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STUDY TITLE: University Research Initiative on the Effects of Offshore Petroleum Development in the Gulf of Mexico

REPORT TITLE: Dominant Infaunal Communities at Risk in Shoreline Habitats: Burrowing Thalassinid Crustacea

CONTRACT NUMBER: 14-35-0001-30470

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KEY WORDS: Gulf of Mexico; Louisiana; Mississippi; beach; infauna; thalassinid; seasonality; sediment; redox; nutrients; bioturbation

BACKGROUND: Oil contamination of intertidal and shallow subtidal substrates threatens mass mortalities in extensive populations of ghost shrimp that dominate many coastal habitats of the northern Gulf of Mexico. Previous evidence suggests that these organisms are important determinants of coastal habitat quality and that reductions in populations may alter physical, chemical, and biological characteristics of the infaunal habitat. Ghost shrimp burrows are documented to form traps for entrainment of oil deep into substrates, and the shrimp themselves are subject to mass mortalities from beachfront oil accumulations. Present studies were undertaken to document abundance and functional roles of ghost shrimp in typical beachfront and bay shoreline habitats of the northern Gulf of Mexico. This information is essential for assessment of environmental impacts from beaching of spilled oil; it facilitates management decisions relative to prevention and amelioration of spill effects in shoreline environments.

OBJECTIVES: (1) To document the scope for potential 1099 in dominant infaunal populations of beaches at risk of contamination by oil spills; (2) to document secondary

ecological impacts that would accompany such losses; (3) to clarify linkages between these burrowers and the ecological processes they modulate.

DESCRIPTION: Initiated in 1989, this study involved selection of sites densely populated by three common intertidal species of northern Gulf thalassinid shrimp that range widely within the western, central and eastern Gulf planning areas. We early recognized that the subject species required reassignment to separate genera, *Lepidophthalmus* and *Callichirus. L. louisianensis* was typically concentrated along muddy shores of low salinity estuaries, while C. *islagrande* and C. major populated sandy beaches facing higher salinity embayments and the Gulf of Mexico. Of the latter, C. *islagrande* was common in upper intertidal sands, especially on high energy beaches, while C. major was restricted to the extreme lower intertidal and subtidal. Of the two primary study sites selected, an estuarine shoreline of Bay St. Louis, Mississippi, was chosen for monitoring of *L. louisianensis,* and Isles Dernieres, Louisiana, was chosen for monitoring of C. *islagrande* and C. major populations. Both sites were areas of potential impact by oil spills, one estuarine and the other open-beach marine. Populations were monitored quarterly for over two years through measurements of densities, biomass, distributions, age and growth structure, and reproductive periodicity. Burrow depths, surface areas, and volumes were determined by resin casting. Grain sizes in the sedimentary matrix were measured and bioturbation rates were estimated. Measures of biological activity included effects on oxidation-reduction conditions, pore and burrow water nutrient concentrations, subsurface oxygen concentrations, and relationships to benthic productivity. Trophic relationships were evaluated from stomach content analyses and carbon ratio studies, as well as analyses of thalassinid fecal pellets and microbial flora of surrounding sediments.

SIGNIFICANT CONCLUSIONS: Seasonality of recruitment and growth naturally alter density and biomass distributions in these populations. Size classes vary areally within intertidal and shallow subtidal habitats. Restoration of populations proceeds by planktonic recruitment and relocations of burrowed postlarval populations. Population densities reflect subterranean burrow wall surface areas and burrow water volumes. Ventilatory irrigation of reduced sediments modulates movement of nutrients in expelled burrow waters. Animal effects on bioturbation rates are profound; this activity results in deep burrows of complex sculpture. Substrate and nutrient effects are potential determinants of productivity for benthic and water column microbiota.

STUDY RESULTS: The project has documented essential population parameters, including (i) seasonality in density and biomass, relative to shoreline; (ii) size partitioning within these distributions; (iii) peak periods of ovarian development, egg laying, and larval recruitment; and (iv) typical rates of growth and mortality in healthy populations. Physical studies of burrows have elucidated relationships between animal size and burrow physiography which, together with data on burrow densities and population size structure, allow extrapolation of burrow effects across large areas of habitat. Likewise, measurements of bioturbation rates by individual animals have facilitated estimates of sediment overturn by the overall populations, giving insight to overall impacts of their dominance in the infaunal assemblage and their conveyer-like effect on the vertical

redistribution of sediments, nutrients, and microflora. Measurements of subsurface oxygen levels, redox conditions, and nutrient contents of burrow and pore waters have in turn quantified impacts of these populations on cycling of nutrients between benthic sediments and the water column, and have suggested possible relationships to productivity of benthic microflora of shallow sediments and burrow walls. Measurements of carbon ratios, identification of stomach contents, and analyses of fecal pellets have helped to establish the food dependencies of these animals as well as nutrient contributions of fecal materials to the sediment surface. Our functional studies of these dense populations show them to convert intertidal and subtidal habitats to porous, hydrological processing grounds of intense biological activity. Enhanced water exchange through these burrow-riddled shoreline sediments is facilitated by the active ventilatory activity of subsurface thalassinids. In turn, subsurface burrow waters, pore waters, and sediments are oxygenated, high concentrations of reduced nutrients are moved to the sediment surface in expelled burrow water, food is brought in from surface waters and benthic sediments, and an abundance of nutrient-loaded fecal pellets is delivered to the sediment surface. While these animals consume oxygen when available, they are facultative anaerobes and can subsist for long periods under hypoxic or anoxic conditions. Findings of this study are relevant to management in terms of (i) providing an understanding of ecological value to be placed on these beach populations and their associated biota; (ii) documenting baseline measures of population and functional parameters in healthy stocks, against which impacted stocks might be later judged; (iii) providing insight into when (seasonally) and where (geographically) these thalassinid stocks are at greater or lesser risk from spill-related events; and (iv) suggesting ameliorative or mitigating measures that might be taken to reduce negative impacts of spills or clean-up efforts on these populations. Our ancillary studies have demonstrated that the species under study are genetic endemics to the northern and northwestern Gulf of Mexico; this infers that population dynamics or processes here reported and management strategies here inferred will not necessarily apply directly to other populations in other geographic areas. However, while unique populations, we also find that they are distributed widely within the northern and northwestern Gulf, that local demes within the Gulf are not highly insular in terms of our allozymic genetic measures, and that there is thus not high risk of genetically significant extinctions from localized spill events.

STUDY PRODUCTS: Felder, D. L., and R. B. Griffis. 1994. Dominant infaunal communities at risk in shoreline habitats: Burrowing thalassinid Crustacea. A final report by Louisiana Universities Marine Consortium for U. S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, La. Contract No. 14-35-0001-30470, OCS Study MMS 94-0007. 98 pp

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