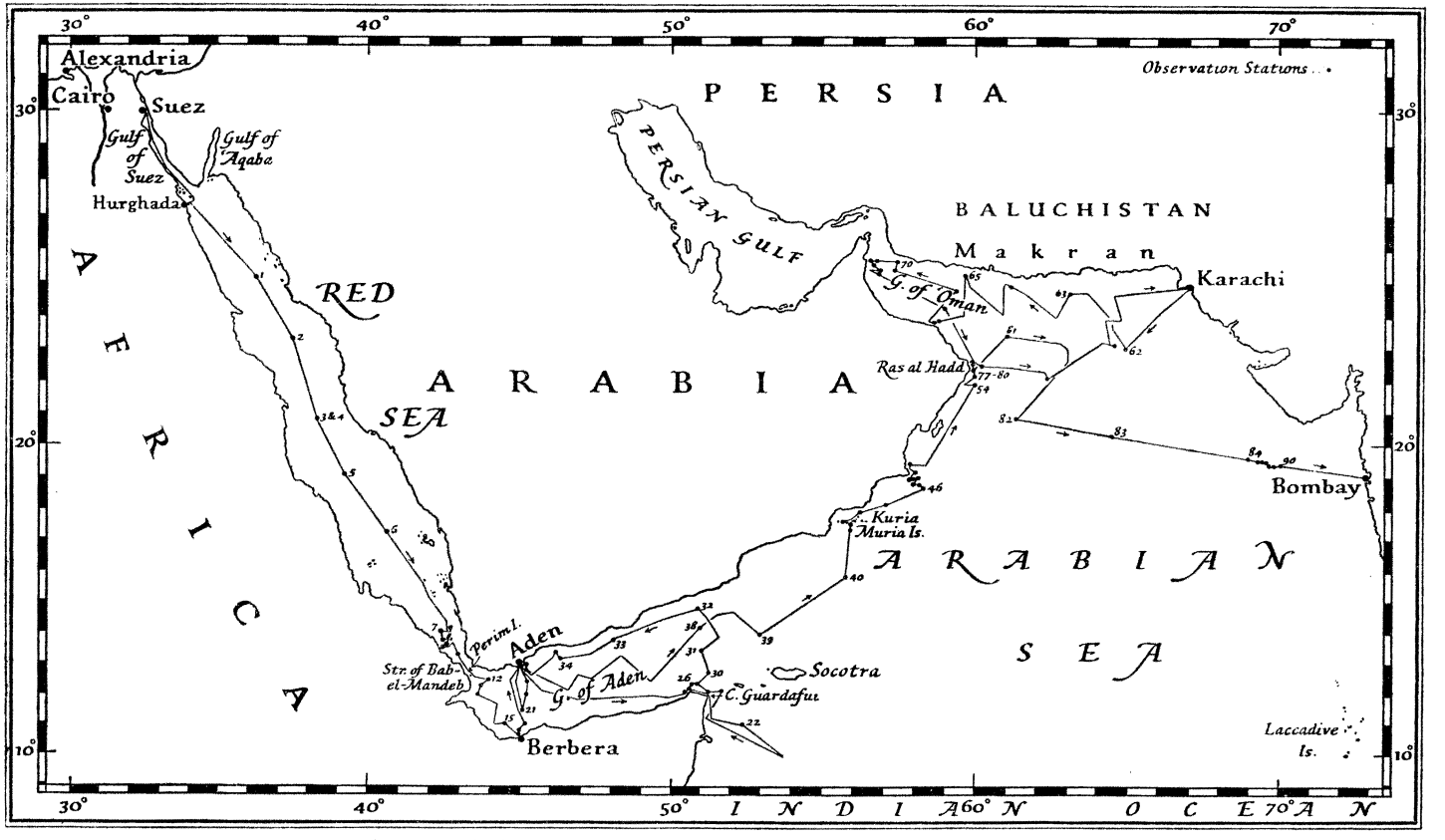
THE JOHN MURRAY EXPEDITION TO THE INDIAN OCEAN, *Abstract from the Reports of Colonel R. Seymour Sewell, SC.D., Leader of the Expedition, communicated by Professor J. Stanley Gardiner, Secretary*

THE John Murray Expedition to the Indian Ocean under Colonel Sewell, of which an account was given in the *Journal* for June 1933, has now completed her work along the Arabian coast, though further observations are planned for the return voyage of H.E.M.S. *Mabahiss* through the Gulf of Aden and the Red Sea. These are important since the hydrographic conditions in the Straits of Bab-el-Mandeb probably fluctuate considerably according to the seasons.

The necessary alterations to the *Mabahiss* were made in the Government dockyards at Alexandria, and these entailed the dividing up of the fish hold, the rearrangement of the cabins, and the fitting of the echo-sounding gear and of the refrigerating plant, so necessary on long tropical cruises where the crew is unaccustomed to "salt horse." All the officials concerned endeavoured to be as helpful as possible, but the language question both on shore and on board has been a difficulty. H.M. King Fuad received Colonel Sewell and the senior members of the expedition at Cairo and showed himself interested and well acquainted with the problems which faced the Murray Expedition. A government reception was also given to the members of the expedition before leaving Alexandria.

The *Mabahiss* has proved an excellent sea boat in every way, though of necessity small for an expedition on which, in addition to the ship's work, three chemists are engaged daily on analytical work, so that the expedition may know of any changes both of *p*H and of salinity as well as of temperature, while still almost on the spot where they occurred, and of oxygen and of phosphates within a day or two. The sounding machine is fitted aft immediately over the propeller where any movement of the ship as she pitches is most felt. This at first, particularly in the Red Sea, where heavy southerly winds were experienced, caused some difficulty and loss of gear, while a water-bottle or two became closed while being sent down and were subsequently "imploded" by the increased pressure. The Hughes-Admiralty Echo Sounding Machine has worked well under the fostering care of Lieut.-Commr. Farquharson, but of course it is desirable that the transmitting and receiving surfaces on the ship's bottom should be almost horizontal, a condition difficult to attain on so small a vessel. The employment of trawls and dredges from any vessel necessitates a knowledge of the ways of the ship, and the crew were of course quite inexperienced. The result was a series of misfortunes on the first cruise culminating in the loss of about 1600 fathoms of trawl warp. The bottom too proved singularly rocky, with the result that there was considerable damage to and loss of nets, but these and all other losses of gear have been made good. The Egyptian officers and crew soon became accustomed to this very new and hard work, and have done well; they will be having some slight satisfaction in that, being on a journey, they need not remember the penalties of the month of Ramadan.



Cruises of the "Mabahiss" in the Red Sea and Arabian Sea

The *Mabahiss* left Alexandria on September 3, after having had a short cruise in the Mediterranean to test the echo sounding; a further test was made at the north end of the Red Sea. On September 9 she called at Hurghada, the Egyptian Marine Biological Station, which is directed by Dr. C. Crossland, and which was found to be well equipped. It has rich coral reefs in its vicinity and, on the west side of the entrance to the Gulf of Suez, is most favourably situated both for the deep waters of the Red Sea and of the Gulf of 'Aqaba, and for the shallower water fauna of the Gulf of Suez. The actual work in the Red Sea began on September 10. Eighteen stations were taken and running soundings were obtained down the centre of its basin, a depth of 2204 metres (1203 fathoms) being obtained in lat. 25° 24′ 12″ N., long. 36° 12′ 12″ E. There proved to be a clear demarcation between the upper surface layer of the water in the Red Sea as compared with the lower stratum. At 400–500 metres the temperature as well as the halogen and oxygen content of the waters seem to be at a minimum, increasing both in shallower and deeper waters; this clearly points to a vertical circulatory movement. Wherever trawling or dredging was carried out, flat or irregularly shaped calcareous masses of rock were found, and these conditions continued south of the Great Hanish rim to Perim. Clearly this rock material is forming *in situ* and is very different from the deposits recorded on the charts. Below 140 metres no living organisms were obtained, but everywhere there would seem to be at least 1 c.c. per litre of oxygen, while the salinity of 40 per mille and the constant temperature of 22° C. should not be unfavourable. Stations were also taken on the cruise along the African side of the Gulf of Aden and in the vicinity of Berbera before proceeding to Aden for coal.

The *Mabahiss* left Aden on her second cruise on September 28, proceeding around the Gulf of Aden and out into the Indian Ocean to the south-east of Socotra and so back to Aden. Unfortunately she had to return to Aden to send the chief engineer, who had been working on the refrigerator, to hospital, as he had been badly gassed. He was able to rejoin the *Mabahiss* in a few days, and meanwhile a specialist engineer from the Orient liner *Orontes* generously gave his help to cure the refrigerator, the expedition again putting to sea on October 3 In all twenty stations were worked in this Gulf of Aden area, most for physico-chemical determinations, some with biological observations also, topographical soundings being almost continuous. Thus the Gulf was traversed along its south and central sides, while subsequently a third latitudinal line was run to the north. These traverses have resulted in the determination of ten definite ridges which run obliquely across the northern and central parts of the Gulf from north-east to south-west, little or no suggestions of the existence of which are visible on the charts. Certain supposed shoal areas were also examined; the reports of the same were probably due to broken water, caused by fish or tidal swirling, as no shallow water was found. The deep channel of the Gulf was found to the south, and clear evidence was obtained of a northerly drift of East African water between Socotra and Cape Guardafui.

In the Straits of Bab-el-Mandeb a series of observations was made on the character of the sea-water, three different strata being found, the uppermost flowing out of the Red Sea, the second and largest into its basin between

70 and 160 metres, and the lowest—a small creep of the deeper waters of the Red Sea—into the Gulf. These observations in September are in striking contrast to previous determinations in April and May, in which the outflowing bottom current is the dominant feature. A number of serial water samples and temperatures was also taken in the Gulf of Aden, showing a complicated system of vertical rotation of the water masses. This was particularly marked in the "Socotra" current, which was emphasized by Matthews in the Reports of the *Sealark* Expedition. Further work in this region included several dredgings and trawlings from 73 to 2312 metres, and the first consignment of specimens was shipped to Cambridge, where the expedition makes its headquarters, the fish going directly to the Natural History Museum.

The third cruise was along the south coast of Arabia to Karachi. The course was set in zigzag down the Gulf of Aden, in order to trace further the ridges previously referred to. Along the south Arabian coast twenty-seven stations were worked. The first two were hydrographic stations; samples of water and temperatures were taken from a series of depths in connection with the "Socotra" current, which appears to sweep the bottom where it enters the Gulf to break up and to pursue diverse courses in its more open northerly and westerly waters. A course was then set for the Kuria Muria islands. These are a dependency of Aden, having been ceded by the Imaum of Muskat in 1854 for a telegraphic and signalling station that never materialized and as a centre from which to prevent the smuggling of guns. They consist of five rocky granite islets about 20 miles off the coast, one being inhabited by a few fishermen. Here it was intended to carry out an extensive survey of the continental slope and to examine the reported coral reefs. Several other points were also examined. As is so common in tropical waters there proved to be a gently sloping continental shelf of medium width, which at about 50 fathoms drops deeply down in a slope that is at places as steep as 1 in 3 and is largely composed of rock. Along all this cliffed coast to Ras al Hadd were found submarine promontories with gullies between. Much of the bottom proved to be composed of rock, sometimes angular granitic fragments which evidently belonged to a scree slope. These and other observations suggest that the whole coast-line owes its existence to geological faulting.

A special examination was made in the motor boat to find the coral reefs charted and recorded as existing on various parts of the South Arabian coast. "Reefs" near the land proved to be composed of rock thickly overgrown with weed of the Sargassum type with clean sand between. Several successful trawlings were made, but true reef-forming corals proved to be entirely absent. The dredges were lowered a number of times in areas where coral banks were reported, but these proved to be covered largely by calcareous algae (*Lithothamnioneae*) of massive type, yielding banks markedly different from those in true coral-reef areas. The reason for this absence of coral-reefs, temperatures and salinities being apparently quite suitable, is not clear. Hydrographic stations were worked carefully to see if there was any upwelling of the cold bottom Antarctic water, but nothing was discovered in the ship-analyses of the water samples to indicate the existence of this or of any other factors unsuitable to the existence of coral reefs. As the surface waters in this region proved to be amazingly prolific in animal life, it is clearly not a matter of food,

for they certainly contain sufficient material for the richest growths of the anemones which deposit coral; a few solitary corals were also obtained.

At the eastern end of the Arabian coast the bottom was found to consist of a brown or green mud, and this near Ras al Hadd smelt strongly of sulphuretted hydrogen. Its depth extended from 95 to 1253 metres, and the occluded water of a bottom sample from 421 metres contained over 29 milligrams of sulphuretted hydrogen per litre. This occurrence is paralleled in the conditions found in the Black Sea and in certain enclosed fjords, but such a phenomenon on an open coast is most unexpected and at present inexplicable. It implies of course an area devoid of all organic life other than bacteria.

The fourth cruise started from Karachi on November 17, and twenty-five stations were worked in the Gulf of 'Oman and its approaches. "Between Ras al Hadd and the Indian coast in the neighbourhood of Karachi the echo-sounder has revealed the presence of a submarine ridge that runs westward towards the entrance to the Gulf of 'Oman more or less parallel to the hill ranges of Baluchistan and Makran. To the south of this ridge and separated from it by a level plain, that has a fairly constant depth of 1850 fathoms (3383 metres), lies a second ridge that runs towards the south-west, and immediately to the south-east of this is a deep gully, bounded in its turn by the edge of a plateau that slopes gradually downwards towards the south-east. The bottom of this gully lies 2000 fathoms below the surface, and its general character is strongly reminiscent of a river-bed. Have we here the now submerged bed of the Indus, when it flowed out into the Arabian Sea at a point more to the north of its present mouth or, possibly, the mouth of the great Indo-brahm river, the existence of which was postulated by Pascoe and Pilgrim ?"

The Persian Gulf is of course a shallow sea, so that phenomena similar to those found in deep enclosed basins such as the Red Sea are not to be expected. Yet there must be in all such large "estuaries" for land drainage some circulation of water which should be reflected in the open seas off them. In the Gulf of 'Oman there were found outflowing currents from the surface down to 30–70 metres, and from 125 to 350 metres on the north, but to 500 metres on the south side of the Gulf. Between these is a stratum of inflowing water with its centre at about 90 metres, while over the bottom is an offshoot of Indian Ocean water moving northwards. The region devoid of animal life discovered near Ras al Hadd was found to extend far beyond the sulphuretted hydrogen area and indeed to continue through the whole extent of the Gulf of 'Oman. The bottom consists of either a soft green mud or of a grey clay and between the depths of from 300 and 1250 metres is practically azoic. The depth limits of this dead area vary in different parts of the Gulf, but in the shallower waters above the depth of 250 metres there is prolific life, 666 specimens of a *bêche-de-mer* (Holothurian starfish) being obtained in one net haul from 210 metres.

On the conclusion of the cruise the *Mabahiss* put into Bombay whence she left for a long traverse to Mombasa, the remainder of her work lying in the more open waters of the Arabian Sea and in visits to the Maldive and other islands. This cruise will be particularly important for the physico-chemical work which has clearly been maintained by Mr. Thompson, assisted by Messrs. Gilson and Mahomed, under conditions of great difficulty.