# Biodeposition by a Fouling Community in the Indian River, Florida[1]

**ABSTRACT: Biodeposition rates were studied for a fouling community with a biomass of 6–10 kg per m$^2$ dry wt including shells in which the barnacle *Balanus eburneus* was a dominant species. The fouling community filtered Indian River lagoon water containing 2–15 mg per l mud-size particles and deposited them as sand-size fecal pellets. Measurements of the fecal pellet flux by sediment traps indicated seasonal variations between 16.7 and 74.8 g per m$^2$ per day. A significant correlation was found between fecal pellet flux and temperature ($r = 0.90$; $p < 0.001$). The average flux of fecal pellet deposition was four times greater than the average flux of suspended particle settling without biological influence. Suspended sediment concentration did not significantly affect the rate of biodeposition. Annual biodeposition was 18 kg per m$^2$.**

## Introduction

Interactions between biota and sediment particles occur in many ways. One of these interactions is the agglomeration of mud-size suspended particles which are removed from the water column by filter feeders. These are later deposited as sand-size fecal pellets. Rhoads (1974) and Drake (1976) reviewed this process and summarized measurements of the rate of biodeposition for a variety of invertebrate species. Haven and Morales-Alamo (1966) reported rates of biodeposition for oysters, several other molluscs and individuals of the barnacle *Balanus eburneus.* The main purposes of this study have been to determine the rate of fecal pellet production from an undisturbed community of fouling organisms and to examine the effects of temperature and suspended sediment concentration on the rate of biodeposition.

## Materials and Methods

The fouling community living on the underside of 0.75 × 1.7 m fiberglass floats was studied *in situ.* The floats support docks at the Harbor Branch Foundation small boat basin near Fort Pierce on the east coast of Florida. Water depth is about 3 m beneath the docks. The boat basin connects to the Indian River lagoon by dredged canals. Tide range is about 20 cm and tide currents are not noticeable in the boat basin.

Gilmore (1977) described the environment of the Indian River. Mook (1976) described the local fouling community, and showed that, depending on time of the year, *Balanus eburneus* was the dominant organism by either number of individuals or area occupied. Biomass of the fouling community was determined by scraping the organisms from an area 5 × 17 cm into a bucket, washing away salt, and drying at 95 °C. At least five replicates were taken at each of nine sampling times through the year for a total of 64 measurements.

Sediment traps were used to measure the flux of fecal pellets. Traps were clear 7 × 21 cm plastic cylinders closed at one end, secured by rubber bands, and spaced 22 cm apart on 110 × 18 cm aluminum frames. This design is consistent with Gardner's (1980) suggestions. Most experiments were done with four traps. Fecal pellet flux was measured with one trap array suspended 30 cm beneath the fouling community. An identical array (control traps) was positioned at the same depth, several meters away in open water. Control traps measured the flux of particles settling from suspension without the influence of filter feeders in the fouling community. Most experiments lasted three days as this yielded an easily managed quantity of pellets of about 1 g dry wt. Other experiments lasted from two to nine days. To determine the fecal pellet flux at 1 to 3-h intervals, one trap was modified by replacing the solid bottom with a funnel. The funnel was connected to the pump input of an ISCO programmable sampler (model 1391) which provided a total of twenty-eight 350 ml samples at chosen time intervals.

Another ISCO sampler input was positioned on the control trap array to evaluate the apparent variability of suspended sediment concentration during the period of fecal pellet flux measurement. Three experiments had simultaneous measurements of suspended sediment concentration and fecal pellet flux. Temperature and salinity (refractometer) were determined daily. For a few experiments, these parameters were continuously measured by a MARTEK TDC water quality analyser and recorded by a two-channel RUSTRAK strip-chart recorder.

In the laboratory, sediment and fecal pellets were recovered from the traps on pre-ashed glass fiber filters and washed free of salt with tap water. Filters were then dried at 90 °C, one hour for suspended sediment samples and overnight for pellets. Filters were weighed to 0.1 mg. Reproducibility of these procedures was checked three times by using an ISCO sampler to collect five sequential samples. An estimate of the organic content of sediment and pellets was obtained by reweighing filters ashed at 450 °C for one hour.

## Results

Average biomass of the fouling community was 6–12 kg per m$^2$ dry wt including shells (range 2.3–14.8) and did not appear to vary seasonally. Important species were *Balanus eburneus, Corophium* spp. and *Crassostrea virginica* with 10 others, which changed in abundance seasonally (Mook 1980).

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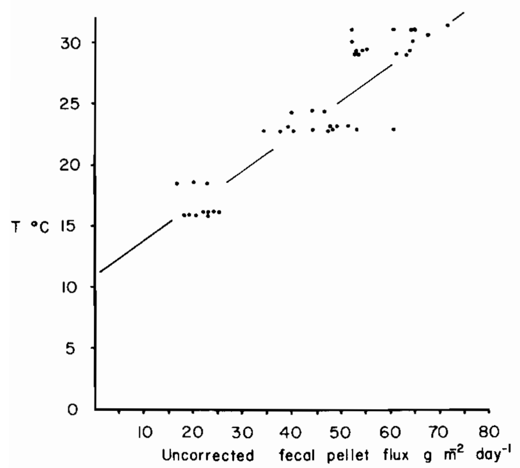


Fig. 1. Relationship between water temperature and uncorrected fecal pellet flux, where $n = 64$, $r = +0.90$, $p < 0.001$, and $y = 0.288x + 10.851$.

A total of 137 measurements were made of the fecal pellet flux from the fouling community during the period October 1979–August 1980. Lowest flux was 16.7 g per m$^2$ per day in January when the water temperature was 20 °C. Highest flux was 74.8 g per m$^2$ per day when the water temperature was 31 °C. Fecal pellet flux was significantly correlated with water temperature (Fig. 1, $r = +0.90$, $p < 0.001$). Control traps were used for all but fall and winter experiments. Therefore, all data could not be corrected for non-biologically influenced settling of suspended particles. To construct Fig. 1, uncorrected data were used so that measurements throughout the annual temperature range of 15–31 °C could be included. An approximate correction can be made by multiplying the uncorrected flux data by 0.8. This was derived from data in Table 1, as the range and average of corrected fecal pellet flux was 70.8–88.2, $\bar{x} = 80.6\%$ of the uncorrected measurement.

Using the temperature-pellet flux relationship in Fig. 1 and the average monthly water temperature (Mook, unpublished data) enabled a prediction of the fecal pellet flux month by month. Lowest flux, 522 g per m$^2$, was predicted for February and highest flux, 2,186 g per m$^2$, was predicted for July and August. Summing these monthly fluxes gave a predicted annual flux of just under 18 kg per m$^2$. Using the bulk density for the pellets of 2.266 g per cm$^3$ (density of clay minerals as 2.7 g per cm$^3$ × 0.74 plus estimated density of organic particles as 1.03 g per cm$^3$ × 0.26 = 2.266 g per cm$^3$), the annual accumulation should be a layer about 8 mm thick. Allowing 50% porosity would increase the thickness to 16 mm.

The organic content for suspended sediment, and sediment and fecal pellets recovered from the traps (Table 1) includes organic material combusted in the muffle furnace and probably some structural water lost from clay minerals (Billen 1978, p. 129). To evaluate this, a sample of mud was collected from the bottom beneath the fouling community. This material was mostly fecal pellets in various stages of disintegration.

TABLE 1. Suspended sediment concentration and flux of particles to traps.

| Date 1980 | Suspended Sediment: Range Mg ℓ$^{-1}$ [a] | Suspended Sediment: $\bar{x}$ mg ℓ$^{-1}$ | Suspended Sediment: $\bar{x}$ % organic | Sediment Flux to Control Traps: range g per m$^2$ per day | Sediment Flux to Control Traps: $\bar{x}$ g per m$^2$ per day | Sediment Flux to Control Traps: $\bar{x}$ % organic | Uncorrected Flux of Fecal Pellets: Range g per m$^2$ per day | Uncorrected Flux of Fecal Pellets: $\bar{x}$ g per m$^2$ day | Uncorrected Flux of Fecal Pellets: $\bar{x}$ % organic | $\bar{x}$ corrected Fecal Pellet Flux (Uncorrected Control): g per m$^2$ per day |
|---|---|---|---|---|---|---|---|---|---|---|
| 7–10 July | 4.1–9.8 | 7.0 ± 1.5 | 52.5 | 5.7–8.2 | 6.7 ± 1.1 | 23.6 | 48.5–58.4 | 52.0 ± 4.4 | 23.0 | 45.3 |
| 11–14 July | 3.1–8.1 | 5.1 ± 1.3 | 53.4 | 9.9–12.8 | 11.2 ± 1.3 | 20.0 | 57.6–73.8 | 64.3 ± 7.0 | 22.7 | 53.1 |
| 18–21 July | 4.1–11.3 | 6.4 ± 1.4 | 53.9 | 13.7–16.2 | 15.2 ± 1.1 | 17.8 | 48.7–53.9 | 52.0 ± 2.4 | 20.8 | 36.8 |
| 21–24 July | 4.1–15.3 | 6.8 ± 2.3 | 48.4 | 15.3–19.0 | 16.8 ± 1.8 | 17.0 | 62.1–67.0 | 64.4 ± 2.5 | 20.2 | 47.6 |
| 25–28 July | 3.7–10.8 | 6.6 ± 1.9 | 54.3 | 10.1–13.1 | 11.1 ± 1.4 | 20.5 | 65.4–70.2 | 67.4 ± 2.5 | 20.2 | 56.3 |
| 28–31 July | 2.7–6.7 | 4.7 ± 1.1 | 52.6 | 13.7–20.4 | 16.8 ± 2.8 | 15.8 | 59.2–67.0 | 64.7 ± 3.7 | 24.0 | 47.9 |
| 1–4 Aug. | 2.1–7.6 | 5.3 ± 1.2 | 58.6 | 10.1–12.5 | 10.9 ± 1.1 | 22.1 | 56.9–62.9 | 60.6 ± 3.3 | 26.1 | 49.7 |
| 4–7 Aug. | 4.0–7.7 | 5.5 ± .8 | 51.8 | 11.1–12.9 | 11.7 ± 0.8 | 22.7 | 67.9–74.8 | 71.4 ± 3.0 | 25.3 | 59.7 |

[a] SD for each determination < ±0.9.

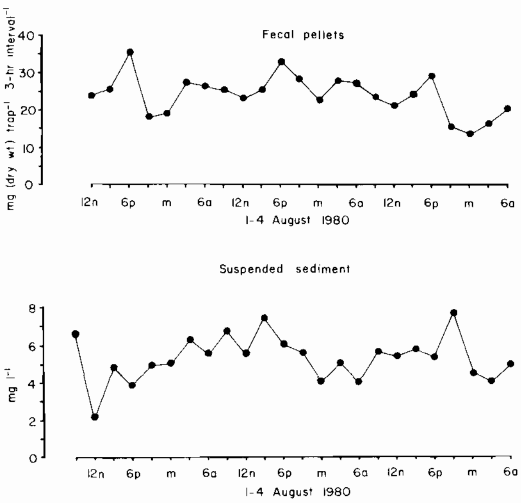


Fig. 2. Simultaneous measurement of fecal pellet flux (upper) and suspended sediment concentration (lower). Sampling interval = three hours, n = noon, m = midnight.

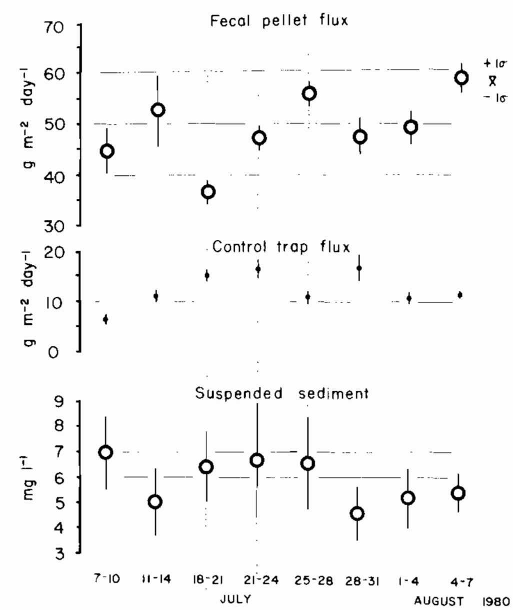


Fig. 3. Relationship between fecal pellet flux (upper), flux of sediment particles to control traps (middle) and suspended sediment concentration (lower) for eight times of measurement. Center of circle = $\bar{x}$, top and bottom of bar = plus and minus one standard deviation, respectively.

The mud was freed from organic matter by boiling with 10% sodium hypochlorite three times. The cleaned mud was dried at 95 °C, divided into five 2.8 g aliquots, powdered, dried to constant weight, ashed at 450 °C for one hour, and reweighed. The weight loss found was 0.228 ± 0.019 g, equivalent to 7.8%. Assuming this weight loss to be water, and assuming the proportion between particulate organic matter and clay minerals is roughly the same for suspended sediment, control trap sediment and fecal pellets, suggests that individual values for organic content in Table 1 should be revised downward by about 8%.

The relationship between suspended sediment concentration and fecal pellet flux with three-hour incremental sampling is given in Fig. 2. This relationship for the three-day experiments is given in Fig. 3. Temperature and salinity for these times (Figs. 2 and 3) was 31–32 °C and 29–35‰, respectively (Mook, unpublished data).

## Discussion

Seasonal change in water temperature exerted a major control on the flux of fecal pellets from this fouling community (Fig. 1). Haven and Morales-Alamo (1966, Table 1, p. 491) reported that in June and July, individuals of the barnacle *Balanus eburneus* with an average weight of 5.4 g, produced 20 mg of biodeposits per animal per week in laboratory experiments with York River water, Virginia. *B. eburneus* is a major component of the local fouling community for this study (Mook 1976) although their individual weight was about 1 g, and many other fecal pellet producing species were present. Deposition of fecal pellets by the fouling community of this study was about 1.23 g per trap per week, corrected for settling of suspended sediment particles. The number of animals above each 35.2 cm² per trap is unknown. Measuremnt of 54 barnacles from the fouling community gave an average diameter of 18 mm, equivalent to about 12 barnacles above each trap assuming rhombohedral packing. Attributing the entire fecal pellet flux to barnacles then gave 103 mg per barnacle per week. Haven and Morales-Alamo (1966, p. 495) suggest that biodeposition by other invertebrates may exceed that of oysters. We believe our data shows the magnitude of this importance as the undisturbed multi-species fouling community of this study yielded biodeposition rates five times that of a single species. Higher water temperatures in south Florida also increase biodeposition rates at all times of the year.

No correlation was found between the concentration of suspended particles and the flux of fecal pellets from the fouling community. This was searched for at one hour (Fig. 2) and three day (Fig. 3) intervals. This lack of correlation is especially clear for three experiments on 18–21, 21–24 and 25–28 July (Fig. 3) when the average suspended particle concentration was steady at 6.4–6.8 mg per l, the average flux of fecal pellets increased, and the average flux of particles settling into the control traps decreased. Haven and Morales-Alamo (1966) reported similar findings for Virginia oysters.

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