THE WOODS HOLE OCEANOGRAPHIC INSTITUTION

REPORT FOR THE YEAR 1953

1954

HENRY BRYANT BIGELOW

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JOHN B. HERSEY, Physical Oceanographer.

LOUIS W. HUTCHINS, Associate in Marine Biology.

BENJAMIN B. LEAVITT, Assistant Professor of Biological Sciences, University of Florida; Associate in Marine Biology.

JOANNE S. MALKUS, Meteorologist.

WILLEM V. R. MALKUS, Physical Oceanographer.

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HILARY B. MOORE, Associate Professor in Marine Biology and Assistant Director, Marine Laboratory, University of Miami; Associate in Marine Biology.

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IV. DIRECTOR'S REPORT

Introduction

ALTHOUGH research is characteristically slow and one may become impatient at times with progress, there are always compensations when dealing with such a fascinating scientific study as that of the ocean. Our investigations ranged this year from studies of microscopical water droplets formed by bursting sea crests, to the physics of cumulus clouds of the Trade Wind belt. One zealous staff member, journeyed some forty miles by dog team over the ice of Frobisher Bay during the spring of 1953 searching for certain cold water fishes. Some of the year's features include:

(*a*) A second summer expedition along the continental slope, Virginia to Nova Scotia, trawling beyond commercial fishing depths.

(*b*) The filament pattern of the inshore edge of the Gulf Stream as observed from the air,— thermally and optically.

(*c*) The use of freed radio telemetering buoys in the vicinity of Bermuda to record wind-drift currents.

(*d*) The discovery of a chain of sea mounts which trend offshore from the New England shelf.

(*e*) Blood studies of Arctic fishes with reference to their physiological adaptation to sub-zero environment.

Due acknowledgments are again made to generous sponsors of oceanographic research at Woods Hole among whom are the U. S. Department of Defense, the National Science Foundation, the Commonwealth of Massachusetts and others.

Support on a broader basis than in the past is one of the established aims of the Institution. The year witnessed in this respect an encouraging growth in our newly established Woods Hole Oceanographic Associates whose numbers now exceed fifty. It is desired to express appreciation in behalf of the Institution to the Associates. Extension of the program to include membership of corporations and institutions is planned. Further comment on these activities is contained under an appropriate subsequent section.

The report of the year's work of the Research Staff as submitted by Drs. Redfield and Iselin follows.

Scientific Program

During the last twelve years an extensive file of North Atlantic temperature and salinity data has gradually been assembled and organized under

the direction of Mr. F. C. Fuglister. Many of the longer cruises, especially during recent years, have been planned with the purpose of filling in gaps in the geographic and seasonal coverage of these basic data. During the past six months Mr. Fuglister has carried out a general review of the situation in descriptive physical oceanography. Has the time come to get out a new atlas of the North Atlantic and would this be markedly superior to the one published in 1936 as part of the reports on the "Meteor" Expedition? How much longer will it be profitable to process all bathythermograph records and average them by one degree squares? With sub-surface temperature data are we approaching the point that was reached some time ago for surface observations where the Law of Diminishing Returns has begun to operate?

Mr. Fuglister's study has brought out a number of new and interesting points. As was suspected, too many data produce the same sort of over-simplification as do too few. The averaging process in the case of the Gulf Stream reduces the maximum temperature marking the warm core of the current and shifts it south of its usual position. In other words, the highest temperatures on the average chart will be along the limit of extreme southward meanders. On the other hand, by plotting the maximum range of temperature by one degree squares where there are sufficient data the regions of strong current are clearly shown, for at any one time the current coincides with a band of closely spaced isotherms, and as it migrates back and forth across a given one degree field a large temperature range will be recorded in the course of time. In this way, Mr. Fuglister's new charts clearly locate the mean positions of the three main branches of the Gulf Stream east of the longitude of the Grand Banks. Surprisingly, very little of this warm current system reaches the Norwegian Sea directly, as most previous charts have shown. No strong currents exist in the northeastern area of the main Atlantic Basin. The Norwegian Sea has its own anti-clockwise system of currents which carry relatively warm water northward along the edge of the Norwegian continental shelf, but rather little of this has entered from the open North Atlantic via the Faero-Shetland Channel. Thus the circulation of the Norwegian Sea is largely maintained by regional thermohaline differences.

Another striking feature of the new 200-meter temperature chart is that in mid-latitudes in the east, the currents are generally weak, the terminal branches of the Gulf Stream being well separated from the beginnings of the Northern Equatorial Current. In this respect the North Atlantic is quite different from the South Atlantic or the South Pacific where relatively strong equator-ward flowing currents appear to exist in the east. Unfortunately the comparative approach in descriptive oceanography will not become really profitable until the southern hemisphere oceans have been more adequately surveyed.

Having established a more or less reliable picture of the average current system over the North Atlantic, it is to be hoped that during the next few years studies will be made that will show up the variations in the system, both seasonally and over longer periods.

Mr. Henry Stommel and Mr. Gunther Wertheim have continued to study the fluctuations in transport through the Florida Straits. Their measurements of the difference in electrical potential between Key West and Havana now cover more than a year. There is evidence that the diurnal tide which is characteristic of the Gulf of Mexico strongly influences the short period variations of flow through the Florida Straits, which have a pronounced 25 hour rhythm.

Mr. von Arx and Dr. Richardson have been studying these pulses as they travel down stream. At least it is their present belief that these pulses are the cause of the interrupted nature of the inshore edge of the current as they observe surface temperature from the PBY-6A by means of the radiation thermometer. A number of successful flights have followed the current northward from the Florida Straits to Cape Hatteras and in a few cases beyond. As seen from the air the inshore edge of the Florida Current consists of overlapping filaments from 50 to 100 miles in length, along each of which the surface waters are strongly converging. When one of these is followed down stream it trends somewhat to the right of the mean direction of the axis of the current. Just before a given filament becomes diffusive and difficult to follow, a new one will be originating 10 or 15 miles further inshore.

Using the CARYN off the Carolinas, Mr. von Arx attempted last spring to examine the variations in surface velocity and the subsurface temperature structure across different parts of these overlapping streaks of surface convergence. Although the CARYN proved to be rather slow for this work and the data are still being analyzed, the original hypothesis has by no means had to be abandoned, namely that the periodic outpouring through the Florida Straits of tidal origin continue to exert an influence on the current for many miles down stream.

During August the CARYN again worked back and forth across the Gulf Stream measuring the variations in the velocity profile that are associated with seaward and landward meanders as located by the ATLANTIS.

It had been expected that during the summer we would have the help of Dr. C-G. Rossby in developing a theory that could begin to account for some of the newly observed characteristics of the Gulf Stream. Unfortunately sickness delayed his visit to Woods Hole until the winter. His assistant, Dr. Chester Newton has been collaborating with Mr. Fuglister and others in a comparative study of the dynamics of the Gulf Stream and of the atmospheric jet streams. Meanwhile, Dr. Willem Malkus has been elaborating one of Dr. Rossby's early theories and feels that he is on the threshold of some new advances.

It has long been a considerable embarrassment that so little progress has been made in observing the characteristics of wind currents. This is the one problem in physical oceanography where the classical theory has remained unchallenged by the observational approach. Ekman's famous spiral is still the best picture available of a wind current.

Mr. Stommel has undertaken to remedy the situation. He chose the Bermuda area in March as most nearly satisfying two of Ekman's simplifying assumptions: namely a deep layer of homogeneous water and an ocean surface that is large compared to the local wind system. The results were inconclusive for a number of significant reasons, but some new insight has been gained into the nature of the problem.

In the first place, he found that in winter the surface waters down to a considerable depth are subject to quite rapid inertial oscillations. These large, more or less eddy-like motions are presumably due to distant storms and can be readily observed with the G. E. K. The currents due to the local winds, at least in weather that permits effective operation of the *Caryn*, are shallower and weaker, and of course superimposed. To say the least this very much complicates the observational problem, for at no easily reached level can the water be considered approximately still.

A further difficulty was due to the fact that the local winds never blew for long steadily or in one direction. New wind currents kept forming on top of old ones. Nothing remotely approaching the simple Ekman spiral was observed. Furthermore, the high eddy viscosity near the surface due to waves was clearly exerting a major influence. The surface water, more often than not, simply moved down wind and not at 45° to the right as the theory calls for. It is clear that only by taking a very large number of observations can one hope to show up the effect of the earth's rotation in the statistical sense.

Although the current poles with large metal drags at various depths were easily set out, and a good technique was developed for handling the piano wire which connected the drags to the floats, when the winds approached force 5 the *Caryn* could no longer be maneuvered so as to measure the distances and bearings of the various markers.

As a result of this experience, during the spring and early summer, Mr. Stommel and his assistants have been developing a free floating, radio buoy from which current meters can be suspended at several depths, and which also records the direction and velocity of the wind.

In September Mr. Stommel and his assistants shifted their base of operation to Bermuda. The *Atlantis* carried down many tons of batteries and buoys. From the outset the operation was an unqualified, if somewhat puzzling, success. Buoys have been launched at intervals of approximately

three weeks and have been monitored continuously out to distances of approximately 60 miles. They report at fixed intervals, usually every three hours, wind velocity and direction, and the difference in direction and velocity between the surface water and the water at some deeper selected level. They have continued to function satisfactorily in winds of over 35 miles per hour. Since early October at least one buoy has been functioning continuously off Bermuda. In general the buoys confirm the importance of inertial currents first detected by the *Caryn* last winter. Usually the buoy circles to the right relative to the water at 300 feet, but occasionally it can circle to the left. Almost never does the buoy progress for long in a persistent down wind direction.

Mr. Arthur R. Miller returned to Woods Hole in April after a year's leave of absence during which time he took part in a survey of Delaware Bay. As part of this survey several temporary tide gauges were set out and these records provide excellent material for a study of meteorological effects on the tides in a large shallow bay. Since his return Mr. Miller has made excellent progress in analyzing these data, and he and Dr. Alfred Redfield have organized a similar study in Nantucket and Vineyard Sounds.

Mr. Donald P. Martineau has been working on two problems of a very different sort. Last winter he undertook a study of the accumulated bathythermograms from the standpoint of diurnal warming. Although few of the observations had been secured with this particular purpose in mind, he found that in a qualitative way it was in general possible to judge the relative importance of the several factors which influence the depth and intensity of the diurnal thermocline. In this way he was able to work out a fairly successful method of predicting the characteristics of the diurnal thermocline on the basis of the wind strength, the cloud cover, the altitude of the sun and the difference in temperature between the air and the water. Mr. Martineau more recently has undertaken a study of the origins and trajectories of the so-called Antarctic intermediate water in the South Atlantic. He finds that isentropic mixing is as well able to account for the observed distribution of temperature and salinity in the layer as the mass movements postulated by the German and British oceanographers who carried out the original surveys.

Mr. Irving Schell has been studying the so-called southern oscillation and has been looking for evidence that the ocean currents are the link whereby persistence effects are carried over long distances. He hopes to be able to show that a change in the index of the southern oscillation is followed by a change in transport of the northward flowing currents in the southern hemisphere oceans. In the case of the Atlantic, an increase of transport of the Southern Equatorial Current, which was brought about in

this way, could be expected to cross the Equator via the Guiana Current and still later to influence the Gulf Stream. While the validity of the southern oscillation is generally recognized in meteorology, Mr. Schell's study seems to be the first attempt to link the oceanic circulation with the gradual weather changes.

Mr. Joseph Chase has completed a study which correlates the varying success of each year class of haddock on Georges Bank with the strength and duration of northwest winds during the winter and early spring months. He could easily show that during its pelagic stage the haddock is very vulnerable to prolonged northwest gales over the bank, but it was much more difficult to deduce from the available data how the time of spawning varies from year to year.

Our meteorological program has begun to attract increasing attention, and each summer more meteorologists are acquiring the habit of coming to Woods Hole. It is evident that without much additional effort our laboratory can become an important focus point in meteorological research.

It happens that during most of the year the members of our permanent staff interested in weather phenomena over the ocean have been mainly occupied with report writing. Mr. Alfred Woodcock and Mr. Duncan C. Blanchard have been working up the data on warm rain clouds secured at Hawaii last year. Dr. Arnold Arons and Dr. Charles H. Keith have completed an experimental and theoretical study of the growth of droplets forming on salt nuclei.

Dr. Joanne Starr Malkus completed a study of observations secured in two trade cumulus clouds in 1952 and then during the early spring took part in a new observational program in the Virgin Island area. The 1953 field work in the tropics included a cooperative program with a group of British meteorologists who were based on Anagada Island. Dr. Malkus is planning soon to spend a year at the Imperial College, London, in order to knit the two groups even more closely together. Dr. R. S. Scorer, one of the leaders of the British group concerned with the dynamics of low level meteorology, visited Woods Hole during the autumn and gave a series of lectures on convective phenomena.

Mr. Andrew F. Bunker has continued to study the modifications of air masses as they pass over long stretches of water. During recent months he has been particularly concerned with the measurement of shearing stresses present in the air at altitudes between 50 feet and 5000 feet. He has also carried on studies of the dynamics of the plane as a means of exploring turbulence. Thus the plane itself has become a calibrated meteorological instrument. It is perhaps worth nothing that the interests of the oceanographers and the meteorologists in the characteristics of a plane do not coincide. The former would like a fairly fast plane of great endurance. The latter are well satisfied with the present PBY-6A because it is so slow.

Research in underwater acoustics, under the direction of Dr. J. B. Hersey, has continued to emphasize increasingly refined measurements at sea of transmission phenomena, reverberation, bottom reflectivity and ambient noise. Of recent months particular emphasis is being placed on scattering of biological origin as a function of frequency. The BLUE DOLPHIN has been chartered for the summer for the specific purpose of catching the biological scatterers that the BEAR with her acoustical gear has located. Thus at long last we hope we have means of making certain in reverberation measurements of the effects of the number of organisms present, their size and their body characteristics. Until now we have usually only been able to secure half of the data necessary to gaining a better understanding of such phenomena.

Advances have also been made in our knowledge concerning the distribution and importance in acoustical transmission of the air bubbles present just below the sea surface. These are of course introduced into the sea by breaking waves. Observations made last winter during periods of strong, cold winds showed that at times down to depths of 50 feet or more the whole water column can become so filled with air bubbles that its ability to transmit high frequency sound almost disappears.

Dr. Hersey and his group have continued to collaborate closely with other laboratories working in underwater acoustics and more and more the importance of the environmental factors is becoming generally recognized.

Mr. Henry Stetson's and Dr. Parker D. Trask's reports on the sediments of the Western Gulf of Mexico have been published and Mr. Stetson's work on the newer samples from the Eastern Gulf is nearing completion.

A new program of studying the changes in underwater topography along the outer Cape Cod beaches has recently gotten under way. Mr. John M. Zeigler who has completed his graduate studies at Harvard in sedimentary geology and who has recently joined our staff has been practicing at aqualung diving. This will enable him to study the underwater transportation of sand at first hand. Mr. L. D. Hoadley has completed a time lapse underwater camera capable of taking up to five thousand pictures. This will be used to study sand ripples and scour.

Mr. Zeigler has on three occasions carried out a survey of the bottom topography in deep water off the southern edge of Georges Bank. A most interesting chain of sea mounts has been discovered trending in a southeasterly direction. These are not only of considerable geological interest, but also since they cross the mean track of the Gulf Stream they should provide almost ideal mooring points for a line of instruments to record variations in the path of the current. So far nine sea mounts have been found with an average separation of about 35 miles.

During the past year considerable effort has been devoted to devising means of obtaining records of the energy spectrum of ocean waves. Under Mr. Robert Walden's direction a capacitance type wave recorder has been developed. This is a moored instrument and therefore only useful in relatively shallow water. Mr. John Holmes has been working on a free floating instrument. Both instruments seem capable of obtaining accurate records in waves up to about 8 feet in height. They are being tested under the high bridge across Narragansett Bay near Jamestown where stereophotographs of the sea surface can conveniently be obtained.

Reliable measurements of the characteristics of relatively small waves are being carried out for the David Taylor Model Basin with the launch *Risk*. The purpose of this work, which is being carried on by Mr. Wilbur Marks, is to test the new St. Denis-Pierson theory of the motion of ships in confused seas. It is hoped that out of this rather precise study of the statistical characteristics of small waves a reliable means will evolve of gaining similar information on storm waves.

In reviewing the work of the marine biologists, in progress since the first of the year, I would like first to mention the investigations done with the support of various civil agencies.

The contract with the Commonwealth of Massachusetts for investigations of the shell fisheries is continuing. At the request of the Department of Conservation Mr. Turner is surveying the crab fishery conducted in Boston Harbor, in order to obtain a basis for their administrative decisions on the desirable length of the open season. This is a matter on which controversy exists between two factions of the fishermen. Like the sea scallop, the rock crab supports a locally important fishery which is being conducted without benefit of any adequate knowledge of its natural history.

Mr. Posgay has been working for several years on the biology of the sea scallop and has attempted to determine the rate at which the scallops grow. To this end he has tagged a large number of sea scallops after measuring them and has liberated them on the fishing grounds. Recently he has been rewarded by the recapture of a considerable number of tagged specimens which are giving the answer to this important question.

The Institution has been represented by Dr. Ketchum as a consultant to the New York City Board of Water Supply in connection with litigation arising from the proposed diversion of water from the Delaware Watershed by New York. Here the question at issue is the effect of the proposed diversions on the salinity of Delaware Bay, particularly in the regions occupied by the New Jersey oyster industry.

This spring the Creole Petroleum Corporation proposed that we send representatives to Lake Maracaibo, Venezuela to outline a program of

observations to enable them to follow the changes in the salt content of the Lake expected to follow the purposed deepening of the channel to the sea. Their immediate concern was with the effects on the corrosive quality of the water, its potability and its use for industrial purposes. Drs. Redfield and Ketchum spent two weeks in Venezuela about the first of June and were able to secure a very complete picture of the hydrography of the Lake. This proved to be a most welcome opportunity since little is known of the character of embayments in tropical regions. Our observations revealed that the Lake has several novel characteristics which we hope to have an opportunity to study further.

Some years ago Dr. Mary Sears was invited by the Peruvian guano interests to examine the plankton in Peruvian waters, which supply the food for the birds on which the industry depends for its raw material. In the course of her studies Dr. Sears has examined the characteristics of the water present at the times of El Nino, when unusual warmth of the surface water is associated with catastrophic destruction of marine life, causing the guano birds to forsake the area. This condition is known to arise when a slackening of the coastal current permits an intrusion of warm water from the north, or from offshore, to invade the coast. Dr. Sears' studies now indicate that conditions may from time to time cause the local coastal water to become destructively warm without recourse to major changes in the circulation. The causes of the destructive condition are thus multiple and more complex than had been supposed.

Dr. Sears, who is well recognized as a marine biologist, and is an authority on the Siphonophores, now qualified as a significant contributor to general oceanography. It may be noted with regret that present conditions do not permit her to carry out her work at sea in person except through engagements with foreign agencies.

Turning to the work supported solely by the Institution, I will mention first the studies of Mr. Schroeder. In continuing the exploration of the fish fauna of the local coast he has made three trips this summer on the chartered dragger *Cap'n Bill II.* These have extended the range southward to Cape Charles and outward to 730 fathoms. Valuable information has been obtained on the southward extension of the range of northern species, but curiously enough little new has been discovered on the extension of the northern range of southern species into this area. As the work has extended deeper the numbers of fish caught has declined without much change in the composition of the catch. On the practical side red fish have been found again and, in more substantial numbers, off Nova Scotia in depths not exploited by commercial fishermen and deep sea red crabs, previously taken in goodly numbers off New England were found in undiminished supply to the southward.

Drs. Scholander and Van Dam accompanied Mr. Schroeder on two of their fishing expeditions in order to continue their studies of the gas contained in the swim bladder of deep living fishes, and the properties of the blood of such fishes which might be concerned with the secretion of the gas under very great pressure. These trips have been so successful that this phase of the investigation is now complete. The study is almost unique as an examination of physiological phenomena which occur under the high pressures of the deep sea.

In March Dr. Scholander made an expedition to Frobisher Bay in Baffin Land with the support of a grant from the Arctic Institute. The problem was to discover how Arctic fish survive at temperatures lower than those at which fish blood is known to freeze (about −0.6°C). With the aid of airplane and dog-sled Dr. Scholander succeeded in finding a hole in the ice where requisite low temperatures existed and in catching six small fishes. Examination of the blood showed that it did not freeze at temperatures higher than the local sea water (about −2°C) and indicated that this condition was due to the unusually high salt content of the blood. These observations promise to add a new chapter to the very interesting history of the development of renal function in fishes and to provide a concrete example of a mechanism by which physiological adaptation to environmental conditions is accomplished.

One of the central points of interest in marine biology today is the productivity of ocean water. By productivity is meant the rate at which energy is absorbed from sunlight to be used in the synthesis of organic matter. It is perhaps analogous to the fertility of the soil. The simplest method of measuring productivity at present is to confine a sample of sea water, with its normal biological content, to a bottle and to expose it to the local conditions of temperature and illumination for 24 hours. By subsequent determination of the oxygen content of the bottle conclusions may be drawn on the rate of production of organic matter by photosynthesis. The current rather extravagant claims for the great productivity of the ocean, relative to the land, are based primarily on measurements made by Dr. Riley using this method.

Recently an alternate method has been devised in Denmark using Carbon 14 as an indicator of carbon assimilation. This method results in very much smaller estimates of the productivity of tropical seas. Dr. Ryther and Mr. Vaccaro, of our staff, have compared the two methods simultaneously on controlled laboratory cultures and have shown that the results agree well, although the Carbon 14 method is the more precise when productivity values are low. This work will clarify the interpretation of much existing information and should lead to rapid advances in our knowledge of this fundamental problem.

The rise in sea level which has occurred during post glacial times, and is still continuing at rates measured by tide gauge records is a matter of interest in geology and oceanography alike. During the summer Mr. Patrick Butler, a student of botany at Harvard, who held a summer fellowship at the institution has studied the pollen buried in the peat of the salt marsh at Barnstable. Since the marsh has built upward as sea level rose, the pollen entrapped at different depths provides an indication of the changes in vegetation during the time sea level has risen. The latter may be related to changes in climate, which can be dated from other evidence. Mr. Butler has distinguished in this way a research of climatic change thought to have occurred some 5000 years ago, and now lying at a depth of 29 feet. This indicates an average rise in sea level of six or seven inches per hundred years — a rate about that given by recent tide gauge records.

Forty-two scientific papers have been published in 1953. These include the "Fishes of the Gulf of Maine," a book of 577 pages by Dr. Bigelow and Mr. Schroeder. A second book of similar proportions by the same authors will bear the 1953 date line, although it will not appear before mid–1954. One number of *Papers in Physical Oceanography and Meteorology* with two rather long papers was also published in 1953. The following contributions of the Institution for 1953 are listed by author and title:

	Contr. No.
BIGELOW, H. B., and W. C. SCHROEDER. Fishes of the Gulf of Maine. Revised edition. *Fish Bull.* 74, *Fish Bull., Fish and Wildlife Service*, 53:1–577, 288 text figs.	592
BIGELOW, H. B., W. C. SCHROEDER and S. SPRINGER. New and little known sharks from the Atlantic and from the Gulf of Mexico. *Bull. Mus. Comp. Zool., Harvard Coll.*, 109(3):213–276, 10 text figs.	596
BLANCHARD, D. C. Raindrop size-distribution in Hawaiian rains. *J. Meteorol.*, 10(6):457–473, 13 text figs.	658
BLANCHARD, D. C. A simple recording technique for determining raindrop size and time of occurrence of rain showers. *Trans. Amer. Geophys. Union*, 34(4):534–538, 2 text figs.	659
BUNKER, A. F. On the determination of moisture gradients from radiosonde records. *Bull. Amer. Meteorol. Soc.*, 34(9):406–409, 2 text figs.	605
BUNKER, A. F. Diffusion entrainment and frictional drag associated with non-saturated, buoyant air parcels rising through a turbulent air mass. *J. Meteorol.*, 10(3):212–218, 4 text figs.	631
FARMER, H. G., and G. W. MORGAN. Ch. 5. The salt wedge. *Proc. Third Conf. Coastal Eng.*, Cambridge, Mass., Oct. 1952:54–64, 4 text figs.	638
FRANCIS, J. R. D. A note on the velocity distribution and bottom stress in a wind-driven water current system. *J. Mar. Res.*, 12(1):93–98, 4 text figs.	639
HELA, ILMO, H. B. MOORE and H. OWRE. Seasonal changes in the surface water masses and in their plankton in the Bermuda area. *Bull. Mar. Sci., Gulf and Caribbean*, 3(3):157–167, 10 text figs.	677

Contr. No.

HOUGH, J. L. Pleistocene climatic record in a Pacific Ocean core sample. *J. Geol.*, 61(3):252–262, 3 text figs. ... 641

KETCHUM, B. H. Ch. 6. Circulation in estuaries. *Proc. Third Conf. Coastal Eng.*, Cambridge, Mass., Oct. 1952:65–76, 8 text figs. ... 642

KETCHUM, B. H., and D. J. KEEN. The exchange of fresh and salt waters in the Bay of Fundy and in Passamaquoddy Bay. *J. Fish. Res. Bd., Canada*, 10(3):97–124, 11 text figs. ... 593

MALKUS, J. S., and M. E. STERN. The flow of a stable atmosphere over a heated island. Pt. 1. *J. Meteorol.*, 10(1):30–41, 6 text figs. ... 624

MALKUS, W. V. R. A recording bathypitotmeter. *J. Mar. Res.*, 12(1):51–59, 5 text figs. ... 634

MOORE, H. B., H. OWRE, E. C. JONES and T. DOW. Plankton of the Florida Current. III. The control of the vertical distribution of zooplankton in the daytime by light and temperature. *Bull. Mar. Sci., Gulf and Caribbean*, 3(2):83–95, 1 text fig. ... 669

OFFICER, C. B., JR. The refraction arrival in water covered areas. *Geophysics*, 18(4):805–819, 9 text figs. ... 629

REDFIELD, A. C. Interference phenomena in the tides of the Woods Hole region. *J. Mar. Res.*, 12(1):121–140, 9 text figs ... 636

ROELOFS, E. W., and D. F. BUMPUS. The hydrography of Pamlico Sound. *Bull. Mar. Sci., Gulf and Caribbean*, 3(3):181–205, 11 text figs. ... 547

SAID, RUSHDI. Foraminifera of Great Pond, Falmouth, Massachusetts. *Contr. Cushman Found. Foram. Res.*, 4(1):7–14, 3 text figs. ... 588

SCHEVILL, W. E., and BARBARA LAWRENCE. Auditory response of the bottle-nosed porpoise, *Tursiops truncatus*, to frequencies above 100 kc. *J. Exper. Zool.*, 124(1):147–165, 2 text figs. ... 648

SCHEVILL, W. E., and BARBARA LAWRENCE. High-frequency auditory response of a bottle-nosed porpoise, *Tursiops truncatus* (Montagu). *J. Acoust. Soc., Amer.*, 25(5):1016–1017 ... 663

SCHOLANDER, P. F., and L. VAN DAM. Composition of the swimbladder gas in deep sea fishes. *Biol. Bull.*, 104(1):75–86, 5 text figs. ... 632

SEARS, MARY. Notes on siphonophores. 2. A revision of the Abylinae. *Bull. Mus. Comp. Zool., Harvard Coll.*, 109(1):1–119, 29 text figs. ... 602

SOULE, F. M., P. S. BRANSON, and R. P. DINSMORE. Physical oceanography of the Grand Banks region and the Labrador Sea in 1951. *U.S.C.G. Bull.*, No. 37:17–85, 21 text figs. (dated 1952) ... 601

STERN, M. E., and J. S. MALKUS. The flow of a stable atmosphere over a heated island. Pt. II. *J. Meteorol.*, 10(2):105–120 ... 625

STETSON, H. C. The sediments of the western Gulf of Mexico. Pt. 1. The continental terrace of the western Gulf of Mexico: its surface sediments, origin and development. *Pap. Phys. Oceanogr. Meteorol.*, 12(4): 1–45, 18 text figs. ... 646

STOMMEL, HENRY. Computation of pollution in a vertically mixed estuary. *Sewage and Ind. Wastes*, 25(9):1065–1071, 3 text figs. ... 640

STOMMEL, HENRY. The role of density currents in estuaries. *Proc. Minnesota Int. Hydraulics Conv.*, Sept. 1–4, 1953:305–312, 7 text figs. ... 655

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STOMMEL, HENRY. Examples of the possible role of inertia and stratification in the dynamics of the Gulf Stream System. *J. Mar. Res.*, 12(2):184–195, 4 text figs. 645

STOMMEL, HENRY, and H. G. FARMER. Control of salinity in an estuary by a transition. *J. Mar. Res.*, 12(1):13–20, 4 text figs. 587

STOMMEL, HENRY, W. S. VON ARX, DONALD PARSON and W. S. RICHARDSON. Rapid aerial survey of Gulf Stream with camera and radiation thermometer. *Science*, 117(3049):639–640, 1 text fig. 644

TRASK, P. D. The sediments of the western Gulf of Mexico. Pt. II. Chemical studies of sediments of the western Gulf of Mexico. *Pap. Phys. Oceanogr. Meteorol.*, 12(4):47–120, 21 text figs. 647

TURNER, H. J., JR. The drilling mechanism of the Naticidae. *Ecology*, 34(1):222–223 630

TURNER, H. J., JR. Fifth report on investigations of the shellfisheries of Massachusetts. Comm. Mass., Dept. Conserv., Div. Mar. Fish.:1–37, 3 figs., 8 maps. (Dated 1952) 656

VAN DAM, L., and P. F. SCHOLANDER. Concentration of hemoglobin in the blood of deep sea fishes. *J. Cell. Comp. Physiol.*, 41(3):522–524 633

VISHNIAC, H. S., and S. W. WATSON. The steroid requirements of *Labyrinthula vitellina* var. *pacifica*. *J. Gen. Microbiol.*, 8:248–255 623

VON ARX, W. S. Cartographic principles applied to wide-field photography. *Photogr. Eng.*, 4(2):60–73, 9 text figs. 649

WATSON, E. E. An experiment to determine the hydrodynamic forces on a cable inclined to the direction of flow. *J. Mar. Res.*, 12(3):245–248, 1 text fig. 686

WOODCOCK, A. H. Salt nuclei in marine air as a function of altitude and wind force. *J. Meteorol.*, 10(5):362–371, 8 text figs. 643

WOODCOCK, A. H. Hawaii as a cloud physics laboratory. *Pacific Science*, 7(4):522–524, 2 text figs. 660

WOODCOCK, A. H., C. F. KIENTZLER, A. B. ARONS and D. C. BLANCHARD. Giant condensation nuclei from bursting bubbles. *Nature*, 172(4390):1144–1145, 2 text figs. 673

WORTHINGTON, L. V. Oceanographic results of Project Skijump I and Skijump II in the Polar Sea, 1951–1952. *Trans. Amer. Geophys. Union*, 34(4):543–551, 4 text figs. 628

Vessels

The winter season in New England waters is not a favorable time for oceanographic field work, yet ATLANTIS was able to get in a few short cruises. Early in March saw her departing on a southern cruise from which she did not return until early June. During the first part of the period ATLANTIS conducted field work out of Guantanamo, Cuba, then in April she joined company with the schooner VEMA, chartered by Lamont Geological Observatory, under Dr. Maurice Ewing to carry out a seismic survey of the Caribbean and Gulf of Mexico waters.

Following ATLANTIS' return to Woods Hole and the semi-annual refit

at Boston, she sailed on a Gulf Stream cruise. Later, in September, found her in Bermuda waters, where she had a close call from stranding in a hurricane which passed over that island. The latter part of 1953 witnessed additional short trips across the continental shelf in the New England area. Total mileage approximated 20,000 in 193 days at sea.

CARYN made two trips to Bermuda, one in the Spring to establish a base party to study wind drift currents, and later in July in company with ATLANTIS. About six weeks CARYN was used in Gulf Stream observations out of Morehead City, North Carolina, part of the time in conjunction with our Navy loaned PBY-6A airplane. In October in the interests of economy CARYN was decommissioned for the remainder of the year.

The BEAR, which was purchased in 1952 under a contract with the Bureau of Ships, proved to be a useful and active unit in acoustical field operations. Due to her somewhat off-shore limitations, her cruises were a matter of days in and out of Woods Hole. In company with the schooner BLUE DOLPHIN which was chartered for the summer, these two vessels carried out bio-physical observations in the area south of Martha's Vineyard. The BLUE DOLPHIN's charter ran from 13 June to 27 August.

Another charter refers to the previous year's deep trawling fishery expedition along the continental slope, Virginia to Nova Scotia, when again the dragger CAP'N BILL II was used on three cruises of seven to eight days duration each. Again as last year some rare specimens were caught, and fish and crab populations met which indicate possibilities of development of economic proportions.

The boat pool of the Institution consisting of ASTERIAS and CLAIR was employed in similar miscellaneous local operations as in former years. The MYTILUS which had been kept as a spare hull in reserve, appeared to have no future use, and was therefore sold.

The sport fishing cruiser ALLURE, a gift to the Institution last year by an Associate, was found unsuitable for the usual field work, and was disposed of in the early summer.

The PBY-6A Navy airplane operated by our own personnel kept active throughout the year with time out only for prescribed engine and structural inspections. The craft's meteorological-oceanographic activities included visits to the West Indies, Newfoundland, Nebraska, and three flights along the inshore boundaries of the Gulf Stream, Miami to Cape Hatteras. The airplane completed operations over the waters around Bermuda during December.

By the year's end two factors were only too evident. Hurricanes had once again greatly decreased the effectiveness of the operations during the latter part of the summer. Perhaps more fundamental is that Loran navi-

gation is becoming marginal for our needs. Although this was a great stimulus to research on the circulation problem when it first became available, it is not sufficiently accurate to help solve several of the critical problems. We need a still more precise system of navigation, and until this has been developed progress in our understanding of the details of ocean currents is not likely to be spectacular. To be able to measure the depth to the bottom in deep water within a fathom or so and at the same time not to know one's geographical position within half a mile or more is not a very satisfactory situation.

The situation regarding the main field instrument of the Institution,—its sea-going fleet, has not improved during the last year for maintenance continues relatively higher than what it would be on newer ships, and age is becoming increasingly apparent. Not only is this true in the rate of material deterioration but also it is met at every turn such as in the efficient operation of the scientific equipment and in the sea-comfort of those on board.

In an effort to ultimately replace existing American craft with more modern designed oceanographic ships, a study and recommendations were completed during the year which received favorable comment from naval circles. Marked improvement in reduction of the noise factor on shipboard was a feature of the study. A committee continues under a research contract between our Institution and the Office of Naval Research on which representatives of several oceanographic activities, in and out of the government, plan to prepare design drawings and estimates. It is hoped that out of this work will come appropriations and the actual construction of a modern ocean-class research ship.

For detailed information on the itineraries of the research vessels and airplane, please refer to Appendix.

Plant

The crowded conditions of the laboratory which have prevailed for several years received no immediate alleviation. Yet the ever growing construction next door of the Office of Naval Research's new Laboratory of Oceanography, augured well for a not too distant relief of cramped working spaces. The new construction in those floor areas used by existing activities such as the garage and stock room, necessitated some interruptions of the normal work to accommodate to the new building.

In order to adjust temporarily the parking of employees' automobiles, an area in the rear of the Institution's village property was leveled and surfaced to accommodate 84 vehicles. Through the kindness, furthermore, of Mr. Wilbur A. Dyer, the Dyer's Dock parking area was made available at no charge for winter use.

The so-called Hall property belonging to the Institution across Main Street from our main laboratory was connected with the town sewer line, and the main building, formerly leased as a grocery store, was utilized during the summer as a temporary office for visiting scientists. Maintenance of the dock and several buildings was provided on a current level sufficient to a neat appearance and the overall utilitarian value of the property.

Personnel

The Research Staff in 1953 numbered 190. Below is shown a tabulation of all Institution personnel (Research Staff and Administrative Staff), as of July 1, 1953. The table for 1952 is included for comparison.

	1952		*1953*	
RESEARCH STAFF				
Full time:				
At Woods Hole	96		79	
Off Campus	6		29	
Secretaries and Clerks	4		8	
Part time:				
At Woods Hole	45		43	
Off Campus	21		17	
Fellowship Holders	14		10	
Visiting Investigators	7	193	4	190*
ADMINISTRATIVE STAFF				
Department Heads and Assistants	11		12	
Secretaries and Clerks	18		19	
General Maintenance and Service Personnel	55		59	
Crews of Vessels	41	125	51	141
Grand Total		318		331

* Includes 71 Staff Appointees and 119 others

It is with pleasure that we record the following additions to and promotions within the Research Staff:

Dr. Carl-G. Rossby, Director, Institute of Meteorology, University of Stockholm, already an associate on our staff, was appointed meteorologist as of September 1.

Dr. Bostwick H. Ketchum, marine microbiologist, was promoted to senior biologist as of December 1.

Appointments to the Research Staff for a period of one year from September 1 were made to the following:

JOHN W. KANWISHER	Research Associate in Biophysics
BENJAMIN B. LEAVITT	Associate in Marine Biology
WILBUR MARKS	Research Associate in Mathematics

WILLIAM S. RICHARDSON	Physical Chemist
JOHN H. RYTHER	Research Associate in Marine Biology
MARSHALL SCHALK	Associate in Geology
ROBERT G. WALDEN	Research Associate in Engineering
RAYMOND WEXLER	Associate in Meteorology
GEORGE W. WHEELER	Research Associate in Physics
JOHN M. ZEIGLER	Research Associate in Geology

In accordance with the policy of the Institution to constantly improve and strengthen the Research Staff, the Board of Trustees voted in August to provide a fund for a sabbatical leave of a top scientist, or to afford the opportunity for a younger scientist to continue his formal education. In the Fall, Mr. William S. von Arx was granted sabbatical leave for a period of approximately one year to pursue earth science courses at the Massachusetts Institute of Technology.

It is with regret that we accepted the resignation of Dr. Charles H. Keith, Dr. William S. Butcher, and Captain Adrian K. Lane. The latter who had been on the Administrative Staff of the Institution for approximately seven years, spent all but the latter one in command of ATLANTIS, logging many thousands of miles at sea.

The Institution lost through death, the services of Mr. Marcus Conlan, Property Custodian, who passed away May 4th, after more than ten years of faithful and untiring service.

Other changes of note is the transfer of Captain John F. Pike from command of ATLANTIS to become Port Captain on July 1, and the assignment of Captain W. Scott Bray as the new master of ATLANTIS.

Dr. Bostwick H. Ketchum attended the Sixth International Congress of Microbiology at Rome, Italy in September. He also represented the Institution at the fifty-first annual meeting of the International Council for the Exploration of the Sea at Copenhagen, and visited several marine stations in Scandanavia, England and Scotland.

Dr. George L. Clarke attended the meeting of the Pacific Scientific Congress held in November at Manila, Philippine Islands.

The following persons were awarded honoraria, grants or fellowships during the year:

AYERS, JOHN C.
BERGERON, TOR
BUTLER, PATRICK
CONOVER, JOHN T.
COUSTEAU, JACQUES-YVES
DOE, L. A. EARLSTON
EWING, WILLIAM M.
FOFONOFF, NICK
FRANCIS, J. R. D.
GILBERT, THEO. W., JR.
HARRIS, EUGENE
LAWTON, C. S.
MONTGOMERY, RAYMOND B.
MOORE, J. R., III
RILEY, GORDON
SCORER, R. S.
STEFANSSEN, UNNSTEIN
VOSS, G. L.
WATSON, EDMOND E.

It is desired to acknowledge with appreciation grants from the National Science Foundation to Dr. Per L. Scholander in the sum of $8500 for studies on the mechanism of gas secretion in fishes; also another grant to Dr. John H. Ryther from the National Science Foundation in the sum of $3000 for studies of the etiology of plankton blooms.

Previous reference has been made to the new supporting organization of the Institution — the Woods Hole Oceanographic Associates. It had its growth quite naturally from small groups of persons in the Woods Hole Community who were welcomed by a tour of the laboratory.

The Associates on May 21 held what they called a Spring Dinner at the appropriate quarters of the New York Yacht Club, and this was followed by a day's excursion in Vineyard Sound, August 1st, of over one hundred Associates and their friends on board the vessels ATLANTIS and BLUE DOLPHIN. On board each vessel several of the oceanographers' instruments were demonstrated, such as water sampling, coring, BT casts and the netting of plankton. Thus the day, which was one of beautiful weather, proved very enjoyable as well as instructive.

The annual meeting which was held on board ATLANTIS resulted in the re-election of the following:

GERARD SWOPE, JR., President
JOHN GIFFORD, Secretary
EDWIN D. BROOKS, JR., Treasurer

and the following Executive Committee:

WINSLOW CARLTON	N. B. MCLEAN	THOMAS J. WATSON, JR.
RACHEL L. CARSON	EDWARD A. NORMAN	JAMES H. WICKERSHAM
GEORGE F. JEWETT	MALCOLM S. PARK	WILLIAM D. WINTER
HENRY S. MORGAN		

By the end of the year plans were well along to offer certain industrial corporations and institutions, interested in the scientific study of the oceans, an opportunity to become members of the Woods Hole Oceanographic Associates.

The following visitors were among those who spent from one day to a few weeks at the Institution at one time or another during the year:

MR. M. AHMED, Central Fisheries Department, Ministry of Foreign Agriculture, Karachi, Pakistan
HIS IMPERIAL HIGHNESS AKIHITO, Crown Prince of Japan
DR. H. BENOIT, University of Strasbourg, France
DR. TOR BERGERON, University of Upsala, Sweden
DR. BERT BOLIN, University of Stockholm, Sweden
MR. E. L. BOUSFIELD, National Museum of Canada, Ottawa, Canada
DR. S. CHANDRASEKAR, Yerkes Observatory, Williams Bay, Wisconsin
MR. H. CHARNOCK, National Institute of Oceanography, England
COMMANDANT JACQUES-YVES COUSTEAU, French Navy

DR. T. B. DAVIE, Vice-Chancellor, University of Capetown, South Africa
MR. EDGAR DEACON, C.S.I.R.O., Sydney, Australia
DR. G. E. R. DEACON, National Institute of Oceanography, England
DR. MAXWELL DOTY, University of Hawaii
MR. E. T. EADY, Imperial College of London
COMMANDER K. P. FARRELL, Royal Canadian Navy
DR. S. JONES, Central Fisheries, Barrackpore, India
MR. D. J. KIM, University of Korea
MR. B. J. MASON, Imperial College, London
MR. H. J. MCLELLAN, Fisheries Research Board of Canada
DR. FRITZ MOLLER, University of Mainz, Germany
MR. WENDELL A. MORDY, Pineapple Research Institute, Hawaii
DR. C. H. MORTIMER, Freshwater Biological Association, Ambleside, Westmoreland, England
DR. A. W. H. NEEDLER, Fisheries Research of Canada
DR. FERGUS J. O'ROURKE, National University, Dublin, Ireland
COMMANDER E. N. POLAND, British Joint Services Mission
LIEUT. PINICH PUKASAB, Thailand Navy
LT. COMMANDER J. E. RUSE, Royal Canadian Navy
DR. R. S. SCORER, Imperial College of Science and Technology, London, England
MR. UNNSTEINN STEFANSSON, University Research Institute, Department of Fisheries, Reykjavik, Iceland
DR. AMAR NATH TANDOM, Poona, India
MR. H. L. A. TORR, Fisheries Research Board, Vancouver, British Columbia

The persons whose names are listed below were members of the Institution (additional to those otherwise listed) for a period of six months or more during the calendar year 1953.

RESEARCH ASSISTANTS, ENGINEERS, AND TECHNICIANS

ANDERSON, NELLIE T.
ATHEARN, WILLIAM D.
BERGSTROM, STANLEY W.
BRADSHAW, ALVIN L.
BRAINERD, SUZANNE
CAIN, HENRY A.
CANGIAMILA, ANGELO
CARTER, ALWYN L.
CHUTE, NANCY W.
CONOVER, JOHN T.
CORWIN, NATHANIEL
CREITZ, GRACE I.
DAVIS, LEE C.
DAVIS, PRISCILLA A.
DAY, C. GODFREY
DUYS, GERRIT, JR.
EDWARDS, MELVILLE E.
FEE, FRANCES M.
GESSNER, ROBERT E.
HANKS, JAMES E.
HAYES, CARLYLE R.
HOADLEY, LLOYD D.
HODGSON, SLOAT F.
KIERNAN, CLAYTON F.
LUFBURROW, ROBERT A.
NEWTON, CHESTER W.
OWEN, DAVID M.
PARSON, DONALD, JR.
PASLEY, GALE G., JR.
PIERCE, PHEBE
PINGREE, FREDERICK DEW.
POOLE, STANLEY E.
POSGAY, JULIUS A.
PURINTON, CHARLES S.
RAICHE, SHIRLEY A.
ROSE, JOHN C.
RYAN, DOROTHY S.
SCHROEDER, ELIZABETH H.
SHULTZ, WILLIAM S.
SPENCER, ALLARD T.
THAYER, MARY C.
TOLLIOS, EVANGELINE P.
VACCARO, RALPH F.
VOLKMANN, GORDON H.
WALSH, MARTHA A.
WHITNEY, GEOFFREY G., JR.
WILKINS, CHARLES H.
WITZELL, WARREN E.

TECHNICAL CLERKS AND SECRETARIES

ALLEN, ETHEL B.
ATWOOD, BARBARA
BERGSTROM, EILEEN J.
BLOEDEL, PAMELA
BOWMAN, PHYLLIS R.
BRADLEY, MABEL D.
BRAILEY, LEOLA R.
CHASE, ALLISON E.
ENGLISH, JEAN
GLAESER, FLORENCE E.
KERNER, PATTY JO
MELLOR, FLORENCE
OSTIGUY, BETTY P.
PARKER, EVELYN M.
PERRY, BARBARA L.
POSGAY, MARJORIE F.
SCHARFF, MARGARET
SODERLAND, ELOISE M.
SOUZA, CECELIA
STEWART, DORIS H.
WILSON, ESTHER N.

ADMINISTRATIVE AND SECRETARIAL PERSONNEL

BACKUS, JEANNE M.
BEHRENS, HENRY G.
BROADBENT, MADELINE P.
BRYANT, EDWIN T.
CASILES, PHYLLIS B.
COOK, CAROL B.
CROCKER, MARION W.
DINGWELL, EVA Z.
DONALD, MARY
DOUTHART, DOROTHY E. S.
FERRIS, ALICE H.
FERRIS, GEORGE A.
GRIFFIN, T. S. PERRY
HATZIKON, KALEROY L.
ORTOLANI, MARY
SANDBLOM, JOHN D.
SOUZA, JANE C.
YOUNG, ANITA M.

TECHNICAL SERVICES PERSONNEL

ALLEN, JOHN L.
BAILEY, FRANK A.
BARSTOW, ELMER H.
BENNETT, PAUL E.
BLAKE, FORREST W.
BODMAN, RALPH H.
BOWMAN, WARREN O.
CHUTE, EDWARD H.
CONDON, J. WILLIAM
DIMMOCK, RICHARD H.
DINGWELL, PAUL E.
DUNKLE, WILLIAM M., JR.
ELDRIDGE, STANLEY N.
EMERY, BEVERLY S.
FELDMAN, JOEL
FISHER, STANLEY O.
GALLAGHER, GLORIA S.
GALLAGHER, WILLIAM F.
GASKELL, FRED
GIFFORD, JAMES E.
GRANT, CARLETON
HAMMOND, WILLIS T.
HODGKINS, HARRY L.
HOWLAND, MYRON P., JR.
MORRISON, KENNETH
MANNING, MARY
NELSON, DONA E.
RENNIE, THOMAS D.
RONNE, F. CLAUDE
SPOONER, CHARLES E.
SPOONER, JOANNE C.
STIMPSON, JOHN W.
THAYER, LAWRENCE A.
VAIL, PHYLLIS L.
WEEKS, ROBERT G.
WING, CARLETON R.

MAINTENANCE, HOUSING, AND CUSTODIAL PERSONNEL

BACKUS, HAROLD
CHRISTIAN, JOHN A.
CROSS, DONALD E.
FIELDEN, FREDERICK E.
POLLEY, ROBERT E.
SALTHOUSE, JAMES
SOLBERG, OTTO
SPARKS, ELIZABETH C.
STANSFIELD, RICHARD
TURNER, CATHERINE
WILDE, PHILLIPS B.
WING, NATHANIEL R.
WOODWARD, FRED C., JR.
YANDO, ANTHONY J.
YORK, JAVAN D.

OFFICERS AND CREW MEMBERS OF VESSELS, BOATS, AND AIRCRAFT

ADAMS, MALCOLM H.
BACKUS, CYRIL
BAILEY, JAMES S.
BARROS, GEORGE M.
BISAILLON, RALPH
BRAY, WINFIELD S.
BUCK, LEO M.
CABRAL, JOHN V.
CASILES, DAVID F.
CAVANAUGH, JAMES J.
CHILDS, ASHLEY B., JR.
CLARKIN, JAMES J.
COLBURN, ARTHUR D., JR.
CONLEY, WILLIAM J.
COOK, HANS
COPESTICK, LOUIS B.
CULLITON, JOHN F.
DAY, JOSEPH V.
ELLIS, KENNETH B.
FAY, DONALD H.
FOURNIER, RICHARD A.
GINGRASS, NORMAN
HENNESSEY, RICHARD F.
HOWE, PAUL M.
HOWLAND, PAUL C.
KARLSON, ARVID
LAMBERT, JOSEPH L.
LYON, THOMAS
MACKEY, MALCOLM R.
MATHEWS, FRANCIS S.
MERCHANT, FLOYD L.
MYSONA, EUGENE J.
O'BRIEN, WARREN E., JR.
PALMIERI, MICHAEL
PETERSON, EDWARD J.
RODERICK, MILTON
ROSE, LAWRENCE
SEIBERT, HARRY H.
SHIELDS, WILLIAM J.
SILVA, MANUEL F., JR.
SMITH, JOHN J.
SPEIGHT, CARL W.
WATERS, FRANCIS V.
WILLIAMS, DAVID H.

V. TREASURER'S REPORT

The accounts for the year 1953 have been audited by Messrs. Seamans, Stetson & Tuttle, Certified Public Accountants of Boston.

Endowment Fund Assets and Endowment Fund

The Endowment Fund cash plus the quoted market value of the investments in bonds and stocks at December 31, 1953 totaled $3,557,401.88, a decrease of $43,589.02 from the December 31, 1952 total. Of the total amount, $10,023.88 was in cash, $1,251,563.00 in bonds, a decrease of $11,741.43 from the book value, and $2,295,815.00 in stocks, an increase of $864,459.47 over the book value.

During the year bonds costing $105,344.62 were sold or redeemed for $102,911.25 which, after adding applicable amortization of bond premiums in the amount of $19.62, resulted in a realized loss of $2,413.75. Stocks and rights with book or assigned values of $125,214.57 were sold for $188,684.69, resulting in a net gain of $63,470.12. The total net gain from all sales or exchanges amounted to $61,056.37, thus bringing the accumulated net realized gain to the Endowment Fund to $285,263.88.

During the year, from the proceeds of the above sales and cash, $152,814.12 was invested in bonds and $130,987.00 in stocks, leaving $10,023.88 uninvested at the year-end.

Plant Assets and Plant Funds

Plant Assets decreased $30,818.84 during the year. This decrease resulted from the sale of the motor boats Allure and Mytilus for a total of $23,650.00. Proceeds of the sales were credited in the case of the Allure to Unexpended Balance of Gifts and in the case of the Mytilus to Surplus. Plant Assets were decreased by the book value of these two boats amounting to $50,458.30. The additions to the Plant Account were principally Laboratory Equipment and Library Books, and totaled $19,639.46. The decreases and additions combined to produce a net decrease in the Plant Assets of $30,818.84.

Current Assets and Current Liabilities

Cash and Accounts Receivable exceeded Accounts and Notes Payable and Unexpended Grants by $96,776.19, an improvement of $113,976.05 over last year. The Notes Payable were reduced $45,000 during the year.

Deferred Expenses decreased $41,613.78 during the year. The benefit of these expenses extends over several years, and each year a proportionate part is added to Current Costs.

Included in Deferred Expenses are the items "Boat Expenses" and "Motor Vessel BEAR". $6,317.36 was added to "Boat Expenses" during the year, and $1,053.14 to the "Motor Vessel BEAR." During the year $30,419.07 of Deferred Boat Expenses were charged to Current Boat Costs, and $17,500.00 of the Deferred Motor Vessel BEAR expense was charged to Current Boat Costs.

The item "Maintenance of Homestead" under Deferred Expenses covers costs of improvement of the parking lot at the Homestead property. This should be fully amortized by the end of 1955.

The Surplus Account decreased from $104,636.47 at the end of 1952 to $17,979.94 at the end of 1953. However, this decrease is principally the result of the transfers to the new General Plant and Equipment Reserve shown on the balance sheet. This reserve was set up by combining the depreciation recovered in past years by charges to overhead expenses which were credited to surplus, the depreciation so recovered in the current year, the periodic replacement fund, and the reserve for equipment purchases. The Reserve is available for replacements or acquisitions of new buildings, boats and equipment or other items for use by the Institution.

The Unexpended Balance of Gifts, amounting to $20,103.26, consists of a $3,258.74 unexpended balance of Woods Hole Oceanographic Associates' dues and contributions, and a $16,844.52 balance remaining from the proceeds of the sale of the ALLURE which was received as a gift from an Associate in 1952.

The Income and Salary Stabilization Reserve was established pursuant to a vote of the Executive Committee for the purpose of having reserve income available in case the income from investments is reduced, and to provide a reserve to meet salary commitments in the event of sudden termination of our Government contracts. At the beginning of each year the Finance Committee votes a percentage on original book value of the endowment to be allocated to the Year's budget. The balance is added to the Income and Salary Stabilization Reserve. The 1953 percentage so voted was 5.3%.

INCOME AND EXPENSES

The total income of the Institution from investments after deducting custodian fees and amortization of bond premiums amounts to $151,862.36, compared to $153,685.24 for the previous year. Of this $23,633.36 was added to the Income and Salary Stabilization Reserve and the balance of $128,229.00 went into the current income. Other income included grants and fees, which brought the total to $183,856.04.

The Institution does contract work for various governmental agencies

on a cost reimbursement basis, and during 1953 received a fee for work under these contracts amounting to $44,032.97, which amount is included in the Institution income.

The Housing and Mess were operated at losses of $4,580.27 and $1,685.12 respectively, which losses were included in overhead costs. The Hall property produced a net income of $105.06. The three comparable figures for the previous year were: Housing, loss of $5,845.21; Mess, loss of $3,001.32; and Hall property, net income of $1,048.49.

In the Income and Expense Statement the item "Cooperative Projects, $10,723.83" represents the expenditures by the Institution on Cooperative Projects, amounting to $57,381.76, less the total of grants and contributions, amounting to $46,657.93 received from the following: Arctic Institute of North America; Research Corporation; Commonwealth of Massachusetts; The Rockefeller Foundation; National Science Foundation and E. I. duPont de Nemours & Company.

Total cost of the operation of vessels during the year was $391,041.27. Of this amount $1,042.41 was charged to Cooperative and Institution Projects. The balance was charged to Government contracts and others.

The return on the investments held at the year-end was at the rate of 4.3% on the market value, 5.6% on the book value, and 6.3% on the original book value of the Endowment.

The Balance Sheets and Statement of Income and Expenses are appended.

BALANCE SHEET

As of December 31, 1953

ENDOWMENT FUND ASSETS

BONDS (LESS RESERVE FOR AMORTIZATION OF BOND PREMIUMS $2,880.33)		$1,263,304.43	
Quoted Market Value	$1,251,563.00		
STOCKS		1,431,355.53	$2,694,659.96
Quoted Market Value	2,295,815.00		
	$3,547,378.00		
CASH			10,023.88
			$2,704,683.84

Note: Bonds having a book value of $399,809.43 are specifically allocated as collateral on the Institution's indebtedness to The New England Trust Company.

PLANT ASSETS

LABORATORY PLANT:			
Land		$27,072.32	
Buildings		336,564.86	
Laboratory Equipment		98,337.63	
Library		24,400.00	$486,374.81
KETCH "ATLANTIS":			
Construction	$218,674.47		
Equipment	41,462.50	260,136.97	
KETCH "CARYN"		98,275.43	
SMALL BOATS AND EQUIPMENT		6,570.55	364,982.95
HALL PROPERTY			26,500.00
HOMESTEAD			134,803.36
			$1,012,661.12

BALANCE SHEET

As of December 31, 1953

ENDOWMENT FUNDS

ENDOWMENT FUND — GENERAL	$2,000,000.00	
ENDOWMENT FUND — FOR UPKEEP OF PLANT	419,419.96	$2,419,419.96
Add accumulated Net Gain on Securities Called or Sold		285,263.88
		$2,704,683.84

PLANT FUNDS

PLANT FUND — GENERAL	$ 640,328.79
PLANT FUND RESERVE	372,332.33
	$1,012,661.12

BALANCE SHEET

As of December 31, 1953

(Concluded)

CURRENT ASSETS

CASH:		
Main Account	$153,846.14	
Operating Accounts	16,212.50	
Office and Boat Funds	1,419.02	$171,477.66
ACCOUNTS RECEIVABLE:		
Governmental Agencies:		
Invoiced	$72,561.13	
Not Invoiced	192,059.59	
	$264,620.72	
Co-operating Institutions	1,874.00	
Other Accounts Receivable	7,501.02	273,995.74
Total Cash and Accounts Receivable		$445,473.40
SUPPLIES AND WORK-IN-PROCESS		33,866.11
DEFERRED EXPENSES:		
Boat Expenses	$30,005.36	
Motor Vessel "Bear"	18,553.14	
Insurance Premiums	8,401.71	
Maintenance of Homestead	3,543.36	60,503.57
		$539,843.08

BALANCE SHEET

As of December 31, 1953

(Concluded)

CURRENT LIABILITIES

ACCOUNTS PAYABLE:			
Sundry Creditors		$11,328.15	
Withheld from Employees for Taxes, Insurance, etc.		11,666.89	
Sundry Accrued Expenses		4,692.28	$27,687.32
NOTES PAYABLE (SECURED BY BONDS HAVING A BOOK VALUE OF $399,809.43)			295,000.00
UNEXPENDED GRANTS			26,009.89
Total Accounts and Notes Payable and Unexpended Grants			$348,697.21
INCOME AND SALARY STABILIZATION RESERVE			23,633.36
UNEXPENDED BALANCE OF GIFTS			20,103.26
GENERAL PLANT AND EQUIPMENT RESERVE			129,429.31
SURPLUS:			
Balance, December 31, 1952		$104,636.47	
Deduct:			
Transfer to General Plant and Equipment Reserve:			
Depreciation Charged to Overhead	$77,081.57		
Periodic Replacement Fund	18,322.82		
Transfer to Unexpended Balance of Gifts	1,025.19	96,429.58	
		$8,206.89	
Add:			
Excess of Income	$2,919.63		
Prior Year Adjustments	6,203.42		
Sale of Motor Boat "Mytilus"	650.00	9,773.05	
Balance, December 31, 1953			17,979.94
			$539,843.08

INCOME AND EXPENSE STATEMENT

Year Ended December 31, 1953

INCOME:			
Investments:			
Interest	$ 36,985,79		
Dividends	115,813.73	$152,799.52	
Less:			
Reserved for Income and Salary Stabilization	$ 23,633.36		
Amortization of Bond Premiums	937.16	24,570.52	$128,229.00
Fees on Government Contracts			44,032.97
Other Income:			
Sundry Projects Credits (Non-Government)		$ 8,379.05	
Donations		1,110.00	
Sale of Equipment		1,150.00	
Hall Property (Net)		105.06	
Miscellaneous		849.96	11,594.07
			$183,856.04
EXPENSES:			
Operating		$98,072.27	
Institution Projects		46,544.86	
Co-operative Projects		10,723.83	
Interest Paid		9,856.05	
Operation of Vessels		627.92	
Adjustment of Contract		600.00	166,424.93
			$ 17,431.11
PAYMENT FOR PLANT ITEMS FROM CURRENT FUNDS:			
Laboratory Equipment		$11,460.53	
Library Books		1,200.00	
Equipment at Homestead		250.95	
		$12,911.48	
Reserved for Equipment Purchases		1,600.00	14,511.48
Excess of Income to Surplus			$ 2,919.63

APPENDIX

ATLANTIS

Cruise No.	Departure and Return	Days Duration	Ports of Call	Scientist-in-Charge
	1–10 February		Local trips	Vine
182	11 February		To Continental Shelf	Hersey
	12 February	2	To Woods Hole	
183	17 February		To Continental Shelf	Hersey
	20 February	4	Woods Hole	
184	6 March		Woods Hole to	Vine
	11 March	4	Bermuda	
	12 March		Bermuda to	
	15 March	4	Guantanamo Bay	
	16 March		To sea	
	26 March	11	Guantanamo Bay	
	28 March		Guantanamo Bay to	
	4 April	8	Kingston, Jamaica	
	6 April		Kingston to	
	9 April	4	Guantanamo Bay	
	11 April		Guantanamo Bay to	
	15 April	5	San Juan	
185	17 April		San Juan	Ewing
	21 April	½	San Juan to Roosevelt Roads	
	21 April		Roosevelt Roads to	
	23 April	3	San Juan	
	23 April		San Juan to	
	5 May	13	Guantanamo Bay	
	8 May		Guantanamo Bay to	
	27 May	20	Galveston, Texas	
	29 May		Galveston to	
	10 June	13	Woods Hole	Ewing
186	7 July		Woods Hole to	Officer
	13 July	7	St. Georges	
	15 July		St. Georges to	
	20 July	6	Woods Hole	
187	23 July		Woods Hole to	Wheeler
	31 July	9	Woods Hole	
187A	1 August	1	Associates Cruise	
188	7 August		Woods Hole to	Richards
	13 August	7	Norfolk	
	15 August		Norfolk to	
	1 September	18	Woods Hole	

ATLANTIS (Continued)

Cruise No.	Departure and Return	Days Duration	Ports of Call	Scientist-in-Charge
189	10 September		Woods Hole to	Stommel
	13 September	4	St. Georges	
	20 September		St. Georges to	
	22 September	3	St. Georges	
	26 September		St. Georges to	
	30 September	5	Woods Hole	
190	14 October		Woods Hole to	Volkman
	18 October	5	Woods Hole	
191	21 October		Woods Hole to	Vine
	26 October	6	Woods Hole	
192	29 October		Woods Hole to	Zeigler
	7 November	10	Woods Hole	
193	10 November		Woods Hole to	Fuglister
	14 November	5	Woods Hole	
194	22 November		Woods Hole to	Schultz
	25 November	4	Woods Hole	
195	7 December		Woods Hole to	Zeigler
	17 December	11	Woods Hole	

CAPTAIN BILL II (CHARTERED)

4	25 June		Woods Hole to Continental Shelf	Schroeder
	1 July	7	Woods Hole	
5	10 July		Woods Hole to Continental Shelf	Schroeder
	17 July	8	Woods Hole	
6	23 July		Woods Hole to Continental Shelf	Schroeder
	30 July	8	Woods Hole	

BLUE DOLPHIN (CHARTERED)

BD 6	13 June		Woods Hole to	Worthington
	24 June	12	St. Georges	
	26 June		St. Georges to	
	30 June	5	Woods Hole	
BD 7	11–19 July	9	Woods Hole	Backus
BD 8	22–30 July	9	Woods Hole	Leavitt
	1 August		Associates' Cruise	
BD 9	4– 8 August	5	Woods Hole	Backus
BD 10	11–14 August	4	Woods Hole	Backus
BD 11	17–27 August	11	Woods Hole	Backus

CARYN

Cruise No.	Departure and Return	Days Duration	Ports of Call		Scientist-in-Charge
56	15–17 January	3	Woods Hole	(Local)	Duys
57	22 January	1	Woods Hole	(Local)	Backus
58	27 January	1	Woods Hole	(Local)	Hersey
59	29 January	1	Woods Hole	(Local)	Hersey
60	30 January	1	Woods Hole	(Local)	Hersey
61	1 February		Woods Hole to		Dietz
	2 February	2	Boston		
	4 February	1	Boston	(Local)	
	5 February		Boston to		
	6 February	2	Woods Hole		
62	17–20 February	4	Woods Hole		Officer
63	1 March		Woods Hole to		Malkus
	5 March	5	Bermuda		
	10–11 March	2	Bermuda	(Local)	Stommel
	15–16 March	2	Bermuda	(Local)	
	16–20 March	5	Bermuda	(Local)	
	23 March	1	Bermuda	(Bermuda)	
	24–30 March	7	Bermuda	(Local)	
	2 April	1	Bermuda	(Local)	
	3– 6 April	4	Bermuda	(Local)	
	10 April		Bermuda to		
	16 April	7	Woods Hole		
64	8 May		Woods Hole to		von Arx
	14 May	7	Morehead City		
	16–20 May	5	Morehead City	(Local)	
	22–31 May	10	Morehead City	(Local)	
	4–11 June	8	Morehead City	(Local)	
	13 June		Morehead City to		
	20 June	8	Woods Hole		
65	28 June–2 July	5	Woods Hole	(Local)	Shultz
66	7 July		Woods Hole to		Johnson
	13 July	7	Bermuda		
	15 July		Bermuda to		
	20 July	6	Woods Hole		
67	23–31 July	7	Woods Hole	(Local)	Bergstrom
68	17–26 August	10	Woods Hole	(Local)	W. Malkus
69	31 August– 6 September	7	Woods Hole	(Local)	Johnson
70	14–24 September	11	Woods Hole	(Local)	Fuglister

BEAR

Cruise No.	Departure and Return	Days Duration	Ports of Call	Scientist-in-Charge
	January through December		Short but frequent trips to sea	Hersey, Vine

PBY-6A, BUNO 46683

Flight No.	Departure and Return	Days Duration	Bases	Scientist-in-Charge
	January	13	Local flights	
P-41	10 Feb.		New Bedford to Kindley AFB	Malkus & Bunker
	11 and 12 Feb.		Local from Kindley	
	14 Feb.	5	Kindley AFB to New Bedford	
P-44	24 Feb.		Otis to Cherry Point	vox Arx
	25 Feb.		Cherry Point to Miami	
	26 Feb.		Miami to Jacksonville	
	27 Feb.	4	Jacksonville to New Bedford	
P-46	9 Mar.		New Bedford to Cherry Point	Malkus
	10 Mar.		Cherry Point to Miami	
	11 Mar.		Miami to San Juan	
	12 Mar.		San Juan to St. Thomas	
	14 Mar.		St. Thomas to San Juan	
	15 Mar. to 7 April		San Juan-St. Thomas and Anegada Area	
	8 April		San Juan to Jacksonville	
	9 April	32	Jacksonville to New Bedford	
P-47	30 April		New Bedford to Quebec	Richardson
	1 May		Quebec to Goose Bay, Newfoundland	
	2 May		Goose Bay to Bluie West 1	
	3 May		Bluie West Local	
	6 May		Bluie West to Rekjavik AFB	
	7 May		Rekjavik to Keflavik	
	9 and 11 May		Keflavik-Keflavik	
	12 May		Keflavik to Bluie West 1	
	13 May		Bluie West to Argentia	
	18–19 May		Argentia local	
	20 May	21	Argentia to Otis AFB	
P-48	2 June		Otis AFB to Cherry Point	Richardson
	3 to 6 June		Daily—Cherry Point local	
	7 June	6	Cherry Point to Otis AFB	
	7 July–19 July	6	Local flights	
P-55	20 July		Otis-Gulf Stream-Cherry Point	Richardson
	21 July		Cherry Pt.-Gulf Stream-Cherry Pt.	
	22 July	3	CherryPt.-Gulf Stream-New Bedford	
	27 July–18 Aug.	8	Local flights	

PBY-6A, BUNO 46683 (Continued)

Cruise No.	Departure and Return	Days Duration	Bases	Scientist-in-Charge
P-62	19 Aug.		Otis AFB to Columbus, Ohio	
	20 Aug.		Columbus to Omaha, Neb.	Bunker
	21 to 28 Aug.		Daily flights to O'Neil area	
	29 Aug.		Omaha to Cleveland	
	30 Aug.	12	Cleveland to Otis AFB	
P-66	25 Sept.		Otis to Cherry Point	Woollard
	27 Sept.		Cherry Point–Montgomery	
	28 Sept.		Montgomery–Houston	
	3 Oct.		Houston–Columbus, Ohio	
	4 Oct.	10	Columbus to Otis AFB	
	7 Oct. to 5 Nov.	11	Local flights	
P-78	8 Nov.		Otis to Kindley AFB	Richardson
	9 Nov.		Kindley to Otis AFB	
	10 Nov.		Otis to Kindley AFB	
	11 Nov.–20 Nov.		Daily local flights over Bermuda	
	23 Nov.	16	Kindley–Quonset	
	7–8 Dec.		Local flights	
P-82	9 Dec.		Otis-Quonset to Kindley	Richardson
	10 to 13 Dec.		Local flights over Bermuda	
	15 Dec.	7	Kindley to Quonset	
	17 to 31 Dec.	4	Local flights	