initiating a bloom of *G. brevis* (*8, 15, 16*). On the basis of this belief, we conducted culture experiments whereby mediums were prepared by adding river water, extracts of peat soils from the western Florida coastal region, or both, to sea water from the Gulf of Mexico. Sea water containing 4 to 10 ml of river water per 100 ml supported limited growth of *G. brevis*. Seven to 10 ml of river water or peat extract per 100 ml of sea water is better, and peat extract or mixtures of peat extract and river water at this concentration are more productive than river water alone. The addition of vitamin B_{12} (0.05 μg/100 ml of medium) improved the reproducibility and growth.

The conditions in a bloom of *G. brevis* often led us to believe that fish which had been killed and subsequently decayed imparted nutrients that helped to perpetuate the bloom. We designed culture experiments to determine whether extracts of partially decayed fish promoted growth. The results of these experiments indicate that the extracts contain one or more growth-promoting substances. Robinson (*17*) lists fish, or portions thereof, as containing vitamins B_{12}, biotin, thiamine, and other B-complex vitamins.

Laboratory cultures of *G. brevis* have attained homogeneous concentrations exceeding 2 million cells per liter. This concentration is far below the highest report (*2, 3*); however, the values cannot be compared. Among other reasons, *G. brevis* in cultures concentrate to form masses that we disperse by shaking before making counts. A similar tendency to concentrate, but on a larger scale, may be expected in nature. Counts of a sample from such a concentration would be high. Ketchum (*5*) considered a tendency of the organism to concentrate as a possible cause of high surface organic phosphorus concentrations.

Mass cultures of *G. brevis* maintained in this laboratory are toxic to fish. We conducted toxicity experiments using *Mollienesia sp.* and *Mambras vagrans* as test fish. Controls consisted of water taken at the collecting point of the fish and unialgal cultures of *G. splendens* containing more than 2.5 million cells per liter. All fish died in the water containing *G. brevis,* but none died in either of the controls. This experiment was repeated with the same results (*18*).

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Visual Detection of Temperature-Density Discontinuities in Water by Diving

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Direct visual oceanographic observations of subsurface physical phenomena, formerly probed only by instrumentation, have gained impetus and have attained a much higher level of significance since the advent of such self-contained diving equipment as the Aqua-lung. Representatives of many of the scientific disciplines who participate in the study of the oceans have found a variety of uses for this direct method of observation, sampling, and measurement. Extensive free-diving research activities are carried on throughout the year at the Scripps Institution of Oceanography. The observation potential of the diving method of detecting, delimiting, and describing the temperature and other physical characters of water masses is, we hope, exemplified by the findings recorded here (*1*).

In certain areas, including places where the use of the bathythermograph (*2*) is difficult or inconvenient and where the water-mass pattern is on such fine scale that ordinary bathythermograph lowerings would likely miss important features, the thermocline and other phenomena can be detected visually and sensually by divers. Investigations of more oceanic waters by diving has been limited, but some information about the interfaces at thermoclines there has also been obtained (*3*).

Visual detection of the thermocline (or thermoclines) and of water-mass differences have been achieved in several ways: (i) indirectly by observing the vertical distribution of living organisms and other suspended particles, (ii) by viewing the refractory plane at the temperature-density discontinuity, and (iii) by the "stream" lines (refraction patterns) formed during the mixing of water masses of different density.

Frequently, plankton and leptopel (*4*) accumulate, so that they are readily visible at the temperature-density interface, where they are detained either above or below the discontinuity by the difference in water density. The groups of macroscopic animals

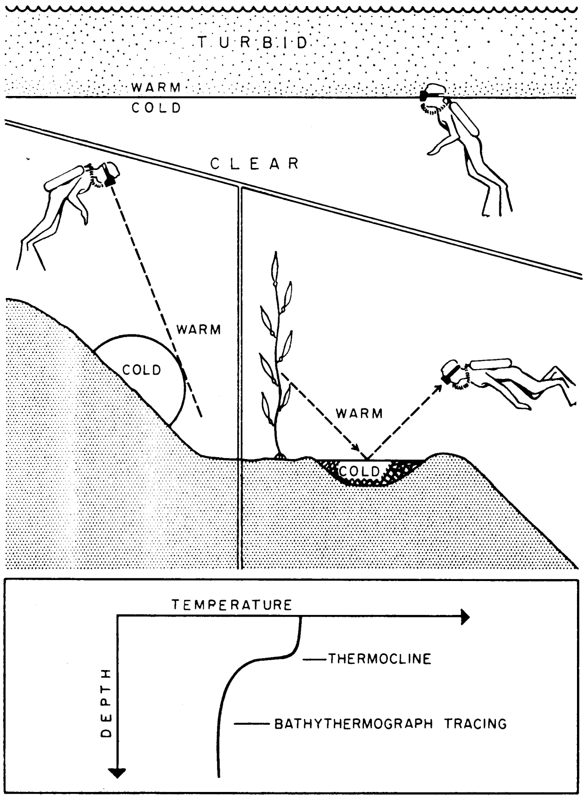

Fig. 1. Schematic representation of three temperature-density discontinuities observed by diving, with a bathythermogram appropriate for each of the temperature changes across the discontinuity.

that very frequently accompany such aggregations may be the only visible indications of a poorly defined thermocline. Patches of "red-water" resulting from blooms of *Gymnodinium* or *Prorocentrum* increase the turbidity of the surface layer, rendering it muddy and reducing visibility. The change to normally clear water below the turbid canopy at the thermocline, sometimes dramatically abrupt, clearly defines the location of the discontinuity. The concentrations of organic matter are most easily ascertained when the interface is near eye level (Fig. 1). Diving observations made in conjunction with simultaneous fathometer recordings of a diffuse near-surface reflection source have shown a definite agreement between the movements of the thermocline and of the associated living organisms and leptopel concentrations.

Difference in density between two water masses have been seen by us: (i) as a smooth, flat refractive plane of demarcation between two undisturbed water masses, and (ii) as an irregular boundary between two unstable masses undergoing mixing. The interface between two relatively quiescent masses of water is nearly parallel to the surface. Such a thermocline is best viewed by looking directly along the interfacial plane. Certain conditions, however, permit a greater angle of detection. A striking observation was made during the fall of 1953, at a time when the surface was calm and the water was clear. In the small tributaries at the head of the Scripps Submarine Canyon, at a depth of 100 ft, there are many small depressions containing trapped plant detritus. Among these accumulations of decaying vegetation were open areas with "pools" of turbid water, free of large pieces of matter. The upper surface of these clear areas in the depressions had a refractive-index differential great enough to reflect a mirror image of some kelp, *Macrocystis pyrifera,* which extended well above the surface of the depression (Fig., lower right). The entrapped water mass was only a few inches thick and, when probed by hand, was found to be markedly colder than the water above it. Other "mirror" pools were found in the vicinity, and all probably represented remaining portions of a cold water mass that had recently left the area. These pools are evidently transient phenomena, since they have seldom been observed.

On 19 September 1954, another interfacial discontinuity was seen near Avalon Harbor, Catalina Island. We descended to the steep sloping bottom at a depth of 60 ft without encountering a thermocline. Swimming along the bottom, however, we encountered an upwardly convex tongue of dense water 4 ft high and 10 ft wide, flowing parallel to the beach. The interface was well defined and easily discerned at any tangent across its surface. A sharp thermal gradient was noted as we penetrated the tongue, which exhibited refractive lines or patterns comparable to the mixing of two miscible liquids of unlike densities.

Unfortunately most of our underwater encounters with well-defined thermoclines and density discontinuities have been made without mechanical instruments or sampling devices, other than a depth gage, and were incidental to other objectives. The amount of oceanographic information available to the human sense is so great that each dive may reveal an enigma that can be only casually noted if the primary purpose of the dive is to be attained. As the utilization of self-contained diving apparatus in oceanographic research continues to expand, many contributions of value will undoubtedly be made, not only through simple observation but also through observation supplemented by the use of instruments and collecting gear carried by the diver. In particular, but not exclusively, we may hope for a more thorough understanding of the rapidly changing, relatively small-scale processes that characterize near-shore waters and are receiving an increasing share of attention from oceanographers.

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