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Project Summary

Physiological Impact of Dredged Sediment on Two Benthic Species

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Several international commissions have recently called for effective short-term biological response measurements which can adequately detect the effects of environmental concentrations of contaminants. Such methods must be relevant to ecological fitness and must have predictive capability value.

This report describes efforts to develop a direct comparison of the effects of Black Rock Harbor dredged material on the bioenergetics of juvenile *Nephtys incisa* exposed in the laboratory and of individuals obtained in the field from a controlled disposal of Black Rock Harbor material. Exposure regimes used in the laboratory studies were comparable to the exposure environments that have been predicted around the BRH disposal site in Long Island Sound. In addition the effects of exposure to suspended BRH material on the bioenergetics of the mysid, *Mysidopsis bahia* were also determined.

This Project Summary was developed by EPA's Environmental Research Laboratory, Narragansett, RI, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The disposal of dredged material can pose problems to the well being and survival of benthic communities on or near the site of disposal. Problems range from the near complete but temporary loss of the infaunal community at the impact zone to the potential long-term impact caused by the bioaccumulation of contaminants from the sediments. Further problems arise from the possible effect on human health through biomagnification of toxic substances through the food chain to edible commercial species.

The management of material through ocean dipsosal becomes difficult at best when one attempts to assess any eventual consequences to the environment caused by the disposal of a particular type of material. Predictive capabilities in the form of a risk assessment are the cornerstone of a sound ocean disposal management plan. Risk assessment, which is the integration of biological effects and environmental exposure, is a sequential assessment procedure designed to provide the decision maker with an estimate of the potential hazards associated with a particular material.

A research plan of this type is currently being evaluated in a joint United States Environmental Protection Agency and Army Corps of Engineers research program in which the effects of dredged material from Black Rock Harbor (BRH), Connecticut on a Long Island Sound benthic species were assessed in the laboratory prior to disposal operations. Following disposal, a field study was conducted to verify the response observed in the laboratory and determine the accuracy of the laboratory prediction. This research program offers a unique opportunity to evaluate the predictive capacity of a variety of biological effects tests.

Effective short-term biological response measurements which can adequately detect the effects of environ-

mental concentrations of contaminants recently have been called for by several international commissions. In order to be of value the measurements must have some relevance to ecological fitness. In addition, these laboratory effects tests must have a predictive capability which allows for the estimation of the degree of ecological change which will take place.

An effects measurement technique which may satisfy the preceding criteria is the determination of biological energy balances along with its corrollaries, including scope for growth. Previous studies using these principles have found a reasonable correlation between changes in energy balances or scope for growth and changes in population fitness. The literature describes a series of detailed field studies which found a reduced scope for growth in *Mya arenaria* collected from oil-impacted sites when compared to individuals from nearby, relatively clean reference populations. These data were related to and predictive of eventual changes in population structure which were observed in the impacted sites. Changes in population structure that might relate to the reduced scope for growth included reductions in yearly growth rate and populations density.

The final report describes efforts to develop a direct comparison of the effects of Black Rock Harbor material on the bioenergetics of juvenile *Nephtys incisa* exposed in the laboratory and on individuals obtained in the field from a controlled disposal of Black Rock Harbor material. Exposure regimes used in the laboratory studies were comparable to the exposure environments that have been predicted around the BRH disposal site in Long Island Sound.

In addition to the research conducted with *Nephtys incisa*, the effects of exposure to suspended BRH material on the bioenergetics on the mysid, *Mysidopsis bahia*, were also determined. *M. babia* is currently being used in the Field Verification Program as a laboratory surrogate for crustaceans that may be found in and around the BRH disposal site.

Discussion

Nephtys incisa

In a previous study reported in the literature, *Nephtys incisa* juveniles exhibited several responses when exposed to BRH material under laboratory conditions. Changes attributed to exposure to BRH sediment included increased maintenance costs, reduced tissue growth, weight loss, and lowered net growth efficiency. Laboratory data reported in this study confirm and extend these findings.

The results of the present study indicate that *Nephtys incisa* living in relatively contaminant-free sediment (REF sediment) are physiologically affected by exposures to suspended BRH particles. The bioenergetic effects of suspended BRH material are evidenced in some physiological processes during the first 10 days of exposure when differences in tissue production and maintenance costs were noted. Continued exposure to BRH material does not appreciably alter the types of physiological changes observed in the worms but rather magnifies the physiological effects noted by day 10.

N. incisa are exposed to contaminants entering the burrow system either in a dissolved form or associated with particulates. Because of the high suspended particle levels (200 mg/l) used in laboratory simulations, the contaminants would be primarily associated with the particulate fraction. Polychlorinated biphenyls levels monitored in the exposure chambers during the experiments indicate that approximately 98 percent of the total PCB present in the water column was associated with the particulate fraction. Furthermore, another study reported that the only histological abnormalities found in *Nephtys incisa* exposed to BRH material in laboratory experiments are thickening of the epidermis and the appearance of macrophages containing black particles. They concluded that the changes in epidermal structure were due to direct contact with BRH particles.

Field studies on *Nephtys incisa* indicate a pattern of seasonal changes. Significant differences in respiration and ammonia excretion rates between stations occurred only during periods when the water temperature was greater than 11°C. When water temperatures were cooler, no significant differences in weight specific respiration and ammonia excretion rates were evident in individuals collected from the various sampling stations. Depending upon the time of year, therefore, water temperature will alter the apparent physiological effects of exposure to BRH material.

A primary objective of the FVP was the field verification of the results obtained from laboratory simulations. Worms collected from the BRH disposal site and from the laboratory experiments exhibited changes in physiological function relative to increasing exposures to BRH material. Since an exact match of exposure environments between the laboratory simulations and field environment could not be made, and because the laboratory exposure environments included higher concentrations of BRH material than were present at the disposal site, the laboratory findings should be considered an upper bound estimate for the effects of BRH sediment on infaunal polychaetes.

Mysidopsis bahia

As with *Nephtys incisa*, *Mysidopsis bahia* exhibited an exposure-dependent response to suspended BRH material. All physiological parameters examined showed changes within six days following the initial exposure. In additon to the sublethal effects found at the lower BRH level, 100% mortality was noted for mysids maintained in the higher (> 50 percent BRH) levels.

Chronic exposure to BRH material results in lowered growth rates in both juvenile and early adult stages. These reductions in growth can be attributed to reductions in the average amount of food ingested and to an increase in maintenance costs. Reductions in energy consumption levels were apparent by day 5 and persisted throughout the experiment. The specific compounds causing the reductions in food ingestion rates are unknown; however, previous research with single contaminants suggest that neutral organics, rather than heavy metals, are the causative agents.

Increased maintenance costs are a generalized metabolic response to contaminant exposure. Regardless of the mechanism responsible, higher maintenance costs reduce the amount of assimilated energy available for growth. The net result is that organisms faced with higher maintenance costs will have less energy (both quantity and quality) which can be partitioned into growth processes. Combined with the lowered energy consumption rates found in mysids exposed to BRH material, it is not surprising that the higher maintenance costs resulted in lower growth rates.

Changes in reproductive success could be due to a variety of factors including the failure of hormonal systems to initiate egg maturation. Although such factors cannot be discounted, results of

the present study indicate that the reproductive alterations were due, in part, to the physiological dysfunctions noted during earlier life history stages.

Changes in community and population structure are the product of changes occurring initially at the organism and suborganism level. Although isolated effects noted at the organismal level may not translate into population changes due to compensatory mechanisms, it is evident that the sublethal changes seen in this study do result in impacts at the population level of organization. Impacts on energetics of juvenile mysids result in changes in secondary production and in the intrinsic rate of population growth. A similar conclusion cannot, at this time, be drawn about bioenergetic dysfunction noted with *Nephtys incisa* juveniles. *N. incisa* populations from the BRH disposal site sampling stations are currently being analyzed through cohort analysis and this data will provide an estimate of how well the bioenergetic data predicted eventual population impacts.

The responses of *Mysidopsis bahia* to BRH material during the entire life cycle indicate that bioenergetic dysfunction in individuals preceded, and was predictive of, changes at the population level. Changes in growth, development, and reproductive success can be directly linked to alterations in energy balance and on every flow noted in early juvenile stages. Diversion of assimilated energy to increased maintenance costs significantly reduced both the quantity and quality of energy available for growth and reproductive processes. The integration of several physiological functions into a bioenergetic index proved to be a sensitive indicator of long-term effects occurring at a higher level of biological organization.

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The complete report, entitled "Physiological Impact of Dredged Sediment on Two Benthic Species," (Order No. PB 87-172 151/AS; Cost: $13.95, subject to change) will be available only from:
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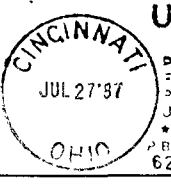

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