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The U.S. Army Corps of Engineers' Coastal Inlets Research, with Special Reference To Shore Bird Habitat

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PURPOSE: The Coastal Inlets Research Program (CIRP) has the mission to advance knowledge and predictive technology to reduce the cost of dredging, promote navigation channel reliability, and quantify the sediment-sharing interactions between inlets and adjacent beaches. Guidance, numerical models, and desktop tools developed by CIRP can be applied to better understand and predict the ecologic viability of the inlet system for the shore bird population. This technical note is directed towards highlighting CIRP and related research products in the System-Wide Water Resources Program (SWWRP) that can readily be applied or adapted to evaluate existing and predict future bird habitat.

BACKGROUND: The U.S. Army Corps of Engineers has a mission to maintain the navigability of Federal coastal and inland channels. Coastal inlet systems can be dynamic and hazardous, requiring dredging of coastal channels to prevent excessive shoaling. CIRP[1] is supporting the Corps, private industry, and academia in addressing engineering and science problems at coastal inlets. Progress is reported on the CIRP Web site (http://cirp.wes.army.mil/cirp/cirp.html), which describes CIRP activities, contains publications for downloading, and gives directions on how to obtain or access products and technology such as models, analysis procedures, and data.

Research and development in CIRP covers field data collection, numerical modeling, physical modeling, lessons learned, and basic research on hydrodynamics (waves, currents, water level), sediment transport, and morphology change as required to progress in the product-oriented applied research. This SWWRP technical note highlights CIRP products of potential interest to the ecological community for evaluating existing and predicting future coastal habitat. Of particular relevance for breeding and nesting of some types of shore birds is the availability of unvegetated sediment, whether created by breaching and new inlet formation, development of inlet shoals, and placement of dredged material.

OVERVIEW OF CIRP AND RELATED RESEARCH: CIRP is being conducted at the U.S. Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL). CIRP collaborates with other Corps research programs to leverage funds and avoid duplication. Two such programs are the Dredging Operations and Environmental Research (DOER) program (http://www.wes.army.mil/el/dots/doer/), where fine-grained sediment transport is investigated, and SWWRP (https://swwrp.usace.army.mil) that has a direct link with

[1] Adapted in part from Holliday, B., W., McNair, C., and Kraus, N. C. (2002). The U.S. Army Corps of Engineers' Coastal Inlets Research Program. *Proceedings Dredging '02*, ASCE, available on CD and from the CIRP Web site.

inlets because of regional-scale barrier island and inlet modeling, dredging, and sediment bypassing. CIRP also collaborates with Corps of Engineers Districts in their ongoing or upcoming inlet studies.

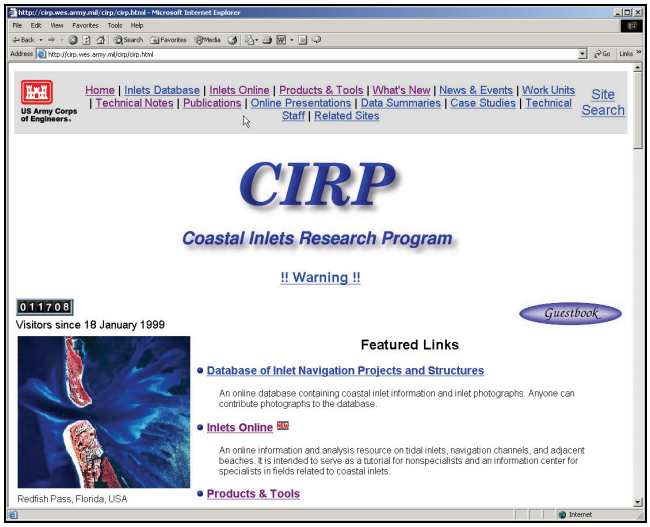

Figure 1. CIRP home page --http://cirp.wes.army.mil/cirp/cirp.html

CIRP publications are posted on its Web site (Figure 1), often in draft form prior to the release of final versions. Publications include technical reports, journal articles, conference papers, and Coastal and Hydraulics Engineering Technical Notes (CHETNs). Electronic versions of technical reports and journal and conference papers in PDF format can be downloaded. The CIRP Web site also includes case study applications of major CIRP numerical modeling technologies together with several simple on-line applications, announcements of upcoming workshops, summaries of past technology transfer events, and planned research activities of CIRP.

CIRP AND RELATED RESEARCH PRODUCTS: Several of CIRP's and SWWRP's products of potential interest to the shore birding community are discussed in the following paragraphs.

Inlets Online (http://www.oceanscience.net/inletsonline). Inlets Online is a Web-based information and analysis resource on tidal inlets and adjacent beaches, Great Lake entrances, navigation channels, and Corps operation and maintenance activities at these sites. Inlets Online is intended to provide technical guidance for nonspecialists and to serve as an information center for specialists in the areas of coastal engineering, coastal geology, oceanography, and coastal zone management. Presently, the Web site includes technical documentation related to aerial photographic interpretation, historical information on federally maintained inlets, and examples of features interpreted from photographs (Byrnes et al. 2002). Inlets Online includes a database of historical aerial photography for federally maintained inlets, and it is being expanded to non-Federal inlets.

Inlets Online is a tutorial for identifying coastal features from aerial photography, how they are measured and analyzed, and how they are related to specific inlet/beach processes. It is also a historical aerial photography database for inlets around the United States. Inlets Online is organized into seven components within the framework listed in Table 1.

Inlets Database. CIRP's Database of Inlet Navigation Projects and Structures is a Web-server-hosted database accessed via a customized Web interface (Hughes 2000). The database contains more than 1,230 individual records of navigation structures and tidal inlets located around the coastlines of the United States and its territories, including 330 records from the U.S.

Great Lakes. Figure 2 shows the Web interface and a partial listing of records beginning with the letter "C."

Table 1
Framework for Inlets Online

Inlet/Beach Processes	Inlet/ Beach Morphology	Engineering Activities	Glossary of Terms	Select a Site	Analysis Methods	Analytical Toolbox
Wave-current interaction Channel navigability Sediment transport Wave diffraction	Storm response Shoals Hard bottom Channel orientation	Structure placement Structure performance Structure rehabilitation Channel dredging Deposition basin Beneficial uses of dredged material Sand transfer plant	Coastal engineering Geology Oceanography Coastal zone management	Documents 154 Federal inlets and many non-Federal inlets	Interpretation of aerial photography	Links to screening codes and decision-support tools

The original database was extended by adding more than 900 digitized historic photographs of tidal inlets and associating them with a database record. Users can construct custom queries and download the tabulated results. Recently, extensive inlet data have been gathered for 154 federally maintained inlets and channels. Work is underway to separate the inlets and structures databases and add cross-links between each inlet and its associated navigation structures. The database will be expanded by including additional data fields and populating vacant fields where possible. Each record has fields for parameters related to the inlet or to the inlet structure. Data fields are grouped into three categories as follows:

a. *Geographic information.* Includes inlet or structure name, state and coast where located, and which Corps District has responsibility over the region.

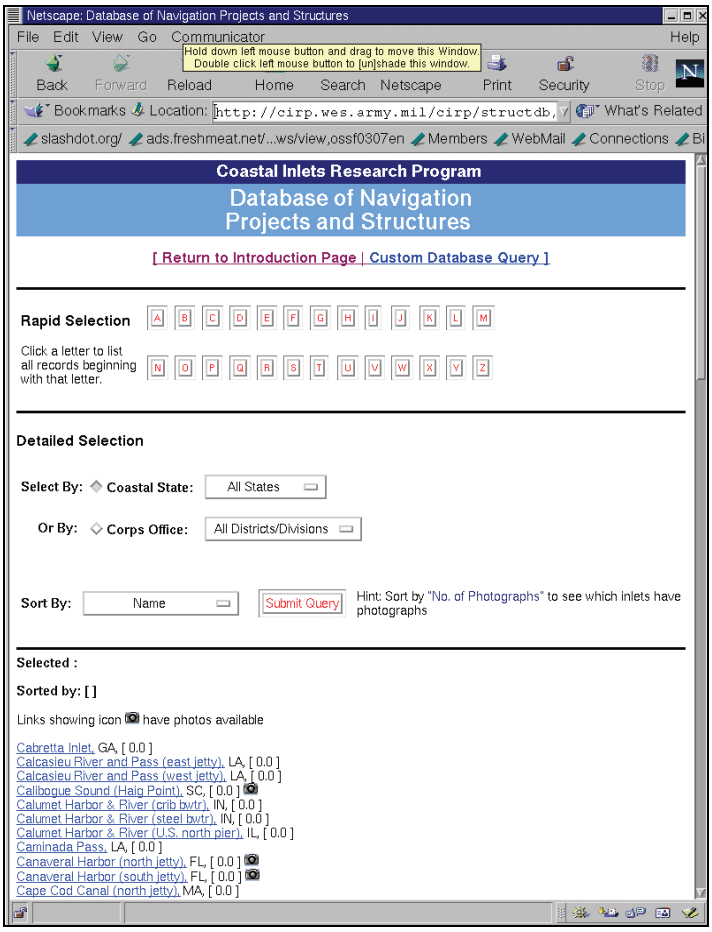

Figure 2. Inlets database sample record query

b. *Structure parameters.* Data related to the inlet structures such as date built, structure length, crown elevation and width, core elevation, side slope, and jetty offset for dual-jetty systems.

c. *Inlet parameters.* Includes parameters such as project width and depth, tidal prism, throat cross-sectional area, bay surface area, ebb shoal volume, tide and current gauge locations, and maximum average flood and ebb currents and direction. Each database field is described on a separate Web page linked to the database Web application.

Sediment Budget Analysis System (SBAS). The Sediment Budget Analysis System (SBAS) is a method for calculating and displaying local and regional sediment budgets including single and multiple inlets, estuaries, bays, and adjacent beaches (Rosati and Kraus 1999, 2001; Dopsovic et al. 2002). It is available for PC's on the Windows operating systems, and for ArcView© 8.x (see CIRP Web site). SBAS allows many local (project-level) sediment budgets to be characterized within one or more regional sediment budgets. Features of SBAS have been designed to facilitate creation, display, and calculation of both local and regional sediment budgets. Figure 3 is a screen capture from SBAS.

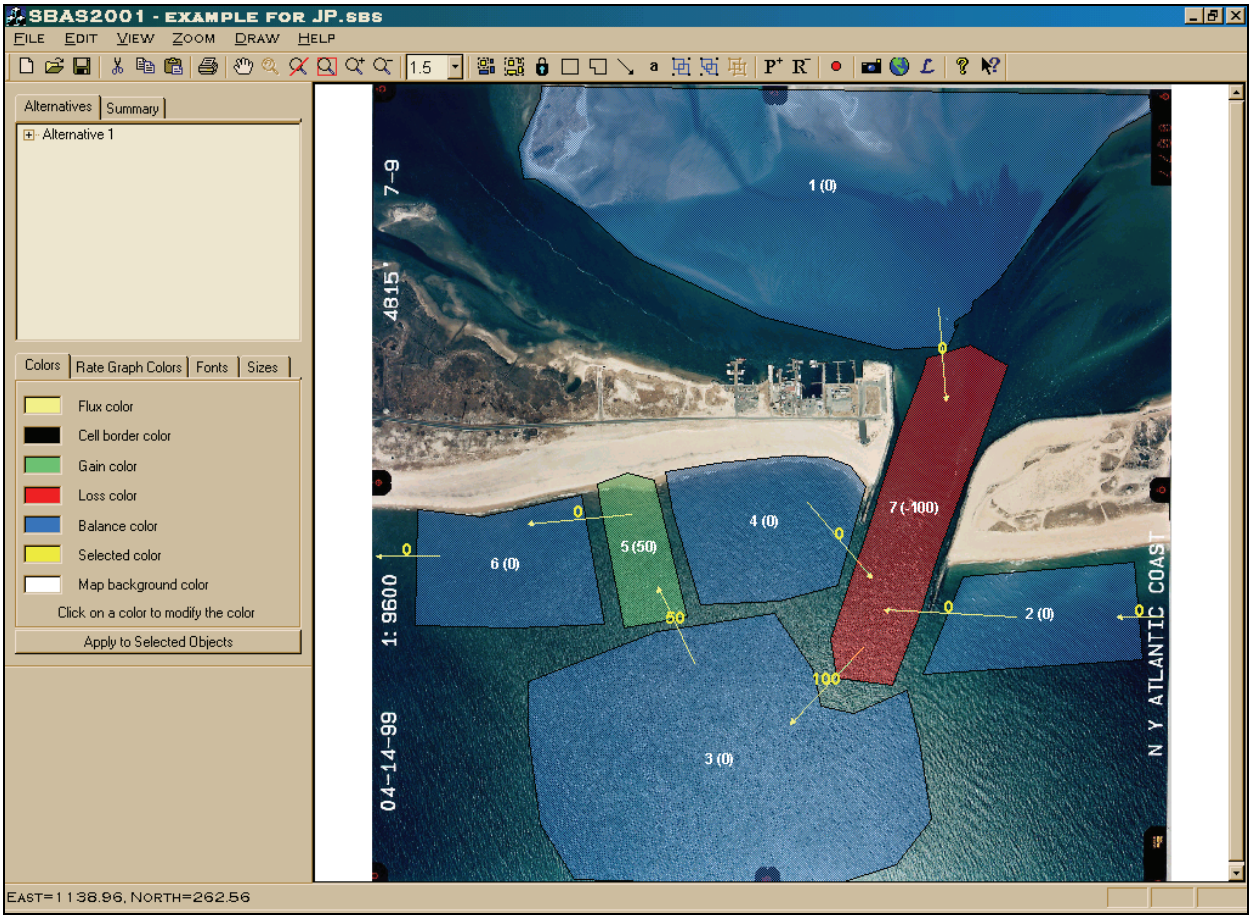

Figure 3. Sediment budget visualization in SBAS, Shinnecock Inlet, Long Island, NY

SBAS is operated within a graphical user interface to solve the conservation of volume (or volume rate of change) equation for each sediment budget cell and any connecting cells through sediment paths. The user drags and pulls the mouse to form squares or rectangles (sediment budget cells) and arrows (sources and sinks into and out of each cell). Volume changes (or volume change rates) are entered in a cell menu that is accessed by double-clicking at a cell. Engineering activities (placement and removal volumes or rates) can be entered with tools appearing on the upper toolbar. Color-coding of the cells indicates whether the cell is balanced or not. Sediment budgets such as calculated in SBAS typically range from a decade to more than a century, and the spatial scale can vary from the vicinity of an inlet to hundreds of kilometers of connected beaches interspersed with sediment sources and sinks.

SBAS organizes the user's workspace and facilitates development and visualization of alternative sediment budgets. Within the right-hand side of the screen, called the Topology Window, SBAS formulates a sediment budget by allowing the user to create a series of cells and arrows representing sources and sinks that characterize the budget. Georeferenced and nonreferenced photographs may be incorporated as background to the budget.

The left-hand side of the screen organizes alternatives within a particular project. Alternatives may represent various time periods, different boundary conditions for the same time period, or modifications to assumptions within the budget reflecting a sensitivity analysis (uncertainty analysis). Alternatives can be copied and modified. Once a sediment budget alternative has been defined, and the user has created sediment budget cells with sources and sinks, values can be assigned to the various components of the sediment budget topology.

Cascade Model. Cascade is a numerical model being developed in SWWRP that simulates regional sediment transport and coastal evolution (Larson et al. 2002). It can account for multiple sediment sources and sinks, such as dredging at inlets, dredged material placement on adjacent beaches, longshore and cross-shore transport, inlet breaching, and wind-blown sand transport (Figure 4). Processes are simulated at local and regional scales, and the interaction between the scales is described in a cascading manner (Larson et al. 2002). Of potential interest to the shore bird community is the capability to predict inlet breaching and the evolution of dredged sediment that is placed on the beach or in the nearshore. Shore birds such as plovers and terns can use the unvegetated sediment formed through these activities as habitat and as foraging ground.

A Piping Plover population dynamics model will be linked to Cascade (Kraus 2006), relating the area of unvegetated sediment that is formed via inlet breaching and placement of dredge sediments to the number of breeding pairs possible in the region. Upgrading Cascade to predict ecological habitat formation and evolution will promote a holistic approach to managing sediments and improving the environment in the coastal zone.

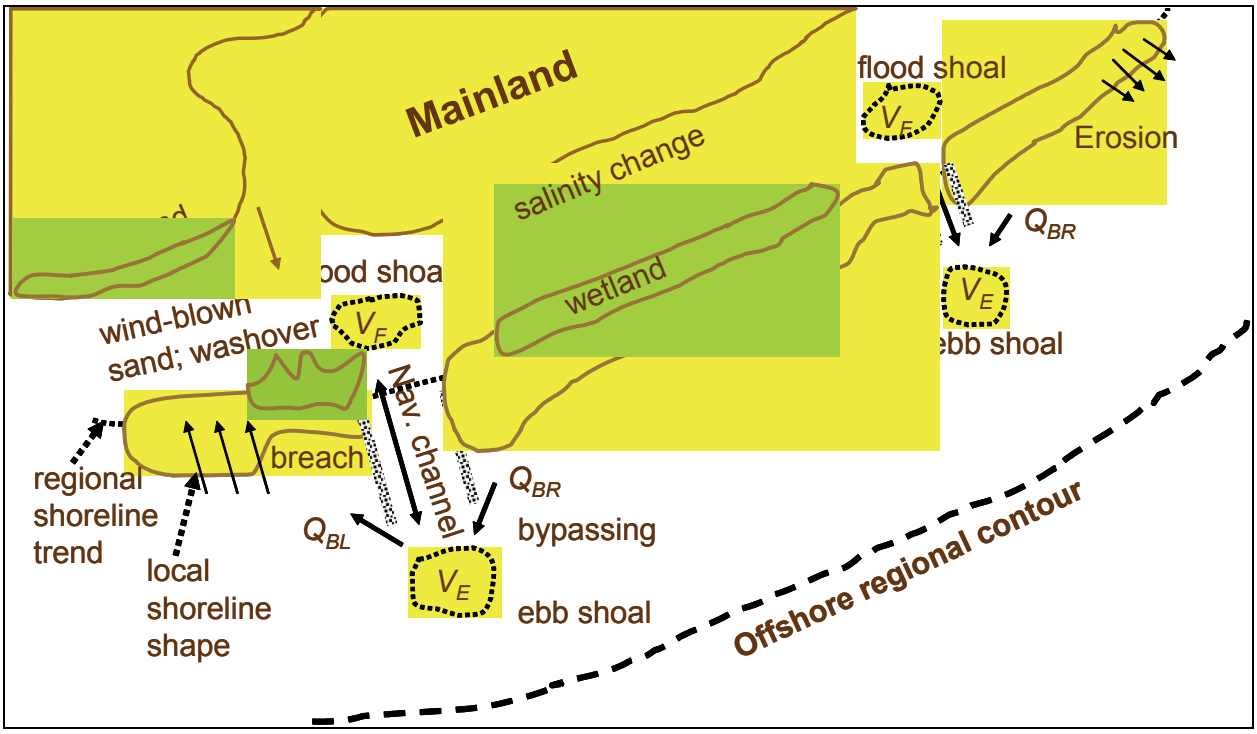

Figure 4. Conceptual diagram showing simulation capabilities of Cascade

TOWARD THE FUTURE: CIRP and SWWRP have several tools and models available for reference and application by the shore birding community, and work continues in this area. Researchers involved with these programs at ERDC are actively seeking ways to integrate the engineering and ecological disciplines in the products. Discussion and partnership with ecological scientists, engineers, and planners are welcome.

ADDITIONAL INFORMATION: This technical note was prepared as a joint activity of the Program Management and Technology Transfer Work Unit, Coastal Inlets Research Program, and the Cascade Work Unit, System-Wide Water Resources Program, U.S. Army Corps of Engineers (USACE). Permission was granted by Headquarters, USACE, to publish this information. This technical note was prepared by Julie Dean Rosati and Dr. Nicholas C. Kraus, U.S. Army Engineer Research and Development Center. For information on the System-Wide Water Resources Program (SWWRP), please consult https://swwrp.usace.army.mil/ or contact the Program Manager, Dr. Steven L. Ashby at Steven.L.Ashby@ erdc.usace.army.mil. This technical note should be cited as follows:

> Rosati, J. D., and N. C. Kraus. 2006. *The U.S. Army Corps of Engineers' Coastal Inlets Research, with special reference to shore bird habitat.* SWWRP Technical Notes Collection ERDC TN-SWWRP-06-2, U.S. Army Engineer Research and Development Center, Vicksburg, MS. https://swwrp.usace.army.mil/

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