Dredging Research

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Predicting mound placement and stability for the Energy Island borrow pit

by Joseph Z. Gailani, Ph.D., U.S. Army Engineer Waterways Experiment Station

Research at the U.S. Army Engineer Waterways Experiment Station demonstrates new methods for optimizing dredged material placement and evaluating mound stability during storm events for contaminated, mixed sand/silt/clay sediments which behave in a cohesive manner. Methods used apply to determining cap stability as well as stability of clean or contaminated dredged sediment mounds that are not capped. Driving the investigation is the added expense of mining sand material for capping purposes, as well as the desire to use such sediments for other applications such as beach nourishment.

Studies include a combination of laboratory experiments and numerical modeling to determine mixed sediment mound placement and stability. Model frameworks are set up to include first-order processes affecting sediment settling, transport, deposition, and erosion. Laboratory experiments better define parameters that affect these sediment processes. Results from the laboratory experiments are integrated into the numerical model, thus reducing uncertainties and providing confidence in model predictions.

Applied research design

WES research staff members are assisting U.S. Army Engineer District, Los Angeles, personnel with design of a contained aquatic disposal facility for contaminated sediment storage. This facility will be located in the North Energy Island borrow pit in Los Angeles/ Long Beach Harbor (see “North Pit,” Fig. 1). WES studies include determining potential scenarios for placing contaminated sediments using split hull barges to achieve the desired sediment mound configuration and long-term stability of the contaminated sediment mound once it is capped.

The WES Multiple Dump FATE of dredged material (MDFATE) model was used to simulated barge placements and the Long Term FATE (LTFATE) model was used to simulate the storm effects on the capped mound.

The original plan was to cap the mound after each placement of contaminated sediments, even though the pit would not be full. This would assure that contaminants were not introduced to the water column or biota due to diffusion, erosion, or biological activity. The mound configuration determined by MDFATE, with a 1.2-m-thick sediment cap added uniformly, was used as the input mound configuration for LTFATE. Cap sediments are proposed to come from dredging which will occur as part of the Queen’s Gate channel deepening project. Queen’s Gate, located just outside the Los Angeles/Long Beach harbor, was selected as the source based on sediment properties and cost of dredging and transport. A detailed study was performed on these sediments to determine their properties and erosion potential. The results were incorporated into the LTFATE model for cap design.

Figure 2 shows the section of the pit where placements will occur, surrounded by ambient depths of 7 to 8 m. The pit bottom is relatively flat with depths ranging from 16 to 20 m. Filled capacity level

Center for Contaminated Sediments

In this issue . . .

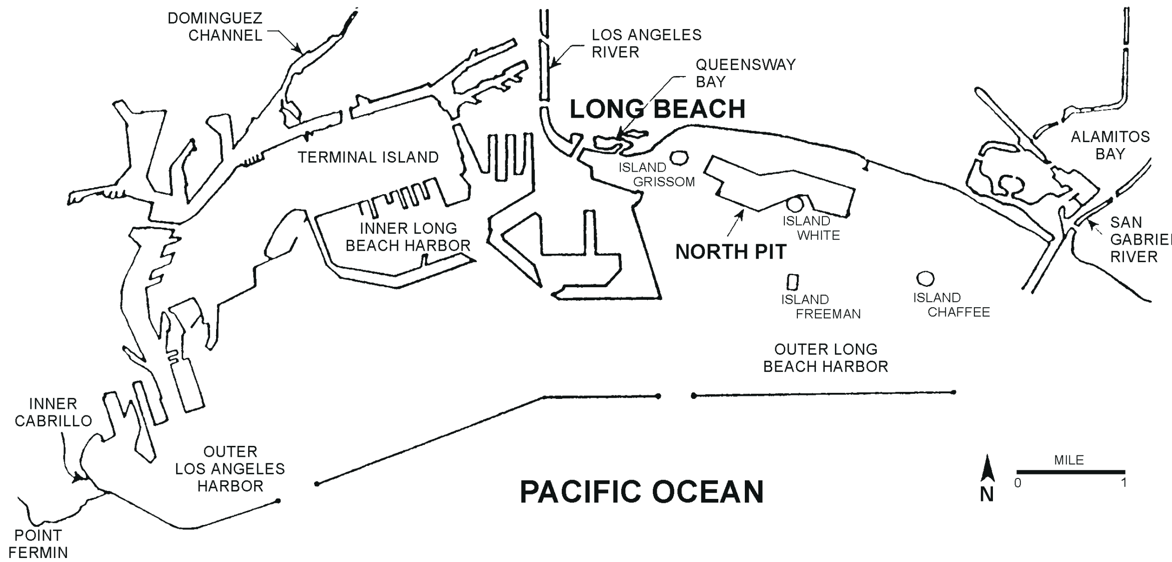

Figure 1. North Energy Island borrow pit location map

WES center harnesses expertise of top scientists and engineers

Contaminated sediments can pose a chronic hazard to the aquatic environment. As a result, impacts of contaminated sediments and the consequences of dredged material placement have come under intense scrutiny by Congress, environmental groups, the public, and numerous federal, state, and environmental resource groups. Research on all aspects of such sediments has become of vital interest and is contributing to the knowledge base for a balanced approach to ecosystem management. In order to facilitate and provide a centralized approach for such research, expertise, and resources, the U.S. Army Corps of Engineers established the Center for Contaminated Sediments (CCS) at the U.S. Army Engineer Waterways Experiment Station.

Additional information is available from Dr. Robert M. Engler, Director of the CCS, U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, phone: (601) 634-3624, e-mail: *englerr@mail.wes.army.mil*.

with the ambient depth is 680,000 m^3. Allowing for a 1.2-m-thick cap (130,000 m^3) reduces the contaminated sediment capacity to 550,000 m^3.

Barge placement modeling

The MDFATE model was used to simulate the barge placements. MDFATE was developed as part of the U.S. Army Corps of Engineers Dredging Research Program. The model simulates multiple disposal events at one site to predict mound buildup. It simulates the effects of local currents and waves on the sediment as it falls through the water column and settles on the mound. The model accounts for effects of grain size and bulk density on settling, changes in volume during deposition, and various dredging and placement methods.

Parameter inputs to MDFATE were based on knowledge gained from past placements, laboratory experiments, and analysis specific to the site. Currents during the period of disposal were estimated using the CH3D three-dimensional hydrodynamic model previously developed for the Los Angeles/Long Beach harbor by WES research staff. Wave conditions were set at typical summer conditions for the site, 0.3-m wave height with 10-sec period. Initial simulations involved placement of 230,000 m^3 of contaminated sediments removed from Marina Del Rey (scheduled for Fiscal Year 1999) and placed in the smaller, eastern most section of the North Energy Island pit. The Marina Del Rey sediments were assumed to have properties similar to those from the Los Angeles River estuary, for which data were available.

The MDFATE model was used to answer several questions. First, what is the final mound configuration and what are the best placement scenarios to minimize mound height variations? Second, what impact do the currents have on sediment deposition location and how can placements be arranged to minimize deposition outside the pit? Placement scenarios should result in a relatively flat upper crest which is less likely to erode than one with excessive peaks. The project pit was divided into nineteen placement cells (Fig. 3) and adjustments were made for adding sediment to the deeper areas, as well as accounting for sediment shifts and movement.

Simulated post-placement depths are predominately 15 to 16 m, mllw. The model also predicted that at most a

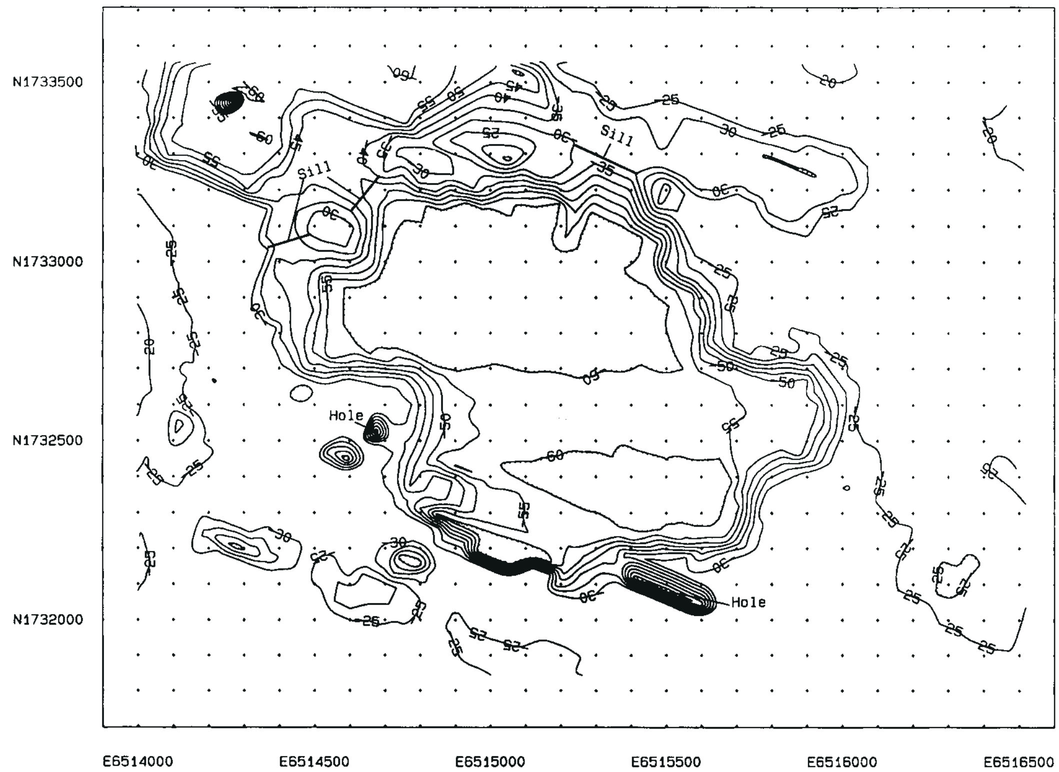

Figure 2. Bathymetry of the eastern section of North Energy Island borrow pit. Depth contours are in feet below mllw; horizontal positions are California State Plane, NAD 83, in feet

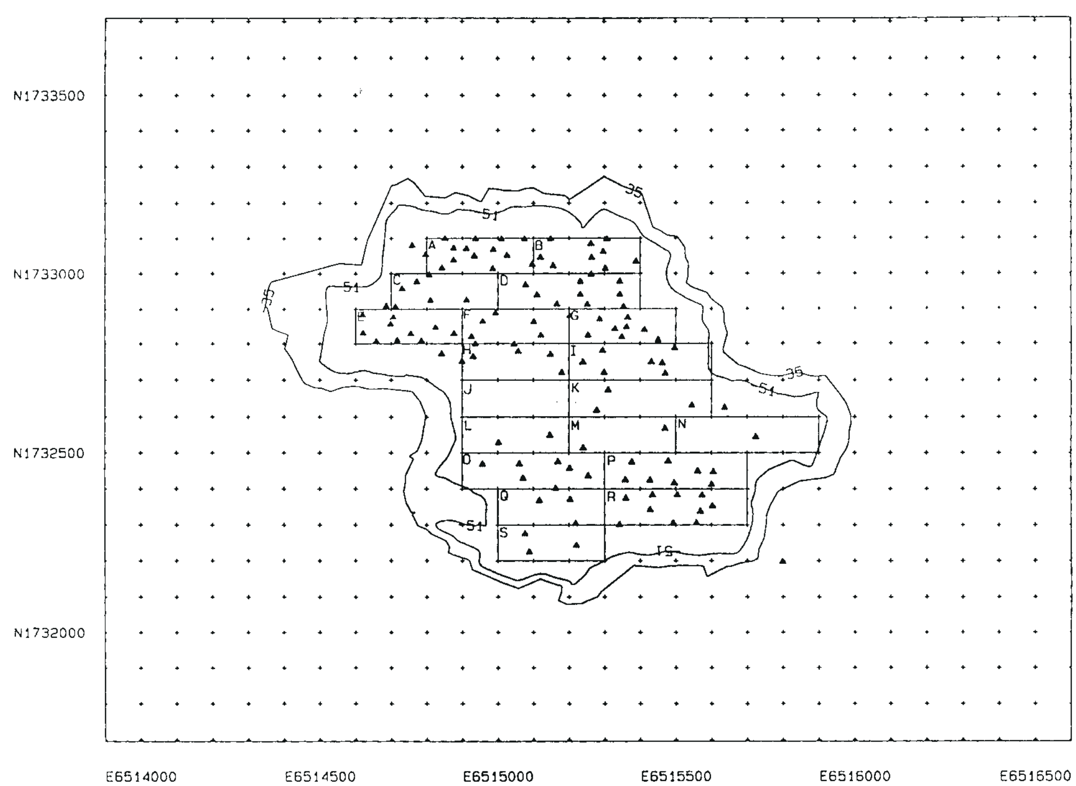

Figure 3. Final barge placement locations for the full 230,000 m^3 are indicated by ▲

small percentage of the material will move beyond the pit confines during placement operations.

Estimating sediment erosion rates

Once the contaminated sediments are placed in the pit, capping operations will begin almost immediately to avoid storm-induced erosion. Cap sediments must withstand shear stresses imposed by storm waves and currents.

Queen's Gate sediments will generally behave in a cohesive manner; and the erosion rates, as a function of near bottom shear stress for mixed sediments, can vary by orders of magnitude depending on grain-size distribution, mineralogy, bulk density, and organic content. The effects of these bulk properties on erosion are not well known. Therefore, analyses of these sediments were undertaken to determine erosion-rate parameter data for use in LTFATE.

An instrument called Sedflume recently developed at the University of California at Santa Barbara is able to measure resuspension rates of undisturbed bottom sediments at shear stresses of 0.1-10 Pa. This measurement covers the magnitude of shear stress experienced at the project pit. The instrument also measures change in erosion potential with depth below the sediment-water interface, i.e., as a function of bulk density. The Sedflume experiments were performed on 1-m-deep core samples created from slurries of sediments from the Queen's Gate site and from relatively undisturbed cores extracted at the site. The cores created from the slurry were permitted to age from 7 to 60 days before erosion tests were performed, permitting analysis of the effects of compaction on erosion rates. The experiments produced estimates for three critical parameters:

- critical shear stress for resuspension as a function of bulk density (it is assumed that below this critical value no erosion occurs),
- erosion rate as a function of shear stress and bulk density. Because the sediment slurries were well mixed, other properties affecting erosion rates, such as organic content and mineralogy, were combined into site specific constants, and
- bulk density of the sediment bed as a function of depth below the sediment/water interface.

Sediment transport simulation under storm conditions

LTFATE simulates sediment transport caused by the action of waves and currents over a mound of arbitrary shape. The model was modified to incorporate site-specific sediment erosion parameters determined from the Sedflume tests. In addition, the LTFATE model requires local bathymetry and local storm conditions for periods of interest data. The bathymetry of the mound used in this study was developed from the MDFATE study described earlier, with a 1.2-m cap added to the calculated relief. To represent the worst-case storms to hit the harbor, the largest wave events recorded in the region in the past 20 years were analyzed. Four storms were selected for simulation. Waves were shoaled to the harbor entrance, then refracted and diffracted to determine wave heights at the pit location. This resulted in a time-history of wave conditions at the project pit for each storm. The storm-induced local current and water elevations at the pit boundary were simulated with the CH3D three-dimensional hydrodynamic model.

Table 1 shows the maximum and average depth of erosion predicted for the four storms. Clearly, the last storm listed is the most intense, with 30 cm maximum erosion on the cap and a 12-cm erosion average. This was a very strong storm with erosion more than twice as great as the next strongest storm. The event is estimated to have a return period of several decades (it is interesting to note that this storm occurred during an El Nino). The simulations indicate that the erosion would not penetrate deep into the cap and would leave sufficient cap material in place to maintain chemical and biological isolation during tested conditions, although the cap should be checked after large storms.

Upon completion of the Los Angeles/Long Beach harbor project, processes refined in the studies will assist planners when dealing with similar situations. Additional information is available from Dr. Joseph Z. Gailani, (601) 634-4851.

Table 1. Storm erosion: mound with 4-ft cap of entrance channel sediments

Storm Date	Maximum Erosion (cm)	Average Erosion (cm)
01/17/88	12	6
01/26/83	5	2
02/14/86	12	6
02/28/83	30	12

Internet offers solution to bioaccumulation data access

by Marsha C. Gay, U.S. Army Engineer Waterways Experiment Station

Bioaccumulation is the process by which organisms absorb chemicals or elements directly from their environment. Evaluating the effects of bioaccumulation of contaminated sediments on the environment is a complex technical and regulatory problem. Although all chemicals have the potential to be harmful, merely identifying a chemical in the tissues of an organism is not enough to conclude that this substance will be harmful in every instance.

According to Dr. Todd S. Bridges, research biologist in the WES Environmental Laboratory, the likelihood that a chemical substance in the tissues of an organism will produce an adverse effect is a function of the physical and chemical properties of the substance, the concentration of the chemical in the tissues of the organism, and the length of time the organism is exposed to the compound. Because the toxicity of environmental contaminants varies widely, the information needed to determine the potential for harm of a contaminant must be identified for each contaminant.

The U.S. Army Corps of Engineers has been using bioaccumulation data to make regulatory decisions on the management of dredged material for more than 20 years. Decisions on what bioaccumulation level is acceptable are based on data that link a given concentration of a substance with measurable biological effects such as reduced survival, growth, or reproduction.

Bioaccumulation data are evaluated in two ways. First, the level of bioaccumulation of a specific contaminant in animals exposed to dredged material is compared with a limit, i.e., a Food and Drug Administration action level or a fish advisory. If the concentration exceeds that limit, then the disposed material could have an "unacceptable adverse effect."

If the concentration does not exceed that limit or there is no established limit for that substance, the level is compared with data collected from animals exposed to a reference sediment. If the level exceeds that of the reference sediment, then the level of bioaccumulation and the toxicological significance of the contaminants are considered (see: *Ocean Testing Manual* and *Inland Testing Manual* at *www.wes.army.mil/el/dots/guidance*).

There are two important limitations to this method: (1) only a small number of published limits are available for comparison with the level of contamination, and (2) applying the evaluation factors from the reference sediments is qualitative and subjective.

A solution to these problems would be to rely on published empirical data where tissue concentrations and effects have been measured in the same organism. Residue-effects data in the same or similar species offer a more direct and objective means of evaluating the potential consequences of bioaccumulation. However, until recently, published residue-effects data have been scarce. "Before residue-effects information could be put to use in a regulatory program, an accessible, centralized repository for this type of data was needed," said Bridges.

To address the "centralized access" problem, the Corps, with support from the U.S. EPA, has developed the Environmental Residue-Effects Database.

According to Bridges, users can query the database on-line by specifying a number of potential criteria (e.g., species, contaminant, etc.). Results provide summaries of relevant studies along with full citations for the original studies. These results can be printed or downloaded electronically as spreadsheet files.

Bridges said that the ERED contains data collected from 218 studies published between 1964 and 1997 and includes data on 229 contaminants, 119 aquatic species, and 19 effect classes (i.e., survival, growth, reproduction, enzyme inhibition, etc.). The database contains information on a broad range of biological effects caused by a particular contaminant in the tissue of an organism.

According to Bridges, "In combination with the use of risk-based approaches for estimating contaminant trophic transfer, we expect that the ERED will provide a solid basis for making more objective determinations about the potential for 'unacceptable adverse effects' resulting from contaminant bioaccumulation." He added that this database is useful to managers who must interpret the environmental meaning of bioaccumulation as required by statutes and regulations. Time and cost savings are significant, since decision-makers can access the database in real time free of charge.

Additional information is available from Dr. Todd Bridges, (601) 634-3626, *bridget@mail.wes.army.mil*. See also "Environmental Residue-Effects Database (ERED) now available on-line," *Dredging Research*, Vol. 1, No. 1, available in PDF format on-line at *www.wes.army.mil/el/dots/drieb.html*.

Calendar of Events

Aug 13-14, 1998 Great Lakes Regional Pollution Prevention Roundtable meeting, Buffalo, NY
POC: merrifld@wmrc.hazard.uiuc.edu

Aug 17-20, 1998 Modeling and Measuring the Vulnerability of Ecosystems at Regional Scales for Use in Ecological Risk Assessment and Risk Management, sponsored by Society of Environmental Toxicology and Chemistry (SETAC), American Society for Testing and Materials (ASTM) Committee E47, and U.S. Environmental Protection Agency (USEPA), Seattle, WA
POC: schiefer@setac.org, http://www.setac.org

Aug 24-28, 1998 Meeting on Water Quality Standards, Criteria and Implementation, Including Water Quality-Based Permitting, sponsored by USEPA, Philadelphia, PA
POC: mrm98@cadmusgroup.com

Aug 30-Sep 3, 1998 Coastal Zone Canada '98 International Conference, Victoria Conference Center, Victoria, British Columbia, CANADA
POC: czc98@ios.bc.ca

Sep 6-11, 1998 PIANC 29th International Navigation Congress, The Hague, Netherlands
POC: Thomas M. Ballentine, US Section PIANC, Casey Building, 7701 Telegraph Road, Alexandria, VA 22315-3868 USA, Voice: (703) 428-7072, FAX: (703) 428-8171

Sep 8-10, 1998 Coastal Environment 98 "Environmental Problems in Coastal Regions" Cancun, MEXICO
POC: liz@wessex.ac.uk
Abstracts Due: 6 January 1998

Sep 15-16, 1998 Beneficial Use of Dredged Material: A Regional Workshop for the Great Lakes, sponsored by the Great Lakes Dredging Team, Toledo, OH
POC: sthorp@glc.org

Sep 16-17, 1998 Sixth Meeting of Great Lakes Dredging Team, Toledo, OH
POC: sthorp@glc.org

Sep 16-18, 1998 Keeping It On the Land...and Out of the Water: Soil Erosion and Sediment Control Techniques for the Great Lakes Basin, sponsored by the Great Lakes Commission, Ohio DNR, USEPA, NRCS, and NACD, Toledo, OH
POC: tcrane@glc.org

Sep 23-25, 1998 Ports 98, First International Conference, Maritime Engineering and Ports, Liguria, ITALY

Sep 24, 1998 7th Annual Ohio Lake Erie Conference, hosted by the Ohio Lake Erie Commission and Ohio Lake Erie Office,Ashtabula, OH
POC: oleo@www.epa.state.oh.us

Sep 25-26, 1998 Areas of Concern Workshop: Transferring Successful Strategies and Techniques, sponsored by the International Joint Commission, Hammond, IN
POC: kirschnerb@ijc.wincom.net

Oct 3-7, 1998 Water Environment Federation's 71st WEFTEC '98, Orange County Convention Center, Orlando, Florida, USA
POC: http://www.wef.org/docs/weftec98.html
e-mail msc@wef.org.

Oct 5- 9, 1998 Annual Convention, AAPA, Westin Galleria/Westin Oaks, Houston, TX USA

Oct 19-20, 1998 Annual Meeting of Great Lakes Commission, Buffalo, NY
POC: mdonahue@glc.org

Oct 21-23, 1998 State of the Lakes Ecosystem Conference (SOLEC), sponsored by USEPA and Environment Canada, Buffalo, NY
POC: http://www.epa.gov/glindicator

International

Report of PIANC's Working Group I-17 available on CD-ROM

"Handling and Treatment of Contaminated Dredged Material from Ports and Inland Waterways 'CDM'," the report of PIANC's Working Group I-17, Volumes I and II, is available on CD.

Volume I contains general guidance for the preparation of dredging projects that handle and treat such materials. The disk also presents the Contaminated Dredged Material Technical Framework (CDMTF), which outlines the case-by-case approach to assessment and selection for handling and treatment of CDM from ports and inland waterways. This volume is written primarily for navigation authorities, permitting agencies, and review agencies.

Volume II is a searchable database of 86 Technology Fact Sheets and 18 case studies. This volume contains much of the technical information and sources of technologies and international experiences in dealing with CDM, details needed by practicing engineers or other professionals who need specific data or pertinent sources of technical information. Direct links from the general material in Volume I exist to more technical sources of information in Volume II.

The CD-ROM is available from

- **General Secretariat of PIANC**
  WTC - Tour 3 - 26th Floor
  Boulevard Simon Bolivar 30
  B1210 Brussels - Belgium
  Fax: +32 2 208 52 15
  Cost: 1,000 BEF

or

- **U.S. Section, PIANC**
  7701 Telegraph Road
  Alexandria, VA 22315-3868
  Voice: (703) 428-7072
  Fax: (703) 428-8171
  Cost: $30.00.

Influence of food ration on sediment toxicity in *Neanthes arenaceodentata* (Annelida: Polychaeta)

by Todd S. Bridges, Ph.D., U.S. Army Engineer Waterways Experiment Station

Design

A 3 x 2 factorial experiment was conducted to evaluate the influence of food ration on observed toxicity in *Neanthes arenaceodentata*. Worms were fed one of three food rations: 0.25x, 1.0x, and 6.0x. The 1.0x ration was composed of 4 mg TetraMarin/worm/w and 2 mg alfalfa/worm/w. Worms in each food ration were exposed to one of two sediments: a clean control sediment collected from Sequim Bay, Washington, USA (SC), or a contaminated sediment collected from Black Rock Harbor near Bridgeport, Connecticut, USA (BRH), that was diluted with SC such that the final concentration of contaminated sediment was 12 percent. Survival and growth were monitored every 2 weeks for 8 weeks. Sediment treatment and food ration had strong effects on survival and growth patterns in *N. arenaceodentata*.

Survival

Most of the mortality within any given treatment combination occurred during the first 2 weeks of the experiment. This decline in survival was greatest for worms exposed to BRH. Survival was significantly lower for worms in BRH compared to SC at the 0.25x and 1.0x ration levels. Survival was not reduced for worms in BRH compared to SC at the 6.0x ration level.

Growth pattern

Worm size during the course of the experiment was positively related to ration level. Significantly reduced size in BRH worms was observed at each monitoring period within the 0.25x and 1.0x rations, but only at weeks 6 and 8 for the 6.0x ration level. The percent difference in size between worms exposed to BRH and SC, when those worms were fed the 0.25x or 1.0x rations, ranged between 55 and 66%. The percent difference in size observed between BRH and SC worms fed the 6.0x ration was much smaller (9-17%).

Results

The results of this study demonstrate that food ration has a strong influence on observed toxicity in *N. arenaceodentata*. The importance of food ration effects on toxicity must be considered while designing chronic sublethal bioassays. To ensure the relevance of bioassay results, the food ration used during a chronic bioassay should produce a pattern of growth in control animals that is similar to patterns of growth observed in nature.

Research Team

Todd S. Bridges, Ph.D., *bridget@mail.wes.army.mil*, J. Daniel Farrar and B. Maurice Duke, contract support.

The Dredging Operations and Environmental Research Program exhibit made its first public appearance at the World Dredging Congress in Las Vegas, NV, in June 1998. Visitors were particularly interested in on-line demonstrations of Corps of Engineers dredging pages.

US Army Corps
of Engineers

Articles for Dredging Research requested

Dredging Research is an information exchange bulletin for publication of WES generated dredging research results. Included are articles about applied research projects. The bulletin serves all audiences and is accessible on the World Wide Web in addition to a circulation of 2,800.

Articles from non-WES authors are solicited for publication, especially if the work described is tied to the use of WES generated research results. Research articles that complement WES research or cover wide field applications are also accepted for consideration. Manuscripts should include suggestions for visuals and a brief biography of the author and should use a non-technical writing style. Point of contact is Elke Briuer, APR, at _briuere@mail.wes.army.mil._

Dredging Research

This bulletin is published in accordance with AR 25-30 as an information dissemination function of the Environmental Laboratory of the Waterways Experiment Station. The publication is part of the technology transfer mission of the Dredging Operations Technical Support (DOTS) Program and includes information about various dredging research areas. Special emphasis will be placed on articles relating to application of research results or technology to specific project needs. The contents of this bulletin are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or the approval of the use of such commercial products. Contributions are solicited from all sources and will be considered for publication. Editor is Elke Briuer, APR, *briuere@mail.wes.army.mil*. Mail correspondence to the Environmental Laboratory, ATTN: DOTS, *Dredging Research*, U.S. Army Engineer Waterways Experiment Station (CEWES-EP-D), 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, or call (601) 634-2349. Internet address: *www.wes.army.mil/el/dots.*

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