CARBON FLOW THROUGH FLESHY MACROALGAE ON CORAL REEFS

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ABSTRACT

Pathways of carbon flow through coral reef fleshy macroalgae were investigated by an annual study of biomass, primary production, detritus production and degradation on Checker Reef, Kaneohe Bay, Oahu, Hawaii. The selected species were the rhodophyte Acanthophora spicifera and the phaeophyte Sargassum echinocarpum.

Biomass harvesting and respirometry experiments were conducted monthly. Macroalgal detritus production was assessed routinely with detritus nets and sediment traps. Degradation was investigated in static incubation systems and supplemented by data from outdoor flow-through experiments and field observations.

Acanthophora spicifera showed seasonal fluctuations of biomass and of weight-specific and chlorophyll-specific daily net production. Maximum rates of weight-specific production of A. spicifera occurred in late autumn, when biomass and chlorophyll-specific production were at low levels. The marked seasonality of biomass and of weight-specific and chlorophyll-specific daily production of S. echinocarpum was related to the annual life history of the species; the early autumn production maximum occurred two months prior to the late autumn biomass maximum. Although weight-specific production showed no strong relationship with the physical environment, chlorophyll-specific production of the two algae was correlated positively with the seasonal environmental parameters, light and temperature. Changes in biomass of A. spicifera correlated negatively with monthly average water motion, while biomass variations of S. echinocarpum correlated positively with monthly average water temperature.

The diurnal pattern of A. spicifera net production showed an asymmetry which was particularly pronounced on clear summer days. This asymmetry was the result of an afternoon depression of net production. Realistic assessment of macroalgal productivity requires detailed information on both diurnal and seasonal variations in metabolic activity.

Turf algae (661-945 gC m^{-2} yr^{-1}) had a higher rate of primary productivity per unit area than fleshy macroalgae (166-207 gC m^{-2} yr^{-1}). However when algal distribution and abundance were considered, A. spicifera was the major contributor (21.8 x 10^3 kgC yr^{-1}) to Checker Reef primary productivity. The limited growth zone of turf algae resulted in its smaller reef productivity (7.9 x 10^3 kgC yr^{-1}).

Checker Reef showed a net export of particulate macroalgal detritus of predominantly small (<1.5mm) size. Macroalgal detritus production was much greater during aperiodic stormy periods (9.9 gC m^{-2} d^{-1}) than at other times (0.7 gC m^{-2} d^{-1}). Acanthophora spicifera and S. echinocarpum represented 2 and 30% respectively of the detritus catch. Bedload movement was slow but resulted in considerable attrition of the algae and constant generation of particulate organic material for both reef export and in situ degradation on the reef flat. Storm displacement of seasonal algae such as S. echinocarpum induced premature senescence, which provided an additional supply of particulates to the reef detrital pool.

Degradation of A. spicifera and S. echinocarpum under static aerobic dark conditions produced a 50-75% dry weight loss in one month. Leaching of dissolved organic carbon (DOC) initially and microbial

degradation subsequently were responsible for loss of algal weight. In outdoor flow-through experiments, S. echinocarpum underwent premature senescence while A. spicifera showed growth but a decrease in the ratio P_m/R. However, no net increase in dry weight of detached algae was evident in the field, where bedload movement and subsequent particle loss exceed growth.

Particulate detritus export represented 3 and 51% of the annual net productivity of A. spicifera and S. echinocarpum respectively. The combined net flux of particulate detritus was only a quarter of the overall primary productivity of the two species. The remaining balance of macroalgal primary production may be accounted for by DOC losses, and processing and utilization of particulate detritus within the reef. The observed high potential for particulate detritus production (e.g. turbulence, senescence) and relatively small net export suggested that the macroalgal-based particulate detrital cycle may be an internal function of Checker Reef.