Reports and Letters

Quantitative Underwater Study of Benthic Communities Inhabiting Kelp Beds off California

By use of a Cousteau-Gagnan Aqualung and a heavy-duty diving suit, the sea bottom off La Jolla, Calif., was explored during the spring of 1955 in an attempt to assess the standing crop of the benthic animals and plants that live in association with the giant kelp, *Macrocystis pyrifera*. This method of investigation insures free movement under water and enables one to make more extensive observations of the submerged communities than one can by dredging or by diving with a helmet (*1*).

The visibility at the bottom is largely limited by the depth, the density of overlying kelp, the turbulence, and the amount of suspended matter in the water. Thus, on clear days at a depth of 20 m, the visibility ranges between 1 and 10 m.

Cross sections of the sublittoral region, which extends more than 400 m from the low-tide level to the outer edge of the kelp beds, were surveyed. The organisms dwelling on the bottom were analyzed quantitatively by the quadrant method. The quadrants used enclosed an area of ¼ m²; for the larger kelp as well as for animals dispersed over wider areas, the number of organisms was counted along lines of 2- or 10-m length in different directions.

The results of this survey reveal a zonal distribution of the chief submerged plants and animals, which seem to be controlled chiefly by light and temperature.

Thus, on the exposed rocks below mean low-water spring tide, a community dominated by the sea grass *Phyllospadix scouleri* flourishes best under surf conditions and extends down to a depth of about 7 m, covering 80 to 100 percent of the rock surface. Epiphytes on *Phyllospadix* consist largely of *Porphyra naiadum* var. *australis, Melobesia mediocris,* and *Ectocarpus granulosus*; *Callithammion californicum* and *Ceramium pacificum* occur as secondary epiphytes. This community is poor in animals, and—apart from *Membranipora, Caprella,* hydroids, and a few small snails—the gross weight obtained in the quadrants is owing mainly to the sea grass and amounts to an average value of 3634 g/m².

Table 1. Standing crop (average fresh weight) of the coralline community at different depths below mean sea level.

Depth (m)	Plants (g/m²)	Animals (g/m²)	Total wt. (g/m²)
1.5	4667	125	4792
7	2490	329	2819
15	1972	392	2364
22	606	377.2	983.2

A *Pterygophora-Eisenia* community flourishes where the sea grass ceases to grow, at first as widely scattered individuals intermingled with *Egregia laevigiata, Cystoseira osmundacea, Codium fragile, Dictyota binghami* and *Dictyopteris zonarioides*; it reaches a climax in deeper water between 10 and 20 m, where the two main Laminariales, *Pterygophora* and *Eisenia* form, together with *Laminaria farlowii,* a "forest" under the large *Macrocystis* plants.

Macrocystis pyrifera forms extensive beds ranging in width between 200 and 500 m in a depth of water from 7 to 25 m. Individuals become more crowded in the middle of the beds, with holdfasts 1 to 2 m apart. At the outer edge, *Macrocystis* becomes replaced by scattered individuals of the elk kelp, *Pelagophycus porra,* in a depth of water of 20 to 25 or 30 m.

Where *Macrocystis* grows on outcropping rocks or on boulders, it meets with competition from sea urchins, which clear whole areas of kelp; this is demonstrated by the patchy appearance of the beds at the surface. Survival of kelp plants depends largely on the enormous production of juvenils, which grow on a variety of substrata, including other algae and sea grass.

The standing crop of the *Macrocystis* plants in these beds is estimated to be between 25 and 40 tons/acre, and average annual yield is estimated to be about 4 to 6 tons/acre (fresh wt.). This was judged by observations at the bottom and on the surface, as well as by studies of aerial photographs, by weighing representative samples, and by laboratory experiments on the growth rate of kelp. Under favorable conditions, the latter ranges between 3 and 5 cm per day.

The lowermost stratum of vegetation is occupied by a coralline community that forms an extensive cover under the larger kelps. *Corallina chilensis, C. gracilis, Bossea orbigniana, B. gardneri, Lithothrix aspergillus,* and *Lithothamnion* spp. are the chief calcified algae inhabiting this substratum. The quantity and quality of organisms inhabiting this community were found to vary with depth as follows: (i) the percentage of cover by the dominant alga decreases with depth, hence the production per unit area decreases; (ii) *Bossea* preponderates over the *Corallina* beyond a depth of 15 m. These modifications are accompanied by modification in the fauna that live in association with the corallines. For example, the sea fans, red and pink abalones, the sea star *Henricia leviuscula,* together with the holothurian *Stichopus parvimensis* and the acorn barnacle *Balanus tintinnabulum,* become noticeable at 20 to 25 m; some of these appear for the first time at such depths. Table 1 gives a comparison of production of the coralline community at different depths.

It has also been found that, while the total weight of plants decreases with depth, that of the animals tends to increase. On the basis of the foregoing survey, an average figure for the standing crop of the organisms that inhabit the rocky bottom of the kelp beds, including *Macrocystis* itself, would approach 9.4 kg/m² of sea bottom, or approximately 38 tons/acre. These figures do not include the pelagic forms.

ANWAR ABDEL ALEEM*
Division of Marine Botany, Scripps Institution of Oceanography and *Institute of Marine Resources, La Jolla, California*

Notes

1. Contribution from the Scripps Institution of Oceanography, new series, No. 824.

* Permanent address: Oceanography Department, Faculty of Science, Alexandria, Egypt.

28 June 1955

Metabolite of Phenobarbital in Human Urine

A metabolic product of phenobarbital was recently isolated from the urine of a dog that had received daily doses of the drug for three weeks. It was identified as the *p*-hydroxy derivative and was subsequently synthesized by Butler (*1*). We have found this metabolite in the urine of two human beings who died after barbiturate ingestion. It was possible to determine the concentrations of the free and conjugated forms.

Ultraviolet spectrophotometry was used for initial quantitation (*2*); this was followed by paper chromatography for the identification of the original drug and for