ADAPTIVE MANAGEMENT THROUGH REGIONAL SEDIMENT MANAGEMENT

Linda S. Lillycrop[1], John W. McCormick[2], Larry E. Parson[3], and Monica A. Chasten[4]

ABSTRACT

The USACE initiated implementation of the Regional Sediment Management (RSM) Program in 1999 with the objective of optimizing the utilization of sediments and management of projects through a systems-based approach. The RSM program supports sustainable navigation and dredging, flood and storm damage reduction, and environmental practices in order to increase overall benefits and reduce lifecycle costs. RSM strives to enhance the planning, construction, and operation and maintenance of projects where the exchange of sediments would occur naturally. RSM is also a means to involve stakeholders to leverage resources, share technology and data, identify needs and opportunities, and develop solutions to improve the utilization and management of sediments. The main focus is to better understand the regional sediment transport processes through integration of regional data and application of tools which improve our knowledge of the regional processes, understand and share demands for sediment, and identify and implement adaptive management strategies to optimize use of sediments and streamline projects. Benefits of this approach are improved partnerships with stakeholders, improved sediment utilization and project management on a regional scale, improved environmental stewardship, and reduced overall lifecycle costs.

Keywords: Dredging, sustainable solutions, regional processes, optimize, sediment budget.

INTRODUCTION

The U.S. Army Corps of Engineers (USACE) has historically managed sediments and projects on a local scale rather than managing the region which encompasses the local projects and sediments. This approach may not consider the impacts of actions on adjacent projects or natural sediment transport processes at a regional scale. Additionally, this approach may not optimize the use of sediments within a region or consider the cumulative impact of multiple local actions on the region over a project lifecycle. Therefore, sediment management actions implemented within the boundaries of project, jurisdictional, or state scales may have resulted in induced erosion or sedimentation on adjacent areas, inefficient planning for dredged material management, and missed opportunities to more cost-effectively manage and use sediment resources (Rosati et. al, 2001).

To address these concerns, the USACE initiated the Regional Sediment Management (RSM) Program in 1999. RSM is a systems-based approach implemented collaboratively with other federal, state, and local agencies. The purpose of the program is to implement adaptive management strategies across multiple projects which optimize the use of sediment while supporting sustainable solutions to the navigation and dredging, flood and storm damage reduction, and environmental enhancement missions. While RSM strategies increase benefits, an additional goal is to reduce costs or collaborate with partners to share costs. For example, within the navigation mission area, RSM seeks to streamline dredging projects, reduce sedimentation, improve placement of dredged sediment, minimize re-handling of dredged sediment, and improve channel reliability. For the flood and storm damage reduction mission area, RSM strives to keep sediments in the littoral system to assist in reducing shoreline and streambank erosion thereby reducing the risk of infrastructure damages due to floods and storms. RSM also provides opportunities to dispose material for ecosystem restoration. All of these examples result in improving environmental habitat while optimizing the use of sediments (Lillycrop et al, 2011).

Historically, the RSM program has provided opportunities to evaluate and implement various RSM actions throughout USACE Districts as pilot projects. Districts have implemented RSM pilot projects with the objectives of improving sediment management practices and strategies within their region and providing lessons learned that will

[1] Program Manager, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, 441 G Street, NW, Washington, DC, 20314, USA, T: 202-761-1837, Email: linda.s.lillycrop@usace.army.mil.

[2] Research Hydraulic Engineer, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, 69 Darlington Ave, Wilmington, NC 28403, USA, T: 910-251-4157, Email: john.w.mccormick@usace.army.mil.

[3] Physical Scientist, US Army Corps of Engineers, Mobile District, 109 St. Joseph Street, Mobile, AL 36602, T: 251-690-3139, Email: larry.e.parson@sam.usace.army.mil.

[4] Project Manager, Operations Division, US Army Engineer District, Philadelphia, Wanamaker Building, 100 Penn Square East, Philadelphia, PA, 19109, USA, T: 215-656-6683, Email: monica.a.chasten@usace.army.mil.

benefit other districts and regions nationally. The actions underwent limited analysis and allowed the districts to implement a rational solution, followed by monitoring, performance assessment, and refinement, all key components to adaptive management. One of the major goals of the RSM program is to improve the efficiency in evaluating potential RSM actions that result in implementation of improved sediment management strategies in the short term. The pilot projects have resulted in significant advancements in technologies in the areas of data collection, management, and analysis; numerical modeling; web-based tools; and communications that have positioned the USACE to more efficiently and effectively implement regional approaches to improve our understanding of regional processes, share information and data, collaborate, and therefore improve decision making in the management of our sediments and projects.

RSM provides an avenue to improve communication and coordination within the USACE as well as with partners and stakeholders. The USACE Districts organize an in-house RSM Product Delivery Team (PDT) with members from across the District representing all entities with initiatives and actions relevant to optimizing the use of sediments. By communicating regarding upcoming projects, sediment challenges and needs, and understanding the sediment processes within the region, the PDT works together to identify, coordinate, and implement strategies to better manage sediment and projects. The USACE also communicates and coordinates with stakeholders and partners with an interest in improving the management of sediments by leveraging resources, sharing technology and data, identifying needs and opportunities, and developing and implementing solutions to improve the utilization of sediments and management of projects.

Benefits of the RSM approach are improved partnerships with stakeholders, optimized use of sediments within a region, improved project management on a regional scale, improved environmental stewardship, and reduced lifecycle costs. This paper discusses the RSM approach with an emphasis on the process to develop and implement RSM adaptive management strategies (Rosati et. al, 2001).

RSM STRATEGIES

The objectives in developing and implementing RSM strategies are to optimize the use of sediments where the exchange of sediments would occur naturally, keep sediments in the littoral system to benefit the shorelines and streambanks within a region, enhance the environment, and reduce sedimentation to assist with maintenance challenges downstream. Common strategies include reducing offshore disposal, bypassing sediments downdrift, nearshore placement or nearshore berms, utilizing confined disposal sites (CDF) sediments, environmental enhancements, reducing sedimentation, and linking multiple projects to accomplish optimizing the use of sediments within a region.

Reduce Offshore Disposal

Sediments dredged from navigation channels are often disposed offshore or in ocean disposal sites that are located outside of the littoral zone, in many cases several miles from the dredging site or shoreline. This disposal practice permanently removes the sediments from natural system, when they could otherwise be used for nourishing shorelines, streambanks, or other uses with a benefit to the environment. This practice is often not efficient or cost effective in comparison to the potential uses of the material in closer proximity to the dredging site. Transporting sediment offshore increases the time line and costs for a dredging operation due to the travel time to and from the disposal site and increased fuel, equipment, and labor costs.

Bypassing Downdrift

Bypassing sediments from jetty fillets, shoals, or navigation channels to downdrift beaches assists with mitigating downdrift erosion associated with inlets and harbors. The majority of bypassing is done in association with navigation dredging where sediment removed from the navigation channel or sediment trapped in updrift fillets associated with jetties is placed directly on downdrift beaches or in the nearshore zone. In addition to sediment bypassing as a mechanism to restore natural sediment transport patterns, the method is used to keep navigational channels and other harbor areas free from excess sedimentation in an effort to reduce maintenance dredging requirements. From an RSM perspective, improved sediment bypassing at inlets and harbors may provide significant benefits to the region as a whole (Clausner, 2000).

Nearshore Placement

Nearshore placement of dredged material provides the opportunity to keep sediments in the littoral zone to enhance nearshore profiles and/or beaches or facilitate marsh creation. Sediments can simply be placed in the nearshore to "feed" the littoral system, or a designed nearshore berm feature can be constructed that attenuates waves and serves as environmental habitat. Maintenance dredged material from channel entrances and ebb shoals is generally not considered beach quality (>88 percent sand), but often includes about 60-80 percent sand. When placed in the nearshore surf zone, the fines and sand particles naturally disperse with the sand remaining in the littoral system and transporting downdrift and onshore (Smith, E.R., and Gailani, J.Z., 2005). Placing beach quality dredged material in the nearshore rather than direct beach placement is becoming a more common practice due to the increasing costs and timelines to meet permit and monitoring requirements. The nearshore placement disposal option reduces the use of limited-capacity confined disposal sites and offshore disposal sites and reduces costs due to decreased dredge mobilization/demobilization and decreased hauling or pumping distances. Linking the navigation channel dredging with beach nourishment or nearshore placement provides a least cost solution while providing benefits to the region (Williams and Prickett, 1998).

Confined Disposal Facilities

Three management alternatives for dredged material currently exist: open-water disposal, confined (diked) disposal, and beneficial use (USEPA/USACE, 2004). Dredged material Confined Disposal Facilities (CDFs) are a major capital and operating investment for the USACE; however, they need to be managed to maximize the useful life of the facilities which includes economic, material, and manpower resources. The finite and dwindling storage capacity of CDFs is expected to present major challenges to the Corps navigation and dredging mission in the future. By identifying alternative strategies which utilize the sediments for environmental enhancement or to provide a resource to the region to reduce erosion or other natural sediment needs, RSM practices can assist with increasing CDF capacity by using material in CDFs or reducing the volume of material placed in CDFs. Recovering material in a CDF requires that the material meet the physical and chemical requirements for the intended use, and both the CDF and targeted material within the CDF must be accessible. Therefore, optimizing use of the material before it is placed in a CDF eliminates the need and expense to recover the material in the future (Bailey et al, 2010).

Environmental Enhancements

Additional benefits of implementing RSM strategies are the resulting enhancements to the environment. Examples include reinforcing natural berms that protect freshwater lakes or wetlands from saltwater intrusion; placing sediment behind an island to mimic historic natural overwash; placing sediment to enhance habitat for nesting shorebirds, seat turtles, beach mice or create bird islands; and placing sediments in the nearshore to create fishery habitat. Sediments are also used for wetland restoration when appropriate sites are located and stakeholders assist with coordination and costs. There are a number of threatened and endangered species that benefit from restored habitat under RSM (Rosati et. al, 2001; Brandreth, 2008).

Reduce Sedimentation

While RSM seeks to optimize the use of sediments to assist with natural sediment processes, RSM also seeks to reduce sedimentation or sediments at the source in an effort to assist with the challenges in managing the sediments downdrift. Through application of numerical models and tools, we better understand the sediment processes and can identify opportunities to reduce sedimentation in harbors and navigation channels, optimize permeable or low crest elevation of structures which influence erosion or shoaling, reduce runoff sediments into riverine systems, divert sediments in rivers and streams, close small tributary, drainage canals or creeks which provide a substantial quantity of sediments, catch upstream sediments through sediment traps, construct deposition basins to increase the time between dredging cycles, etc. RSM practices should be considered in the project planning process to consider potential impacts of sedimentation on adjacent projects as well as within the region.

Linking Multiple Projects

RSM provides the opportunity to comprehensively evaluate multiple projects within a region to determine best management practices for utilizing and improving the management of sediments. However, the phasing, contracting, and funding associated with linking multiple projects can be difficult. The RSM program seeks to identify and resolve these challenges in advance to that opportunities to coordinate actions across multiple projects are not missed. Coupling of navigation projects and adjacent storm damage reduction projects is one of the most obvious RSM strategies. In addition to taking advantage of navigation dredged material as a valuable resource for beach nourishment, the shared costs between funding sources and reduced dredge mobilization/demobilization costs are significant. Additionally, coupling projects provides the opportunity to combine permit actions, reduce overall project timelines, and improve relationships and collaboration across the region encompassing the projects. RSM evaluations should be performed to identify the range of options available in order to minimize costs while meeting acceptable project performance, thus optimizing use of sediments. The linking of adjacent or multiple projects within a region should be considered to leverage resources, whether to take advantage of dredge fleet availability, optimize sediment resource usage, or regional permitting.

RSM APPROACH

The RSM approach, Figure 1, is an iterative process incorporating adaptive management to use lessons learned to improve long term management while achieving short-term goals. The steps to implement the RSM approach are outlined in the flow chart, Figure 2, and described in the following paragraphs. The process begins by gaining a better understanding of the region through integration of regional data and application of tools that improve our knowledge of the sediment sources and sinks as well as the demands for sediment. A regional sediment budget is commonly developed to provide a conceptual and quantitative model of the magnitudes and pathways of sediment transport at inlets and beaches for a given time frame (Rosati and Kraus 1999, 2001). With this information, the USACE and partners identify RSM adaptive management strategies to optimize use of sediments within the region. The strategies are evaluated through application of decision support tools that utilize the best available science and engineering. The USACE and partners coordinate permits, agreements, schedules, etc so that implementation of the strategies are "Dredge Ready" when funding becomes available (Arden and Kraus 2010). Once a strategy is implemented, the performance is monitored and evaluated to determine whether the action behaves as predicted. If the strategy performs as predicted, the action is incorporated as standard practice. If the strategy does not perform as planned, adaptive management approaches are used to modify and implement a revised strategy. The revised action is monitored and evaluated. This cycle continues until a balance between efficient project performance and project constraints are reached.

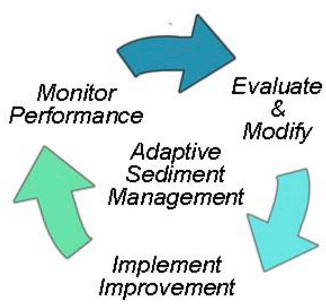

Figure 1. The RSM approach.

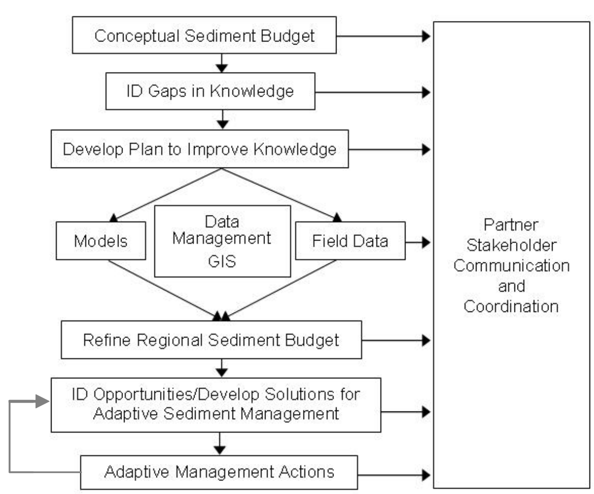

Figure 2. Steps for implementing regional sediment management approach.

Step 1: Understand the Region

The first step in the RSM process is to develop a conceptual regional sediment budget. A sediment budget is the primary tool for RSM because it identifies the sediment sources and sinks, or gains and losses, engineering activities, the sediment transport pathways, and the beach and bathymetry changes over the region. This information is the bases for understanding the sediment related challenges and formulating solutions to optimize the use of sediments to meet those challenges. Information and data needed to develop a conceptual sediment budget is obtained through a literature review of studies, projects, and other available information. The conceptual sediment budget also provides an understanding of the gaps in information, or areas lacking in information and data, therefore providing a focus for moving forward in better understanding the region.

Step 2: Collaborate; Establish Partnerships

The key to a successful RSM program is the communication, coordination, and involvement of partners and stakeholders who have an interest in improving the management of sediments within the region. Reaching out to partners in developing the conceptual sediment budget can lead to a wealth of additional information, data, and knowledge. Partners help in identifying sediment related problems, work to identify solutions, and ultimately help make decisions to better manage the region. A lesson learned is to bring partners and stakeholders into the program early to initiate communication and to begin to develop an understanding of the needs and opportunities of all participants (Lillycrop et al., 2003). Bringing together several organizations to collaborate on the management of a region can be initially difficult because every organization has a different need or goal depending on their mission. By communicating, working together, and a willingness to compromise for the advancement of the region, solutions can be developed and implemented which meet the many needs of a region. Coordination and communication is accomplished through regional meetings, workshops, conference calls, webinars, and sub-groups assigned to work through specific challenges.

Step 3: Develop a Plan to Improve Knowledge

Through the conceptual regional sediment budget, the gaps in knowledge, information, and data are identified, as well as a general understanding of the sediment needs and challenges over the region. Through communication with partners and stakeholders, a strategy is developed to fill the gaps and refine the conceptual sediment budget. In developing the strategy to improve regional knowledge, a lesson learned is that successful implementation of RSM requires application of engineering tools appropriate for regional management and analysis. Regional engineering tools include: 1) the regional sediment budget including micro-budgets at sub-regional and project levels; 2) numerical models to evaluate hydrodynamic conditions, sediment transport, and shoreline change at regional, sub-regional, and project scales; and 3) a data management and Geographic Information System (GIS) for managing and storing historic and new data, performing analysis of data and model results, and sharing of information and data. Each tool requires contemporary and historical data sets for input and analysis. Data collection should support filling data gaps in order to provide comprehensive regional datasets. Ideally, continuous synoptic surveys are available on a regional scale. Through this effort to refine the conceptual regional sediment budget, our knowledge of the hydrodynamic and sediment transport processes occurring over the region is greatly improved (Lillycrop et al., 2003).

Step 4: Collect or Obtain Regional Data

Effective implementation of RSM practices requires regional datasets for developing sediment budgets, application of numerical models, and to analyze and understand the morphologic changes along the shoreline resulting from offshore forcing. The following data are necessary to perform regional coastal processes management: 1) hydrodynamic and meteorological data: waves, water-levels, currents, winds, and storm data; 2) historic bathymetric, topographic, and shoreline data; 3) regional, continuous, current, and synoptic bathymetric and topographic surveys; 4) georeferenced/ortho-rectified aerial photography and/or satellite imagery; and 5) historical dredging information and data (Lillycrop et al., 2003).

Repeat regional data sets are necessary for quantifying the topographic and bathymetric volume changes integral to the creation of meaningful sediment budgets and to understand the morphologic changes resulting from various forcing. Recognizing this need, data collection technologies have emerged to enhance coverage (ie. jet skis, all terrain vehicles, lidar surveys). Data collection efforts have expanded beyond project boundaries and often combine multiple projects.

Step 5: Data Management, Analysis, and Visualization

Early in the RSM program it was recognized that moving from project level to regional datasets requires a data management system to adequately manage, analyze, archive, and share the large volume of data acquired across the region. The system would require a standardized architecture to maximize the sharing of data and applications across various organizations, and eliminate duplication. The result was the eCoastal enterprise GIS for RSM which provided an interface to hydrographic, topographic, photogrammetric, and historic dredge material data as well as custom applications designed to facilitate engineering analyses. The eCoastal GIS serves as the link between data management, engineering analyses, regional numerical models, and stakeholders (Wozencraft et al, 2001). For example, information such as beach profiles, navigation project surveys, aerial photos and dredging records comprise the historic data for comparison with baseline data established in 2000. These data will be instrumental in calibrating and verifying the sediment budget.

Step 6: Regional Numerical Models

After an understanding and quantification of the regional sediment pathways and magnitudes has been developed through data analysis and formulation of the regional sediment budget, numerical models are often applied. Numerical modeling can give insights to understand storm and seasonal processes that are averaged in the longer historical analysis, and applications can assess the implications of proposed engineering activities on the local project area as well as cumulative changes of the proposed projects (and possibly other projects) in the littoral system.

Step 7: Analyze Data and Revise Regional Sediment Budget

Evaluating the success of previous RSM activities and relative merits of proposed alternatives requires assessment of historical data including shoreline and bathymetric volume change, analysis of engineering activities, and formulation of a regional sediment budget. Key to the RSM approach is the need to evaluate data and improved strategies on a regional spatial scale that is commensurate with the littoral sediment transport system over longer temporal scales that range from years to multiple decades.

The regional sediment budget represents the long-term, best estimate of sediment transport, engineering activities, and bathymetric and topographic change over a defined period of time (years to decades). As implied by the term "budget", the sediment budget is intended to balance sources and sinks of sediment with known engineering activities and observed volume change within the region. However, an unbalanced budget can provide information about areas needing additional data to improve understanding or resolve conflicting information. Since inception of RSM practices within the USACE over the past decade, sediment budget visualization and presentation methods have progressed to include free PC-based software and GIS applications that facilitate a standardized format.

Step 8: Collaboratively Develop and Implement Adaptive Management Strategies

Early in the Mobile District implementation of RSM, the District focused efforts on prioritizing those projects and associated issues that could be addressed to quickly realize the benefits resulting from the RSM approach. The experience gained from these initiatives continues to be extended and applied to other projects. The Mobile District completed the 8 Step RSM approach, including taking action to implement RSM strategies on several pilot projects, within a 3-year timeframe. Through the RSM approach, the Mobile District identified five primary initiatives as the main focus: 1) Perdido Pass, 2) Pensacola Harbor (Fort McRee), 3) East Pass (Norriego Point), 4) St. Andrews Inlet (Gator Lake), and 5) beneficial use of dredged river sand from the Apalachicola River to nourish Alligator Point, FL. Sediment management challenges were identified and alternatives considered for improved utilization and management of sediments. The intent was to implement a change, develop a monitoring scheme, and evaluate benefits linked to improved project performance. When initiatives are implemented that maximize regional benefits, these changes will then be permanently incorporated into management practice. If significant benefits are not realized as a result of the initiative, then a modified or different alternative will be considered and the process repeated. This approach is critical towards improving the design, maintenance, and overall regional management practices across the region (Parson and Rees, in publication).

Case Study: Perdido Pass, Alabama

The objectives of the Perdido Pass RSM strategy were to reduce erosion downdrift thereby enhancing the storm protection along the shoreline, reduce rehandling of material that returns to the pass, and optimize sand bypassing resulting in reduced O&M and overall lifecycle costs (Parson and Rees, in publication).

Perdido Pass is a federally authorized navigation project located along the Alabama coast in the northern Gulf of Mexico (Figure 3). The pass is a natural tidal inlet stabilized by two rubble mound jetties constructed in 1968-69. The east jetty was constructed with a weir section that allows transport of littoral sediments to the deposition basin located between the east jetty and the navigation channel. Maintenance dredging is conducted on a 3-year cycle with approximately 267,610 cubic meters (CM) 350,000 cubic yards (CY) dredged per cycle. Since 1971, over 4.6 million CM (6 million CY) of sediment has been dredged from the navigation channel and deposition basin, and placed in the six disposal areas (DA) shown in Figure 4. Prior to RSM, DA6 and DA7 were the primary sites used. About 22,938 to 45,876 CM (30,000 to 60,000 CY) were placed in DA6 to keep the jetty base from flanking with the shoreline. The volume placed in DA7 varied between 76,460 and 229,380 CM per cycle (100,000 and 300,000 CY per cycle) depending on the amount of beach erosion that occurred between each cycle. However over time, DA7 gradually filled with more disposal occurring than was being removed through littoral processes. When insufficient disposal capacity was available, alternative site DA1, a littoral zone disposal area west of the pass, was used. When using this site, extensive down time occurs due to the rough sea conditions and the requirement to use a spill barge in the unprotected littoral zone site (Dyess, Memorandum For Record). Use of the six DAs resulted in the majority of sandy material permanently removed or slow to return to the littoral system, and a portion of the material placed adjacent to the west jetty returned to the navigation channel resulting in rehandling during the next dredging cycle. Additionally, the beaches downdrift of the pass were experiencing erosion (Parson and Rees, in publication).

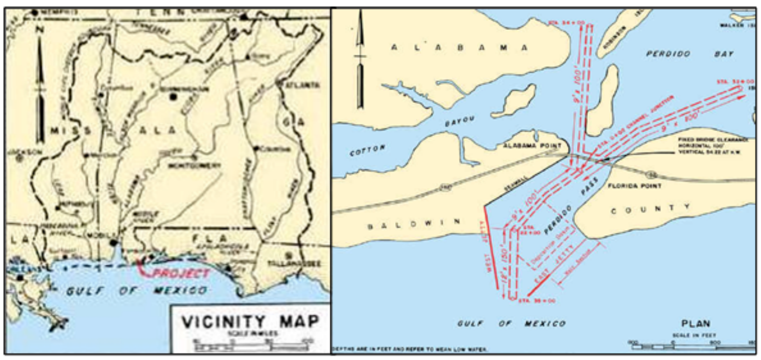

Figure 3. Perdido Pass, Alabama.

Figure 4. Perdido Pass disposal areas.

RSM Evaluation and Analysis

The efficiency of past bypassing practices at Perdido Pass were investigated through a geomorphic examination of nearshore bathymetry data in the vicinity of the Pass, analysis if imagery (Figure 5), and through application of numerical models for nearshore wave transformation and shoreline change (Figure 6). The intent of the investigation was to determine if dredging and placement practices at Perdido Pass could be modified to achieve more effective sand bypassing and to estimate the minimum discharge distance needed to prevent rehandling of bypassed material (Gravens, 2003).

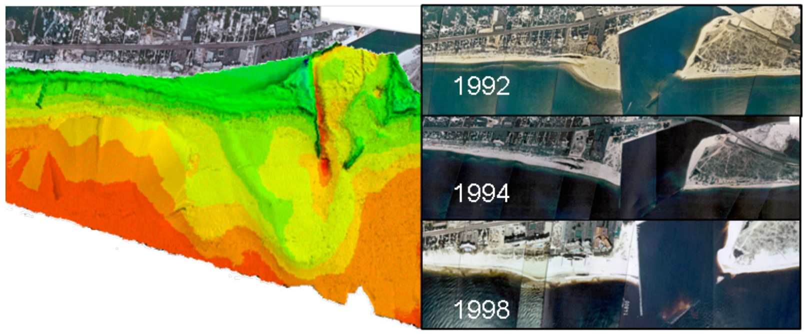

Figure 5. Perdido Pass nearshore bathymetry data and imagery.

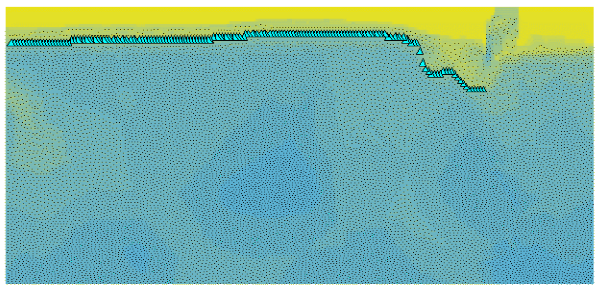

Figure 6. Numerical model grid and save stations.

The geomorphic examination quantified the form of the ebb tidal shoal and the downdrift distance to the shore connection of the bypassing bar. Representative incident wave conditions were transformed to near-breaking conditions using the steady-state spectral wave model STWAVE (Smith et al, 1999). These near-breaking wave data provided the environmental forcing necessary to drive the shoreline change model GENESIS (Hanson and Kraus, 1989). The GENESIS model together with Wave Information Study (WIS) hindcast wave estimates, the STWAVE output and shoreline position data were used to estimate shoreline change and the evolution of bypassed material placed at various distances west of the west jetty at Perdido Pass. Multiple simulations of the typical 2-year bypassing cycle were performed and results were inter-compared to develop recommendations for modifying bypassing practices at Perdido Pass (Gravens, 2003).

Recommendations

To improve sand bypassing, it was recommended that DAs 1, 3, 4, and 7 no longer be used since these sites permanently remove sediment from the littoral system. The evaluation of the Pass recommended that material be placed downdrift at a distance beyond the influence of the ebb tidal shoal; therefore maximizing sand retention and minimizing sand returning to the navigation channel. However, some material must continue to be placed in DAs 2 and 6 to maintain the structural integrity of the jetties. To maximum benefits, direct beach placement was recommended. Additionally, monitoring the performance of the action is recommended to evaluate the behavior and movement of sediment management actions. Through execution of the monitoring plan and subsequent analysis of the monitoring data, knowledge gained will assist in making better project management decisions for determining the optimum placement of maintenance material for maximum return to the littoral system (Gravens, 2003).

Implementation

Through coordination with Operations, Planning, and Engineering within the Mobile District, the resource agencies, and the project stakeholders and sponsors, the initiative was implemented in the fall and winter of 2002 to 2003. About 328,778 CM (430,000 CY) of sand was dredged from the navigation channel with 305,840 CM (400,000 CY) placed on the downdrift beaches west of the Pass and 30,000 CY placed in DA6. The project was monitored to assess the performance of the placement strategy with documented lessons learned. Through implementation of this RSM strategy, the west beach disposal site was expanded a 4.8 km (3 mi) distance from the west jetty (new DA8), providing the ability to place sediment farther downdrift and eliminated the need to use the littoral zone site, DA1 (Parson and Rees, in publication). It is estimated that this RSM strategy results in a cost savings of $300,000 per dredging cycle (3-years) or an annual savings of $100,000 (Dyess, Memorandum For Record).

Benefits of this initiative were more efficient sand bypassing associated with maintenance activities which contribute to alleviating coastal erosion downdrift; a reduction in material which returns to the pass which reduces rehandling; and wider downdrift beaches which increases habitat for sea turtles and shore birds, and augments natural dune creation which is beneficial for dune dwelling organisms and provides greater storm protection. Educating the public through outreach activities improved cooperation from private property owners. This adaptive management strategy has been incorporated as standard practice in the management of sediments at Perdido Pass (Parson and Rees, in publication).

Hurricane Ivan 2004

Hurricane Ivan was one of the most destructive hurricanes to impact the Alabama and Florida Panhandle coasts in recorded history. Ivan made landfall in Gulf Shores, AL, approximately 24.1 km (15 mi) west of Perdido Pass on September 16, 2004. At landfall, the hurricane was a Category 3 storm with maximum sustained winds of 209 kph (130 mph). Storm surge was estimated at 3.4 to 4.3 m (11 to 14 ft) Mean Sea Level and peak wave heights were estimated at 16.2 m (53 ft) approximately 101.4 km (63 mi) offshore. These conditions resulted in extensive erosion along the Alabama and Florida Panhandle shoreline. At Perdido Pass, approximately 428,176 CM (560,000 CY) of sand transported from Florida Point, located east of the pass, into the Perdido Pass navigation channel and back bay. Prior to Ivan the Florida Point dune and berm system provided environmentally sensitive habitat for least terns, piping plovers, the Perdido key beach mouse, and sea turtles. Through Emergency hurricane appropriations, material in the shoaled navigation channel were hydraulically dredged and placed to restore the environmentally sensitive habitat within the Gulf State park area east of the pass. Project coordination initiated in November 2004 with dredging and placing about 428,176 CM (560,000 CY) commencing and completing in February 2005 and March 2005, respectively.

RSM Coordination and Permits

Through the ongoing RSM coordination and collaboration with stakeholders at Perdido Pass, the timeframe for coordination and developing the scope of channel dredging and environmental restoration was greatly reduced. The multi-agency team was established and assembled in December 2004. An adaptive management approach was used throughout the project with stakeholders keeping in close contact to manage issues as they arose. Various on-site coordination meetings were held from January 2004 through completion of the project in late March 2004. The collaboration and commitment of all agencies involved and the data and information required for the planning and implementation would not have been possible without the RSM coordination and success ((Haubner, et al, 2010).

CONCLUSIONS

RSM within the USACE has evolved since the initial implementation in 1999. Our technical capabilities have enhanced from the project to regional and national scales, providing the ability to evaluate and implement actions to improve the utilization and management of sediments. Adaptive management practices provide the opportunity to try new strategies and revise those strategies to reach a balance between efficient project performance and project constraints. With advancements in data management, coastal process modeling, and improved coordination, the RSM program provides the potential to implement RSM actions in time scales on the order of dredging cycles. Collaboration and coordination with partners and stakeholders has advanced RSM as standard practice among many organizations. The RSM program continues to flourish in meeting the objectives to optimize the utilization of sediments and management of projects and implement adaptive management strategies across multiple projects which support sustainable navigation and dredging, flood and storm damage reduction, and environmental practices which increase benefits while reducing costs.

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REFERENCES

Arden, H.T., and Kraus, N.C. (2010). "Proactive strategy for "dredge-ready" operation and maintenance at low-use navigation projects." Coastal and Hydraulics Laboratory Engineering Technical Note ERDC/CHL CHETN-IV-75, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Bailey, S.E., Estes, T.J., Schroeder, P.R., Myers, T.E., Rosati, J.D., Welp, T.W., Lee, L.T., Gwin, W.V., and Averett, D.E. (2010) "Sustainable confined disposal facilities for long-term management of dredged material." DOER Technical Notes Collection ERDC TN-DOER0D10. U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Brandreth, M.B, (2008). "Innovative Creation of Piping Plover Habitat at the Cape May National Wildlife Refuge, Cape May, NJ," USACE Planning Community of Practice Conference, Galveston, Texas.

Clausner, J. (2000). "Sand bypassing cost and performance database," Coastal and Hydraulics Laboratory Engineering Technical Note ERDC/CHL TN-II-41, U.S. Army Engineer Research and Development Center, Vicksburg, MS. .

Gravens, M.B., (2003). "Sediment management at Perdido Pass, Alabama," Proceedings Coastal Sediments Conference 2003, St Petersburg, Florida, May 19-21, 2003.

Hanson, H., and Kraus, N.C., (1989). GENESIS: Generalized Model for Simulating Shoreline Change, Report 1, Technical Reference. Technical Report CERC-89-19, U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS.

Haubner, D., McMillen, R., Chasten, M., Lillycrop, L., and Williams, G. (2010). "Emergency beach-fill procedures: Lessons learned following the 2004 hurricane season." Coastal and Hydraulics Engineering Technical Note ERDC/CHL CHETN-II-52. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Lillycrop, L.S., Rosati, J.D., Wozencraft, J.M., and Dopsovic, R., (2011). "Advancement of technologies for practicing Regional Sediment Management." Proceedings Coastal Sediments Conference 2011, Miami, Florida, May 3-6, 2011.

Lillycrop, L.S., Wozencraft, J.M., Hardegree, L.C., Dopsovic, R., and Lillycrop, W.J. (2003). "Lessons Learned in Regional Sediment Management: The Mobile District Demonstration Program Technical Program Implementation," Coastal and Hydraulics Laboratory Engineering Technical Note, CHETN-XIV-13 2003, US Army Engineer Waterways Experiment Station, Vicksburg MS.

Parson, L.E., and Rees, S.I. (in publication). "Northern Gulf of Mexico RSM demonstration program initiatives," Coastal and Hydraulics Laboratory Engineering Technical Note, CHETN-XIV-xx, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Rosati, J. D., and Kraus, N. C. (1999). "Sediment Budget Analysis System (SBAS)," Coastal Engineering Technical Note CHETN-IV-20, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Rosati, J.D., and Kraus, N. C. (2001). "Sediment Budget Analysis System (SBAS): Upgrade for regional applications," Coastal and Hydraulics Laboratory Engineering Technical Note ERDC/CHL CHETN-XIV-3, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Rosati, J.D., Carlson, B.D., Davis, J.E., and Smith, T.D. (2001). "The Corps of Engineers' National Regional Sediment Management Demonstration Program." Coastal and Hydraulics Laboratory Engineering Technical Note ERDC/CHL CHETN-XIV-1, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Smith, E.R., and Gailani, J.Z. (2005). "Nearshore placed mound physical model experiment." DOER Technical Notes Collection ERDC TN-DOER-D3, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Smith, J.M., Resio, D.T., and Zundel, A.K., (1999). STWAVE: Steady-State Spectral Wave Model, Report 1, User's Manual for STWAVE Version 2.0. Instruction Report CHL-99-1, U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS.

U.S. Environmental Protection Agency/U.S. Army Corps of Engineers (2004)."Evaluating environmental effects of dredged material management alternatives - a technical framework." EPA842-B-92-008, Washington, DC: U.S. Environmental Protection Agency and U.S. Army Corps of Engineers.

Williams, G.L., and Prickett, T.L. (1998). "Considerations for planning nearshore placement of mixed dredged sediements." DOER Technical Notes Collection ERDC TN-DOER-N3, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

CITATION

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