Case Study

Southwest Pass Sedimentation and Dredging Data Analysis

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Abstract: The United States Army Corps of Engineers (USACE) maintains the Mississippi River, Baton Rouge, Louisiana, to the Gulf of Mexico Project as part of its Navigation mission to enable safe, reliable, and cost-effective marine transportation throughout the country. The entrance channel for this vast inland port system is known as Southwest Pass (SWP) and is the most highly utilized commercial deep-draft waterway in the nation. In recent years, the SWP has been prone to rapid-onset shoaling, with predictive lead times based on upstream river discharge rates of only about 14 days. The daily survey frequency in combination with the Dredging Quality Management (DQM) dredging records now available provide the framework for better understanding the dynamic shoaling conditions and the relative role of USACE dredging activity toward restoring full channel navigability. **DOI: 10.1061/(ASCE)WW.1943-5460.0000684**. *This work is made available under the terms of the Creative Commons Attribution 4.0 International license, https://creativecommons.org/licenses/by/4.0/.*

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Introduction

The United States Army Corps of Engineers (USACE) maintains the Mississippi River, Baton Rouge, Louisiana, to the Gulf of Mexico Project as part of its Navigation mission to enable safe, reliable, and cost-effective marine transportation throughout the country. The entrance channel for this vast inland port system is known as Southwest Pass (SWP) and is the most highly utilized commercial deep-draft waterway in the nation. In recent years, the SWP has been prone to rapid-onset shoaling, with predictive lead times based on upstream river discharge rates of only about 14 days. Due to operational, logistical, and acquisition challenges of mobilizing industry and government fleet dredges on short notice, these shoaling rates have led to prolonged, multi-month periods of draft restrictions for vessels transiting through SWP, thereby reducing the amounts of cargo that can be transported per voyage and increasing overall shipping costs for a wide range of commercial cargos. The economic costs of these disruptions to shipping operations are significant, given that an average of over 250 M tons of cargo transit SWP each year. To transport these vast amounts of critical bulk commodities, a *daily* average of 13 oceangoing vessels drafting at least 10.7 m (35 ft) are needed to transit SWP and access global markets. To counteract the aggressive channel shoaling and restore full navigable depths, the USACE has dredged an annual average 19.1 million m^3 (25 million CY) of sediment since 2015.

So as to better understand the dynamic sedimentation processes and to increase lead times for dredge contingency planning, the study presented here shows how several enterprise USACE datasets have been compiled to provide both a quantitative and qualitative analyses of shoaling events and dredging operations within SWP. Hydrographic surveys capturing navigation channel bathymetric conditions are compiled, standardized, and made available through the USACE eHydro system. Likewise for dredging operations, the onboard diagnostic sensor arrays for dredges under contract with the USACE provide detailed information to the Dredging Quality Management (DQM) geospatial data archive. The DQM system monitors critical aspects of dredge activity, including precise dredge locations and the volumes of material removed from depth contours within the channel cross section. Separate records maintained by the New Orleans District (MVN) for cutterhead dredge work were also obtained to support this data analysis.

The present study uses historic hydrographic surveys uploaded through eHydro to quantify shoaling volumes and morphologic patterns across a range of spatial scales. The daily survey frequency in combination with the DQM dredging records now available provide the framework for better understanding the dynamic shoaling conditions and the relative role of USACE dredging activity toward restoring full channel navigability. These results can help contribute to improved channel maintenance strategies and operations, potentially reducing the extent and duration of shoal-related draft restrictions through SWP. Responsible stewardship of taxpayer dollars compel the USACE to be judicious and deliberate with dredging outlays, and this work represents a novel, data-driven analysis to achieve this objective.

Background

The USACE is responsible for maintaining and improving approximately 19,300 km (12,000 mi) of shallow draft, i.e., 2.75–4.3 m (9–14 ft), inland and intracoastal waterways, 20,921 km (13,000 mi)

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of deep draft (4.3 m or 14 ft and greater) channels, 400 ports, harbors, and turning basins, 239 Locks and Dams, as well as 800+ Bridges. These individual projects compete for federal funding and dredging assets. The Mississippi Baton Rouge to Gulf Project is the most highly utilized commercial deep-draft waterway in the nation and home to 4 of the top 13 rated ports by Tonnage. The South Louisiana Port, Port of New Orleans, Port of Plaquemines, and Port of Baton Rouge accounted for a total of 507,929,991 t of Domestic and Foreign cargo in 2018 (USACE 2019). The entrance channel to the Mississippi River, known as the SWP, stretches a span of just over 56 km (35 mi) [(Mile 13.4 Above Head of Passes (AHP) to Mile 22 Below Head of Passes (BHP)]. This reach of the channel has become one of the top maintenance priorities for the USACE Navigation program due to its critical importance as an access point to global markets. With the Mississippi River system was draining 41% of the contiguous United States, large amounts of sediment are frequently transported directly into the waterway (Mossa 1996; Allison et al. 2012). According to recent USACE Engineering Research and Development Center (ERDC) studies, the SWP 90% shoaling rate is roughly 68,000 m^3/day (89,000 CY/day). This rapid-onset shoaling presents challenges for waterway managers with securing and mobilizing the industry dredging fleet in a timely manner, and the resulting delays have led to sailing draft restrictions for commercial vessels transiting SWP.

These challenges were on full display in 2019, which proved to be the wettest year on record in the United States (NOAA 2020), leading to prolonged periods of aboveaverage discharge and the accompanying transport of massive amounts of sediment. Due to the prolonged high-flow conditions and resulting aggressive shoaling, the SWP required significantly more dredging via multiple dredge vessels to regain full sailing draft for transiting vessels. Particularly, during the month of April 2019, the SWP had five hopper dredges (four industry) and two cutterhead dredges all working concurrently in an attempt to overcome heavy shoaling and to restore the channel to full, congressionally authorized dimensions. Despite this significant dredging effort in 2019, the SWP still endure 205 days of draft restrictions put in place by the local Pilots Associations to ensure that vessels maintained safe underkeel clearance (Table 1). With a daily average of 13 oceangoing vessels drafting at least 10.7 m (35 ft) transiting the SWP, every foot of depth is crucial to the shipping industry. When Draft restrictions are in place, the shipping companies must decide whether to "light-load" and/or anchor outside the channel until conditions allow for safe passage. Either of the options adds significant costs to the shippers.

Channel Surveys and Dredging Data

The USACE routinely surveys navigation channels in order to assess channel conditions relative to the congressionally authorized dimensions. The frequency of the hydrographic surveys depends on a variety of factors, but in general channels that shoal rapidly require more frequent hydrographic surveys to quantify channel conditions and identify areas where shoaling activity has a potential to disrupt normal shipping operations (USACE 2013). Access to these hydrographic surveys is therefore fundamental to the maintenance and navigability of the navigation channels. As such, the USACE has developed an enterprise hydrographic survey processing tool (eHydro) to support a standard and efficient process for survey data accessibility (Niles 2013). Through the eHydro tool, the hydrographic surveys are processed for individual channel reaches as defined by the National Channel Framework (NCF) (Libeau 2007). The time stack of hydrographic surveys is combined into a file structure per reach to support efficient processing of the channel surveys. Owing to the dynamic conditions and aggressive shoaling history, hydrographic surveys of SWP are conducted on nearly a daily basis by MVN to monitor channel conditions, with more than 6,500 hydrographic surveys uploaded from January 2015 through December 2019. This paper focuses on the 13 reaches for SWP where Reach 1 begins near Venice, Louisiana. and extends downriver to Reach 13 just beyond the jettied entrance channel to the open water of the Gulf of Mexico (Fig. 1).

Table 1. Summary of dredging activity in SWP

Fiscal year	Total dredging expenditures in SWP ($ × 1M)	Total sediment volume removed ($m^3 \times 1M$)	Total sediment volume removed (CY×1M)	Draft restriction (days)
FY15	$66.0	14.1	18.5	6
FY16	$65.4	16.1	21.0	147
FY17	$62.4	17.0	22.3	29
FY18	$62.1	15.4	20.1	79
FY19	$147.8	35.8	46.8	205

Having a rich dataset enables robust temporal analysis of shoaling rates and sediment transport patterns through the SWP. The Corps Shoaling Analysis Tool (CSAT) quantifies shoaling by comparing a record of hydrographic surveys (Dunkin et al. 2018). The shoaling forecast from a CSAT analysis has been used in combination with dredging information to determine areas of increased sedimentation within navigation channels (Hamilton et al. 2018) as well as combined with the detailed Waterborne Commerce annualized tonnage figures within the Channel Portfolio Tool to support a quantitative approach to channel maintenance (Dunkin and Mitchell 2015).

The USACE-DQM Program has been in place for over a decade and is comprised of sensor arrays outfitted to dredging vessels conducting USACE Civil Works projects and any work requiring Department of the Army permitting (USACE 2006). Onboard the dredge, multiple sensors continuously monitor dredge activities and operations. Sensor data are transmitted to the DQM for processing, storage, and distribution. In this study, the detailed spatiotemporal data provided by the DQM system enables unprecedented accuracy for tracking dredging operations relative to the dynamic sediment infilling patterns made clear via the daily hydrographic surveys accessible via eHydro. Although DQM has been required for hopper dredges working on USACE projects for many years, DQM only recently became mandatory for pipeline dredging projects in USACE (2020). So as to provide a complete retrospective of recent dredging activity in SWP, cutterhead dredging records collected by the USACE New Orleans District for tracking operational mission readiness were used to compile daily production reports from 2010 to 2019. These reports contain the daily starting and stopping location by station and the total volume of sediment dredged for cutterhead vessels working in SWP.

Sedimentation and Dredging Analysis Approach

Processing Hydrographic Surveys

Most channel condition surveys are conducted using single-beam echosounders along cross-channel transects, a defined distance apart, typically at 152.4-m (500-ft) intervals (Byrnes et al. 2002). If the intent of the survey is to focus on a particular pre-dredge or post-dredge area, transect spacing may be varied to provide the desired coverage of the region of interest. The spacing between survey lines represents a necessary compromise that provides timely channel conditions in a rapidly changing environment.

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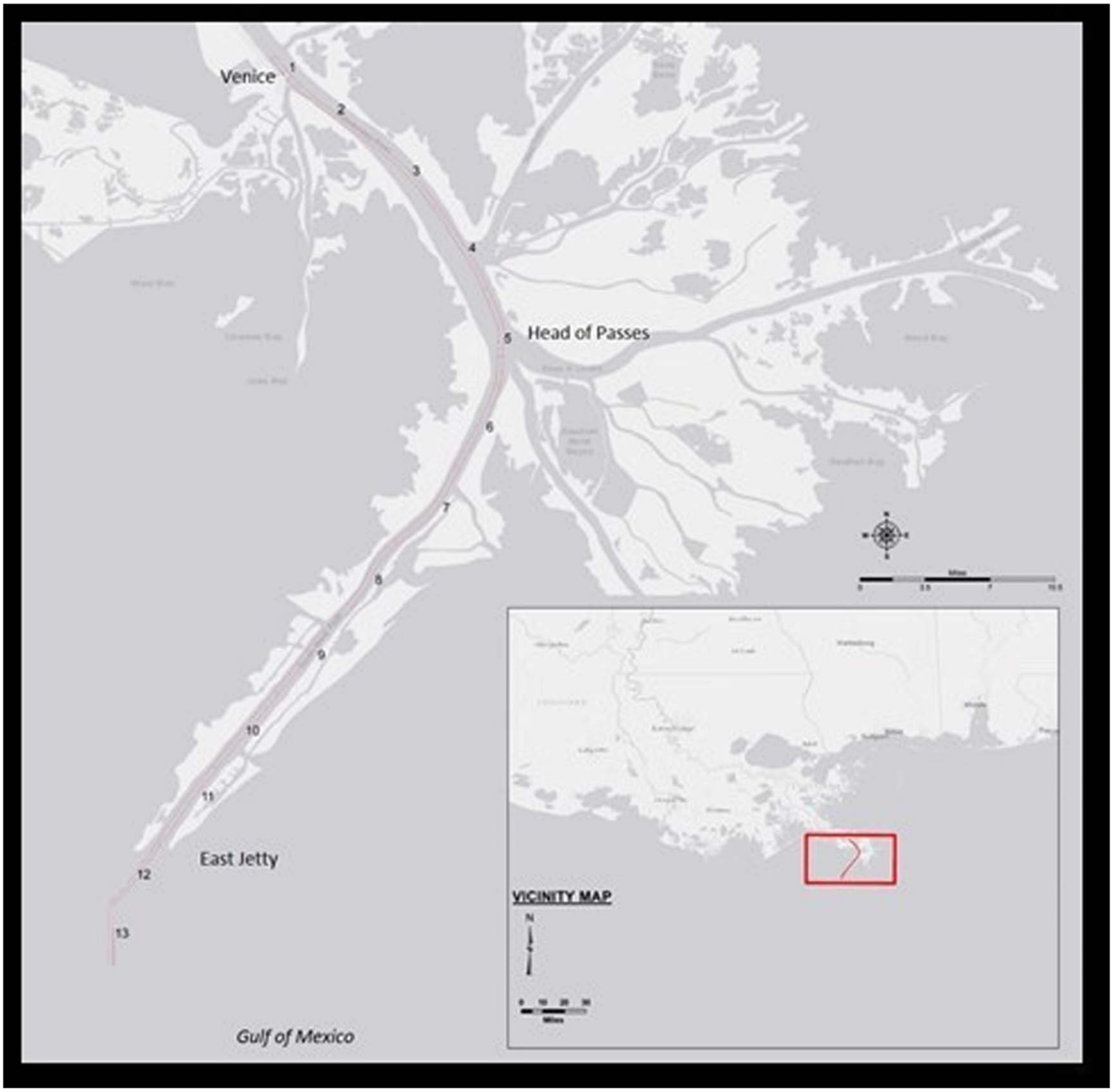

Fig. 1. (Color) Overview of SWP navigation channel in the lower Mississippi River. (Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS User Community.)

Therefore, interpolation between points is necessary to describe the bathymetric surface. Each survey consists of a scattered point dataset referenced to the Louisiana South State Plane (ft) Projected Coordinate System Louisiana South State Plane. Surveys of SWP collected prior to January 26, 2017, were referenced to Mean Low Gulf (MLG), and surveys after that date were referenced to Mean Lower Low Water (MLLW). The surveys originally in MLG were transformed to MLLW using the elevation offset described in USACE (2017).

Once the survey data were in common horizontal and vertical reference systems, they were used to construct triangulated irregular networks (TIN) to represent the bathymetric surface between survey lines. Each TIN was converted to a raster format with consistent raster cell dimensions of $3.05\ \text{m} \times 3.05\ \text{m}$ $(10\ \text{ft} \times 10\ \text{ft})$. Finally, the rasterized datasets were stored as space-time cubes in NetCDF format.

The near-daily frequency of surveying in SWP means that conditions in many parts of the channel are recorded at a temporal sampling rate that enables unusually detailed analysis of shoaling patterns and trends. For the portions of the channel that are not sampled frequently, a linear temporal interpolation technique was used to provide a daily time series of bathymetry for the entire channel. A series of transects were generated perpendicular to the navigation channel centerline at a 30.5-m (100-ft) spacing. Bins constructed from these transects help summarize bathymetric conditions at a finer resolution than those the reach boundaries currently provide. In addition to summarizing the observed bathymetric changes between surveys, these transect bins also help with relating the hopper dredging activity from DQM to regions of the channel.

The bathymetric surveys are useful for tracking the movement of sediment through SWP. To do this, the volume of sediment above a reference datum can be calculated for each bin of SWP

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for each day where there is an available survey. Here, two sets of calculations were performed: one with a reference datum corresponding to the authorized depth of −14.8 m (−48.5 ft) and another with a reference datum set at −24.4 m (−80 ft). The −24.4-m (−80 ft) depth was chosen in order to track the volume changes in the deepest parts of the channel. Fig. 2 shows the channel bed volume above the −24.4-m (−80-ft) datum totaled across all bins for each day of water year 2018 (October 2017 through September 2018). Fig. 2 also includes the daily Mississippi River discharge at Belle Chasse (USGS Site #7374525) near River Mile 75 to demonstrate the fluctuations in river flow. The magnitude of sediment volume, roughly 93.3 million cubic meters (122 million cubic yards), is not important as the focus here is on the change in the channel bed volume. Because the volumes shown in Fig. 2 are directly calculated from the surveys, the volume increases are due to deposition while volume decreases are the result of both erosion and dredging.

During water year 2018, we see the channel bed volume above the −24.4-m (−80 ft) datum reflect increases and decreases in a similar pattern as the river discharge, as shown in Fig. 2. This is expected because the river discharge is an important driver of sedimentation dynamics. The greatest amount of sediment volume above −24.4 m (−80 ft) is 97.4 million m^3 (127.4 million CY) on March 17, 2018, while the lowest volume is 90.7 million m^3 (118.6 million CY) on 6/28/2018. The time of problematic increase in sediment volume occurs from February 27 to March 17 where an increase of 3.7 million m^3 (4.9 million CY) occurs in 18 days. This demonstrates the challenge faced by waterway managers who must procure and deploy dredging resources in response to these large volume increases that can occur over the course of just a few weeks. The 2018 sudden increase would have been even larger if dredging already planned by MVN had not begun during this time window.

Incorporating Dredging Data

The DQM dredge load summaries provide summary statistics for the dredging cycles completed by the hopper dredge fleet. DQM considers a dredging cycle to begin with the hopper sailing light, followed by dredging, sailing loaded, and then ends when a disposal event has completed. All available dredge load summaries reported within the vicinity of SWP were analyzed to extract key characteristics for this study. The major attributes of interest were the dredge position (latitude/longitude) when the dredge completed the dredging phase of the dredge cycle, the date and time that the dredge completed the cycle, and the average loaded volume of the dredge as it sailed heavy to the disposal site. After extracting these properties from all the dredge summaries, the data were cleaned to remove any outliers or anomalous entries. The hopper load volume was then aggregated to the transect bin containing the reported loaded latitude/longitude position and daily dredging volume totals were computed.

The volumes contained within the cutterhead dredging records were proportionally distributed among the transect bins overlapped by the starting and stopping locations. Bathymetric conditions are shown for time periods prior to, during, and after cutterhead dredge activity near Head of Passes (Fig. 3). Blue represents areas that are deeper than the authorized depth whereas red areas are shallower and thus indicate areas of reduced navigability. On February 18, 2019, a cutterhead dredge arrives at the location and begins work clearing the shoal encroaching the western portion of the navigation channel [Fig. 3(a)]. On February 28, 2019, just 10 days after arriving, the cutterhead dredge has removed approximately 273,000 m^3 (357,000 CY) of sediment within the navigation channel [Fig. 3(b)]. On March 10, 2019, the dredge continued to work within the vicinity of Head of Passes for 10 more days removing approximately 277,000 m^3 (362,000 CY) of additional sediment, when on March 10, 2019, the cutterhead dredge departed Head of Passes and began working elsewhere in SWP. The post-dredge bathymetry shows a sizeable reduction of a portion of the shoal [Fig. 3(c)].

The significant shoaling in 2019 had five hopper dredges (four industry) and two cutterhead dredges all working concurrently to restore the channel to full, congressionally authorized dimensions. The most significant periods of shoaling occurred from January 2019 through March 2019 where volume above authorized depth ranged from 745,000 m^3 to 1,290,000 m^3 (974,000 CY to

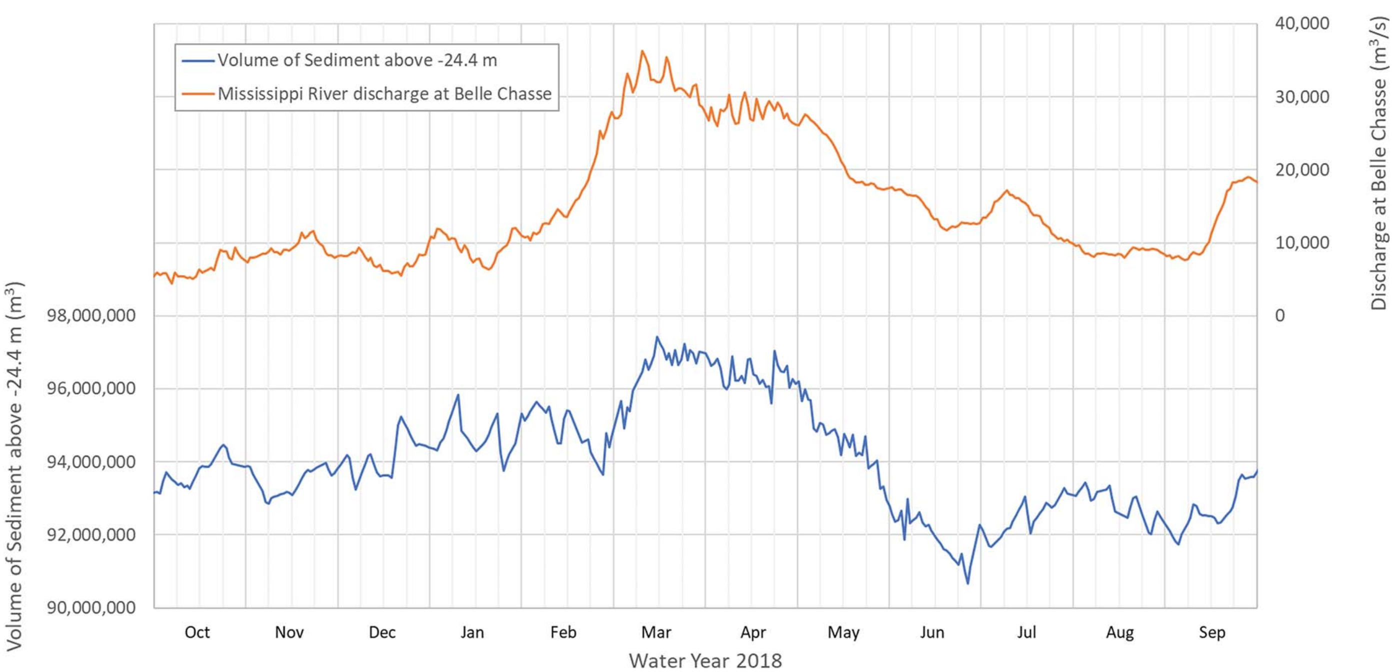

Fig. 2. (Color) Channel bed volume changes and river discharge for water year 2018.

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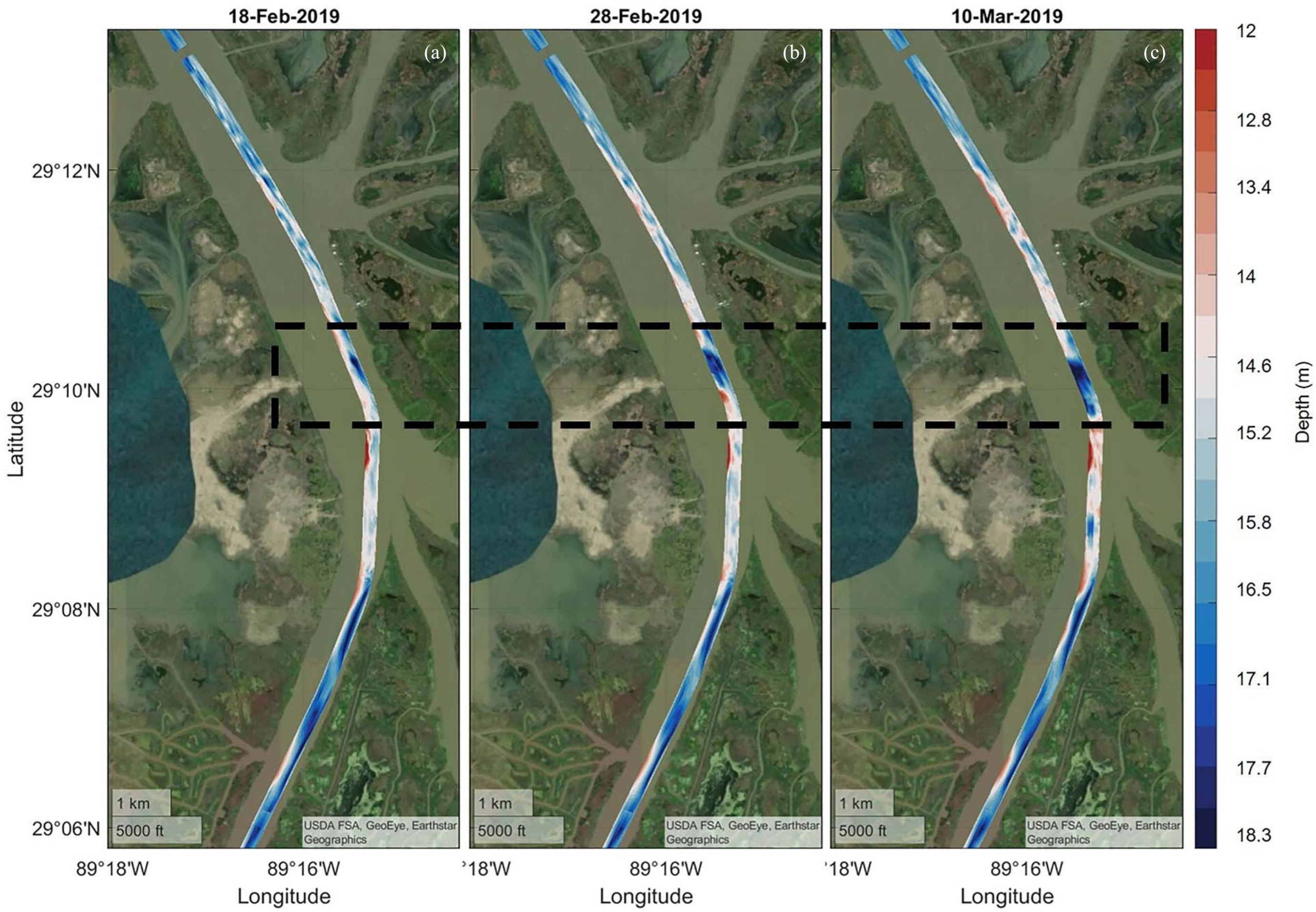

Fig. 3. (Color) Channel conditions at the Head of Passes at three different dates in 2019: (a) when cutterhead dredge arrives on February 18, 2019; (b) 10 days subsequently on February 28, 2019 [approximately 273k m^3 (357k CY) removed]; and (c) another 10 days subsequently on March 10, 2019 [approximately 277k m^3 (362k CY) removed]. Areas deeper than the authorized depth are shown in blue, whereas areas shallower than the authorized depth are in red. The region within the black dashed line follows the progression of the dredge from February 18, 2019, through March 10, 2019. (Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.)

Table 2. Volume in SWP for the dates shown in Fig. 4

Date	Volume above authorized (m^3)	Volume above authorized (cy)
January 10, 2019	744,825	974,194
March 10, 2019	1,294,587	1,693,256
June 1, 2019	437,439	572,149
September 1, 2019	302,934	396,222

1,690,000 CY) (Table 2). The significant volume above authorized depth is not uniform along the river. Shoaling during the January 2019 timeframe is fairly consistent along the river with the most significant volume of sediment above authorized depth occurring on the southern portion of the river near East Jetty [Fig. 4(a)]. The dredges initiated production in February 2019 and focused efforts to remove sediment along the river. The most aggressive shoaling occurs at Head of Passes and East Jetty for the March 2019 timeframe [Fig. 4(b)] where prolonged periods of aboveaverage discharge and the accompanying transport of massive amounts of sediment resulted in a significant volume of sediment above authorized depth. Due to the prolonged high-flow conditions and resulting aggressive shoaling, the SWP required significantly more dredging via multiple dredge vessels to regain full sailing draft for transiting vessels [Figs. 4(c and d)].

Discussion

This effort combines several enterprise datasets for channel conditions (eHydro) and USACE-contracted dredging activities (DQM and MVN District records) to provide waterway managers with finer spatial and temporal resolution with which to analyze and address the shoaling behavior at SWP. As shown in Fig. 5, significant volumes of sediment were observed shallower than the authorized depth over several periods between January 2015 and January 2020. In response, from 2015 through 2018, cutterhead dredges were deployed subsequent to the initial hopper dredge response. In 2019, the hopper dredge fleet was used extensively at Head of Passes, River Mile 0. The 30.5-m (100-ft) transect bin approach provides a detailed dataset of the spatiotemporal shoaling patterns along the river and the dredging response to counteract the aggressive shoaling and maintain navigability for commercial shipping.

When comparing the reported annual dredging volumes from MVN relative with the computed volumes from the DQM and cutterhead dredge summaries, in most cases, the computed volumes are less than the reported quantities (Fig. 6). One potential

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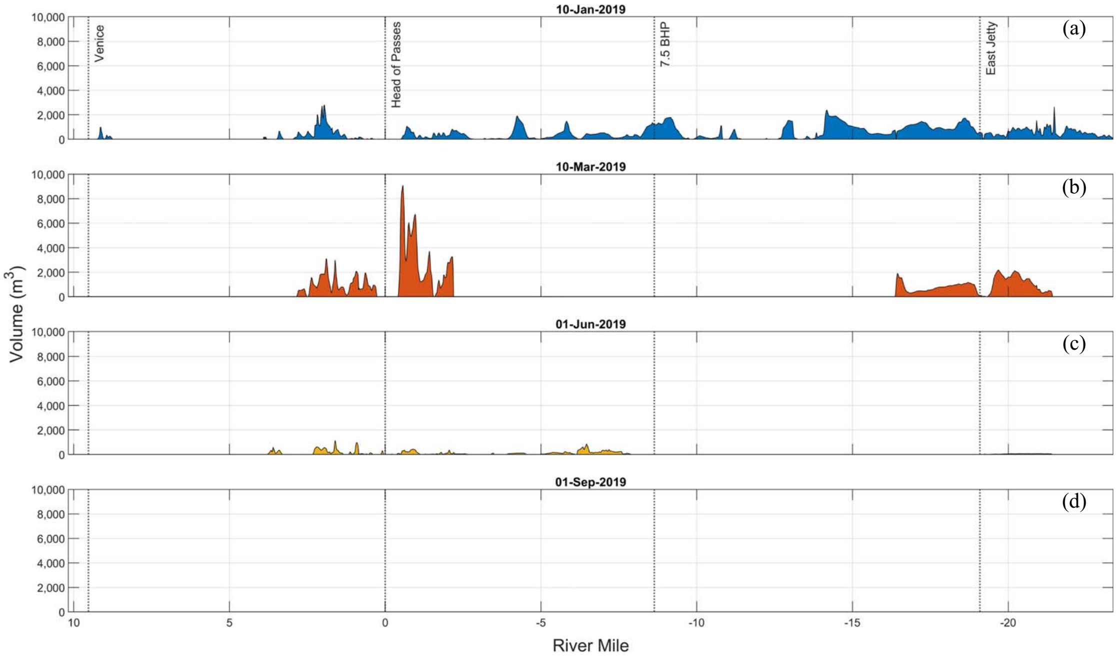

Fig. 4. (Color) Volume shallower than the authorized depth in SWP for four dates in 2019. Channel conditions on (a) January 10, 2019; and (b) March 10, 2019, have the most significant quantity of sediment above authorized depth. On (c) June 1, 2019; and (d) September 1, 2019, the volume of sediment above authorized depth is limited compared with the winter and spring volumes.

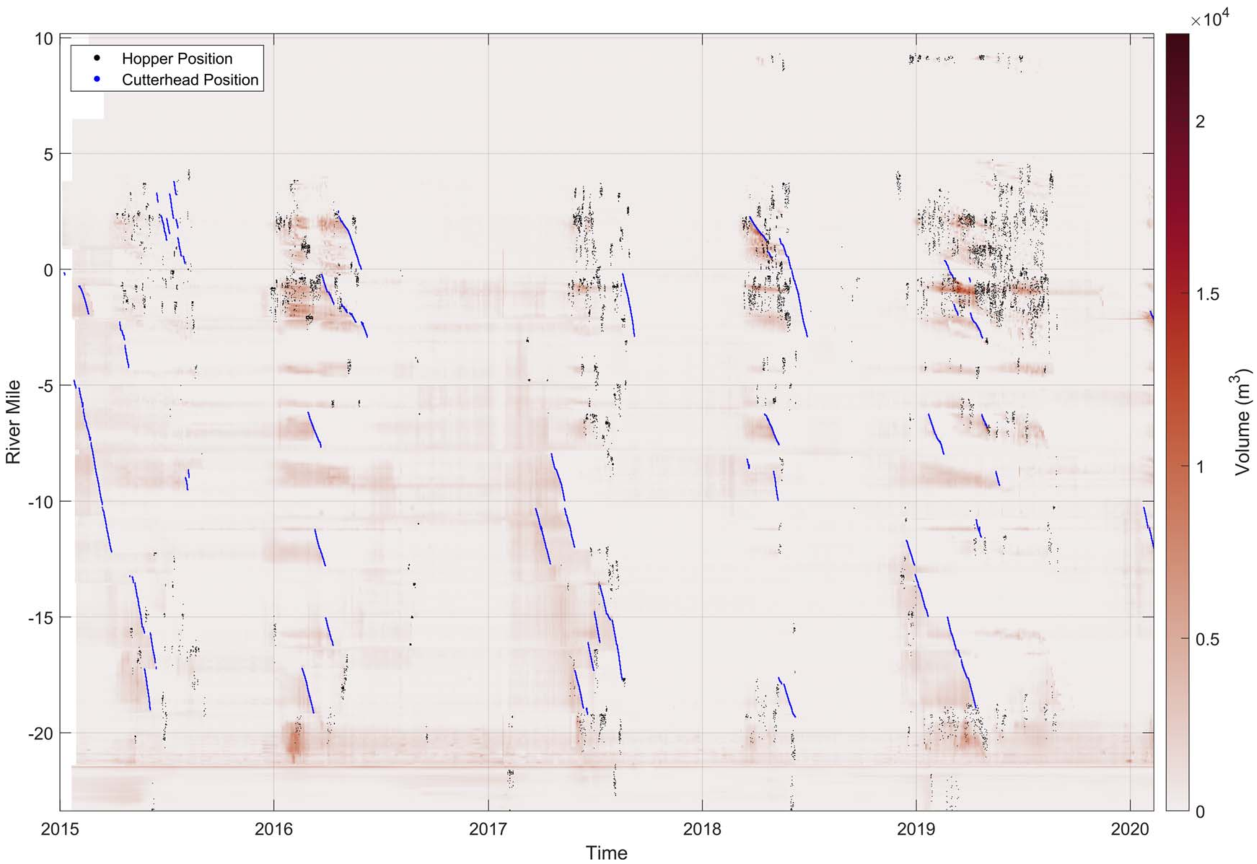

Fig. 5. (Color) Volume of sediment above authorized depth between January 2015 and January 2020. Distance along river is shown relative to Head of Passes, where Reach 1 begins at +10 mi AHP and Reach 13 ends at −25 mi or 25 mi BHP. Volumes are reported per 100-ft transect bin with the darker red representing more volume of sediment above authorized depth. The dredge position locations are shown for hopper dredges (black dots) and cutterhead dredges (blue dots). As sediment begins to accumulate along the river, dredges are used to remove sediment. From 2015 through 2018, cutterhead dredges are deployed following hopper dredge movement. In 2019, the hopper dredge is used extensively at Head of Passes, River Mile 0.

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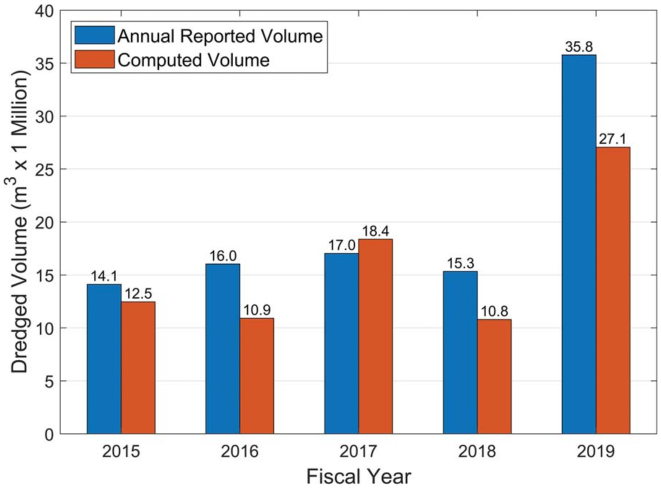

Fig. 6. (Color) Reported annual total of dredged volume throughout SWP and computed volume from hopper and cutterhead dredging records. The reported dredging totals were obtained from internal agency communication.

Table 3. Cutterhead dredge Production in SWP by reach (m^3 × 1M)

Reach	FY15	FY16	FY17	FY18	FY19	Total
1	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00
4	1.20	1.05	0.00	1.12	0.00	3.37
5	0.89	1.57	0.93	1.56	0.87	5.82
6	0.61	0.44	0.28	0.30	0.61	2.24
7	1.14	0.81	0.00	0.99	1.24	4.18
8	1.51	0.00	1.55	0.43	0.34	3.83
9	0.61	0.82	1.90	0.00	1.14	4.47
10	1.27	0.72	2.40	0.00	1.70	6.08
11	1.12	1.14	2.41	0.66	1.48	6.81
12	0.00	0.00	0.00	0.05	0.00	0.05
13	0.00	0.00	0.00	0.00	0.00	0.00
SWP Total	8.34	6.55	9.47	5.11	7.39	36.85

Table 4. Hopper dredge production in SWP by reach (m^3 × 1M)

Reach	FY15	FY16	FY17	FY18	FY19	Total
1	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.07	0.50	0.57
3	0.05	0.08	0.00	0.00	0.39	0.51
4	0.85	1.29	1.58	1.29	5.41	10.42
5	0.95	1.78	2.00	2.63	9.20	16.55
6	0.07	0.21	0.67	0.24	0.54	1.74
7	0.03	0.15	0.71	0.20	0.79	1.87
8	0.01	0.00	0.14	0.20	0.08	0.42
9	0.24	0.13	0.75	0.12	0.53	1.77
10	0.68	0.69	0.27	0.04	0.43	2.10
11	0.83	0.21	0.60	0.47	0.53	2.62
12	0.31	0.21	1.51	0.36	1.20	3.59
13	0.11	0.00	0.67	0.07	0.12	0.98
SWP Total	4.13	4.73	8.90	5.69	19.70	43.15

explanation for this difference is the inclusion of agitation dredging techniques employed within SWP that are not fully captured by either the DQM dredging data or the cutterhead summaries.

Tables 3 and 4 show the total annual dredged volumes for cutterhead and hopper dredges, respectively, for each of the 13 reaches comprising SWP. There is a tendency for annual dredge totals to

Table 5. Mean volume observed above authorized depth in SWP by reach (m^3 × 1M)

Reach	FY15	FY16	FY17	FY18	FY19	Total
1	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.01
3	0.00	0.00	0.00	0.00	0.01	0.01
4	0.03	0.05	0.02	0.03	0.05	0.18
5	0.05	0.10	0.06	0.05	0.11	0.37
6	0.05	0.05	0.05	0.02	0.05	0.22
7	0.08	0.06	0.09	0.06	0.06	0.34
8	0.09	0.08	0.08	0.05	0.07	0.36
9	0.04	0.05	0.08	0.01	0.04	0.21
10	0.05	0.05	0.09	0.01	0.04	0.22
11	0.07	0.05	0.06	0.01	0.08	0.27
12	0.05	0.14	0.10	0.05	0.12	0.47
13	0.06	0.04	0.05	0.02	0.03	0.20
SWP Total	0.57	0.67	0.67	0.29	0.63	2.84

Table 6. Maximum volume observed above authorized depth in SWP by reach (m^3 × 1M)

Reach	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**	**Total**
1	0.00	0.00	0.00	0.00	0.00	0.00
2	0.01	0.00	0.00	0.04	0.04	0.08
3	0.01	0.01	0.00	0.00	0.04	0.05
4	0.14	0.28	0.13	0.34	0.28	1.16
5	0.23	0.57	0.44	0.27	0.52	2.02
6	0.15	0.15	0.20	0.09	0.16	0.74
7	0.25	0.21	0.27	0.26	0.26	1.25
8	0.25	0.18	0.32	0.18	0.18	1.11
9	0.09	0.15	0.33	0.03	0.18	0.77
10	0.21	0.17	0.36	0.02	0.21	0.96
11	0.41	0.24	0.45	0.05	0.24	1.41
12	0.15	0.60	0.35	0.21	0.43	1.75
13	0.12	0.06	0.08	0.04	0.11	0.41
SWP Total	2.02	2.58	2.94	1.52	2.65	11.71

significantly exceed the average and maximum observed sediment volumes within the authorized channel template for the corresponding reaches, as presented in Tables 5 and 6, respectively. These differences can be attributed to the practice of dredging the channel to an advanced maintenance depth deeper than authorized depth, which is intended to provide a buffer against anticipated shoaling activity. These comparisons provide waterway managers with additional quantitative insights when they develop dredge evaluating for informing and balancing the inherent tradeoff decisions between the costs of dredging activity and the inferred duration of a fully navigable channel.

Summary and Conclusions

To better understand the dynamic sedimentation processes and to increase lead times for dredge contingency planning, the study presented here shows how several enterprise USACE datasets have been compiled to provide quantitative and qualitative analyses of shoaling events and dredging operations within SWP. The approach used in this study allows the problem of rapid-onset shoaling to be differentiated from the separate challenge posted by the sheer volume of sediment and the dredging load required to restore full navigability. River discharge is an important driver of sedimentation dynamics, and by using enterprise datasets, shoaling activity in SWP can be identified and contextualized in terms of infilling rates and resulting dredging load to restore navigability and

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compared with conditions elsewhere, thereby informing the trade-off decisions confronted by waterway managers tasked with maintaining the nationwide marine transportation system.

Future Work

Given the different modes of transport through which sediment shoals into navigation channels (Pope 2000), it would be worthwhile to apply the methodology used in this study beyond the footprint of the federal navigation channel. Expanding surveys and the volumetric change analysis outside of federal channel footprint could provide a waterway manager some level of advanced warning of shoaling induced by other sedimentation modes.

The main criterion used in the present study to evaluate channel conditions was the volume of material shallower than a specified datum. While this metric is useful for monitoring the volume of shoaled material within the navigation project, there are situations where it fails to relate shoal configurations adequately and interfering with navigation channel usability (Scully and Mitchell 2017). Vessel navigability methods have been proposed to evaluate the navigability of waterways in the presence of shoals (Hartman 2020). Further refinement of the vessel navigability algorithm would provide dredging managers with estimates of actual dredge load quantities to restore navigation at authorized depth when compared with the full channel volume quantities presented in this study. The navigability routing algorithm is an iterative process that initially attempts to route a vessel drafting at the maintained depth and quantifies the volume of material necessary to successfully route a vessel through the channel. If routing proves to be unsuccessful, then the algorithm identifies the dredging required to support navigation through the channel at the maintained depth.

Data Availability Statement

Some or all data, models, or code used during the study were provided by a third party. Direct requests for these materials may be made to the provider as indicated in the Acknowledgements.

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