THE RELATIONSHIP BETWEEN THALLUS FORM AND THE PRIMARY PRODUCTIVITY OF SEAWEEDS

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ABSTRACT

Production rates were determined in the field by the oxygen-electrode method for 45 species of marine macro-algae from four different environments in the Southwestern United States. Thin sheet-like and finely-branched thallus-forms showed greater rates than other forms. There was a close relationship between productivity and two-dimensional thallus area for the macrophytes having relatively large surface area (i.e. thin and finely branched forms). However, the productivity values for the range of coarsely-branched to encrusting forms were in closer agreement with respect to thallus area than with respect to dry weight. No apparent relationship was revealed between the productivity of an alga and the division to which it belongs.

INTRODUCTION

Surprisingly few productivity estimates are available for marine macrophytes although seaweeds are conspicuously abundant throughout all oceans of the world. Mann[1] recently summarized the available production data for frondose macrophytes and Littler[2] reported on the productivity of tropical crustose coralline algae. The emerging picture suggests that reef and coastal algal populations may rank among the highest primary producers on earth.

Only two studies have considered algal structure and its relationship to primary productivity. Odum, Keunzler and Blunt[3] found that uptake of ^{32}P and primary productivity were correlated with the surface-to-volume ratios of severn marine benthic algae; however, the light intensity they used (450 ft-c) was probably well below saturation. Kanwisher[4] conceptualized an algal frond as a population of photosynthetic cells in a structural matrix. He noted that, on a dry weight basis, massive forms containing

Littler, M.M. 1981. The relationship between thallus form and the primary productivity of seaweeds. Pages 398-403 in G.E. Fogg and W.E. Jones, eds. Proceedings of the eighth international seaweed symposium, Bangor, North Wales, 18-23 August 1974. The Marine Science Laboratories, University College of North Wales.

relatively higher ratios of structural to photosynthetic components tended to have a lower photosynthetic capacity than the more delicate forms.

Clearly, field data on the relationships of algal morphology in respect to physiological function (e.g. productivity) have adaptive implications and may reveal ecological "strategies" heretofore unexplored. The present research was undertaken to test the hypothesis that morphology and production capacity are related and, in so doing, begin to look at the adaptive significance of thallus form as it pertains to the productivity ecology of rocky intertidal seaweeds.

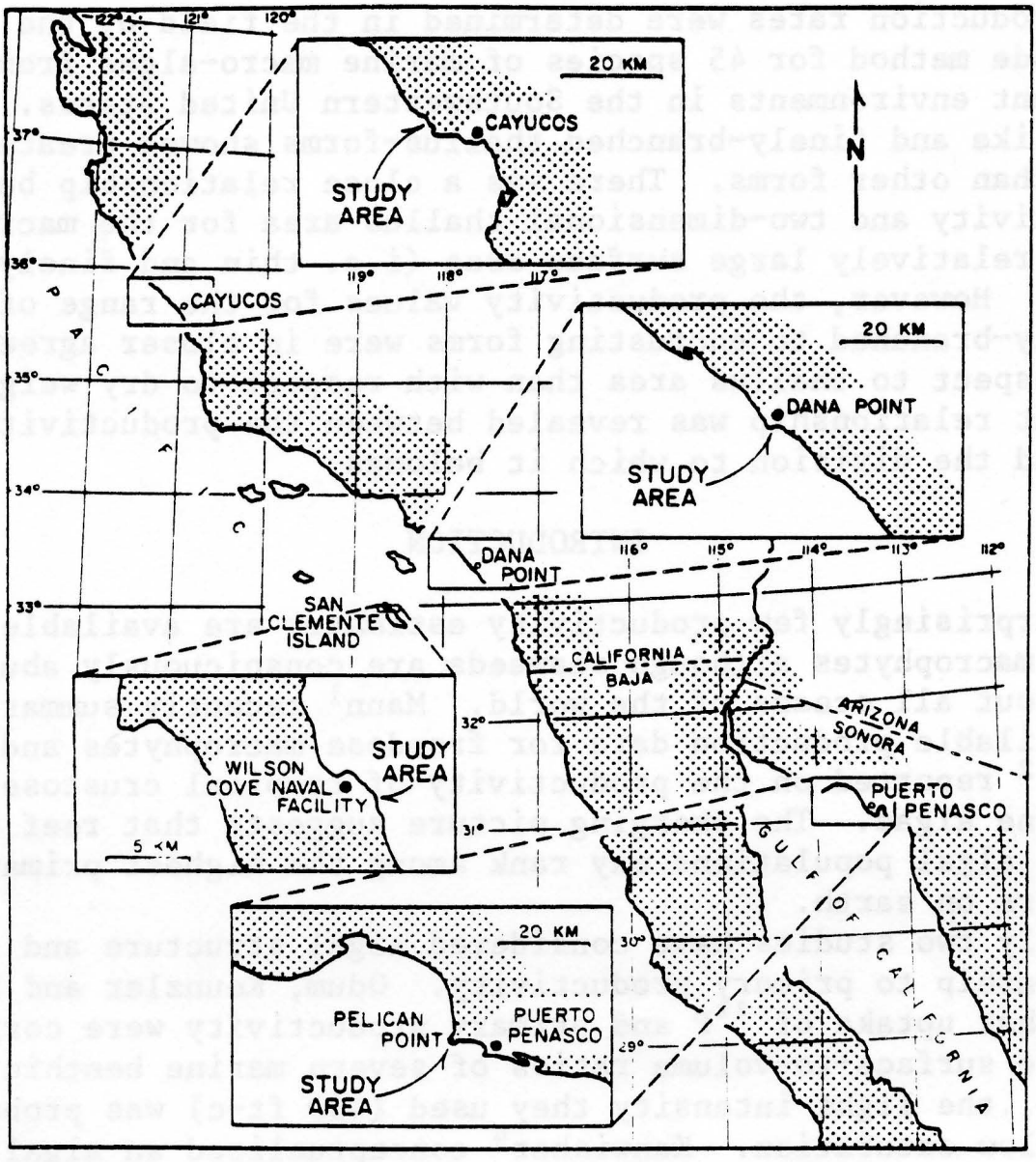

Fig. 1 Location of the four areas studied in Southwestern United States.

MATERIALS AND METHODS

This research was performed at four markedly-different intertidal habitats in the Southwestern United States and Mexico, with the latitudes and longitudes given in Figure 1. Work was done at Dana Point on 4th February, Cayucos on 19th February, Puerto Peñasco on 5th March and San Clemente Island during 19th and 20th May 1973, consistently under overcast skies of 20,000 to 65,000 lux. The methods concerning the handling of algae, incubation, oxygen analysis and calculations of productivity in respect to projected thallus area (i.e. normal to the incoming radiation) and dry weight were identical to those given in detail by Littler and Murray[5].

RESULTS AND DISCUSSION

The macrophytes have been ranked (Fig. 2) in thallus-form groups from highest to lowest producer on a dry-weight basis. The thin sheet-like forms are by far the greatest producers per unit of biomass followed by finely-branched forms, with saxicolous prostrate forms producing somewhat less than any of the other macrophytes. Finely-branched forms produced more than coarsely-branched forms, in agreement with the findings of Kanwisher[4] and Odum *et al.*[3] A life-form more suited to obtaining light energy and nutrients would seem, as a working hypothesis, to explain the differences measured. *Enteromorpha* sp., *Ulva californica* and *Porphyra perforata* comprise a group with considerably higher rates than other algae measured. The extremely thin construction of these three minimizes internal self-shading; also, they have larger cells than most other macroalgae resulting in relatively little self-shading by non-photosynthetic wall components.

A ranking of production rates on the basis of thallus area is given in Fig. 3. The same patterns are generally recognizable, from highest to lowest producer, as were evident on the basis of dry weight (Fig. 2). It is apparent that thin and finely-branched seaweeds show higher production rates per unit area than coarsely-branched forms, which, in turn, are higher than either saccate forms, prostrate forms or thick sheet-like forms.

For the thin sheet-like and finely-branched forms, productivity was closely correlated with dry weight and with surface area. The above trend would seem to be due to the fact that nearly all of the biomass in the thin and finely-branched forms is photosynthetic, which results in a close functional relationship between primary

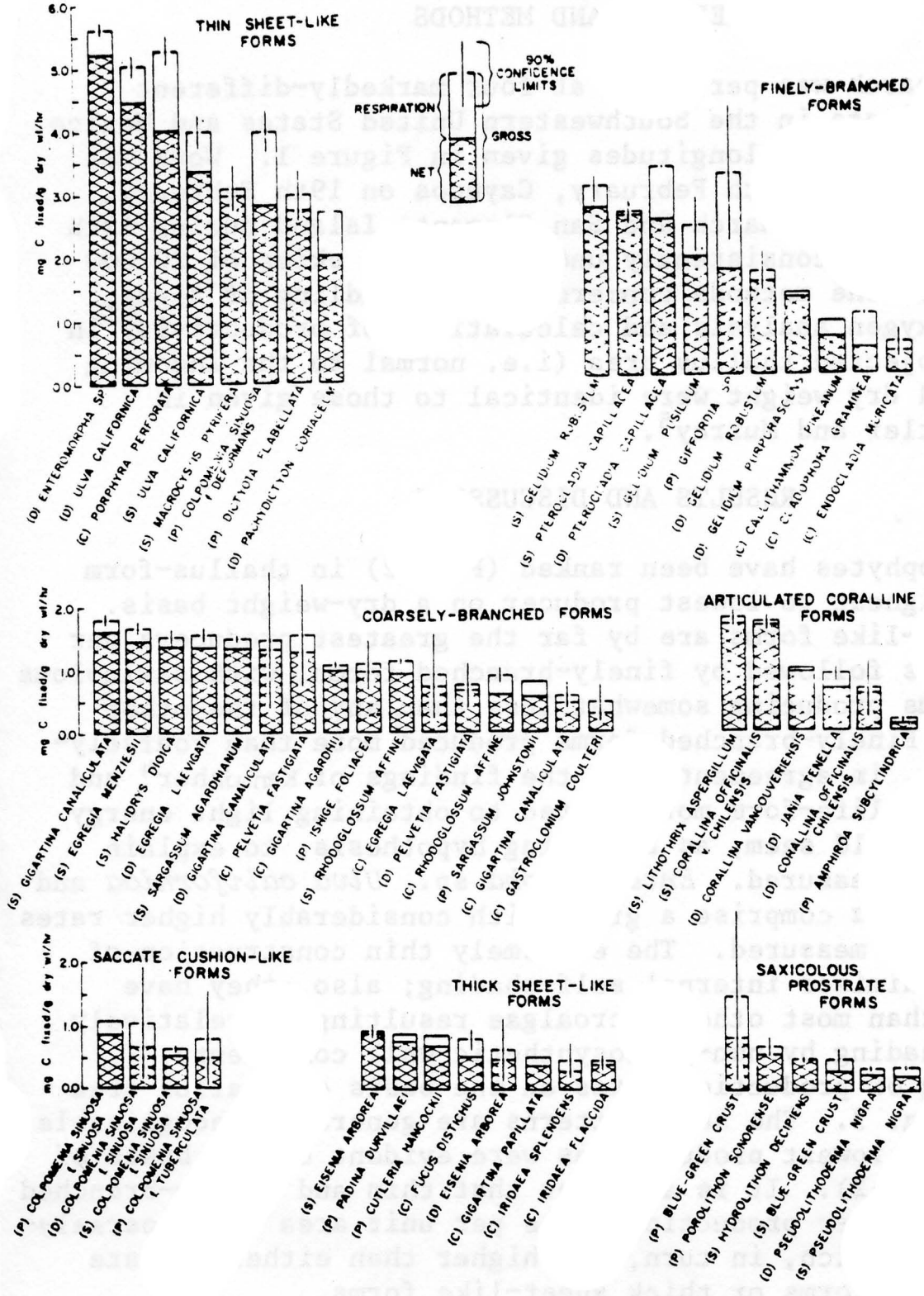

Fig. 2. The net and gross primary productivity (mg C/g dry weight/hr) of seven thallus-form groups of macroalgae measured at Dana Point (D), Cayucos (C), Puerto Penasco (P) and San Clemente Island (S). Where 90% confidence limits are lacking, they are greater than + or - the mean.

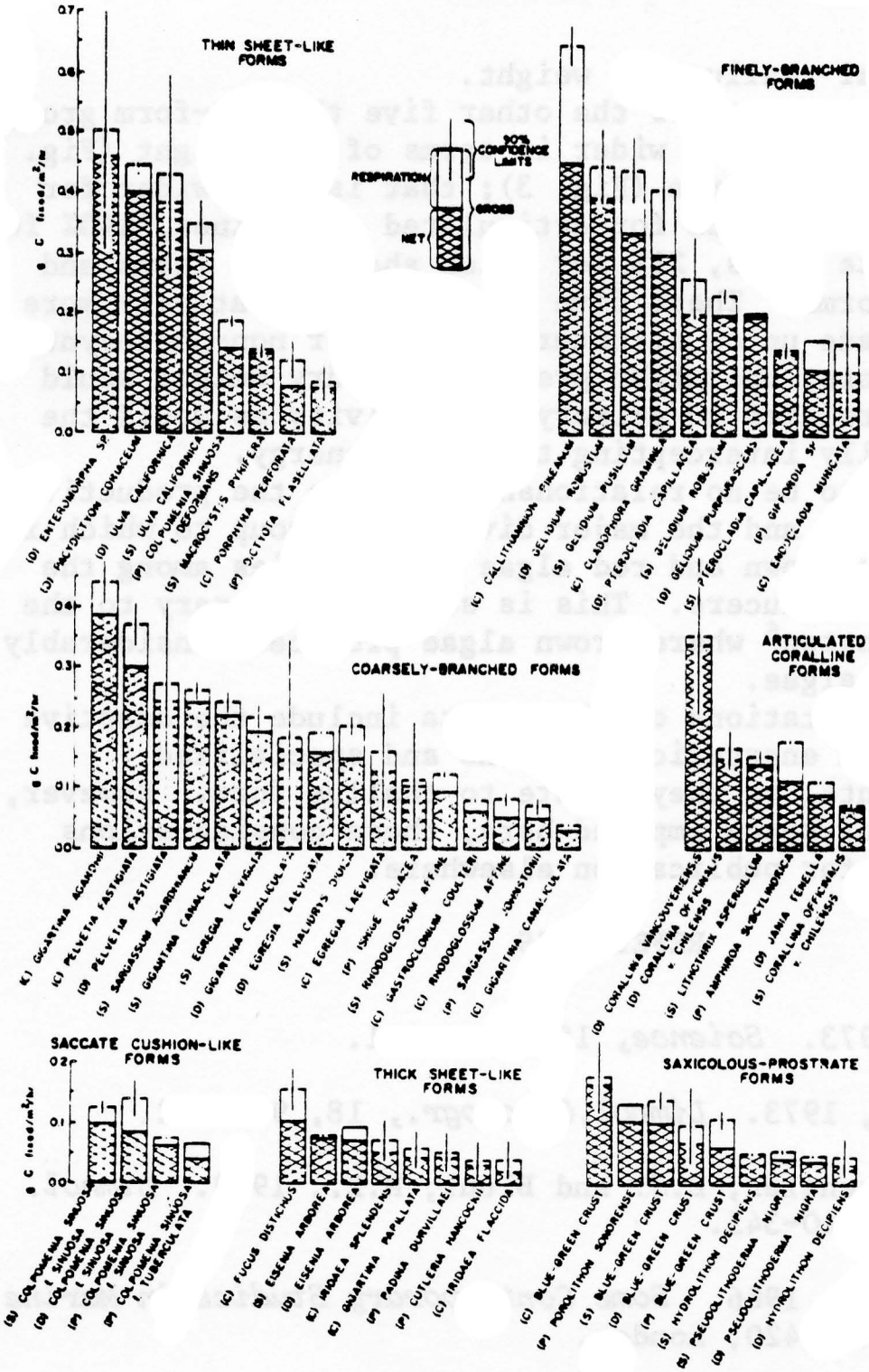

Fig. 3. The net and gross primary productivity in grams carbon fixed per hour per square meter of two-dimensional (*i.e.* normal to the light path) thallus area of seven thallus-form groups of macroalgae measured at Dana Point (D), Cayucos (C), Puerto Peñasco (P) and San Clemente Island (S). Where 90% confidence limits are lacking, they are greater than + or - the mean.

production and total thallus dry weight.

This was not the case for the other five thallus-form groups where confidence limits were wider in terms of dry weight (Fig. 2) than in terms of surface area (Fig. 3); that is, 14% wider for coarsely-branched forms, 73% for articulated corallines, 143% for saccate cushion-like forms, 21% for thick sheet-like forms and 5% for prostrate forms. These five groups have relatively more of their biomass made up of structural and other non-photosynthetic components; therefore, one might predict that dry weight would not be so closely related to primary productivity as would the surface area actually intercepting the light energy.

There appears to be no relationship between the productivity of a given macrophyte and the major divisional group to which it belongs, since both brown and red algae have species among the highest and lowest producers. This is somewhat contrary to the trend noted by Johnston[6] where brown algae produced considerably in excess of other algae.

Further interpretations of these data include the adaptive "trade-offs" between energetic functions and specialized structural components, as they relate to thallus form. However, due to the limits of space imposed here, these considerations are being prepared for publication elsewhere.

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