Influence of Domestic Wastes on the Structure and Energetics of Intertidal Communities near Wilson Cove, San Clemente Island

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ABSTRACT

The thrust of this project was directed toward studies of:

- The role of stresses imposed by domestic waste waters on marine intertidal organisms.
- How natural communities of such organisms deal with high-energy inputs from the particulate matter derived from human wastes.
- The processes controlling community development, food web structure, primary productivity, and seasonal fluctuations in polluted waters.

Little seasonality was observed in the abundances of the dominant populations of both outfall and unpolluted areas throughout the study. For the unpolluted area, the species inhabiting the mid-intertidal coralline algal turf (i.e., *Gigartina canaliculata, Sargassum agardhianum,* and *Laurencia pacifica*) and the larger overstory forms (*Egregia menziesii* and *Halidrys dioica*) showed the greatest seasonality; most increased in the spring to fall period. In the outfall area seasonality was less obvious than for the unpolluted communities. Blue-green algae, *Ulva californica,* and *Gelidium pusillum* showed little variation in abundance, as was also the case for the suspension feeders *Serpulorbis squamigerus* and *Anthopleura elegantissima.* The conspicuous absence or reduction of canopy-forming species such as *Phyllospadix torreyi, E. menziesii, S. agardhianum,* and *Halidrys dioica* resulted in less vertical stratification (spatial heterogeneity) in the outfall habitat. Diversity (H_e' for the control = 2.67, outfall = 2.06) showed little seasonal patterns in either the polluted or unpolluted habitat and corroborates the data on populational abundance in reflecting temporally constant community structure. An average of 48% fewer species were sampled in the outfall area compared with the control.

The organisms most abundant in the upper and mid-intertidal of the outfall region were filamentous or short turf-forming algae (i.e., blue-green algae, filamentous Ectocarpaceae, colonial diatoms, *Ulva californica,* and *Gelidium pusillum,* all of which have previously been reported in aquatic environments under sewage stress. These forms all possess morphologically simple thalli with high surface to volume ratios, have high rates of production, allocate a large proportion of their resources to reproduction, and have been characterized as members of early successional stages in the development of epibiotic marine communities. These features led to the interpretation of the outfall species suite as r-selected strategists. Comparisons of the contents of specific samples from season to season revealed considerable short-term fluctuations of the algal dominants indicating frequent mortality and recruitment. The Wilson Cove sewage contains abundant nutrients while simultaneously sporadically emitting toxicants which result in the community development being held in a disclimax state, hence, the domination by opportunists or r-selected strategists.

The communities occupying the peripheral and seaward margins of the outfall intertidal showed less cover of opportunistic algae and increased abundance of suspension-feeding animals. These macro-invertebrate populations (e.g., *Serpulorbis squamigerus, Anthopleura elegantissima*) appear to be maintained by the sewage inputs in that their abundance is constant over time and are very much lower in the unpolluted area.

Species comprising much of the mid-intertidal turf characteristic of the sewage disturbed area showed considerably greater productivity per unit of thallus area than any of the other algae measured. Primary production was found to vary greatly between intertidal macrophyte populations of the same species as well as between thalli within a given population. This makes seasonal field studies difficult because the variations encountered at any given season tend to obscure differences between seasons. However, the trend shown by many of the macrophytes was for a winter minimum and spring to fall maximum in light-saturated net productivity. Increasing day length would appear to be more closely related to the large increases in the seasonal development of standing stock than the reasonably uniform production rates determined by this study.

Much of the variation in macrophytic calorific values was related to differences in life-form strategies. Those forms with relatively more structural tissues (presumably selected for by competition for space and light, predation, or physical shearing stress), and hence relatively less energy allocated to growth and reproduction, contain lower total

calories per unit weight. On the other hand, fugitive or opportunistic species selected for rapid growth and high productivity and containing few predator or competitor defenses tend to have relatively high calorific values. Encrusting forms that are easily accessible to all herbivores may have evolved reduced palatability through selection for thallus constituents with reduced calorific values. Each algal phylum was characterized by a different modal value (i.e., Chlorophyta, 4.78 kcal/g dry weight; Rhodophyta, 4.39 kcal; Cyanophyta, 4.38 kcal; Phaeophyta, 4.22 kcal). In nearly every case, outfall macro-invertebrate populations had higher energy contents than did control populations. Energy-rich compounds appear to be entering the intertidal food web through the populations of omnivores and suspension feeders in the outfall community, which may explain their enhanced standing stocks in the peripheral regions of the plume. Gut content studies further support this interpretation.

The outfall area successional plots showed rapid recovery (nearly 100% by 0.8 month) following the experimental disturbance, and nearly all of the recruitment resulted from suspended propagules. Biological communities that developed on the experimental unpolluted area plots had not fully recovered after 1.0 year (30.3% Bray-Curtis similarity). The outfall dominants (*Ulva californica, Gelidium pusillum, Pseudolithoderma nigra*, Ectocarpaceae, and colonial diatoms) clearly have the capability for resiliency and rapid recruitment even under the influence of sewage. The successional data afford additional support of the hypothesis that the upper to mid-intertidal region of the sewage-affected area, which represents a fluctuating environment directly exposed to deleterious components of discharged sewage (e.g., pine oil disinfectant), is dominated by disclimax communities.

Thirty finfish species from 13 families were observed or collected by gill net in the outfall and control areas during two sampling periods, June 1975 and January 1977. All observations and collections indicated there was a much higher concentration of fishes in the vicinity of the outfall than in the nearby unpolluted area. During both June and January, a greater number of species (1.3 and 1.5 times larger, respectively) and individuals (4 and 2 times larger), and a larger biomass (6 and 3 times greater), was obtained in the outfall gill net than in the control gill net. Percentage similarity values comparing outfall and control gill net catches for the June and January sampling periods were nearly equal (37.5% and 38.5%, respectively). *Atherinops affinis*, abundant in the outfall area in June, was absent (except for one specimen) in January, while *Atherinopsis californiensis*, a closely related species, was absent in the outfall area in June but abundant in January. The outfall is apparently an attractant and a food source for a few species that are generalized feeders, especially *Atherinops affinis, Atherinopsis californiensis, Girella nigricans*, and *Hypsypops rubicundus*.

This study provides the first response data for six southern California articulated coralline algae (*Corallina officinalis* var. *chilensis, Bossiella orbigniana, Amphiroa zonata, Lithothrix aspergillum, Haliptylon gracile*, and *Corallina vancouveriensis*) and four non-calcareous macrophytes (*Ulva californica, Gelidium pusillum, Halidrys dioica*, and *Phyllospadix torreyi*) under exposure to untreated, primary, secondary, and secondary-chlorinated sewage effluent as evaluated by continuous net productivity measurements and long-term culture studies in the laboratory, as well as measurements of gross production rates in the field. *Bossiella orbigniana, L. aspergillum*, and *C. officinalis* var. *chilensis* were shown to possess relatively broad homeostatic capabilities and had enhanced net primary productivity when exposed to primary treated sewage. In the long-term cultures, *A. zonata, B. orbigniana*, and *C. officinalis* var. *chilensis* all demonstrated enhanced growth in the presence of primary sewage. Chlorine had only a short-term effect, and species responses to secondary and secondary-chlorinated sewage were virtually identical beyond the second week in culture. *Corallina officinalis* var. *chilensis*, from three separate populations with differing pollution histories, showed a tolerance to sewage corresponding to the extent of previous exposure, which indicates that this species may be able to acclimatize physiologically to sewage stress. The more sewage-tolerant macrophytes displayed low photosynthetic quotient values during exposure to effluent, while higher values were associated with forms having little physiological tolerance to sewage. Differences in calcification rates, nitrogen sources, photorespiration, and light intensity were all eliminated as causes of this phenomenon. It is postulated that tolerant species exhibit carbohydrate metabolism during exposure to effluent stress, while intolerant forms tend toward protein and lipid metabolism.