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Inlets Online: A Tutorial for Evaluating Inlet/Beach Processes Using Aerial Photography

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PURPOSE: This Coastal and Hydraulics Engineering Technical Note (CHETN) describes a Web-based information and analysis resource on tidal inlets and adjacent beaches, Great Lake entrances, navigation channels, and U.S. Army Corps of Engineers (USACE) Operation and Maintenance (O&M) activities at these sites. Version 2.0 of “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. “Inlets Online” also includes a database of historical aerial photography for Federally maintained inlets. All of the information presented in this CHETN may be accessed at: <http://www.oceanscience.net/inletsonline>.

BACKGROUND: Various coastal features (natural and engineered) can be interpreted from near-vertical aerial photography. Most coastal projects developed by USACE rely on data interpreted from aerial photography as a relatively low-cost means of compiling synoptic information for qualitative and quantitative assessment of coastal process dynamics. These data often are integrated with other historical data sets (waves, currents, meteorological data, coastal structure parameters, beach replenishment events, dredging, etc.) as a means of developing remedial solutions to defined problems. As such, aerial photography and the interpretation methods used for compiling coastal feature information form the foundation of “Inlets Online.”

This CHETN summarizes the key components of “Inlets Online,” describes how information is organized within the tutorial, and demonstrates how coastal data can be extracted from aerial photography. Analysis procedures and aerial photography interpretation methods are used to demonstrate how information related to navigation channels (including the ebb and flood shoals, bayward channels leading to the inlet, seaward channels, dredging, material placement, structures, etc.) and adjacent beaches can be extracted from source data.

“Inlets Online” is an interactive tutorial for evaluating inlet/beach processes, primarily based upon aerial photography. Scientists and engineers can easily access the information via a Web browser. “Inlets Online” currently serves two functions as:

- a. 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.
- b. A historical aerial photography database that serves as a reference to the user who has particular interest in inlet systems around the U.S.

Based on these two functions, “Inlets Online” is organized into seven components, as shown in the main menu. Under each component, a list of related topics is used to document process/response characteristics in the coastal zone at and adjacent to natural and engineered inlet systems. The framework for “Inlets Online” is as follows:

- a. Inlet/Beach Processes
 - (1) Wave-current interaction
 - (2) Channel navigability
 - (3) Sediment transport
 - (4) Wave diffraction
- b. Inlet/Beach Morphology
 - (1) Storm response
 - (2) Shoals
 - (3) Hard bottom
 - (4) Channel orientation
- c. Engineering Activities
 - (1) Structure placement
 - (2) Structure performance
 - (3) Structure rehabilitation
 - (4) Channel dredging
 - (5) Deposition basin
 - (6) Beneficial uses of dredged material
 - (7) Sand transfer plant
- d. Glossary of Terms
- e. Select a Site (Inlet database)
- f. Analysis Methods (Aerial photo interpretation)
- g. Analytical Toolbox

INLET/BEACH PROCESSES, MORPHOLOGY, AND ENGINEERING ACTIVITIES: Each of these three environmental components is characterized by representative examples that describe coastal features identified from aerial photography. Each example presents a dated aerial photograph and a brief description of the observations documented on the image. Users can pan the image and zoom to details on the screen. The narrative describes what feature is identified, how it is associated with natural processes or engineering impacts, and how it is related to site history. Figure 1 shows an example screen. Figure 2 illustrates the enlarged image and the zoom in/zoom out options for viewing. There is at least one example for each topic. Many of the common topics,

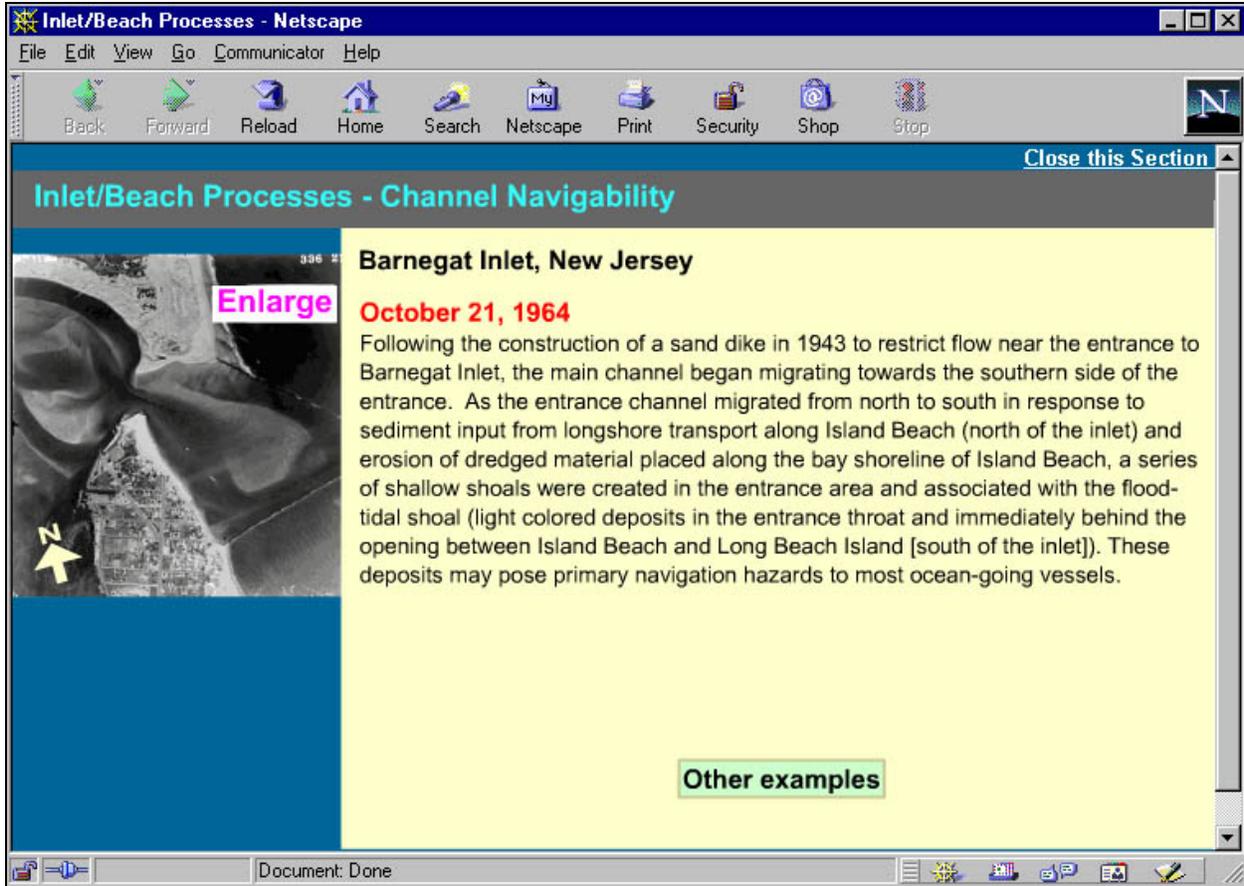


Figure 1. Screen layout illustrating *Inlet/Beach Processes – Channel Navigability*

such as ebb shoal morphology, have multiple examples covering various inlets. Practical case studies that illustrate specific coastal topics demonstrates analysis techniques and their real-world implementation.

GLOSSARY OF TERMS: This part of “Inlets Online” includes a collection of commonly used terms in coastal engineering, geology, oceanography, and coastal zone management. Many of the definitions are derived from the USACE *Coastal Engineering Manual* “Glossary of Coastal Engineering Terms” (Headquarters, U.S. Army Corps of Engineers 2002) and the American Geologic Institute’s *Glossary of Geology* (Jackson 1997). The terms are alphabetically indexed and can be conveniently located with sorted lists for each letter. Term definitions appear in the definition area on the screen to the right of the term list when users click the left mouse button on a selected term (Figure 3). As new terms are identified or existing term definitions are modified, updates will be incorporated. The terms and definitions included in “Inlets Online” have been carefully evaluated to reflect most recent technical updates and accepted usage.

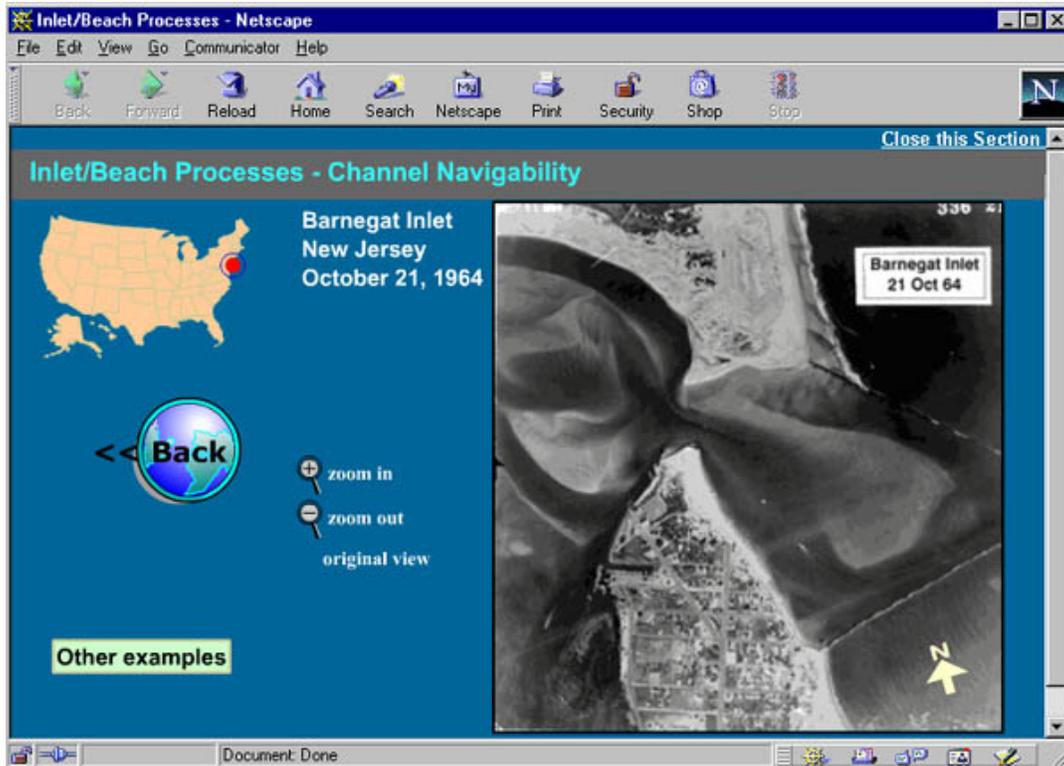


Figure 2. Screen layout illustrating enlarged image and zoom in/zoom out option for viewing

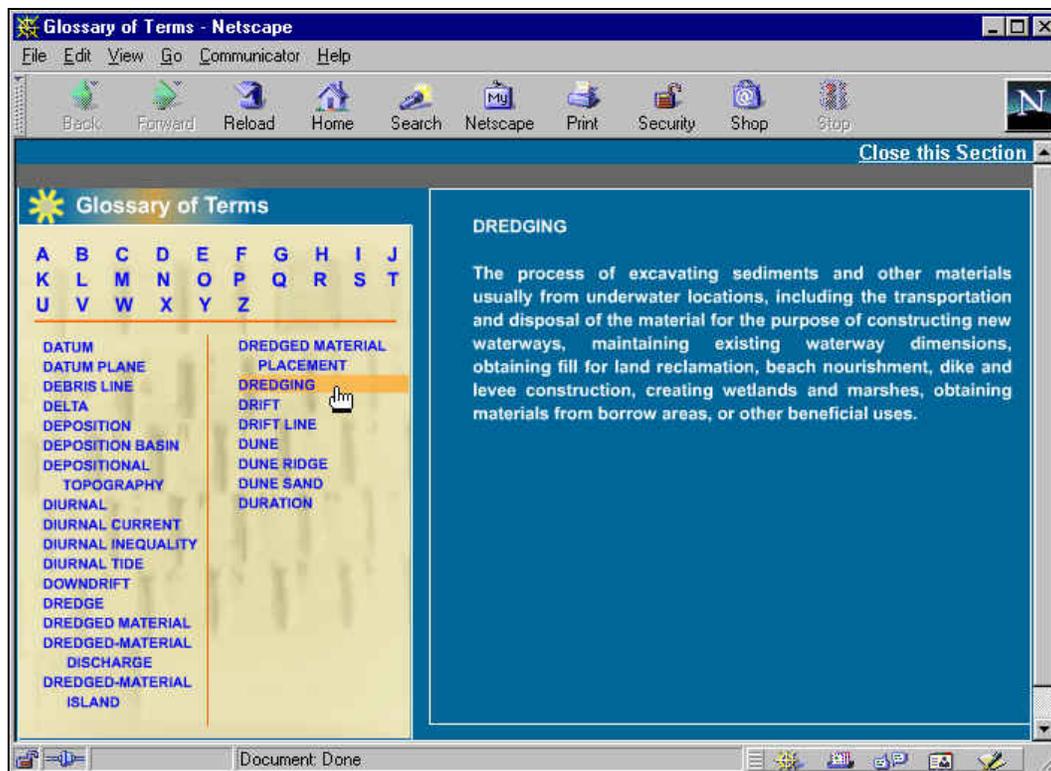


Figure 3. *Glossary of Terms* index menu and screen layout

SELECT A SITE: The *Select a Site* component serves as a reference database of aerial photography and historical information. The database documents all the 159 Federally maintained inlets that are under the charges of eight USACE Divisions. Users can retrieve inlet information by clicking on a site location map or searching the database by Division and District names. The retrieved information includes a general topographic site map; a brief description of construction and rehabilitation history, including dredging records, where available; a Corps project report from the Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Program; a link to the District Web site; and a sorted list of historical aerial photography with thumbnails. The user can browse to view the enlarged photograph, read a description of the image, and download the original high-resolution scanned aerial photograph (300 to 400 dpi at 9”x 9” original size) as a zipped JPG file.

EXAMPLE SEARCH: The following screen captures illustrate the steps a user takes to retrieve data for Ocean City Inlet, MD:

- a. Choose from the index map (Figure 4).
- b. Click on **Ocean City Inlet** from the regional map (Figure 5).
- c. The display window shows the information retrieved from the database (Figure 6). Available photography records are sorted according to date. Users can browse to the topographic site map, the construction and rehabilitation history, the Corps project report, each enlarged aerial photograph, a brief description of coastal features illustrated on the photograph, and a link to the District Web site. Links to download high-resolution imagery as ZIP files also are available.

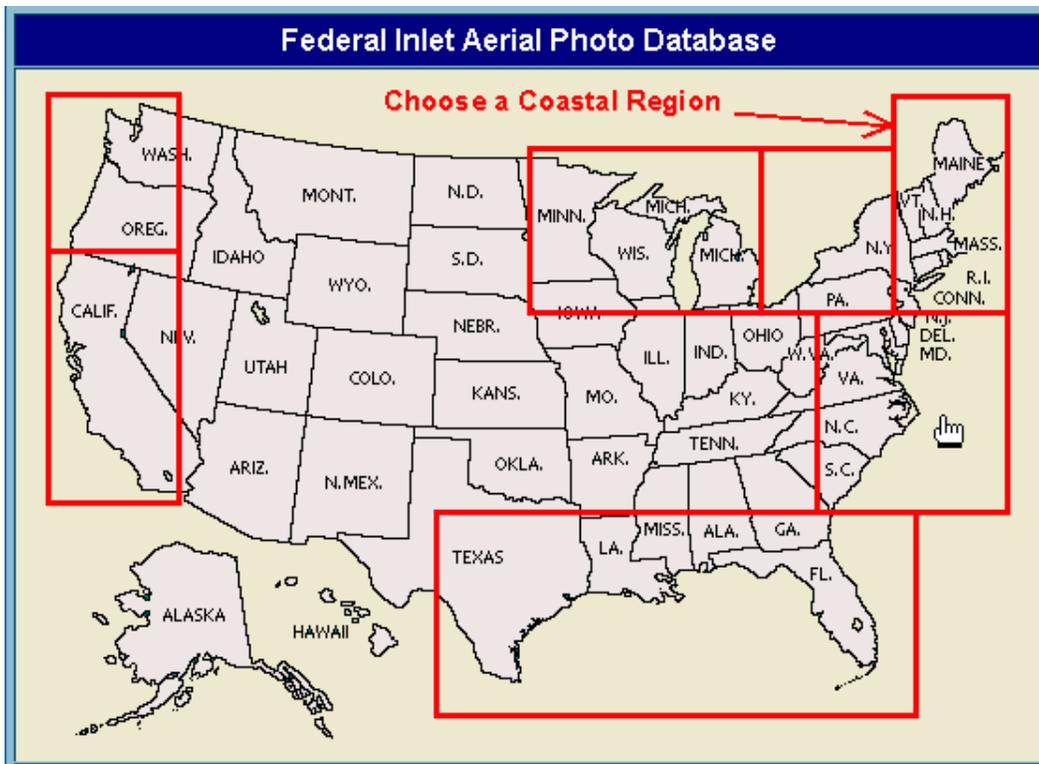


Figure 4. Choose a coastal region from index map

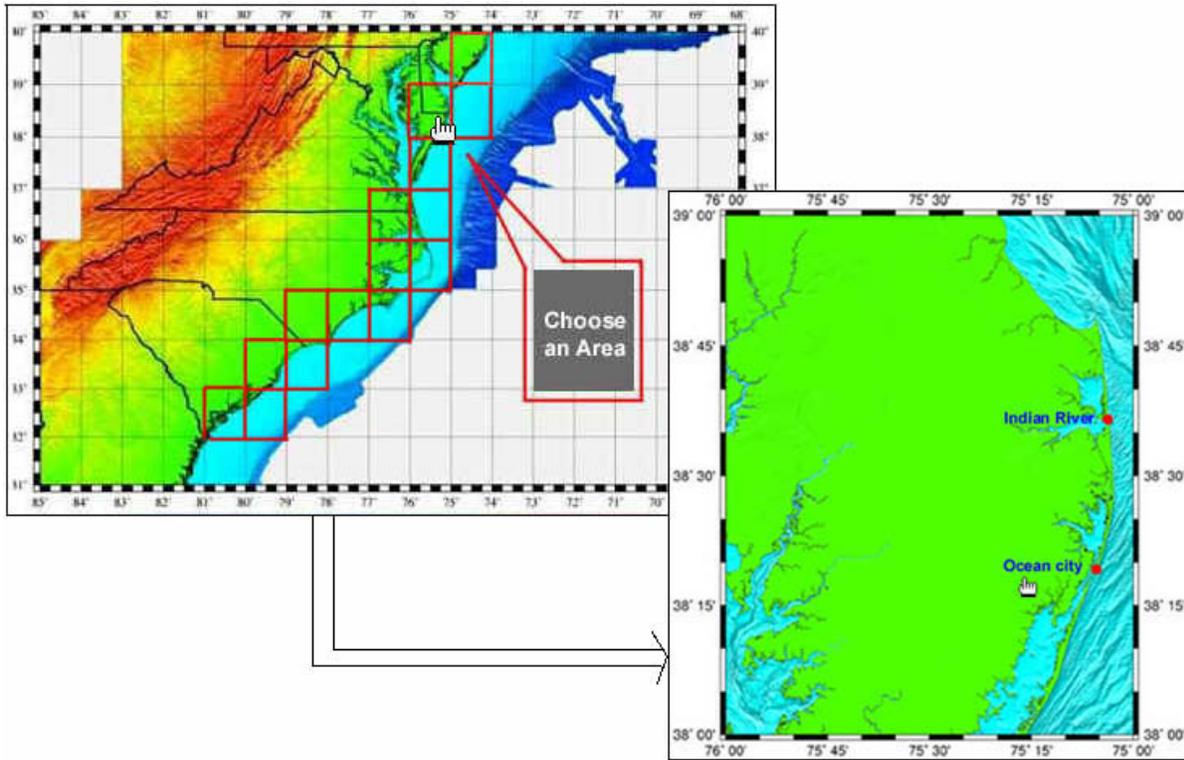


Figure 5. Choose Ocean City Inlet from regional map

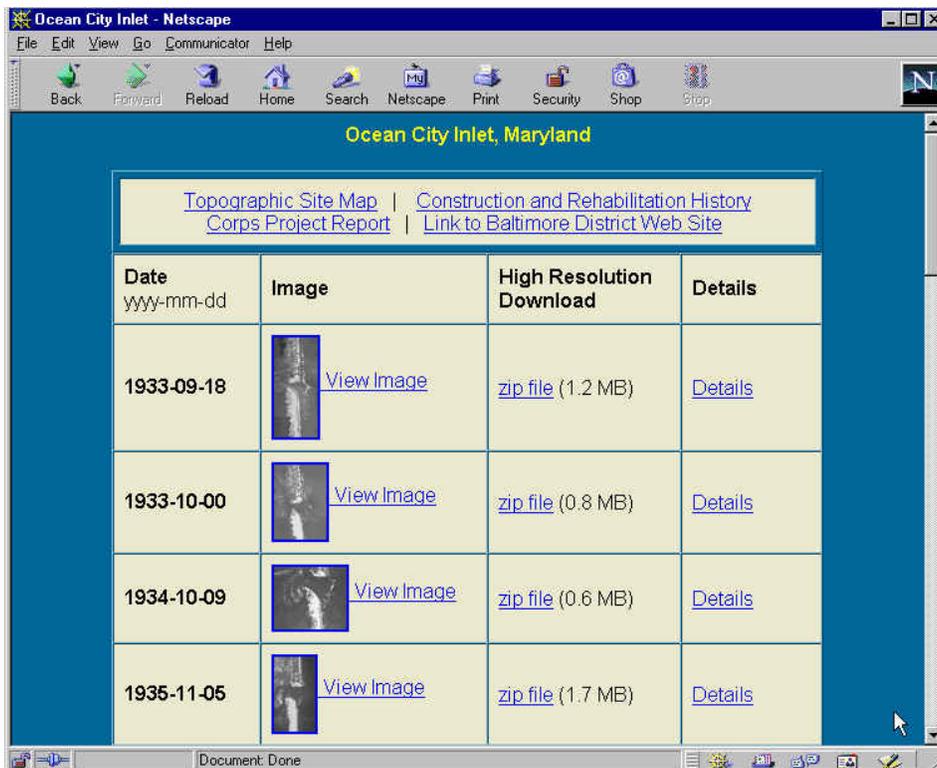


Figure 6. Data display window illustrating information retrieved from database

ANALYSIS METHODS: This component of “Inlets Online” focuses on the types of information that can be interpreted from near-vertical aerial photography and the methods by which this information is compiled. Emphasis is placed on accurate identification of coastal process/response features as compared with various feature examples documented in the *Inlet/Beach Processes*, *Inlet/Beach Morphology*, and *Engineering Activities* sections. The kind of information commonly required for evaluating coastal processes/response at an inlet system includes:

- Location of the high-water line or berm crest (used for identification of shoreline position; also used to estimate beach volume change)
- Features indicating structure condition (permeability to sediment transport, stability, etc.)
- Position of ebb- and flood-tidal shoals
- Features indicating recent engineering activities (jetty construction, structure rehabilitation, beach nourishment, beneficial use of dredged material, sand transfer plant, etc.)
- Location of channel center line
- Features indicating channel navigability (wave-current interaction and other wave patterns)
- Location of vegetation line and dune line
- Evidence of sand spit development (direction of longshore transport)
- Location of bluff line
- Evidence of washover deposition and its extent (lobe penetration, longshore impact, sand volume estimates)
- Location of deposition basin
- Wind-blown sand features
- Location of the break point bar
- Location of hardbottom features

As part of the tutorial, methods of interpretation are demonstrated interactively. Information appears on the screen as pop-up lines, images, and text in response to clicking on a menu button, moving across a highlighted key word, or entering an image. Extracted feature lines can be turned on and off as overlays on aerial photography. In Figure 7, the example demonstrates high-water shoreline interpretation. A line is traced dynamically when the user presses the **Trace Shoreline** button; the line disappears when the user clicks the **Shoreline Off** button. The definitions for high-water line and berm crest pop up when the user points to the words. As another example, Figure 8 displays a series of images of Shinnecock Inlet that illustrate the growth and shifting of ebb shoals with time. As the cursor moves over each image, identified shoal features are highlighted in red. In addition, a description for each image is displayed when the corresponding image is clicked.

The primary purpose of this component of “Inlets Online” is to acquaint users with standard procedures for interpreting near-vertical aerial photography. By comparing a raw aerial photograph with features extracted from the photo, the user can visualize the delineation of specific features, their position relative to other features, and changes that occur over time (multiple images).

Before an image/photograph is interpreted to extract features, various criteria are met for quality assurance purposes. The user should first examine the original photograph (black and white versus color, scale, date flown, etc.) for baseline characteristics. Once completed, a general analysis work flow involves:

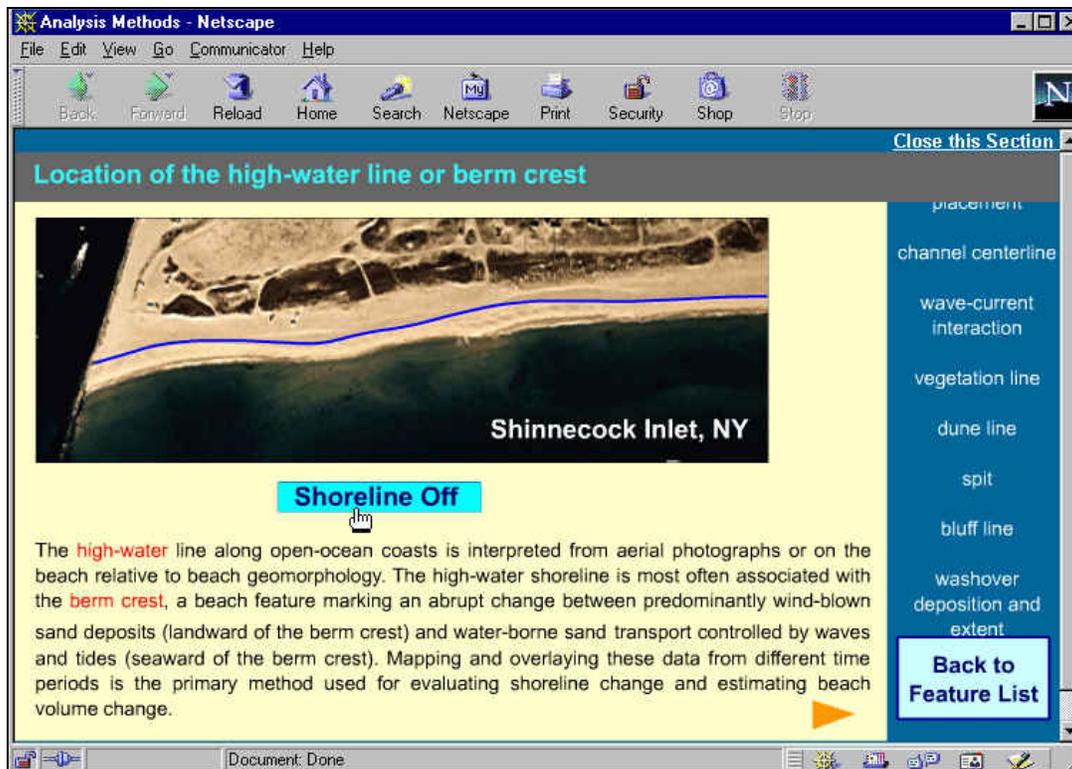


Figure 7. Demonstration of high-water line interpretation

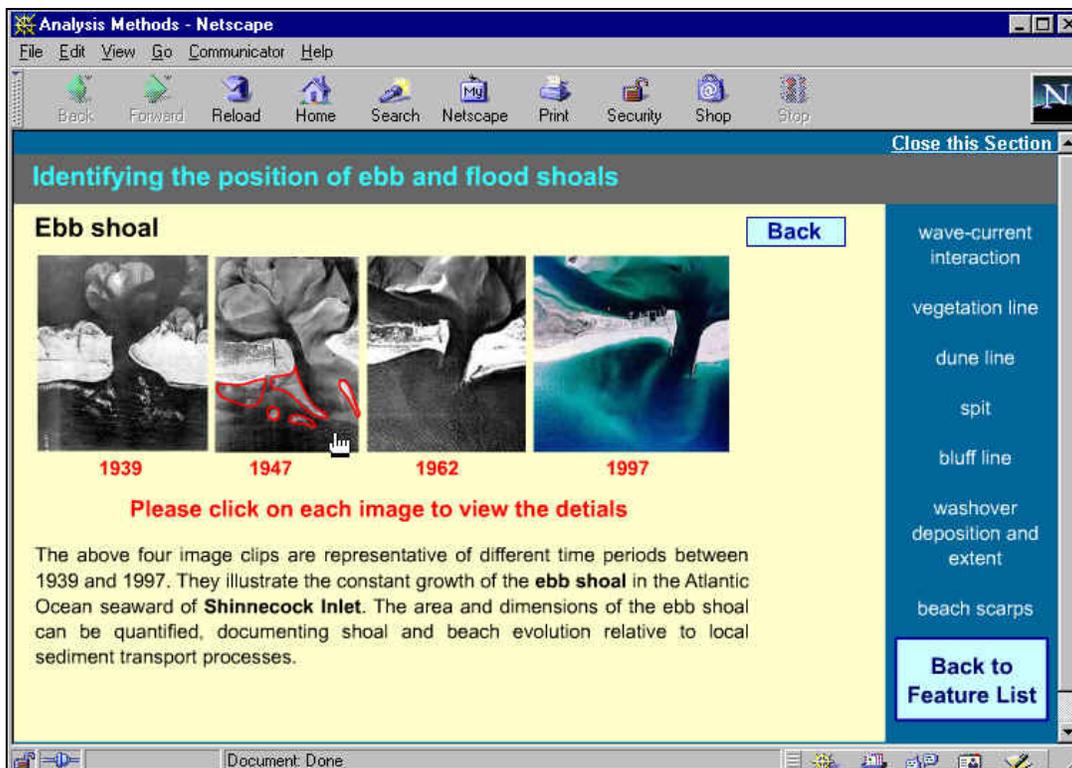


Figure 8. Example of ebb shoal configuration changes with time

- a. Scan the photograph at a resolution appropriate for proposed analyses.
- b. Enhance specific features on the digital image for accurate interpretation (adjust contrast and brightness, edge sharpening, etc.).
- c. Geo-reference the image if data will be measured and quantified.
- d. Extract specific coastal features that may be important to inlet/beach processes and engineering activities.
- e. Incorporate data into a Geographic Information System (GIS) for further analysis.

ANALYTICAL TOOLBOX: This part of “Inlets Online” includes links to analytical packages that are commonly used by scientists and engineers to manipulate coastal data sets. Most of the products were developed under the Coastal Inlets Research Program (CIRP). More detailed information can be found on the CIRP Web site at <http://cirp.wes.army.mil/cirp/products.html>.

FUTURE WORK: Based on the defined framework, the information in “Inlets Online” is expanding to include additional aerial photography and historical documentation. Many more examples will be included in the *Inlet/Beach Processes*, *Inlet/Beach Morphology*, and *Engineering Activities* sections. The *Select a Site* database is being updated constantly to make more photographs and documentation available. In addition, new information addressing the purpose of “Inlets Online” will be incorporated. Planned additions include access to shoreline position data, methods for compiling shorelines and bathymetry data from maps, methods for quantifying potential measurements errors from map and photographic sources, and direct links to the CIRP inlet processes database. It is anticipated that a K-12 educational component also will be added to attract and engage emerging scientists and engineers.

ADDITIONAL INFORMATION: This CHETN was produced under the Coastal Inlets Research Program (CIRP) work unit “Inlet Channels and Adjacent Shorelines,” by Dr. Mark R. Byrnes and Ms. Feng Li, Applied Coastal Research and Engineering, and by Ms. Julie D. Rosati at the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory. Questions about this Technical Note can be addressed to Dr. Byrnes at mbyrnes@appliedcoastal.com, or to Ms. Rosati at Julie.D.Rosati@erdc.usace.army.mil. For further information about CIRP, please consult the Web site <http://cirp.wes.army.mil/cirp/cirp.html> or contact the CIRP Program Manager, Dr. Nicholas C. Kraus at the Nicholas.C.Kraus@erdc.usace.army.mil or by telephone at (601) 634-2016. This CHETN should be cited as follows:

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