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Disturbance of fluvial gravel substrates by signal crayfish (Pacifastacus leniusculus)

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The reworking of substrates by organisms, termed bioturbation, is considered a fundamental processes in marine and terrestrial environments but has remained relatively unstudied in fluvial environments. This studies looks at the bioturbation of fluvial gravel substrates by signal crayfish, an internationally important invasive species. We investigated the impact of signal crayfish activity in a laboratory flume. Bioturbation by crayfish on both loose arrangements of gravel and water-worked surfaces were studied and two sizes of narrowly-graded gravel were used; 11 – 16 mm and 16 – 22 mm. A laser scanner was used to obtain high resolution digital elevation models (DEMs) of gravel surfaces before and after crayfish activity. These DEMs were used to quantify topographic and structural changes to the surfaces due to the activity of crayfish. It was found that crayfish moved substantial quantities of material from all surfaces within six hours of introduction. The majority of the disturbance was associated with small scale (≤ 1 median grain diameter) movements of surface grains due to walking and foraging by crayfish. This textural change resulted in a structural alteration to the substrate surface. After six hours of crayfish activity, there was a 14% reduction in the imbrication of the grains from water-worked surfaces.

Crayfish also constructed shallow pits and heaped excavated material into a series of mounds around its edge. Crayfish would always posture in pits in the same way. They would fold their vulnerable tails under their body and place their claws in front of their heads. When in pits crayfish predominately orientated themselves so they were facing an upstream direction. This implies that crayfish dig pits in order to streamline their bodies in the flow and lower their protrusion. Although pits and mounds contributed a relatively small proportion to the overall disturbance of substrates, they significantly increased the roughness of substrates. Pit and mound construction was far more prevalent in loose gravel surfaces. This suggests that water-working of gravel substrates not only reduces the vulnerability of grains to entrainment from the flow, but also disturbance by crayfish.

Subsequent to topographic analysis, surfaces disturbed by crayfish were entrained in the laboratory flume and compared to control surfaces on which crayfish were not present. Substantially more material was entrained from crayfish disturbed surfaces than control surfaces for both loose and water-worked gravels. In loose 11 – 16 mm gravels, 20% more grains were entrained from surfaces disturbed by crayfish. For water-worked surfaces this increased to 46%. Not only was the increase in entrained material greater for water-worked surfaces but it was also statistically significant.

During extended periods of low flow, gravel beds consolidate with the ingress of fine material and grain rearrangement. Both generally increase grain interlock and both increase the stresses required to entrain bed material during the next flood event. This study indicates that crayfish may oppose the process, jostling grains into less stable positions and increasing grain exposure through the mounding of material excavated from pits. Both will affect gravel stability during flood events. This study shows that invasive species may be having detrimental impacts on the physical environment as well as the wider ecological community.