GOOMEX: Experimental Design and What the Data Mean

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The Gulf of Mexico Offshore Operations Monitoring Experiment (GOOMEX) was performed to develop and recommend sensitive and appropriate techniques for monitoring activities of offshore oil and gas production. To accomplish this goal, a broad range of biological, biochemical and chemical methodologies were tested to detect and assess potential chronic, sublethal, and long-term effects of offshore oil and gas production. GOOMEX study components included measurements of abiotic characteristics to indicate environmental state (e.g., chemical patterns in sediments and water, geological patterns, and physical patterns) and biotic responses (e.g., tissue body burdens, detoxification response by fish and invertebrates to contaminant exposure, sediment toxicity to invertebrates, meiofaunal, macrofaunal and megaepifaunal community structure, harpacticoid reproduction and population genetic structure, megaepifaunal reproduction). Program design started with two null hypotheses:

1. H_o: There are no differences in any sedimentological, chemical, community, population, reproductive, toxic or detoxification measures between seasons, among platforms (or platform groups), or with distance or direction away from platforms (or platform groups).

2. H_o: There are no functional responses between chemical contaminant gradients and community, population, reproductive, toxic or detoxification measures.

The obvious, and usual, approach to test the first hypothesis is to perform a series of univariate analysis of variance (ANOVA) computations for all variables being measured at all stations in the study design. However, the categorical variables in such a design, particularly distance from a platform, are just surrogates for the expected contaminant gradient. The second hypothesis is designed to test for changes with respect to any contaminant gradients that might exist among and within platforms stations. Therefore, a multivariate approach is used to test the second hypothesis.

The experimental design to test the two hypotheses was based on a dose-response model. Briefly, there were four cruises(one in summer and winter, in two consecutive years), three platforms (MAI-686, MU-A85, and HI-A389, each at progressively deeper water depths), five distances away from a platform (50 m, 100 m, 200 m, 500 m, and 3000 m), where each distance was sample on a radial transect from the platform (5). The five radii were symetrical around MAI-686 and MU-A85, but not at HI-A389. At HI-A389, all radii were southeast of the platform deeper than the 100 m depth contour, because there is a shallow (~ 50 m) reef (the Flower Gardens) northwest of the platform. The experimental design is a complex partially hierarchical design, where the radial transect is a random nested variable within platforms. A total of 25 boxcores were taken at each platform during each cruise. Boxcores were subsampled for component measurements. The design resulted in 300 sediment samples, which is sufficient to ensure a robust ANOVA, but the real power lie in the fact that all measurements could be tied to a specific sample ensuring a robust multivariate analysis. Megaepifauna and fish were collected with trawls, not boxcores, so the design is simply reduced to two distances from a platform Near 50 - 100 m, and Far 3000 m), but maintains robustness.

In general, results from the GOOMEX study indicate that effects were limited to 100 m from platforms. Relative to background (i.e., 200 m), the zone near platforms had sediments with higher levels of contaminants and toxicity; reduced levels of abundance, species diversity, genetic diversity, and reproductive success; and feeding guilds with more deposit feeders. The HI-A389A platform had much higher levels of contaminants with concordant biotic responses that other platforms, apparently because of near-bottom shunting to avoid dispersal to the nearby Flower Gardens.

Mercury behaved like other divalent metals in sediments. The average concentration of mercury at HI-A389 was twice as high as the other two platforms. The highest average concentration (0.41 ug/g) was found within 50 m of the platform, but decreased to 0.12 at 100 m. Although they are the highest found, they are low relative to the probable effects level (0.7) thought cause biological effects. The natural background level for sediments in the Gulf of Mexico appears to be around 0.04 ug/g).

Metal concentrations were measured in tissues for 37 species. Except for shrimp, there was no statistically significant evidence that metal concentrations were higher near platforms that away from platforms, even though many of these organisms might be preferentially using the platform as a reef-like habitat. There was statistical evidence that tissue concentrations were higher at the HI-A389 platform than other platforms. Fish tissue concentrations were generally low, for example the average concentration was 0.45 ug/g for all flounder species, 0.39 ug/g all hake species, 0.24 ug/g and for all snapper species. Shrimp had statistically higher tissue concentrations near (0.36 ug/g) platforms than far (0.19 ug/g) from platforms. These values are well below the federal guidelines set by FDA to protect human health, which is1 ppm (i.e., ug/g). Most states also use this guideline, but Wisconsin uses 0.5 ppm to conform with Canadian standards. Some regulating bodies develop site-specific criteria. Proposed guidelines are based on actual consumption, not fish tissue levels. For flounder, 10 (5 near and 5 far) of 119 individuals were above 1 ppm. For hake, 3 of 42 (all from far sites) were above the 1 ppm level. For shrimp, 2 of 57 (all from near sites) were above the 1 ppm level. None of the 41 snapper were above the criteria.