common facilities, including computing, ships, some workshop services and, from 1984, library services. Part of the new site was, however, reserved for future possible expansion of the Marine Biological Association.

Several new lines of research were begun by the Association in the period under review, for example in physical chemistry, oceanography and deep-sea biology. However, for over a year from March 1967 practically the whole effort of the Laboratory was directed to studying

the effects and lessons of the *Torrey Canyon* oil-spill in west and north Cornwall. Field observations and monitoring programmes were combined with laboratory experiments on the fate and effects of crude oil and of the chemical dispersants applied to the spill. The first year's work is summed up in a specially published volume edited by the Director of the Laboratory,[98] and subsequent work is referred to in a later study of some of the long-term consequences.[99]

As early as 1965 it had been noticed that the plankton off Plymouth was changing its character, with young stages of bottom-living fishes becoming abundant again, and by 1970 the change was confirmed as affecting many aspects of life in the sea, including phytoplankton and fish.[100] The reverse of the changes reported in the 1930s indicated that some kind of cyclic fluctuation had been observed, possibly connected with a minor warming of the climate between 1920 and 1960, and it was predicted that if the cooling of the sea detected from 1962 onwards was to continue, then the improvements to the Devon fishing prospects, already noticed in the late 1960s with return of cold water fish such as cod, haddock and lemon-sole, might also be maintained.[100] The biological cycle was named the Russell Cycle, after Sir Frederick Russell, who had detected the earlier changes and had continued work on the later part of it after his retirement from the Directorship of the Laboratory in 1965.

Development of the sea-going facilities at Plymouth was accelerated with help from the Natural Environment Research Council. A long-planned 40 ft twin screw motor launch was brought into commission in 1967. The new vessel, called *Sepia* is fast enough to bring back delicate living material from as far out as the Eddystone, yet handy enough to trawl close inshore and in the Tamar estuary. In 1970 it was also possible to replace the 48 year old inshore motor-boat *Gammarus* with a new 34 ft boat of the same name. By this time the 60 ft trawler *Sula* was also in need of an extensive refitting, and the decision was made to replace her with a steel-hulled vessel of the same length, expressly designed for trawling over the stern and for carrying live fish in sea-water tanks fitted below deck. The new vessel, called *Squilla* entered service in 1973, and allowed increases in research work on the physiology of fish and squid, but, perhaps inevitably, this vessel has inherited the reputation of her predecessors, *Salpa* and *Sula*, for being uncomfortable for scientific work as distinct from trawling.

The Library also underwent great changes from 1967 onwards. Leila Serpell resigned that year and was replaced by Allen Varley, the first qualified librarian to take charge. The stock of books was increasing at such a rate, for example 52 new journal titles in one year, that plans had to be started for another extension to the building.[37] The *Torrey*

Canyon affair, already reported, placed additional strains on the library staff and facilities. In 1970, on the initiative of the Natural Environment Research Council, two information scientists were appointed, one to develop an information service for staff and visiting research workers, the other to assemble a comprehensive collection of marine pollution literature on which to base an external pollution information service. Two major pollution bibliographies[101,102] and monthly titles bulletin, *Marine Pollution Research Titles,* were published.

International efforts to produce a comprehensive abstracting journal for the aquatic sciences at last resulted in the production of *Aquatic Sciences and Fisheries Abstracts,* organized and edited by the Food and Agriculture Organization of the United Nations. The Natural Environment Research Council became the British partner in this project, with the library of the Marine Biological Association supplying monthly batches of abstracts from 1973 onwards. An additional science graduate was appointed to the library staff in 1974 to cope with this work, and subsequently the library has become more involved in this and other international activities relating to information management and exchange.[103]

Early in 1972 3000 volumes of less frequently consulted works had been removed to an outside store, while plans continued for a three-storey addition to the south front of the library. With help from the Natural Environment Research Council, it was possible to begin the library extension in 1973. The building operations were complicated by the need first to complete a new workshop at the east end of the site, then to demolish the old workshop to free space for building. On completion of the operations in 1975 it was possible to bring back the stored books and rearrange the other contents. The extension more than doubled existing shelving, and space was also provided, on a temporary basis, for some of the other scientific activities of the Association, pending later expansion of books and journals.

The last of the famous Easter vacation courses in marine biology took place in 1973, supervised by N. A. Holme and P. E. Gibbs. In view of the large number of undergraduate courses being held, the Association decided to concentrate on more advanced teaching, as for example in marine chemistry and physiology.

In 1975 Professor J. E. Smith, F.R.S. (later Sir Eric) retired. Professor E. J. Denton, F.R.S. was appointed Director, the first physiologist to hold the post, and a recognition of the growing role of experimental studies in the development of the Laboratory. Professor Denton had worked at the Laboratory since 1957, and had made important contributions to the physiology of fish and squid, most notably on their vision, buoyancy and hearing. The staff of the

Association continued to expand into new fields of research, particularly physical chemistry and oceanography, helped by secondment to Plymouth of a small unit from the Institute of Oceanographic Sciences, Wormley. The foundations were thus laid for another period of investigation of the physical, chemical and biological properties of the waters off the mouth of the Channel and in the Celtic Sea, following in the footsteps of Garstang,[55] Harvey[64] and Cooper[94] in the three previous generations. With new instruments it was possible to delineate water masses more exactly, and great attention was paid to physical boundaries between them, including fronts and the vertical discontinuity that develops in summer between the warmer surface waters and the colder deep waters. For the scientific work of the Association's staff in this period we can do no more than mention a few of the lines. The scope of researches by visitors from the Universities and other Institutions, both British and overseas, is even wider. Visiting research workers have always been an important part of the Association's activities, and their numbers have continued to increase. In some subjects, particularly physiology, they make up a major part of the effort, as shown by the published contributions listed each year,[37] but all fields of research benefit, as do the staff, whose contacts are thus broadened.

In 1975, with financial prospects becoming less certain, the Association decided to postpone building operations, and give priority to improvement of sea-going facilities.[37] Plans had been started in 1969 for replacement of *Sarsia* with a more modern and stable vessel with greater laboratory space for experimental studies. Although *Sarsia* served the Association's scientific staff and visiting workers for 28 years, she was felt to be out-dated even when new, lacking low-speed manouvrability and the electrical power required by modern apparatus. She was also extremely uncomfortable in bad weather owing to the shallow-draught hull, and although inexpensive to operate, had a low ratio of scientists to crew. During the many years (12) between the start of planning a replacement, and its arrival in service, the Natural Environment Research Council, and their research vessel service group, were of great help in improving several aspects of *Sarsia* and thus keeping up sea-going investigations from Plymouth. Most notably the main engines were uprated, extra generators installed, and finally a bow-thruster fitted to permit accurate station-keeping.

Improvements were also carried out to the laboratory sea-water system between 1970 and 1980, by extending the intakes in the Sound to several feet below extreme low tide, and installation of new pumps and pipes. The research system was converted from closed to open, with pumping maintained for up to 8 hours a day, marking a complete

break with the concepts on which the 1888 system was based (p 162), and giving healthier conditions for invertebrate animals. New tank rooms were also built, including a suite installed over the old reservoirs, and utilising the closed system still favoured for providing greater clarity of water in large tanks.

By 1979 it was not possible to maintain *Sarsia* economically, and the Natural Environment Research Council purchased a stern trawler built in France in 1974, expressly to form a basis for the new ship for Plymouth. This 43 m (141 ft) long vessel was converted to the requirements of the Association in 1980/81 and entered service as the *Frederick Russell* in July 1981.[37] This vessel soon proved superior in every way to *Sarsia,* and was able to continue working in deep-water through the winter months. Partly as a consequence, when the financial climate worsened, and it was necessary for the Natural Environment Research Council to economise on sea-going facilities, the *Frederick Russell* was taken over by NERC Research Vessel Services both to provide sea-time for Plymouth and act as a replacement for the *John Murray,* an older vessel which was becoming expensive to maintain. This change marked the end of the Marine Biological Association's direct involvement in the management of ocean-going vessels, begun in 1901 with the purchase of *Oithona.* However, it had to be recognised that the increasing sophistication of modern vessels means sharing of facilities and requires professional management.

This period also saw two changes of President of the Association. Professor C. F. A. Pantin had died unexpectedly in 1966, and Professor A. L. Hodgkin (later Sir Alan) took over to help guide the Association through a period of great problems. In 1976 Professor J. Z. Young became President, a role he still fulfils today.

The library continued to expand bibliographic activities in recent years, and several titles are now compiled and published at Plymouth.[104] In 1977 the library card catalogue was photographed and printed in book form in 16 volumes, and has since been sold by the publishers to major libraries in many countries. In addition several other subject and regional bibliographies have been compiled on contract for Government Departments and United Nations agencies. A good proportion of the costs of the pollution information service is being met by international funding, including the compilation of data on environmental chemicals and toxic compounds. During the start of the information explosion in the 1960s it was optimistically thought that the commercial computer-based information services would make in-house information processing unnecessary. In practice these commercial services are more useful for retrospective searches rather than a help to scientific staff who need to be kept aware of the latest

developments in their subject, though they can be of use in peripheral areas and in preparing to start new lines of investigation. Throughout its life, the library has been fortunate in that successive Directors and Council members have appreciated its value to research work, and have helped to shelter the collections from the worst effects of financial restrictions. However, it has to be recognised that information processing is still an expensive and labour intensive process in spite of sophisticated computers (or possibly because of them), and in future it will be necessary to reconsider how best to deploy the resources available.

Indeed, at the time of writing, all scientific research is once again in the process of reconsideration by the Government. The value to the nation of the activities of the Marine Biological Association, and other marine laboratories, has been pointed out recently by Professor R. I. Currie, in a short article celebrating the Centenary of both the Marine Biological Association and the Scottish Marine Biological Association.[105] The Marine Biological Association now employs just over 100 people, of whom 25 are leading scientists. The Laboratory is visited each year by about 170 research workers and many short term visitors from other institutions at home and abroad. The Laboratory is also of importance locally in Devon, through educational as well as research activities, and is the premier organization in a group that includes also the Institute for Marine Environmental Research, and the Environmental Science Departments and the School of Maritime Studies at Plymouth Polytechnic. Together these institutions make Plymouth and Devon a centre of excellence for the study of the sea.

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