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Implementing Engineering With Nature within the Corps: A Workshop

by Cynthia J. Banks, Thomas J. Fredette, Burton C. Suedel, and Todd S. Bridges

PURPOSE: This document summarizes the major findings of a workshop entitled "Engineering With Nature: Designing Navigation Infrastructure for Greater Environmental Sustainability"[1] held September 7-8, 2011, in Charleston, South Carolina. The goal of the workshop was to identify opportunities to advance science, engineering, and operational practice leading to expanded environmental benefits from navigation infrastructure and operations within the US Army Corps of Engineers (USACE). This was accomplished through in-depth discussions of relevant experiences, issues, and lessons learned. The workshop was sponsored by the Dredging Operations Environmental Research (DOER) Program and served as a conduit for sharing technical presentations, networking, and generating outcomes that will support the DOER program.

BACKGROUND AND PROBLEM: The USACE Navigation Mission is to provide safe, reliable, efficient, effective, and environmentally sustainable waterborne transportation systems for movement of commerce, national security needs, and recreation. The challenge for the USACE is to provide an efficient, cost-effective way to achieve its missions, while simultaneously producing environmental and social benefits. USACE infrastructure and operations are currently viewed as often in conflict with environmental and social interests. The concept of Engineering With Nature (EWN) bridges two existing concepts: Working with Nature and Building with Nature. The concepts, principles, and practices associated with Working with Nature (as developed by the International Navigation Association, PIANC) and Building with Nature (as developed through a partnership between government and private sector interests in The Netherlands) support the development of navigation infrastructure. Both approaches stress maximizing the use of natural processes and generating environmental benefits. These ideas have garnered much support from navigation interests in many countries. The EWN concept calls for an ecosystem approach, whereby USACE, in collaboration with our partners and stakeholders, seeks to understand and use natural processes in order to achieve a broad range of project objectives within aquatic systems. EWN is also consistent with — and advances — the USACE Environmental Operating Principles, the USACE Campaign Plan, and the USACE Civil Works Strategic Plan (USACE 2002, 2010a, 2011). Incorporating an EWN strategy within the USACE will enable our navigation infrastructure to provide sustainable economic, environmental, and social benefits.

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[1] The phrase Engineering With Nature is being intentionally written using a capital "w" to emphasize the commitment of joining natural processes with engineering approaches.

Photo #1. A series of four chevrons along the Mississippi River. Chevrons are horseshoe-shaped structures that both guide river currents to keep the channel navigable and generate low flow pools and small islands immediately down-river, providing habitat for fish and other species.

TECHNICAL PRESENTATIONS: The workshop agenda created opportunities for advancing science, engineering, and operational practice, all of which focused on the expansion of environmental benefits from navigation infrastructure and operations. Discussions of relevant experiences, issues, and lessons learned (Appendix A) were the cornerstones of the agenda. Participants in the workshop were representatives from USACE Headquarters, USACE Engineer Research and Development Center (ERDC), academia, industry, and seven USACE Districts, including Chicago, Jacksonville, Mobile, New England, New Orleans, Seattle, and St. Louis (Appendix B). During the 1.5-day workshop, 15 technical presentations (Appendix C) were delivered on a broad range of issues related to identifying, developing, and quantifying environmental benefits associated with navigation, such as innovative engineering and operational practices, modeling, benefits quantification, and strategic communications. Each presenter was charged with introducing his or her respective concepts, projects, efforts, and achievements for his or her respective issue.

DISCUSSION: On the second day of the workshop, participants were divided into three breakout groups to discuss specific questions related to opportunities for and obstacles in the way of implementing the EWN concept. Each group was asked to answer the question "What are the biggest opportunities for USACE to advance EWN?" Each group also discussed one of three specific questions: 1) What gaps in science, technology, engineering, or organizational practice should be addressed to advance EWN? 2) What communication products are viewed as valuable to the EWN concept? and 3) What are the top four obstacles to implementation of the EWN approach and what steps can be taken to minimize those obstacles? The information presented below summarizes participant input during breakout group discussions.

What are the biggest opportunities for USACE to advance Engineering With Nature? Workshop participants identified a number of potential opportunities to advance EWN. Several participants indicated that an authentic cultural change within the organization was needed to further the concept of EWN. Participants indicated that cultural change could be accomplished by (1) incorporating an internal experimental framework; (2) producing reports demonstrating that USACE fully endorses the concept; and (3) identifying additional funding streams such as large-scale restoration programs. Another stated opportunity was implementing high profile pilot projects representing real-world examples whereby the USACE can "learn by doing." Existing navigation structures provide a more straightforward and near-term opportunity to demonstrate the EWN approach. For example, multiple chevrons, as constructed in the Mississippi River by the St. Louis District, (Photo #1) can be used to illustrate the repeatability or response of such structures under varying conditions (USACE 2010b). Also acknowledged was that the USACE has both the engineering and the scientific expertise to add EWN modifications to existing structures, and that better integration of these strengths provides a very good opportunity to advance the EWN strategy. Incorporating research more broadly into the planning, design, and construction of projects was noted as an opportunity. Sound research can be built into many district-level projects to advance knowledge of structural system response, materials, etc. There are projects that are fairly early in the development stage — e.g., Puget Sound, Mississippi River — that could offer partnership opportunities.

What gaps in science, technology, engineering, or organizational practice should be addressed to advance EWN? Workshop participants identified several potential gaps that, if not addressed, could hinder advancing the EWN concept with the USACE. There was a stated need for a comprehensive benefits assessment process, which should include traditional economics, non-traditional economics, social aspects, and ecosystem services components.

There is a need for tools and techniques that can (1) measure long-term performance of EWN projects; (2) assist scientists and engineers with assessing the interactions between navigation structures and nature, especially from an ecosystem-scale perspective; (3) help scientists and engineers make informed decisions in the face of complex management problems with multiple objectives; and (4) lead to flexible engineering designs. Involving material engineers was another stated need.

Successful EWN projects will require multi-disciplinary teams — including engineers and scientists — that can access information in other disciplines in spite of the fact that every discipline has its own, separate jargon. Ecological life-cycle assessment of design and material choices is needed. Testing designs for application under a broad range of locations will allow researchers to better understand how designs and materials can be used sustainably. Organizational practice can be improved by better communicating how EWN techniques that are working in one situation can be used in other situations as well.

What communication products are viewed as valuable to the Engineering With Nature concept? Communication is important when introducing a new concept and cultivating productive partnerships. Group responses indicated that strategic communication plans should be developed that would provide specific guidelines about how to best communicate the EWN concept. Developing strong ties with USACE leadership so they would serve as champions of the concept was viewed as important, as was promoting relationships with other ERDC personnel, district liaisons, and local sponsors. Building a travelling project delivery team that could canvass USACE and other partners to share the concept and suggest ideas for partnering and collaboration was also suggested. Multiple means of communication are needed so that those who are interested in the concept can obtain information. One means of communication would be a shared database — similar to the Knowledge Hub and SharePoint — that is externally accessible and user-friendly. USACE Communities of Practice (CoPs) would serve as gateways for internal EWN collaborations, particularly the Environmental and the Planning CoP. A travelling exhibit displayed at national conferences within the USACE and engineering communities could be used to disseminate EWN factsheets, brochures, etc. Communicating the EWN concept through technical presentations at USACE national meetings would be one way of communicating the EWN concept. As an organization, the USACE should readily share success stories through multiple channels, including a dedicated website. Non-traditional venues should also be explored — for example, social media outlets such as Facebook or YouTube — as a means of communicating to a broader audience.

What are the top three obstacles to implementing the Engineering With Nature approach and what steps can be taken to minimize those obstacles? Rather than identifying the top three existing obstacles, participants identified several categories of potential obstacles to implementing the EWN concept and steps to take to minimize these obstacles. Obstacles were organized into the general categories of funding, institutional constraints, technology, communications, and metrics.

Funding issues related to construction, repair and maintenance costs, cost sharing, operations and maintenance (O&M) pressures, and risk and uncertainty implications all were identified as potential impediments to implementation. For example, if an EWN project attracted an endangered species would the presence of that species impede our future ability to repair/maintain projects in a cost-effective manner? In such a case, early discussion among partners and local sponsors of such issues and potential contingencies should be encouraged to alleviate such concerns.

Institutional constraints, such as the challenges associated with interagency coordination, lack of trust between the USACE and stakeholders, and the "status quo" mindset, were all identified as potential implementation obstacles. Suggested mechanisms to overcome these constraints included agency-wide promotion and recognition of creativity and innovation so that creativity becomes part of the USACE culture, as well as the establishment of EWN performance goals at the district level. Obstacles related to technology issues, including a lack of research and development and technical support, were noted. Case studies are also needed for developing a technical knowledge base of EWN projects. USACE District employees should be educated as to the possibilities of incorporating the EWN concept into navigation projects, and interdisciplinary teams should be formed to help solve problems that may arise when attempting to incorporate the concept. Case studies of projects in which the concept has already been implemented should be documented and this institutional knowledge should be broadly communicated.

Under the topic of communications, a few potential hindrances were identified. Implementation of the EWN concept could be hampered by public perception of the effort and a lack of public relations knowledge transfer, interagency coordination, and education. One way of overcoming these issues is to revise the Coastal Engineering Manual (EM 1110-2-1100; *http://chl.erdc.usace.army.mil/cem*) to include guidelines for implementing EWN concepts in navigation infrastructure projects. Support for such changes can be accomplished by sponsoring USACE training programs, courses, and workshops. Interagency coordination goals should be developed to help broaden the support base.

A final potential obstacle identified by participants was the lack of available metrics that can be used to establish goals and measure success of EWN projects. Developing such metrics to be used as a routine part of USACE research can help to overcome such obstacles, while providing a meaningful way of quantifying EWN benefits and project success.

RECOMMENDATIONS: The EWN workshop provided an opportunity for exchange of knowledge and information about current research and real-life projects. The workshop also helped participants develop a strategy for advancing and implementing the principles of EWN within the USACE navigation program. Participants in the workshop identified relevant opportunities for improving future practices; opportunities that could ultimately shape the development of USACE strategies and next steps to take for pursuing the broader goals of EWN. As the workshop concluded, the major recommendations were articulated. These recommendations included:

- **developing strategic communication plans:** Implementing efficient public relations will be a key component of a successful communications plan. Various traditional and non-traditional communications tools are needed for widespread dissemination of informative materials (i.e., factsheets, brochures, presentations).
- **promoting the EWN concept and ideas:** A clear understanding of the EWN concept and ideas before engaging others and encouraging them to help us disseminate the concept is necessary. We need to begin promoting the concept at all levels, particularly at HQUSACE and federal resource agencies. Another way to promote the concept is to conduct meetings, workshops, and conferences. Pilot projects should also be undertaken.
- **marketing previous successes and learning from impediments:** Avenues for communicating successful past experiences (e.g., St. Louis District chevrons) should be developed. Documenting successes and issues will be essential to the advancement of the concept, as well as for staying informed about what the USACE and others are doing in this area.
- **documenting projects and opportunities:** The future of EWN research would benefit from the development of a series of highly visible projects. Documentation of these projects will be critical to the long-term success of broadly implementing the concept.
- **engaging others:** As USACE continues to implement this innovative approach in its projects, it will be important to build trust and strong relationships with organizations such as National Oceanic and Atmospheric Administration (NOAA), the US Fish and Wildlife Service (USFWS) and other federal, state, and local agencies.

POINTS OF CONTACT: For additional information, contact Cynthia Banks (601-634-3820, *Cynthia.J.Banks@usace.army.mil*) or Dr. Thomas Fredette (978-318-8291, *Thomas.J.Fredette@usace.army.mil*). This technical note should be cited as follows:

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Appendix A: Workshop Agenda

Engineering With Nature (EWN) Workshop

Tuesday, September 6

6:30 – 8:00	**Informal Meet & Greet Social:** Meet in Hotel Lobby at 6:15 pm

Wednesday, September 7

8:00 – 8:30	**Coffee and Registration**
8:30 – 9:00	**Welcome and Introductions:** Drs. Todd Bridges and Thomas Fredette, USACE-ERDC
9:00 – 9:25	**Engineering With Nature:** Dr. Todd Bridges, USACE-ERDC
9:25 – 9:50	**Environmental Enhancements and Navigation Infrastructure within the U.S. Army Corps of Engineers**: Dr. Thomas Fredette, USACE-ERDC
9:50 – 10:15	**Building with Nature: Challenges for sustainable development of surface water infrastructure**: Stefan Aarninkhof*, Anneke Hibma, Mindert de Vries, Martin Baptist, Gerard van Raalte and Mark van Koningsveld, Royal Boskalis Westminster nv, Papendrecht (The Netherlands) and EcoShape
10:15 – 10:30	**Coffee Break**
10:30 – 10:55	**Ecologically-informed engineering reduces loss of intertidal biodiversity on artificial shorelines:** Mark Anthony Browne, University College Dublin
10:55 – 11:25	**Breakwaters for the creation of Submerged Aquatic Vegetation habitat**: Evamaria W. Koch*, Nicole Barth, Dale M. Booth, Cindy Palinkas and Deborah Shafer, Horn Point Laboratory, University of Maryland, Center for Environmental Science
11:25 – 11:30	**Announcements**
11:30 – 1:00	**Lunch**
1:00 – 1:25	**Fish Passage Operations at Jim Woodruff Lock and Dam**: Brian Zettle, USACE-Mobile District
1:25 – 1:50	**The Manatee Pocket Dredging Project: Environmentally Beneficial, Sustainable, and Cost-Effective:** Michael P. Whelan*, David L. Stites, Kathy Fitzpatrick, and Larry T. Dale, Taylor Engineering, Inc.

1:50 – 2:15	**Building an Improved Weir Decanting System: Economical, Safer, Longer Life-Cycle and with Environmental Provisions:** Coraggio Maglio*, Justin Grover, and Fred McAuley, USACE-Jacksonville District
2:15 – 2:30	**Coffee Break**
2:30 – 2:55	**A New Look at Great Lakes Breakwaters. Can they be Greener?**: Dr. Burton Suedel, USACE-ERDC
2:55 – 3:20	**Closure of Rollover Pass, Bolivar Peninsula, Texas: Restoring Natural Conditions in a Major Texas Estuary:** David L. Stites*, Michael P. Whelan, Michael Trudnak, and E. Ray Newby, Taylor Engineering, Inc.
3:20 – 3:45	**Reservoir management to minimize mercury in fish: lessons from a hydropower storage basin:** Dr. Jody A. Kubitz, Cardno ENTRIX
3:45 – 4:10	**Review of Savannah River Dissolved Oxygen Conditions and Comparison to Biota Survivability Studies**: Russell Short, Geosyntec
4:10 – 4:35	**Environmental Sediment Management Structures on the Mississippi River:** Michael Rodgers*, Robert Davinroy, and Dave Gordon, USACE-St. Louis District
4:35 – 5:00	**Leveraging Water-Based Infrastructure to Maximize the Restoration of Coastal Ecosystems:** Mark O'Leary, JJR, Ltd.
5:00 – 5:25	**The Role of Multi-Criteria Decision Analysis (MCDA) in Project Development:** Dr. Burton Suedel, USACE-ERDC
5:25 – 5:30	**Wrap Up** • Recap Day 1 findings • Review agenda for Day 2

Thursday, September 8

8:00 – 8:15	**Coffee**
8:15 – 8:30	**Overview of the Day**
8:30 – 10:00	**Breakout Session**
10:00 – 10:15	**Coffee Break**
10:15 – 11:45	**Report out from Breakout Sessions**
11:45 – noon	**Closing Remarks and Adjournment**

Appendix B: EWN Workshop Participants

Name	Affiliation
Aarninkhof, Stefan	EcoShape
Baker, Kelsie	USACE-ERDC
Banks, Cynthia	USACE-ERDC
Bowers, Keith	Biohabitats
Bridges, Todd	USACE-ERDC
Browne, Mark	University College of Dublin
Carter, Eddy	GEC, Inc.
Clarke, Doug	USACE-ERDC
Corbino, Jeffrey	USACE-New Orleans District
Francese, Rebecca	Waterway Surveys & Engineering, Ltd.
Fredette, Thomas	USACE-ERDC
Grover, Justin	USACE-Jacksonville District
Koch, Evamarie	University of Maryland
Kubitz, Jody	Cardno Entrix
Lillycrop, Linda	USACE-ERDC
Maglio, Coraggio	USACE-Jacksonville District
Michalsen, David	USACE-Seattle District
O'Leary, Mark	JJR
Pope, Joan	USACE-Headquarters
Rayaprolu, Sirisha	USACE-Jacksonville District
Rodgers, Michael	USACE-St. Louis District
Rogers, Catherine	USACE-New England District
Shea, Charles	USACE-Chicago District
Short, Russ	Geosyntec Consultants
Stities, David	Taylor Engineering, Inc.
Suedel, Burton	USACE-ERDC
Tazik, Dave	USACE-ERDC
Vaccaro, Jack	Vaccaro Environmental Consulting
Wells, Brian	USACE-Charleston District
Whelan, Michael	Taylor Engineering, Inc.
Wilber, Dara	Bowhead
Zettle, Brian	USACE-Mobile District

Appendix C: Presentation Abstracts

Engineering With Nature: Enabling Efficient and Sustainable Delivery of Benefits through Optimal Alignment of Natural and Engineering Processes

Todd S. Bridges[1] and Jim Walker[2]
[1]USACE, Engineer Research and Development Center, Vicksburg, MS
[2]USACE, Headquarters, Washington DC

Since the 1970s, engineering and ecology have come together only in fits and starts, as illustrated by efforts to combine environmental engineering and ecosystem restoration over the last 40 years. No practice has been substantiated as a fully fledged solution, one capable of application across complex systems. With more recent advances in engineering and ecological science, these fields are ripe for integration now into a single approach for infrastructure development that can benefit all interests and stakeholders. We call such an approach "Engineering With Nature" (EWN). The key opportunity being sought through EWN is better engineering that collaborates with natural processes and forces in the development and operation of infrastructure.

Engineering With Nature in navigation represents a solution for a complex challenge, one characterized by shared and competing interests interacting in a time of increasing constraints and diminishing resources, with no significant relief in circumstances in sight.

Navigation remains essential to enabling individual and global economies. Natural and societal circumstances affecting environmental interests associated with navigation continue to collide in many regions. Prospects are worsening as climate change effects unfold. Cost and time pressures on a key enabler of navigation, dredging, are unremitting. Government policy, regulation and agency practices re-enforce a status quo that is increasingly unacceptable to many stakeholders and clearly out of phase with the state of the relevant sciences and technical disciplines.

Within this milieu, USACE infrastructure and operations are viewed as often being in conflict with environmental and social interests. Clearly, the USACE requires a more efficient, flexible, cost-effective and clearly sustainable means of achieving its missions that is in harmony with the highest interests of key stakeholders. Such a means must include working in ways that foster collaboration and cooperation with our partners and stakeholders. For navigation, these include Ports, commercial interests, the EPA, the NOAA, the FWS and NGOs. Doing so will build credibility in our leadership and capabilities among stakeholders required for mission success.
EWN can be thought of as the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits. Assuring safe, reliable, and cost-effective navigation is a timely focal point for its first application within the USACE.

EWN represents a cost-effective approach for enabling the navigation community to achieve sustainable navigation systems with increased safety and efficiency through harmonious alignment of navigation, engineering and ecosystem functions.

Broadly defined, Engineering With Nature is an action-oriented, results-producing approach that capitalizes on innovative science and engineering to achieve optimal performance of engineering systems in balance with natural processes. Narrowly defined, EWN is a structured approach for designing, implementing and maintaining projects guided by an integration of economic, environmental, social, science and technical objectives to yield sustainable positive outcomes. EWN is smart and right for the present times and the times ahead.

Environmental Enhancements and Navigation Infrastructure: A Study of Existing Practices, Innovative Ideas, Impediments, and Research Needs

Thomas J. Fredette, Christy M. Foran, Burton C. Suedel, Sandra M. Brasfield, Cynthia J. Banks and James H. Lindsay

USACE Engineer Research and Development Center
Environmental Laboratory
Vicksburg, Mississippi 39180

Navigation infrastructure projects all involve human management of some aspect of the natural environment such as current flow, channel depth, or linkages between waterways (e.g., dredged channels, locks, jetties, canals). While minimizing unintended and adverse impacts from such endeavors is the goal of environmental assessment, there are also environmental enhancements that can be incorporated into the design of projects; hence the concept of environment enhancements and navigation infrastructure (EENI). These potential features are more easily incorporated into the planning process when identified early. USACE policy (2009 Campaign Plan, 2002 Environmental Operating Principles) supports the concept of incorporating environmental design features as part of USACE projects, but realities associated with funding policies must also be factored into decisions to include such elements. The investigation we conducted focused specifically on navigation infrastructure elements, and sought to (1) identify existing and potential navigation project features designed with the express intent of enhancing environmental benefits; (2) identify laws, regulations, and policies (formulation boundaries) that both support and hinder such design features (3) identify opportunities for increasing environmental benefits for navigation projects within existing formulation boundaries; (4) propose potential changes to formulation boundaries that would further increase opportunities for environmental benefits; and (5) identify potential areas where research may increase the opportunity to integrate environmental features into future projects.

The study was conducted by surveying, interviewing, and engaging key individuals with knowledge of navigation, policy, and funding requirements both within and outside of USACE. This included introducing the concept in meetings with the USACE environmental planning chiefs, providing a presentation during a National Dredging Team conference call, providing email announcements, and on-line webinars. A 51-question on-line survey was designed to gather information on existing projects, views on constraints, and innovative ideas for design and research. For example, information obtained about existing projects identified similar initiatives focused on civil works projects, including the European EcoShape project and the Upper Mississippi River Restoration Environmental Management Program. The results of the study included research recommendations and policy development ideas from survey participants, which centered on potential improvements related to promoting the EENI concept, documenting existing projects, conducting pilot projects, prioritizing project sites, researching new ideas, developing EENI goals, seeking new funding mechanisms for EENI, maximizing use of coordination mechanisms, and developing interagency agreements. Study results generated will serve as an impetus to advance the concept of EENI and USACE environmental sustainability goals.

Building with Nature: Challenges for Sustainable Development of Surface Water Infrastructure

Stefan Aarninkhof[1,5], Anneke Hibma[2,5], Mindert de Vries[3,5], Martin Baptist[4,5], Gerard van Raalte[1,5] and Mark van Koningsveld[2,5]

[1] Royal Boskalis Westminster nv, Papendrecht (The Netherlands)
[2] Van Oord Dredging and Marine Contractors, Rotterdam (The Netherlands)
[3] Deltares, Delft (The Netherlands)
[4] IMARES, Wageningen (The Netherlands)
[5] EcoShape | Building with Nature, Dordrecht (The Netherlands)

Recent years have shown increased awareness of the environmental impacts (and possible benefits!) of surface water infrastructure works. This awareness is shared by a wide range of stakeholders, including government agencies, NGOs, private companies, and the general public. It has inspired the development of a 30-million-euro innovation program called Building with Nature, which started in 2008 and is carried out by a consortium of Dutch dredging contractors, consultancies, research institutes, universities, and government agencies. Driven by a genuine belief that things can be done better, the program aims for a paradigm shift in the field of coastal and marine engineering: To adopt nature as a starting point for the design and realisation of surface water infrastructure. Building *with* nature, rather than against.

Mid-2011 the programme is in full swing. A number of practical case studies are investigated in The Netherlands and abroad, such as the Sand Engine Delfland, ecological landscaping of a sand borrow area for the Maasvlakte-2 land reclamation, oyster reef stabilization of intertidal areas, sand import in the eastern Scheldt, adaptation of the Frisian IJsselmeer coast and innovative coastal defence measures in Singapore. All of these studies involve real-world pilot experiments, which generate a wealth of information for the development and validation of Building with Nature design strategies. Data and tools are stored in an Open Earth data system, to facilitate easy access and rapid exchange of information. Guidelines for project initiation, design, and realisation are developed and shared through and interactive wiki environment. Example results, with a focus on environmental sustainability and habitat development, will be discussed at the workshop.

We believe the use of Building with Nature strategies for the development of surface water infrastructure will inspire ecologists and engineers to maximally explore environmental benefits of projects; hence, add importantly to the ecological surplus and public appreciation of navigation infrastructure works.

Ecologically-informed engineering reduces loss of intertidal biodiversity on artificial shorelines

Dr. Mark Anthony Browne
IRCSET Post-doctoral Fellow
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Novel ecologically informed engineering reduces loss of intertidal biodiversity on artificial shorelines. Increasing coastal urbanization, growing populations, and environmental impacts of climatic change, are causing "pristine" biodiverse intertidal habitat to be replaced with expensive, but necessary, infrastructure. Experiments in Sydney Harbour manipulated the façades of featureless, species-poor seawalls by adding holes, cavities and experimental habitats to mimic rock-pools. Numbers of species increased by 110% in these engineered habitats. These advances provide new insights about habitats essential for survival of organisms on seawalls and show how creating artificial habitats on infrastructure increases urban biodiversity.

Breakwaters for the Creation of Submerged Aquatic Vegetation Habitat.

Evamaria W. Koch[1]*, Nicole Barth[1], Dale M. Booth[1], Cindy Palinkas[1] and Deborah Shafer[2]
[1]University of Maryland Center for Environmental Science, P.O. Box 775, Cambridge, MD 21613
[2]Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, MS 39180

The acceleration of sea-level rise has increased coastal erosion and, as a result, shorelines are being hardened at an increasing rate. Although the impact of structures like rip-rap, groins, and breakwaters on physical and geological processes is relatively well known, the impact on plants and animals is much less clear. This study evaluated the potential detriments and benefits of breakwaters to submersed aquatic vegetation (SAV) habitats in Chesapeake Bay. By reducing wave energy and longshore currents, breakwater-protected areas trap fine and organic sediment particles which decompose and release nutrients back into the water column, thereby fueling the growth of epiphytic algae on SAV leaves, eventually leading to their death. As a result, breakwater-protected areas are often unvegetated, especially after deposition of fine and organic particles over several years. When a source of sand is associated with the breakwater (e.g., sand deposited during construction or eroding sandy shoreline), the fine and organic particles that are deposited in the breakwater protected area are "diluted" by the deposition of sand, keeping the sediment enriched but not allowing it to reach toxic levels. Under such conditions, breakwaters can be beneficial for SAV. Under circumstances that lead to the excessive deposition of sand (e.g., tall, eroding cliffs), the breakwater-protected area becomes shallower over time and SAV transitions into marsh vegetation and ultimately terrestrial vegetation. Therefore, breakwaters can be used for SAV habitat creation but only if the balance between fine organic matter and sand deposition is maintained over time. Too little sand input leads to nutrient over enrichment and death of SAV due to excessive epiphytic growth while too much sand input leads to the loss of SAV in favor of intertidal and terrestrial vegetation.

Fish Passage Operations at Jim Woodruff Lock and Dam

Brian Zettle, USACE Mobile District

The construction of Federal and private dams in the Alabama-Coosa-Tallapoosa (ACT) and Apalachicola-Chattahoochee-Flint (ACF) River Basins have blocked historical migratory pathways for native fishes to access important spawning habitat. In an effort to restore access to previously available spawning habitat for Alabama shad, the US Army Corps of Engineers (Corps) has worked collaboratively with several other agencies to study fish passage opportunities at Jim Woodruff Lock and Dam in the ACF Basin. The Corps has participated in interagency study efforts over the past six years by incorporating operations that use the navigation lock to give the fish access to nearly 200 miles of previously inaccessible spawning habitat in the Flint and Chattahoochee rivers. Restoration of these and other migratory fish populations can improve the overall ecology of the ACF river system, Apalachicola Bay, and the Gulf of Mexico. Based on the ACF data analysis, the navigation lock technique has also been utilized at the Claiborne and Millers Ferry locks and dams in the ACT River Basin since 2009. These ongoing studies suggest that the locking technique could be used to help migratory fishes in other parts of the country repopulate from declines experienced after construction of Corps projects.

The Manatee Pocket Dredging Project: Environmentally Beneficial, Sustainable, and Cost-Effective

Michael P. Whelan, P.E., D.CE.* (1), David L. Stites, Ph.D.(1), Kathy Fitzpatrick, P.E.(2), Larry T. Dale, G.C.(3)

The Manatee Pocket Dredging Project, a successful, environmentally sustainable dredging project, benefits local navigation, infrastructure, and the environment in Martin County FL. The Pocket, a long, narrow estuarine embayment lined with marinas and homes, contained shoals of sandy and organic sediments affecting navigation and water quality. The permitted project design (used as the basis for the bid offering) included hydraulic dredging of potentially contaminated sediments, pumping of the dredge slurry through more than four miles of residential development to a confined disposal facility (DCF) at the end of a local airport runway. The permit required intensive batch testing of each truckload of sediment taken from the DCF to allow determination of appropriate sediment disposal (lined landfill disposal or commercial industrial use).

Dickerson Florida, the winning dredging contractor, met the project's goals of sediment removal, channel creation, development of submerged benthic habitat, and increasing the tidal flow with a lower risk, lower carbon footprint, higher reuse, and lower cost plan. Dickerson won the contract by identifying (1) a means to reduce the high concentrations of contaminants of concern at specific locations and (2) cost-effective alternatives to a very risky dredge material management plan. The solutions provided a safer, more reliable, more environmentally sound, and locally acceptable project.

Dickerson used a design-build approach to resolve project challenges at the proposal stage and submitted an alternate engineering plan with its bid. This approach required Dickerson to accept some failure risk at the bid and initial project stages but allowed the team to provide the county with a better project than identified in the bid offering. The engineering plan required Dickerson to collect additional field samples to clarify the distribution of the contaminants of concern and use that data to define a dredging plan mixing sediments with high and low contaminant concentrations to achieve industrial/commercial cleanup standards. The plan relocated the DCF to a safer, closer location (the Dickerson team had identified several acceptable locations at the proposal stage). Finally, a two-cell DMMA design allowed Dickerson to manipulate, if necessary, the sediment mix within the CDF in one section and use the second, downstream section to achieve the necessary turbidity levels before discharging the dredge water. The Dickerson plan required only one booster pump in the overland conveyance of the dredged sediments (compared to as many as four for the permitted plan) and eliminated the risk of a high pressure pipeline beside residences and roads.

Risk acceptance and engineering design work in the proposal phase paid off with a winning bid and approved permit modifications. All of the dredged sediments meet commercial industrial use standards. The overland pipeline route, about one mile long, reduced booster pump requirements from four to just one and eliminated costs to put the pipeline under residential driveways and roads. The smaller project allowed a shorter dredging period. These changes reduced the project carbon footprint, increased sediment reuse, and produced a local community very satisfied with the project results.

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Building an Improved Weir Decanting System: Economical, Safer, Longer Life-Cycle and with Environmental Provisions

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Navigation dredging is a primary business line for the USACE and much of the standard operations are viewed as rather simplistic. As technology has improved so should the standard operational systems, even if they have been working well for decades. Dredged disposal areas are the end of the line for much of this work; however, they are only as functional as their biggest bottle neck, the control structures. The Jacksonville District in the past few years has fundamentally changed their standard weir design from a corrugated half pipe riser system to a box riser weir system. This system upgrade includes redundant shop-fabricated, coal-tar, epoxy-coated, steel-box riser weirs, composite weir boards, floating docks for safer weir face access, emergency shutoff flap gates and continuously fused High Density Polyethylene Pipe outfalls. Permanently installed discharge outfalls and planting vegetation for shoreline stabilization can further reduce operational issues. This system change has halved initial installation cost, increased safety in monitoring and adjusting weir boards, tripled the life expectancy, and added emergency environmental shut-off controls.

A New Look at Great Lakes Breakwaters. Can They Be Greener?

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The overall goal of this effort is to increase application of environmental sustainability to the design and maintenance activities associated with Great Lakes breakwaters, jetties, and other navigation infrastructure. At present, when new structures are built or existing ones are maintained, the primary objectives are to meet the navigation safety objectives and minimize, to the extent feasible, adverse environmental impacts. Our study goal is to add an additional objective to such efforts to also look for opportunities to design or maintain the structures such that they provide better ecosystem habitat or achieve some level of greater sustainability. This would involve managers, planners, engineers, and ecologists taking some time to ask, "Could we be creative and do more for ecosystem services in addition to serving the primary project purpose?" Such creative efforts might involve adding design features to the structures that would enhance fish spawning habitat, create preferable species habitat or refuge, or serve other ecosystem needs. For example, adding short spurs to a jetty may increase habitat diversity and substantially increase use by certain species life stages, or adding a gravel apron in front of a rock breakwater might both absorb wave energy and provide fish spawning habitat.

The study approach involved (1) assembling an inventory of potential actions that could be conducted to add environmental enhancements to Great Lakes navigation infrastructure through interaction with regional experts; (2) classifying the existing navigation infrastructure; (3) developing a compatibility matrix of the potential actions and infrastructure classes; (4) developing a project geo-database; (5) conducting a screening demonstration; and (6) recommending possible pilot projects, especially in association with Great Lakes Areas of Concern (AOC).

Closure of Rollover Pass, Bolivar Peninsula, Texas: Restoring Natural Conditions in a Major Texas Estuary

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The Rollover Pass Closure Project, led by Taylor Engineering, Inc. and the Texas General Land Office (GLO), will close a manmade pass between the Gulf of Mexico and Rollover Bay/East Bay (part of the Galveston Bay system) in Texas. This unusual project will restore the natural ecosystem conditions in Rollover Bay and East Bay, and help improve air quality in the Houston Galveston Brazoria non-attainment zone.

The state of Texas constructed the pass in 1955, with the assistance of the US Army Corps of Engineers, at one of the lowest consistent grades on Bolivar Peninsula. As intended, the pass provided effective fish passage and shoreline recreational fishing. The pass also contributed to considerable environmental impact in the area. The pass has resulted in altered (increased) salinities in Rollover Bay and East Bay, has doubled the dredging necessary to maintain the Gulf Intracoastal Waterway (GIWW) Rollover Pass reach, and has eroded Kemp's ridley turtle nesting beach habitat west of the pass on Bolivar Peninsula. The pass currently spans 200 feet between failing sheetpile walls, ranges between 6 and 20 feet deep, and extends approximately ¼ mile between the Gulf and East Bay.

Hurricanes that pass near Bolivar Peninsula often push gulf waters across this section of the peninsula to Rollover Bay. The opportunity to close the pass came in 1999 when Hurricane Ike compromised the integrity of the sheetpile walls maintaining the pass and completely destroyed the town of Gilchrist (which had developed around the pass). The state developed a property buyout program and funded the pass closure project through the GLO.

The closure project, now in final design phase, will fill the pass with sediments dredged from the nearby GIWW, restore the local Gulf of Mexico and East Pass ecosystems to their former conditions, reduce dredging requirements in the GIWW, and return the area to its historic physical condition. The pass will largely eliminate the annual beach nourishment projects, required because of ongoing beach erosion downdrift (west) of the pass. The reduction in annual dredging will reduce by half emissions from GIWW dredging activities in the Rollover Pass reach of the system, which lies within an air quality non-attainment zone. Finally, pass closure will eliminate the need to maintain the pass infrastructure, which now needs replacement. The project's major negative impact is loss of recreational fishing opportunities. The GLO, with input from the local stakeholders, is planning (and will develop) new recreational infrastructure to replace the lost recreational area that currently exists.

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Reservoir Management to Minimize Mercury in Fish: Lessons from a Hydropower Storage Basin.

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Inorganic mercury from atmospheric deposition and other sources can be converted to methylmercury, an organic form by sulfate-reducing bacteria. Methylmercury binds to proteins in aquatic and marine animals, and biomagnifies in food chains. Top predators can receive sufficient exposures of methylmercury that result in adverse effects in water bodies where the mercury concentrations in water are present at trace (parts per trillion) levels. The speciation of mercury in water bodies is influenced by the sulfur cycle; specifically, reduction and oxidation reactions that occur when sediments are flooded or exposed to the atmosphere. The changing water levels of wetlands and reservoirs can alter the sulfur cycle in sediments and hydric soils; this affects mercury speciation and, in turn, mercury biomagnification. These linkages are relevant to understanding the behavior of mercury in managed water bodies such as reservoirs, stream systems with navigational locks and other water bodies that experience changes in water surface elevations in response to droughts and floods, in combination with the many other needs for water. In the Deer Lake Area of Concern, alterations in the hydraulic regimen have been used to minimize the net methylation of mercury in a former hydropower reservoir, and decrease the mercury content of top predator fish. This remedy was determined to be superior to others using the third generation Global Reporting Initiative (GRI G3) sustainably reporting procedure. Implementation of this remedy also improved the reservoir habitat for a cool water (walleye) fishery, and prevented mercury from being transported to a native brook trout stream and the coastal habitats and associated food webs in Lake Superior. Information from this complex system can be applied to sustainable management of other water bodies where mercury is a concern, especially stream and coastal systems in which hydraulic regimens are managed for navigation.

Review of Savannah River Dissolved Oxygen Conditions and Comparison to Biota Survivability Studies

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The Savannah River is the focus of extensive long-term studies in support of the Savannah Harbor Expansion Project (SHEP). Substantial concern exists regarding the environmental impacts resulting from changes in dissolved oxygen (DO) concentrations as a result of maintenance or new work dredging activities that occur in the navigation channel and at various port facilities. Portions of the Savannah River have been designated Essential Fish Habitat (EFH) by the South Atlanta Fishery Management Council and adopted by the National Marine Fisheries Service (NMFS) under the Magnuson-Stevenson Fisheries Conservation and Management Act (MSA). Protection of fisheries resources under MSA or the Endangered Species Act involves habitat management approaches, of which maintaining DO concentrations is considered an important parameter.

A research project was developed to evaluate the DO concentrations present in the Federal Navigation Channel and Turning Basin adjacent to Elba Island. The purpose of the investigation is to provide an indication of the DO levels that would be encountered during dredging operations in the months of June-September. These data will be useful in managing dredging operations in relation to important environmental conditions. DO measurements were collected at six (6) stations near Elba Island extending across the Savannah River. Measurements were obtained at five (5) feet (ft) depth intervals beginning at -5 ft and extending downward to near bottom which was a maximum of -45 ft. Data were collected beginning in mid-June 2011. Measurements were recorded approximately every two weeks. The DO measurements representing "natural conditions" will be compared to the results of laboratory biota DO survivability studies, which include striped bass. DO concentrations vary throughout the day and with water depth. In some instances, DO concentrations in the area of study of the Savannah River were below 4 milligrams per liter (mg/L). DO concentrations decreased with depth by roughly 0.5 mg/L from the surface interval to the near-bottom DO concentration. The striped bass laboratory studies exposed juvenile fish to DO concentrations of 2 mg/L, 3 mg/L, and 4 mg/L and monitored gill ventilation rates and prey consumption. Responses to those DO concentrations were used to define physiologically stressful conditions. At DO levels of 2 mg/L, striped bass larvae were often observed to remain motionless. At DO levels of 2 mg/L, prey consumption rates were half the number at 3 mg/L.

Environmental Sediment Management Structures on the Mississippi River

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For the past 20 years, the St. Louis District Corps of Engineers has proactively developed innovative river engineering structures that help ensure environmental sustainability on the Mississippi River. These structures are designed and implemented in both the main channel and side channels not only to ensure maintenance of the 9-foot navigation channel, but to create and provide aquatic habitat for a variety of important fish species. This talk summarizes the design development of these structures, and the ensuing physical and biological monitoring conducted before and after construction.

Leveraging Water-Based Infrastructure to Maximize the Restoration of Coastal Ecosystems

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Coastal habitat has been severely degraded or destroyed along most of the coasts from waterfront development, ports, marinas, dredging and pollution related to these activities. Public and private resources directly related to restoring coastal habitat are so limited that they can't be relied upon to restore even most of these losses. The challenge and opportunity, therefore, is to leverage resources targeted for non-environmental uses (e.g., dredging, navigation, shore protection, etc.) to benefit lost habitat and ecological processes. This paper proposes a process for determining habitats to restore or recreate based on an understanding of the historic character and extent of regional habitats proximal to a given project, balanced with what is possible and practical given the proposed project, and existing environmental factors. This paper uses several case studies from around the Great Lakes to demonstrate how habitat has been incorporated into projects funded for other uses, and summarizes obstacles to and recommendations for using this approach more widely.

Role of Multi-Criteria Decision Analysis (MCDA) in Project Development

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The USACE has developed a risk-informed decision-making approach that draws from the fields of risk and uncertainty analysis and multi-criteria decision analysis (MCDA). It provides an approach to defining attributes that capture a diverse set of objectives and establishing a set of preference weights that reflect the priorities of different stakeholder groups. Emphasis is placed on open communication with stakeholders to solicit their views on problems and opportunities related to project alternatives. To ensure that all such concerns are factored into project planning, MCDA can be used as a means to combine the results of technical analysis with value information obtained from stakeholders. Interactive meetings of stakeholders, experts, and decision analysts can be used to assign weightings to the metrics used for evaluating project alternatives. To illustrate how stakeholders can be integrated into project planning in this manner, two case studies, one related to dredged material management in Korea and a second related to post-hurricane Katrina project planning are presented. Such stakeholder engagement can be used as part of a broader decision framework to discover the nature of disagreements and spur additional analysis, study, and negotiation. A common resulting theme was that input based on local experience and knowledge was critical to a successful project.