ERDC/CHL TR-18-16

Coastal and Hydraulics Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

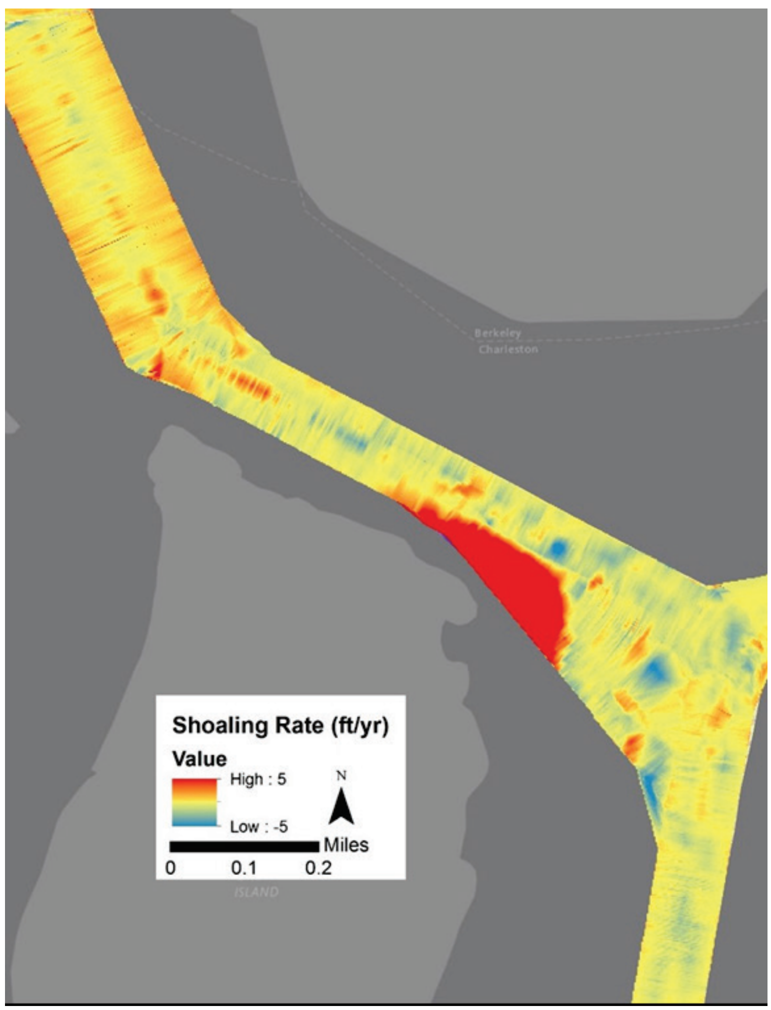
ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

Coastal Inlets Research Program (CIRP)

Corps Shoaling Analysis Tool: Predicting Channel Shoaling

Lauren M. Dunkin, Lauren A. Coe, and Jay J. Ratcliff

November 2018



Coastal Inlets Research Program (CIRP)

ERDC/CHL TR-18-16
November 2018

Corps Shoaling Analysis Tool: Predicting Channel Shoaling

Lauren M. Dunkin, Lauren A. Coe, and Jay J. Ratcliff

Coastal and Hydraulics Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Final report

Prepared for Headquarters, U.S. Army Corps of Engineers
Washington, DC 20314-1000

Under Project no. 468429, "Coastal Navigation Portfolio Management"

Abstract

This report provides background and additional application s of using the Corps Shoaling Analysis Tool (CSAT) and the various output files generated. The CSAT calculates channel shoaling volumes using historical channel surveys and uses the shoaling rates to predict future dredging volumes. Shoaling rate grids can be used to identify hot spots or areas of increased sedimentation. In addition, limiting the time period for analysis to more closely align with a specific event (e.g., meteorological activity or change to dredging schedule/type) may provide insight into the impacts that these events cause to the sedimentation within the channel. The volume tables that quantify the amount of sediment needing to be dredged at depth and time increments also support decision making that will maximize the use of dredging funds and minimize disruption to vessel traffic through the navigation channels.

Contents

Figures and Tables

Figures

Tables

Preface

This study was conducted for Headquarters, U.S. Army Corps of Engineers (HQUSACE), as part of the USACE Coastal Inlets Research Program (CIRP), under Work Unit “Coastal Navigation Portfolio Management,” Project no. 468429.

The study was executed by the Coastal Engineering Branch (HN-C) of the Navigation Division (HN) of the U.S. Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL). At the time of publication of this report, Ms. Mary A. Bryant was Acting Branch Chief of HN-C, and Dr. Jackie S. Pettway was Division Chief of HN. Mr. W. Jeff Lillycrop, ERDC CHL, was the ERDC Technical Director for Civil Works and Navigation, Research, Development, and Technology Transfer Portfolio. Ms. Sheryl A. Carrubba, Acting Chief, HQUSACE Navigation Branch, was the Navigation Business Line Manager. Ms. Tanya Beck, ERDC CHL, was the CIRP Program Manager.

The Acting Deputy Director of ERDC CHL was Mr. John T. Tucker III, and the Acting Director of ERDC CHL was Mr. Jeffrey R. Eckstein.

COL Ivan P. Beckman was the Commander of ERDC, and Dr. David W. Pittman was the Director.

Unit Conversion Factors

Multiply	By	To Obtain
feet	0.3048	meters
miles (U.S. statute)	1,609.347	meters
tons (2,000 pounds mass)	907.1847	kilograms

Abbreviations

Term	Meaning
CPT	Channel Portfolio Tool
CSAT	Corps Shoaling Analysis Tool
eHydro	U.S. Army Corps of Engineers, Enterprise Hydrographic survey tool
NCF	National Channel Framework
USACE	U.S. Army Corps of Engineers
WCSC	U.S. Army Corps of Engineers, Institute for Water Resources, Waterborne Commerce Statistics Center

Notation

Term	Meaning
CPT	https://cpt.usace.army.mil.
CSAT	Hindcasting shoaling analysis tool
eHydro	Enterprise Hydrographic survey tool
NCF	Authorized channel boundary

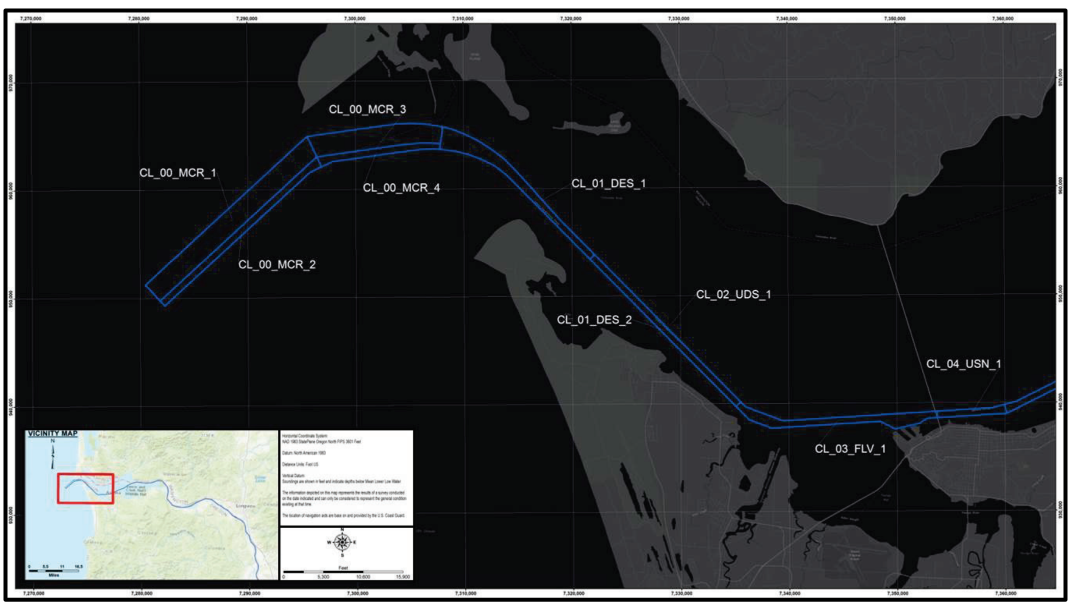
1 Introduction

Background

The U.S. Army Corps of Engineers (USACE) Civil Works mission includes support for the Navigation mission to maintain waterborne transportation systems for safe and efficient movement of commerce, national security requirements, and recreation. The delineated boundaries of the navigation channels for the National Channel Framework (NCF) provide a footprint of the authorized channel boundary. Each USACE district is responsible for maintaining the NCF. The NCF was initiated in 2005 to establish a Geographical Information System representation of the USACE coastal navigation channels.

The channel framework is divided into reaches that cut the channel into smaller sub-sections that may be related to known shoaling areas, change in authorized depth, or might be more specific to visual mapping requirements. The reach within the channel framework is a known boundary that is used to divide the hydrographic surveys (Figure 1).

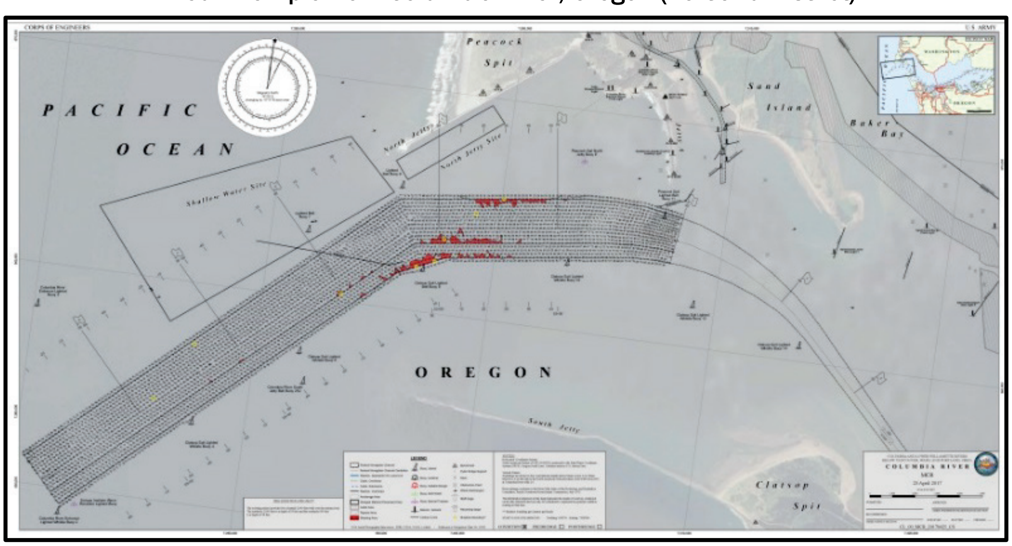
Figure 1. Channel reaches defined in the NCF. Example for Columbia River, Oregon (Portland District).



Recurring hydrographic surveys are a fundamental part of the USACE mission for maintaining navigation channels. USACE districts are responsible for surveying channels areas within their district boundary and publishing those survey results. The frequency of collection and survey techniques may vary for a myriad of reasons, which may include budget considerations, Operations and Maintenance (O&M) schedules, and/or fluctuations in sediment transport as a result of seasonal or episodic events. Regardless of these variations, USACE coastal districts with a navigation mission are required to process hydrographic survey data through the enterprise Hydrographic survey tool (eHydro 2017) to allow for efficient and standardized methods to disseminate the geospatial data to federal agencies. An operation order divided the implementation plan into stages where all hydrographic surveys were processed through eHydro in stages via an implementation plan (USACE 2016).

Survey depths are represented in the eHydro map product as individual numbers while the areas shallower than the authorized depth are delineated by a red polygon (Figure 2). eHydro is used to process individual surveys and generate standard products that are provided to National Oceanic and Atmospheric Administration. In addition, the USACE Headquarters requires a roll-up summary of the present channel conditions annually. The eHydro tool produces standard reports that provide channel conditions at the time of survey and comparisons to the authorized channel dimensions.

Figure 2. Map product from eHydro showing the survey depths and shoal areas, highlighted in red. Example from Columbia River, Oregon (Portland District).



Objective

Identifying the location of channel shoaling through time can be used for the quantification of sediment volumes within the channel boundaries. Reviewing multiple channel surveys improves this understanding of sediment movement within the channel and the identification of potential sediment pathways. Previous efforts to predict channel shoaling relied solely on historical dredging records to quantify the cumulative volume dredged over the years and then applied a linear fit to the resulting line to determine shoaling rates (Rosati 2005). This type of approach is typically generalized for an entire channel and does not allow for analysis of reach-specific dredging requirements. A single shoaling rate for the entire channel provides a limited view of the variability associated with natural sediment fluctuation through the navigation channel. In addition, under this historical method areas of increased shoaling are not easily identified within the channel and may require extensive historical knowledge of the area to understand the processes.

In 2012, Commander, Navy Installations Command, requested assistance from the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, to develop a standard method to forecast dredging requirements at U.S. Navy Fleet Concentration Areas (FCAs). A site-specific algorithm was developed for each FCA to project future shoaling. The goal of the Navy study was to develop a standard method for estimating dredging requirements for the next five budget cycles using hydrographic surveys and dredging records. The shoaling tool developed for the Navy study was modified to leverage ongoing efforts by the USACE to standardize the manner in which hydrographic surveys are uploaded and processed through its eHydro program.

Approach

Several tools developed by the USACE to better manage the large quantities of data associated with navigation channel dredging are uniquely available to support the USACE mission for maintaining federal navigation projects. The development of the Corps Shoaling Analysis Tool (CSAT) began in 2014 and leverages (1) the hydrographic survey process through eHydro to provide input files for the shoaling analysis and (2) the NCF to provide the boundaries of the navigation channel.

To efficiently manage limited dredging funds for USACE navigation channels, identifying shoaling within the channel may lend insight into more cost-effective solutions for maintaining navigation channels. Combining channel shoaling with other datasets further increases the utility to make better dredging plans for existing and future needs.

Organization of this report

This report is organized into four chapters:

- Chapter 1 represents an overview of navigation channel and shoaling.
- Chapter 2 provides an overview of the CSAT and specific data tables.
- Chapter 3 presents additional applications of the CSAT.
- Chapter 4 summarizes the CSAT and provides concluding remarks.

2 Channel Shoaling Analysis

Each USACE coastal district is tasked with maintaining its navigation channels to provide navigably safe and efficient thoroughfare to vessels. Hydrographic surveys provide the condition of the channels and are vital to quantifying channel availability for navigation in addition to dredging requirements. The operation order for coastal districts to utilize the eHydro tool for processing surveys provides a standardized approach to storing these survey datasets. Comparing multiple surveys provides valuable data indicating sediment movement and quantities of material within the specified channel framework. To efficiently process these large datasets to provide channel shoaling predictions, a custom suite of computer codes were created to allow for a national-level tool that supports channel shoaling analysis.

Survey input files

The eHydro surveys are used to create the input files for CSAT. The survey XYZ files within the eHydro package of zipped files are used to generate a bathymetry raster of uniform grid points with a set cell size of 10 feet (ft) × 10 ft for all coastal navigation channels and is designed to be fixed regardless of changes to the survey methods at the district level (Figure 3). One exception for the cell size occurs in the Gulf Intracoastal Water Way where the cell size increases to 25 ft × 25 ft to account for the large reach dimensions and survey resolution.

The uniform grid files are saved as Network Common Data Form (netCDF) files to reduce redundancy in storing files since the X,Y locations are specified and do not change between surveys for a particular channel reach. The X,Y location values are stored only once while the Z or elevation value is updated with each new survey. In addition, the date timestamp is saved for each survey. Storing the data in a netCDF format and creating the uniform grid allows for matrix calculations to efficiently compare and combine surveys to quantify shoaling. The districts are continuing to upload new surveys as they become available, and since the eHydro workflow splits the surveys by the reach boundaries, this practice results in thousands of surveys for some channels. For example, the Columbia River channel in Portland has over 100 reaches, which has resulted in over 1,500 eHydro geodatabases from 2011 to 2016. In contrast, the netCDF file format allows for new survey data to be loaded without having to reproduce the existing data within the file structure. The uniform grid scheme also reduces processing time since only the new surveys have to be run through the CSAT input file code. The input files are updated yearly to help inform the dredging budget process; however, the input file code is flexible enough to run for specific districts or channels for any time period.

Figure 3. Uniform grid within the NCF boundary.

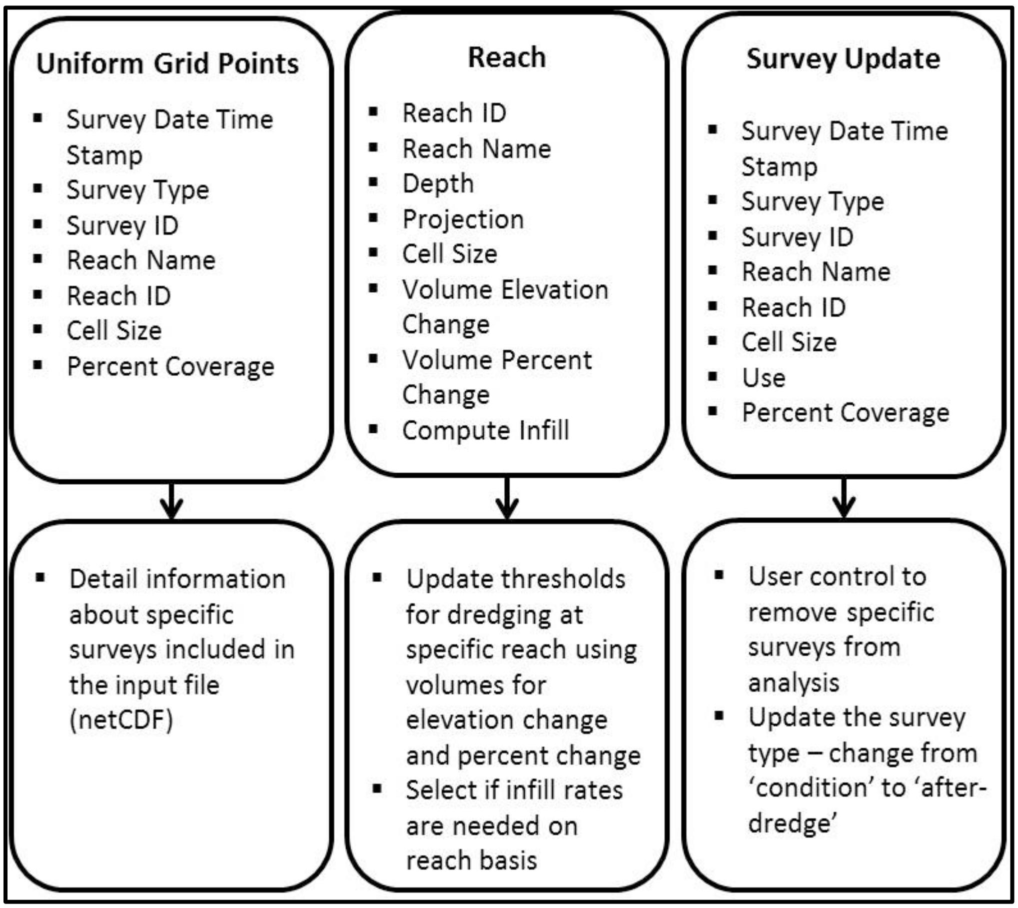
Survey comparison

All surveys that are processed through eHydro can be used in the shoaling analysis. The surveys between dredging events make up a comparison set of survey pairs. The first survey after a dredge event starts the new comparison set, therefore knowing when and where dredging occurred in the channel is important. The surveys processed through eHydro are not required to define the survey type. Therefore, thresholds and checks were included in the code to determine if a survey was conducted after a dredge event.

In addition, the code also checks for duplicate surveys, which are flagged for removal from the analysis. Duplicate surveys may be uploaded through eHydro by district error or if the district used the same survey to provide a complete channel survey and to serve as the patched condition survey for a specific data call. The code checks elevation differences between the surveys and identifies elevation changes that are zero. Therefore, the check is data driven and does not rely on specific survey names. Regardless of the reason for the duplicate survey, the code identifies these cases to ensure only unique surveys are included in the analysis.

Several tables are generated as part of the CSAT input creation process. These tables provide information about the surveys and reaches and are used to assist with the quality control process and to allow flexibility for the user to change thresholds or assumptions about the surveys and reaches. Specific information about the tables and uses within the CSAT process are available in Figure 4.

Figure 4. Example of files in the various tables with attributes and details for using within CSAT.



The reach table is used to change thresholds for specific reaches (Table 1). The end user has control over thresholds to identify dredging events if the surveys are not labeled as "after-dredge." The Volume Percent Change and Volume Elevation Change tolerances are both used to check for After Dredge Events. If either of these tolerance values is exceeded, CSAT will flag the specific survey as an after-dredge event. Additional user override options include manually removing a survey from the analysis (Table 2). The user may choose to remove a survey or surveys from the analysis to focus the predictions on specific date ranges or to account for changes to the channel dimensions (width or authorized depth).

Table 1. Example of a reach table in CSAT.

Reach_ID	CH_02_CHL_8
Sheet_Name	CHARLESTON LOWER HARBOR
Reach_Name	ANCHORAGE BASIN A
Depth	45
Name	CH_02_CHL
Projection	South Carolina
CCR_line_2	1004+30 to 1078+00
raster cell	10
Volume Elevation Change	-5000
Volume Percent	2.5
compute infill	FALSE

Table 2. Survey update table example.

Survey Date Stamp	Survey Type	Survey ID	Reach Name	Reach ID	Cell Size	Use	Coverage
20140323		MS_01_SJC_20140323_EX1C	001 Sea Bar and Jetty Channel	MS_01_SJC_1	10	0	100
20160323	After-dredge	KA_02_NAD_20160323_CS	ENTRANCE CHANNEL	KA_02_NAD_1	10	1	100

Shoaling analysis

The shoaling analysis within CSAT is data driven and requires hydrographic surveys of the channel to predict shoaling rates. The basis of a hindcasting algorithm assumes that historical trends will continue unless there are external factors that have been altered. In the case of navigation channels, the dimensions of the width and depth are consistent between years and require extensive studies and authorizations for any changes to occur. Other variations in hydrographic surveys may result from changes to survey techniques or different datum usage.

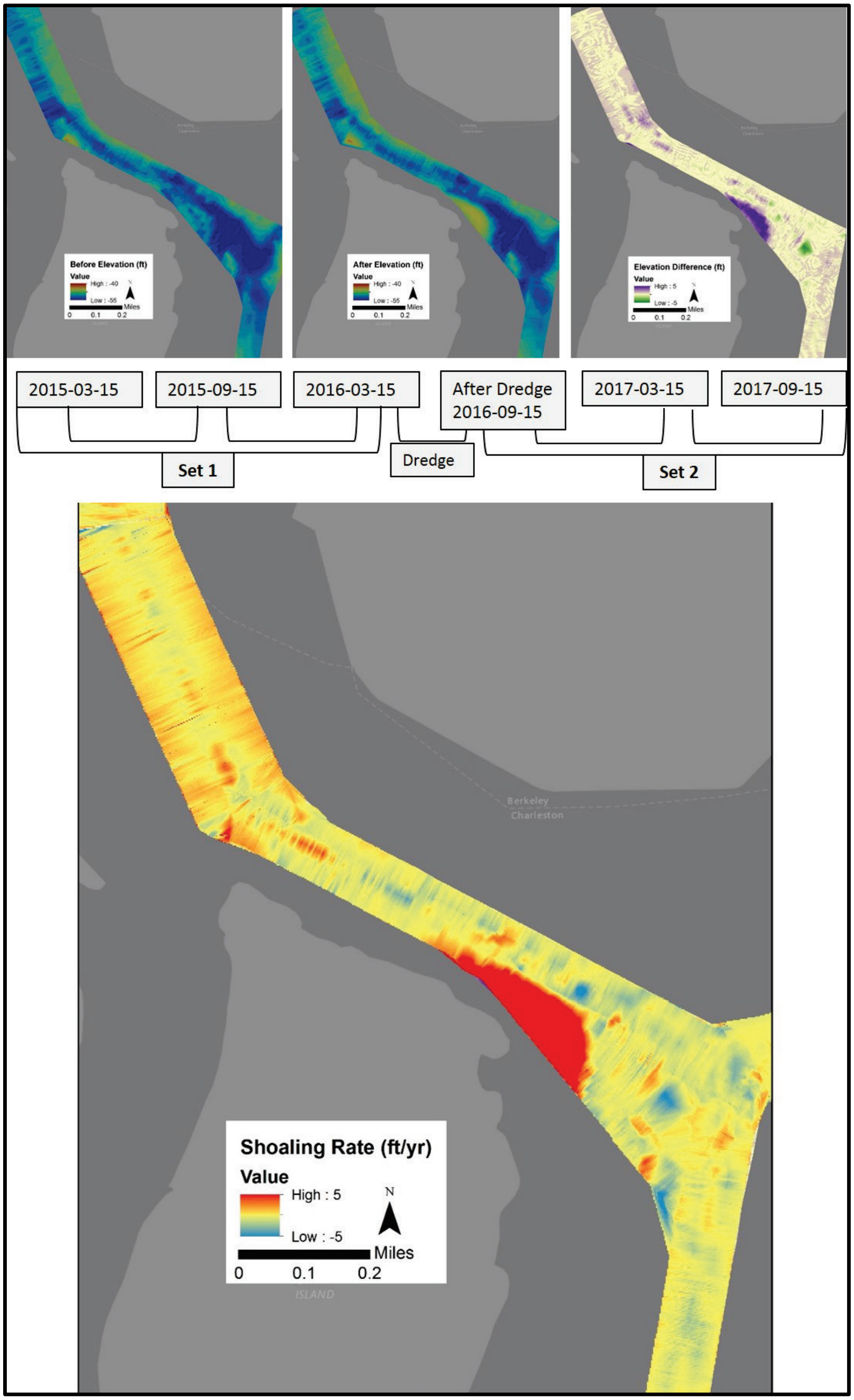
Any modifications to the channel design need to be identified so that only the surveys after the updates are used in the analysis. Additionally, the analysis should be performed using surveys measured with the same vertical datum. Any datum discrepancies require reprocessing and upload through eHydro, or the user may opt to remove the surveys from the analysis in CSAT. The CSAT code assumes the surveys are all in a consistent vertical datum. Any inconsistencies must be corrected before the surveys are loaded into eHydro.

Meteorological events may also influence the shoaling predictions, particularly in areas that have a limited number of surveys. Seasonal variations in rainfall totals or extra-tropical storm events that impact the channel may result in changes to the sediment flux in the system. The goal of the CSAT is to provide a standard, repeatable method for using all hydrographic surveys to predict average shoaling rates. Therefore, fluctuations due to anomalous events should be considered when interpreting the results. In addition, the user may choose to remove the survey from the analysis and classify the survey as emergency response to avoid skewing the results.

Once the thresholds are specified and preliminary changes to the survey table have been completed, the CSAT code can be run to generate the shoaling rates. The following methods are used to calculate the shoaling rates within the CSAT code:

1. Elevation differences are calculated for the survey pairs between dredging events (Figure 5, top). Each survey set comparison is then combined to provide an overall channel shoaling prediction (Figure 5, bottom).
2. The elevation difference grids created for the survey pairs are then combined to find the average, maximum, and minimum change rates at the individual cell.
3. The cell change values are merged to provide a reach value for the average, maximum, and minimum shoaling rates in addition to volume of sediment fluctuations between survey sets.
4. Output files per reach with shoaling rate grid and volume tables are created for result validation and to assist with any modifications to thresholds or surveys used in the analysis. Although these files are used primarily for quality control (QC) purposes, other applications have been identified and are discussed in Chapter 3.

Figure 5. Survey elevation differences for individual survey comparison (top), an example of the survey comparison scheme (middle), and the shoaling rate grid calculated from combining the survey elevation differences with the time rate of change (bottom).



Quality control (QC) files

Computations to help during the quality check process include tabular files of the percent overlap of surveys and survey comparison between survey pairs. The survey overlap table (Table 3) is used to ensure there is sufficient overlap between surveys to include the comparison in the analysis. Channels with long reaches may have limited survey overlap due to survey methods, and therefore these adjoining surveys may be combined if the surveys are part of the same contract. Another reason that low percent overlap may occur is if districts survey known shoaling areas or sediment hot spot areas and then follow the migration of the shoal without performing a full channel survey.

Table 3. Percent overlap example output file.

Before Survey	After Survey	Percent Overlap
20150115	20150521	94.8
20150521	20150730	95.2
20150730	20151001	69.2
20151001	20160309	73.9

The survey comparison table provides additional information at the reach level regarding changes occurring between two surveys (Table 4). The elevation difference between the two dates provides additional information about episodic events that may have impacted the area or changes to the dredging plan. Viewing the changes between specific dates can also lend insight into any anomalous events that may impact the results. Periods of increased rainfall may be reflected in higher than normal change rates whereas periods of drought may result in less sediment accumulating.

Table 4. Survey comparison table showing elevation change and volume change between surveys.

Before Survey	After Survey	Elevation change rate (ft/year)	Volume change rate (cubic yards/year)
20121015	20130117	1.26	177,711
20130410	20131210	0.29	50,523
20130410	20140326	0.34	55,623
20130830	20131210	0.88	155,855
20130830	20140326	0.65	114,426
20131210	20140326	0.42	75,910
20150115	20150521	0.56	99,767

Before Survey	After Survey	Elevation change rate (ft/year)	Volume change rate (cubic yards/year)
20150115	20150730	0.67	118,082
20150521	20150730	0.83	145,347
20151001	20160309	1.53	279,867

Shoaling rate tables

In addition to the tables used in the QC process, other output files from CSAT provide valuable information ranging from specific values at individual cells to reach-level data. The grid cell value table includes the location (X,Y coordinates), average shoaling rate (feet/year), maximum shoaling rate (feet/year), minimum shoaling rate (feet/year), last Z elevation (feet), number of surveys used in the analysis, and standard deviation of average shoaling rate (Table 5). The data within this table are used to create the shoaling rate raster showing average, maximum, or minimum shoaling. The values at each X,Y cell location are quantified by comparing all survey sets and calculating the average, maximum, and minimum shoaling rates. The average shoaling rate value is calculated at every grid cell and is the average shoaling that has occurred. The average maximum shoaling rate is calculated at every grid cell and is the highest shoaling that has occurred for that cell by comparing the survey difference sets. Similarly, the minimum shoaling rate is the lowest shoaling that has occurred at each cell by comparing all the survey sets.

Table 5. Grid cell value table includes X,Y location and shoaling rates for the average, maximum, and minimum along with the last survey elevation in addition to number of surveys and the standard deviation.

X	Y	Average (ft/year)	Average Maximum (ft/year)	Average Minimum(ft/year)	Last Z (ft)	Number Surveys	Standard Deviation
2348558	338760.1	0.358568	3.246073	-9.67391	-57.5433	13	0.009693
2348548	338750.1	0.905631	7.348999	-7.9961	-56.02	15	0.009191

With information regarding historical shoaling rates, districts can use CSAT to make prediction of the quantity of sediment in cubic yards necessary to be removed in future scenarios (Table 6). The last hydrographic survey is used as the “Now” volume of material that would need to be removed to obtain the dredge cut elevation. The average shoaling rate for each grid cell is projected onto the last survey elevation and is multiplied by the time increment thereby enabling a prediction of quantity of material that would need to be removed to meet the specific channel depth as specified by the dredge cut column.

Table 6. Channel reach volume table with values every 6 months and at varying 1 ft depth increments. (CY = cubic yards)

Dredge Cut (ft)	Now (CY)	6 months (CY)	12 months (CY)	18 months (CY)	24 months (CY)	30 months (CY)	36 months (CY)
-45	195,320	271,020	373,070	492,200	624,890	771,020	931,220
-44	125,140	173,140	238,620	331,710	444,910	572,680	713,450
-43	76,249	109,860	153,260	210,570	293,080	399,730	522,310
-42	43,628	65,655	95,990	135,350	186,480	258,070	356,920
-41	24,409	37,093	56,313	83,402	119,100	165,270	227,370
-40	14,958	21,022	31,470	48,147	72,041	104,370	146,170
-39	10,060	13,343	18,250	26,832	41,017	61,922	91,020
-38	7,083	9,092	11,945	16,084	23,035	34,823	53,059
-37	5,194	6,480	8,241	10,728	14,312	19,888	29,576
-36	3,865	4,787	5,944	7,496	9,673	12,784	17,358
-35	2,806	3,555	4,412	5,465	6,843	8,751	11,457

3 Additional Analyses

Input for the Channel Portfolio Tool (CPT)

The CSAT volume tables provide valuable information that can be combined with navigation tonnage data to support a system approach to channel optimization. The CPT (CPT 2018) (available at https://cpt.usace.army.mil) is a web-based decision support tool that provides access to dock-level tonnage data that are maintained by the USACE Waterborne Commerce Statistics Center (WCSC) (Mitchell 2012; Mitchell and Walker 2009). The WCSC also routes tonnage from origin to destination using a proprietary waterway network that has been modified for use in CPT. Query functions within CPT allow the user to objectively compare channels for prioritization of dredging budget requests through O&M.

The tonnage and economic data that are available within the CPT provide the commerce information needed to understand uses of the navigation channel and benefits associated with maintaining depths at various intervals. The shoaling rates provide quantitative results that are used in combination with the WCSC data.

Since the WCSC waterway network is represented as a polyline and the reaches within the NCF are defined as polygon features, the CPT channel alignment process was required to create a spatial link for the WCSC channel lines with the channel boundaries from the NCF (Figure 6). The result of this joining creates a new channel file that has the same dimensions as the NCF with the unique link numbers for the WCSC data. The granularity of the WCSC line data was used to either merge or split the NCF reaches. The new CPT channel files include the WCSC link numbers that provide the relationship between the WCSC tonnage data and the channel boundaries. The CPT channel files are used to extract the shoaling rate grid so that the shoaling rates can be quantified within the reaches that align with the WCSC links. The volume tables are also generated for the CPT channel reach (Figure 6).

Figure 6. Spatial link between the WCSC lines and the NCF polygons.

The CSAT volume tables for the CPT channel reaches are loaded into CPT to provide data needed to support a dredging work plan for a 3-year budget cycle. The volumes at the incrementing depths and 6-month time interval provides Navigation managers with knowledge about optimal dredging depths and timeframes for dredging. The Navigation managers can adjust options within CPT to modify costs associated with dredge equipment mobilization and demobilization and dredging cost per cubic yard. Combining the cost information and annualized tonnage data with the CSAT volume table provides a range of options to identify the most cost-effective time and depth increment to conduct maintenance dredging (Dunkin and Mitchell 2015).

The pseudo-benefit cost ratio developed for the work package formulator within CPT has flexibility for users to adjust options dynamically to plan for various scenarios (Dunkin and Mitchell 2015). For example, if the mobilization/demobilization costs decrease due to changes in fleet schedules or other planned projects, then the time interval between dredging events and the dredge depth will decrease in this scenario. However, in the scenario where costs increase, dredging to a deeper depth may allow for a longer window of time before maintenance dredging is required. The various scenarios to optimize the dredging plan are customizable for each CPT reach. The CSAT shoaling rates provide valuable datasets to use within the CPT and support decision making that will maximize dredging funds and minimize disruption to vessel traffic through the navigation channels.

Channel infilling

Channel infilling rates can be calculated by dividing the surveys used in the shoaling analysis into separate groups. Infilling rates can be computed to better understand differences between dredge events or seasonal variation. The CSAT input table provides users with flexibility to compute the infilling rates.

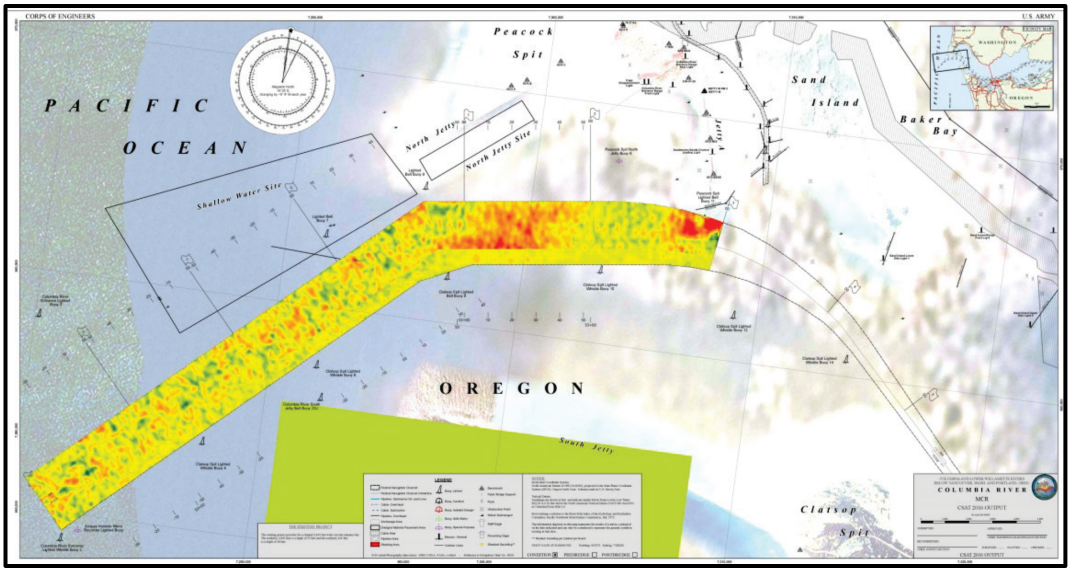
Dredge efficiencies may vary depending on the type and the condition of the sediment being removed. The New Orleans District (MVN) requested support to compare dredges that performed work at two separate times for the Calcasieu Channel. Fluid mud is an issue for Calcasieu Channel, particularly in the entrance and outer bar portions of the channel. As such, different dredges were compared to determine the respective infilling rate between the dredging events. MVN was provided shoaling rate maps in addition to tables that provided the infilling rate for each dredge event.

Seasonal variations and extreme storm events may also be studied more closely using output files from the CSAT, constraining the surveys to align with the time period of interest. In addition, the shoaling rate analysis may be used to focus survey or dredging resources at known hot spots to assist with an emergency response effort. While CSAT requires survey data to determine shoaling rates and elevation changes, if sufficient data exist from a previous event, these results may be valuable in prioritizing new survey locations based on past infilling rates.

Shoaling rate maps

The eHydro 3.14 release has implemented a mapping tool to allow districts to create shoaling rate maps specifically for the district using the district standard chart scheme (eHydro 2017). The CSAT output file includes the average, maximum, and minimum shoaling rates, number of surveys, and standard deviation for a particular channel reach and is defined at each grid point. The high-resolution data provide input needed for the eHydro map tool to create raster grids using the shoaling rates. An example of an average shoaling rate raster map product is shown in Figure 7.

Figure 7. Map showing the shoaling rates for the Columbia River channel (Portland District). The red shade signifies areas of higher shoaling while the green shade signifies lower shoaling areas. Areas with minimal shoaling are shown as yellow.



4 Conclusion

The CSAT calculates channel shoaling volumes using historical channel surveys and uses the shoaling rates to predict future dredging volumes. The CSAT leverages ongoing efforts by the USACE to standardize the manner in which hydrographic surveys are uploaded and processed through its eHydro program. The CSAT estimates future localized shoaling rates through a hindcasting algorithm and historic shoal volumes and is designed to incorporate new hydrographic surveys as they become available. The addition of hydrographic surveys ensures that the shoaling rate predictions are continually updated, and thus trends from seasons or other dredging maintenance changes are incorporated in the shoaling analysis.

The CSAT output files provide valuable data needed for various applications, which are listed below:

- Shoaling rate grids can be used to identify hot spots or areas of increased sedimentation.
- Constraining the time period to more closely align with a specific event (extratropical storm, rainfall or drought periods, dredge schedule change or dredge type change) may lend insight into the impacts that these events caused to the sedimentation within the channel.
- Volume tables with the 3-year predictions at the incrementing depths provide information within CPT to support prioritization of maintenance dredging needs for the 3-year budget cycle.

Since CSAT uses historical hydrographic surveys to predict future shoaling rates, it is recommended that management implement survey protocols to survey the full channel on a recurring basis and upload all surveys, to include condition and before/after-dredge surveys.

References

Channel Portfolio Tool (CPT). 2018. U.S. Army Corps of Engineers, U.S. Army Engineer Research and Development Center, Coastal Hydraulics Laboratory. Accessed August 2. https://cpt.usace.army.mil.

Dunkin, L. M., and Mitchell, K. N. 2015. Quantitative approach to navigation channels asset management. In *Proceedings of the Western Dredging Association and Texas A&M University Center for Dredging Studies Dredging Summit and Expo 2015*. Houston, Texas. https://www.westerndredging.org/index.php/information/proceedings/category/305-table-of-contents-with-hyperlinks

eHydro. 2017. *Hydrographic Survey Version 3.10: Users Guide*. https://cops.usace.army.mil/sites/GEO/HSM/HYDAPP/Documentation/eHydro%20User%20Guide%20v310.pdf

Mitchell, K. N. 2012. *A Review of Coastal Navigation Asset Management Efforts within the Coastal Inlets Research Program (CIRP): Part 2; the Channel Portfolio Tool*. ERDC/CHL CHETN-IX-29. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://chl.erdc.usace.army.mil/chetn

Mitchell, K. N., and J. E. Walker. 2009. Depth-utilization analysis for estimating the economic activity supported by dredging. In *Proceedings, Western Dredging Association/Texas A&M University Annual Dredging Conference*. Phoenix, AZ. http://cirp.usace.army.mil/pubs/pdf/mitchell-walker_WEDA09.pdf

Rosati, J. D. 2005. *Coastal Inlet Navigation Channel Shoaling with Deepening and Widening*. ERDC/CHL CHETN-IV-64. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://hdl.handle.net/11681/1969

USACE. 2016. *USACE Daily Tasking Order 16-02-22*. Implementation of USACE eHydro Data Reporting Process. Washington, DC. https://team.usace.army.mil/sites/HQ-CO/PDT/HQ-G33/Lists/Orders%20Log/Attachments/1820/USACE%20Daily%20Tasking%20Order%2016-02-22_signed.pdf

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
November 2018	Final Report	

4. TITLE AND SUBTITLE
Corps Shoaling Analysis Tool: Predicting Channel Shoaling

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Lauren M. Dunkin, Lauren A. Coe, and Jay J. Ratcliff

5d. PROJECT NUMBER
468429

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) (see reverse)
Coastal and Hydraulics Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER
ERDC/CHL TR-18-16

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Headquarters, U.S. Army Corps of Engineers
Washington, DC 20314-1000

10. SPONSOR/MONITOR'S ACRONYM(S)
HQUSACE

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This report provides background and additional application s of using the Corps Shoaling Analysis Tool (CSAT) and the various output files generated. The CSAT calculates channel shoaling volumes using historical channel surveys and uses the shoaling rates to predict future dredging volumes. Shoaling rate grids can be used to identify hot spots or areas of increased sedimentation. In addition, limiting the time period for analysis to more closely align with a specific event (e.g., meteorological activity or change to dredging schedule/type) may provide insight into the impacts that these events cause to the sedimentation within the channel. The volume tables that quantify the amount of sediment needing to be dredged at depth and time increments also support decision making that will maximize the use of dredging funds and minimize disruption to vessel traffic through the navigation channels.

15. SUBJECT TERMS
Decision making—Mathematical models, Dredging, Dredging spoil, River channels, Sedimentation and deposition

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Lauren Dunkin
Unclassified	Unclassified	Unclassified	SAR	30	**19b. TELEPHONE NUMBER** *(Include area code)* 228-596-480

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18