DEPTH-UTILIZATION ANALYSIS FOR ESTIMATING ECONOMIC ACTIVITY SUPPORTED BY DREDGING

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ABSTRACT

The U.S. Army Corps of Engineers (USACE) has the federal mission of maintaining the national waterborne transportation infrastructure. In support of this mission, the USACE invests hundreds of millions of dollars annually towards operation and maintenance, primarily dredging, of federal channels and waterways. Limited funding in recent years has forced project managers to make difficult decisions concerning which projects and sub-projects are to be dredged and which are to be considered lower priority awaiting extra funding. Examiners from the Office of Management and Budget have conveyed to USACE the need for providing more detailed economic justification for the money spent each year maintaining the many hundred of channels and sub-reaches to project depths. Indications are that overall funding will not increase significantly until the economic case for dredging activities is improved. This paper presents work being conducted within USACE towards providing this justification through development of a decision tool for aiding in channel maintenance prioritization. By analyzing detailed records already collected by the USACE Waterborne Commerce Statistics Center (WCSC), quantitative information can be compiled on the extent to which commercial shipping utilizes maintained project depths. By cross-referencing commodity codes used by WCSC with those in the U.S. Customs foreign cargo value database, estimates can be made concerning the tonnage and value of cargo transiting at each 1-ft increment of maintained depth in any given segment of waterway. This approach differs from the present USACE system for evaluating channels, in which the total tonnage transiting at all depths is analyzed to determine the relative importance of a waterway segment. In the new framework, channels are evaluated by examining the tonnage and cargo value transiting at the marginal depths; that is, those depths vulnerable to shoaling during each budget cycle and, therefore, most dependent upon USACE maintenance dredging. In addition to improved economic justification of maintenance dredging, this approach offers an objective, consistent framework for prioritizing channels within the USACE navigation portfolio.

Keywords: Army Corps of Engineers, dredging, economic impact, navigation, portfolio management.

INTRODUCTION

The Nation's waterway infrastructure constitutes a vital transportation mode essential for continuous, reliable movement of bulk commodities and manufactured goods, activity that is central to ensuring a resilient, dynamic economy. The U.S. Army Corps of Engineers (USACE) is the government agency tasked with maintaining the vast portfolio of federal deep-draft (>15 ft) navigation channels and waterways. Each year, USACE invests hundreds of millions of dollars towards Operations and Maintenance (O&M) of the deep-draft waterway infrastructure, with the majority of these funds expended on periodic dredging of navigation channels, ports, and harbors. This maintenance is necessary to ensure that channel depths are sufficient for safe and reliable passage of large, ocean-going tankers, container vessels, and bulk carriers.

The USACE Navigation Mission and the Harbor Maintenance Trust Fund

Since the first federal appropriations for waterway improvements on the Mississippi and Ohio Rivers were made in 1824 (The History of USACE 1998), federal authorization has been granted to more than 150 deep-draft navigation projects. Designation as a federal waterway is established by the Congress, with authorized channel depths and widths set according to detailed economic forecast studies that aim to maximize national economic development (NED) over a 50-year planning horizon. However, as the federal portfolio of waterway projects has expanded, and as deep-draft channel depths have increased with the advent of larger global shipping vessels, annual appropriations for O&M dredging and related activities have frequently not kept pace with levels needed to maintain all channels to their full authorized dimensions.

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The Water Resources Development Act of 1986 established the Harbor Maintenance Trust Fund (HMTF) to help avoid these sorts of funding shortfalls. Revenue into the HMTF is collected via a 0.125% *ad valorem* tax on all foreign imports and domestic traffic shipped through the Nation's coastal ports (Grier et al. 2005; Government Accountability Office (GAO) 2008). However, during the last several years, payments into the HMTF have exceeded outlays, resulting in a cumulative "surplus" in the account that has reached in excess of $4.0 billion as of fiscal year 2009 (U.S. Treasury Accounts Summary 2009). Indications from the Office of Management and Budget (OMB) are that total outlays from the HMTF cannot be expected to increase without improved justification for present funding levels. Lacking the time and resources to produce such justifications, USACE operations managers at all levels have been forced to make difficult decisions wherein many projects are maintained at less-than-authorized depths. The funding shortfalls and uncertainty surrounding future outlays have potential for additional side effects such as suppressed reinvestment activities (i.e., new dredges) within the dredging industry, since the lack of transparent, consistent O&M budgeting makes it difficult to predict dredging demand in out years.

The funding imbalance within the HMTF has resulted in calls for increased outlays from several stakeholder groups and independent reviews (e.g., Transportation Research Board 2004). OMB examiners have responded to USACE requests for increased outlays from the HMTF with calls for improved justifications of existing funding levels for annual maintenance dredging, specifically concerning the rationale for how the funding is allocated across the portfolio of navigation projects (GAO 2008). Though detailed economic studies are conducted prior to original project construction (initial channel deepening) to ensure economic justification over the project life-cycle, time and resource constraints and the large volume of projects across the USACE navigation portfolio have heretofore prevented equivalent studies from being conducted concerning the maintenance dredging activities occurring during each budget cycle.

This is not to say that USACE maintenance dredging expenditures constitute an insignificant share of the overall annual budget. Indeed, depending on project size and site-specific dredging requirements, annual maintenance dredging expenditures at the local level can range from tens of thousands of dollars to tens of millions of dollars annually. Table 1 shows the total USACE annual maintenance dredging expenditures (USACE Dredging Program 2009) over the period from 2000-2008.

Table 1. Total USACE Maintenance Dredging Expenditures, 2000-2008

Fiscal Year	Total USACE Maintenance Dredging Expenditures (millions of dollars)
2000	$541.0
2001	$557.0
2002	$558.7
2003	$597.2
2004	$618.6
2005	$628.9
2006	$670.5
2007	$730.7
2008	$749.4

These figures represent a significant investment in waterborne transportation infrastructure. The challenge to USACE R&D is to provide for improved justification of these expenditures, and to produce a consistent, transparent framework for prioritization of the navigation project portfolio. Because these efforts are aimed at increasing outlays from the HMTF, the work presented in this paper has focused largely on the deep-draft navigation projects found in coastal regions.

Value of Deep-Draft Channels

As justification for the significant USACE investments made each year towards deep-draft channel maintenance, it is noted that the Nation's coastal ports and entrance channels handled roughly 1.5 billion tons of foreign cargo in 2004 (the last year with publicly available figures), with a total monetary value of $958 billion. For perspective, this latter figure represented 41.9% of the monetary value of all foreign trade via all modes (US Bureau of the Census,

Foreign Trade Division 2009). Indeed, waterborne transport is the means by which large percentages of many key foreign trade commodities enter and leave the United States. Table 2 offers a summary for the top 10 most valuable commodity groupings of foreign trade in 2004, along with the percentage of $-value transported via coastal ports and channels, and the corresponding tonnage amounts.

Table 2. Summary of Top 10 Foreign Trade Commodities by $-value, and Waterborne Percentage of Each

Top 10 Foreign Trade Commodities by $-value (All modes: e.g. air, truck, rail, etc.)	$-value (millions of dollars)	Waterborne percentage of total $-value	Tons of Waterborne Cargo (thousand short tons)
Motor Cars & Passenger Vehicles	148,023	59.4%	7,635
Crude Oil From Petroleum And Bituminous Minerals	136,358	87.0%	518,508
Automatic Data Process Machines	83,771	22.7%	1,168
Parts & Accessories For Motor Vehicles	68,197	30.0%	3,684
Electronic Integrated Circuits & Microassembled Parts	65,884	0.4%	9.8
Parts For Typewriters & Other Office Machines	48,074	25.8%	746.0
Oil (not Crude) From Petroleum & Bituminous Minerals	47,930	95.0%	166,198
Medicaments Mixed Or Not, In Dosage Form	38,326	12.2%	105.2
Transmission Apparatuses For Radio & Television; Televisions, Cameras & Recorders	37,639	9.0%	74.7
Aircraft, Powered; Spacecraft & Launch Vehicles	37,165	1.1%	1.6

One can see that with the exception of electronic integrated circuits and aerospace vehicles, the top 10 most valuable foreign trade commodities rely heavily on the waterborne transportation infrastructure. This particularly holds for the bulk energy commodities of crude petroleum and refined petroleum oils, with 87% and 95% of all such foreign goods transported through coastal ports and channels, respectively. These two foreign commodity groupings are also at the top of the list for waterborne commodities in terms of gross tonnage for 2004, as shown in Table 3.

Table 3. Summary of Top 10 Waterborne Foreign Trade Commodities by Tonnage, 2004

Top 10 Waterborne Foreign Trade Commodities by Tonnage	Tons (thousand short tons)	$-value (millions of dollars)
Crude Oil From Petroleum And Bituminous Minerals	518,508	118,573
Oil (not Crude) From Petroleum & Bituminous Minerals	166,198	45,511
Coal	72,500	3,499
Corn (maize)	48,388	5,449
Wheat And Meslin	33,083	4,921
Petroleum Coke, Petroleum Bitumen & Other Residues	30,125	1,546
Portland Cement, Aluminous Cement, Slag Cement	26,795	934.6
Soybeans	25,245	6,077
Petroleum Gases & Other Gaseous Hydrocarbons	25,088	5,444
Iron Ores & Concentrates	20,472	634.0

Examining just waterborne imports and exports, and with tonnage as the ranking criterion, the top 10 commodities are dominated by bulk energy commodities and agricultural goods. In addition to the figures for coastal ports and channels shown in Table 2, in 2004 there were 324 million tons of cargo shipped domestically over coastal waters (including the Great Lakes), and 626 million tons of cargo shipped on the inland waterway system (Institute for Water Resources 2005). It is clear that the U.S. waterway infrastructure plays a vital role in the national economy. This paper will explore approaches currently under development within USACE for improving the economic justification of annual coastal channel maintenance dredging investments.

MAINTENANCE PRIORITIZATION OF USACE NAVIGATION PROJECTS

Current Prioritization Methodology

OMB examiners have conveyed to USACE personnel the need for improved justification and prioritization of current annual appropriations for maintenance dredging as a precondition for increased outlays from the Harbor Maintenance Trust Fund. The present system employed by USACE personnel for prioritizing deep-draft projects uses total gross tonnage as the metric of comparison. The data needed for this assessment originates from the Waterborne Commerce Statistics Center (WCSC), part of the Corps' Institute for Water Resources (IWR). Each year, WCSC publishes figures concerning shipments of cargo over the USACE navigation project portfolio in the form of detailed reports entitled *Waterborne Commerce of the United States*. The reports contain records for all USACE navigation projects, providing information on tonnage, traffic type (foreign, domestic, inbound, outbound, etc.), commodity breakdowns, and numbers of vessel calls.

For this discussion, it is helpful to note that a USACE navigation project typically encompasses an entire port zone (e.g. Mobile, Charleston, Seattle, etc.), though large port areas are sometimes divided into multiple projects. Within each project, there are often many miles of maintained channels, and projects usually contain multiple reaches, such as an entrance channel, bay channel, and river channels. Presently, for O&M dredging allocations, USACE gives priority to the navigation projects handling at least 10 million tons of waterborne cargo annually (GAO 2008). This threshold results in roughly 60 high-use projects receiving preference for yearly maintenance dollars. The 10 million ton standard does not guarantee that all work packages associated with a high-use project will be approved for funding, not does it preclude all lighter-use projects from consideration. However, it does serve as a general basis for the majority of annual maintenance work package considerations. Table 4 shows the top 20 USACE navigation projects ranked in terms of average total tonnage from 2001-2005 (IWR 2006).

Some discussion is in order to help put the figures in Table 4 in perspective. The first point to be noted is that the tonnage associated with the various projects is not mutually exclusive across projects. For example, much of the tonnage transiting the St. Mary's River, the St. Clair River, Detroit River, and the Channels in Lake St. Clair, MI can be attributed to shipments that utilize all four projects while transiting the Great Lakes system. This is also true of the Galveston Entrance Channel, which carries all coastwise traffic (foreign and domestic) via the Houston Ship Channel and Texas City Channels. In other words, the totals in Table 4 make no distinction between "through" tonnage that transits a project without stopping and tonnage that actually docks within a project. This potential ambiguity has implications in determining the relative contributions of ports and harbors into the HMTF. Moreover, it underscores the point that the waterway infrastructure serves as a transportation network, and that any given shipment of cargo may rely on multiple USACE navigation projects. A reduction in the level of service (e.g., allowable draft) in one project could therefore result in disruptions and economic consequences system-wide.

The second point to note is that the raw tonnage totals do not give any indication of cargo type, traffic type, cargo value, or the drafts of the vessels used to transport the tonnage. An important premise of the approach presented in this paper is that the extent to which maintained depths are utilized by transiting vessels is a useful metric when attempting to prioritize navigation projects across the USACE navigation portfolio. Allocation of limited resources across a large portfolio of projects is a difficult task, made more challenging by the limited amounts of time and resources available to decision makers when assessing project needs on a rolling budget cycle. Therefore, although the tonnage totals shown in Table 4 offer an expedient way for USACE decision makers to evaluate the relative significance of navigation projects, it is recognized that incorporation of additional data such as draft and cargo value would provide improved justification for maintenance dredging investments.

Table 4. Top 20 USACE Navigation Projects Ranked by Average Total Tonnage, 2001-2005

Top USACE Projects, Ranked by Tonnage	Tonnage (thousand short tons)	Top USACE Projects, Ranked by Tonnage	Tonnage (thousand short tons)
1) Mississippi River: Baton Rouge To Gulf of Mexico	420,635	11) Corpus Christi Ship Channel, TX	76,289
2) Galveston Harbor & Channel, TX	196,092	12) Detroit River, MI	72,156
3) Houston Ship Channel, TX	191,583	13) Channels in Lake St. Clair, MI	66,243
4) New York Harbor, NY	143,451	14) Texas City Channel, TX	60,464
5) Sabine-Neches Waterway, TX	137,268	15) Calcasieu River & Pass, LA	52,241
6) Los Angeles-Long Beach Harbors, CA	124,270	16) Mobile Harbor, AL	51,371
7) Philadelphia To The Sea (Delaware River and Bay)	123,413	17) Columbia & Lower Williamette Rivers Below Vancouver, WA & Portland, OR	50,028
8) NY-NJ Channels (Arthur Kill & Kill Van Kull)	112,748	18) Tampa Harbor, FL	47,505
9) St. Mary's River, MI	78,759	19) Thimble Shoal Channel, VA (Mouth of Chesapeake Bay)	45,173
10) St. Clair River, MI	77,141	20) Duluth-Superior Harbor, MN & WI	42,592

Finally, it should be noted that the tonnage totals do not apply uniformly to all sub-reaches within a project purview. Depending on the distribution of docks and cargo terminals within the port area, certain reaches (e.g., the entrance channels) may have significantly higher tonnage totals than others. However, in the present USACE prioritization methodology, there is no systematic way of distinguishing these lighter-use reaches from the high-use channels within the larger navigation projects. While it is true that local project operations managers exercise due discretion in allocating maintenance funding across the various channels and sub-reaches they are responsible for maintaining, without ready access to detailed commerce figures reflecting use by commercial shipping, time and resource constraints force them to base decisions largely upon (significant) experiential knowledge and best judgments. The result is an *ad hoc* system of channel maintenance, leading to difficulties when trying to defend maintenance dredging funding decisions. The work presented herein aims to remedy this situation.

Depth-Utilization Approach via Channel Prioritization Tool (CPT)

In addition to the publicly-available tonnage figures published each year, WCSC also maintains a confidential dock-level database of commerce statistics with an even higher degree of resolution. The information contained in the database is given trade secret status, and is therefore not released to the public. The data is available to USACE personnel and has mostly been accessed by planners and economists during detailed economic justification studies for new construction and project expansions. Heretofore, these data have not been used in a structured, sustained way in support of annual O&M funding decisions. In addition to the dock-level resolution, a significant added dimension of detail includes vessel draft data tied to individual commodity shipments. If all docks along a particular reach of maintained channel are taken together and the vessel draft records aggregated, valuable information can be gleaned concerning the extent to which maintained depths are being utilized by commercial shipping.

In the past year, a software package has been under development by USACE R&D to assist decision makers with extraction and processing of pertinent data subsets from this large confidential database collected and collated each year by the WCSC. The Channel Prioritization Tool (CPT) uses structured query language coupled with a user interface to allow for customized, reach-specific reportage of tonnage, commodity, cargo value, and vessel draft data. Users are able to set sorting and filtering criteria such that decision maker priorities are more fully reflected.

Distribution of Tonnage across Channel Depths

Maintenance dredging of navigation channels typically is concerned with the marginal channel depths. Only as a result of severe shoaling events (e.g., hurricanes and major inland flooding) do depth reductions of more than a few feet occur in a given year. This means that much of the waterborne commerce utilizing a given segment of channel is not impacted directly by year-to-year shoaling and modest reductions in channel depth. Therefore, USACE personnel responsible for prioritizing annual maintenance dredging activities would benefit from knowing which reaches support the most commerce at the marginal, shoal-vulnerable depths. CPT provides for this sort of analysis, and Figure 1 shows a CPT-generated breakdown of tonnage levels at various channels depths for a sample reach chosen for the purposes of illustration.

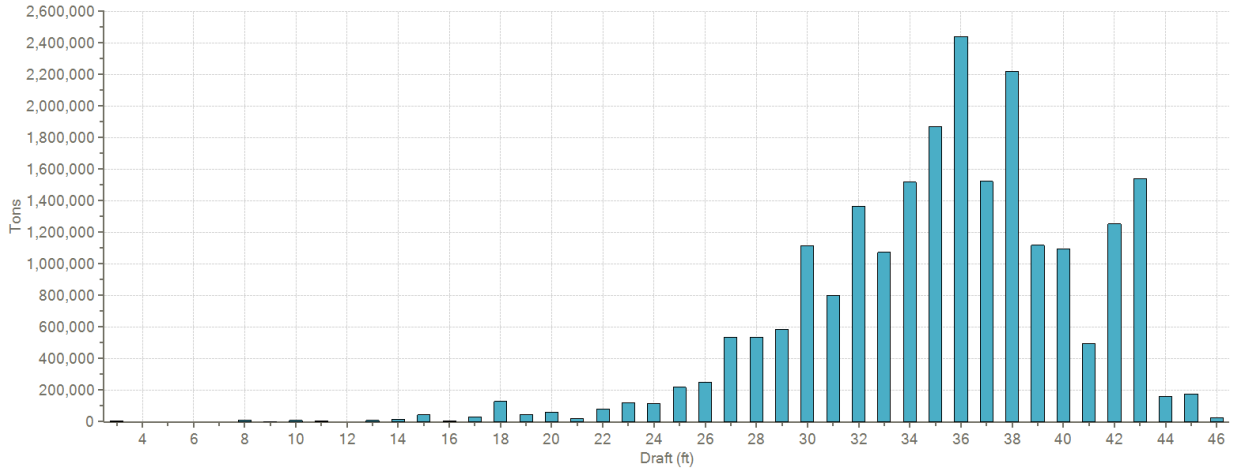

Figure 1. Tonnage levels across the range of channel depths for a sample reach

The decision maker is now able to visualize the distribution of tonnage transiting the reach across the range of channel depths, not just the single cumulative tonnage amount. By comparing this tonnage distribution to the current channel limiting depths and shoaling levels anticipated in the next budget cycle, a much more informative view of the benefits of dredging (and in turn, the consequences of forgoing channel maintenance) can be formed.

Traffic and Commodity- Specific Analysis

CPT allows for further analysis of the cargo transiting a given reach at each 1-ft draft increment. Beyond the distribution of tonnage across channel depths, there is useful information concerning the composition of this tonnage, such as relative percentages of foreign and domestic traffic, and inbound and outbound cargo. Figure 2 shows the distribution of tonnage for the same sample reach shown in Figure 1, but with the additional breakdown showing the relative levels of foreign imports and exports. Similar results can be generated showing domestic traffic levels. The availability of these additional breakdowns has implications for future strategic planning across the USACE navigation project portfolio. For example, federal policy makers might decide to encourage improved multi-modal transport of goods and commodities, with rail and highway terminals better-aligned with principal foreign trade ports in order to move cargo more efficiently throughout the Nation. USACE personnel might then be directed to allocate O&M funding such that these broad policy aims are supported. Such directives could then be more easily complied with through use of the CPT analysis package.

Likewise, future policy-level guidance could move towards supporting particular commodity groupings, such as imports of bulk energy commodities like crude petroleum and coal, or exports of agricultural goods. Without a mechanism for quickly analyzing the USACE project portfolio, decision makers would struggle to allocate annual maintenance funding so as to comply with such policy aims. Based upon the data found in the WCSC database, CPT allows the user to observe specific commodity types transiting at each 1-ft increment of maintained channel depth. Figure 3 is a breakdown for the shoal-vulnerable depths of the sample reach shown previously in Figures 1 and 2.

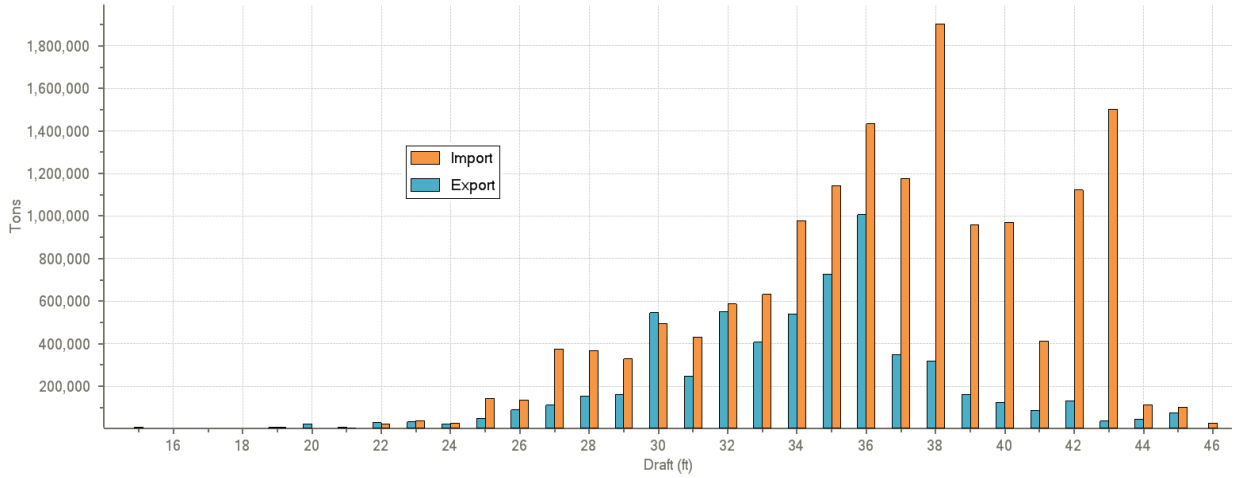

Figure 2. Draft breakdown for sample reach, showing tons of imports and exports

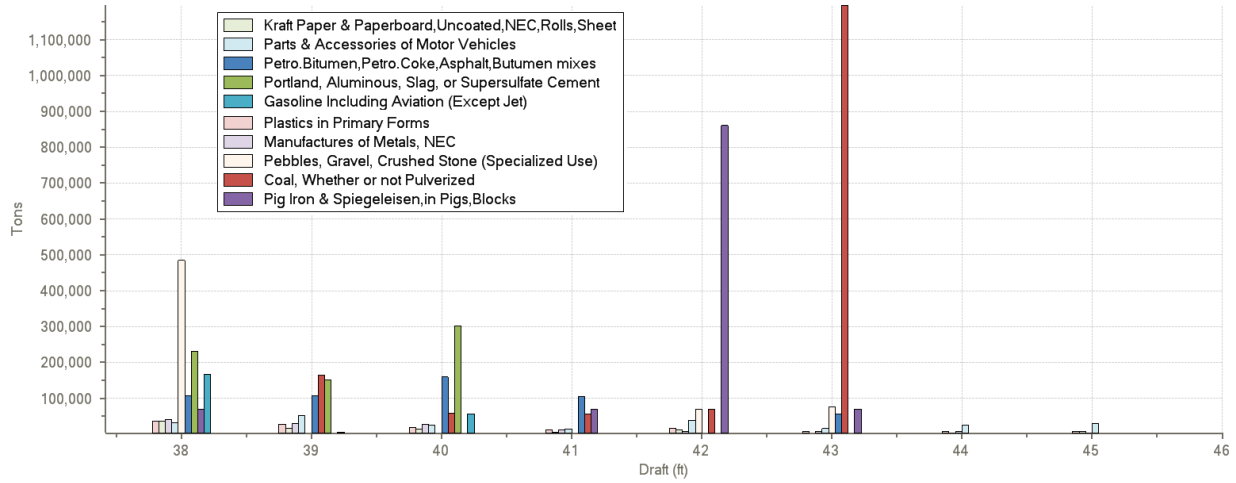

Figure 3. Draft breakdown for sample reach, showing the top 10 commodities when ranked by tonnage

Cargo Value Estimates

OMB examiners have requested improved economic justification for the significant annual investments made by USACE towards navigation channel maintenance. However, the dock-level database maintained by WCSC does not contain information concerning the monetary value of the various commodity groupings. Such information allows for relative economic impact assessments of reductions in channel depth to be made. In order to include this capability within CPT, a separate dataset maintained and published by the Foreign Trade Division of the U.S. Census Bureau (2009) was cross referenced with the WCSC data. The port-level cargo value tables found in the Customs database contain tonnage and dollar-value figures for roughly 5500 different commodity classifications. This necessitates cross-referencing and nesting with the roughly 660 different commodity classifications employed by the WCSC database. An example of the final cargo value estimates generated with CPT is shown in Figure 4. It shows the same sample reach presented above, with cargo value totals for each 1-ft increment of maintained channel. The capability to include the monetary value of cargo transiting at maintained channel depths represents a significant improvement over the current gross tonnage-based method for maintenance prioritization.

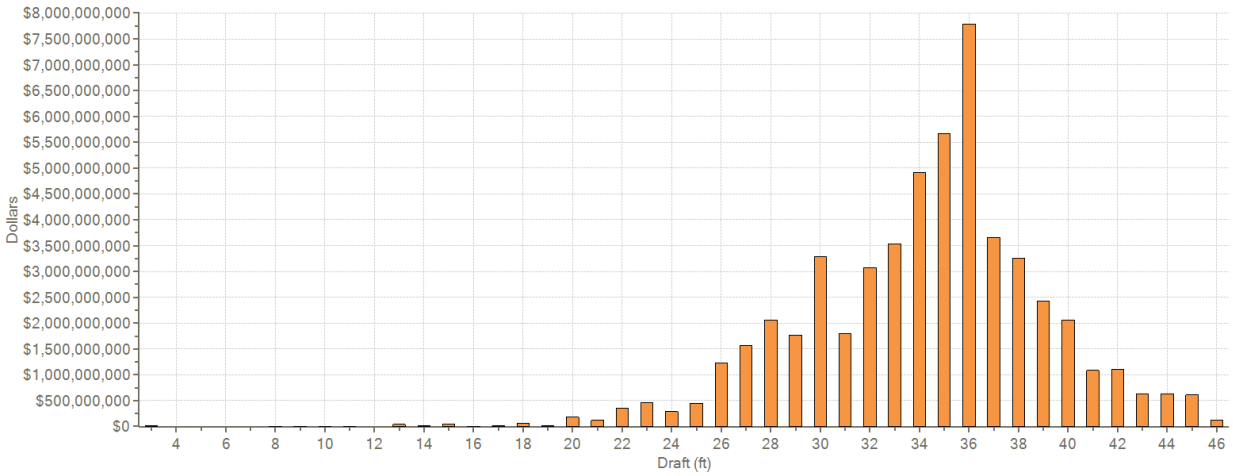

Figure 4. Cargo value for each 1-ft draft increment for sample reach

The cargo-value breakdown provides clear, direct information concerning the value of goods and commodities directly dependant upon maintenance dredging of deep-draft channels. For example, suppose the sample reach is expected to experience a 3-ft reduction in navigable depth in the upcoming budget cycle if maintenance dredging is not conducted. Figure 4 shows that nearly $1.5 *billion* worth of commodity movements would be disrupted by such a decision. This is not to say that the economic consequences would be equal to $1.5 billion, but shipping operators would experience a degree of economic loss owing to lighter vessel drafts and fewer goods transported per trip. So, although it is true that the value of cargo transiting at the marginal channel depths does not fully convey the true economic benefits of dredging (or economic consequences of loss of depth), it is nonetheless a useful metric when attempting to compare the relative economic significance of deep-draft channels across the navigation portfolio.

This additional capability of CPT also illustrates the role of container shipping in the national economy. Because most manufactured and specialty goods are shipped via container vessels, ports with large container handling facilities tend to have higher overall cargo value figures. Global trends in the international shipping industry are leading to ever larger and deeper-draft container vessels, and it is thought that the ability of ports to accommodate these vessels will have large implications for future economic growth (Hackett 2003). Figure 5 shows a breakdown of the top 10 commodities for the sample reach when ranked by cargo value.

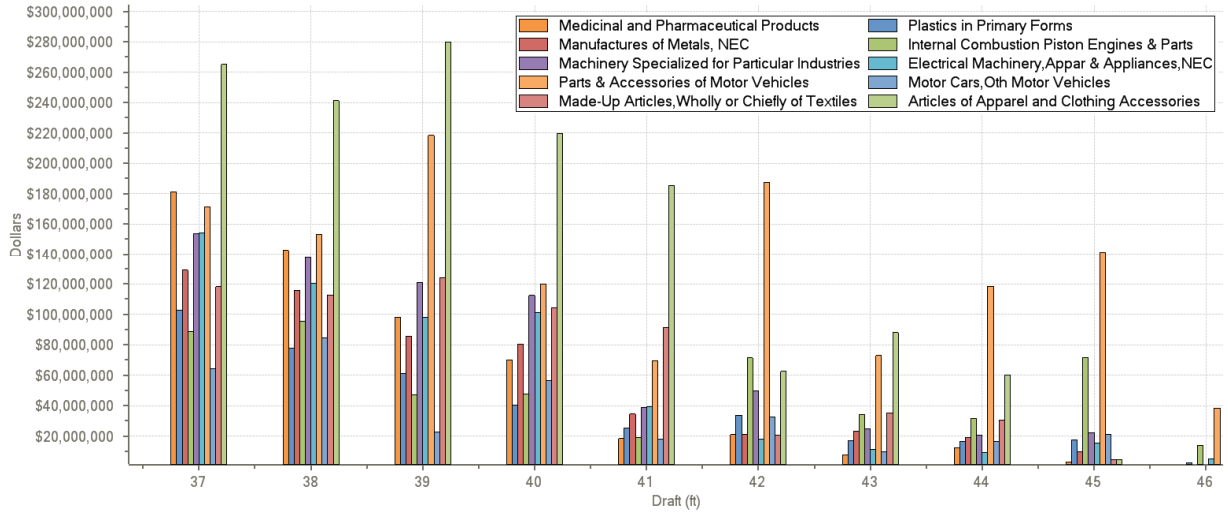

Figure 5. Draft breakdown for sample reach, showing the top 10 commodities when ranked by $-value

The differences (and a few similarities) in the top 10 commodities according to the two ranking metrics is apparent, as shown in Figures 3 and 5. With tonnage as the criterion, the top 10 list is comprised largely of bulk commodities

and goods in primary forms, whereas the cargo-value criterion results in mostly manufactured machinery and specialty equipment.

Improved Justification and Prioritization

Discussion thus far has focused on the increased level of detail that CPT provides to USACE personnel requiring channel usage statistics for decision support. However, in assessing the relative needs of projects in the navigation portfolio for maintenance funding, the physical condition of the dredged channels must also be considered. USACE district offices perform periodic channel condition surveys and typically release the resulting navigable depth information to the public. Continued development of CPT is focused on automated uploading of the latest channel condition surveys for each project sub-reach. These features will allow users to directly observe the tonnage, commodities, and cargo value that will be disrupted should funds for maintenance dredging be withheld.

CPT capabilities have been discussed and shown for a single sample reach chosen for illustration. Similar analyses can be quickly and easily conducted for many hundreds of project sub-reaches in the USACE navigation portfolio. Allocation of limited resources across a portfolio necessitates prioritization of projects according to consistent, rational criteria that reflect decision maker priorities. The CPT interface and analysis package offers a significant initial step towards this goal.

CONCLUSIONS

The USACE must serve as a responsible steward of taxpayer dollars while maintaining the critical waterborne transportation infrastructure. Coastal deep-draft channels and ports play a vital role in ensuring steady, reliable movement of goods and commodities in support of healthy national economy. This paper has presented work being conducted by USACE R&D towards improved justification and prioritization of annual maintenance dredging investments across the portfolio of deep-draft navigation projects. Detailed records collected and maintained by the Waterborne Commerce Statistics Center are queried by means of a convenient graphical interface and analysis package called the Channel Prioritization Tool (CPT). This package provides USACE personnel with a much higher level of detail concerning commercial use of navigation projects, and it produces valuable decision support for maintenance dredging funding allocations. In particular, the extent to which commercial shipping utilizes the channel depths maintained by USACE can be quantified by examining the tonnage and cargo-value of goods transiting at the marginal, shoal-vulnerable depths. Maintenance dredging investments should be made so as to maximize the benefits to the national economy, but application of rational and consistent prioritization criteria across the vast USACE navigation portfolio demands advanced information management capabilities. CPT and the depth-utilization approach represent a strong initial step towards providing improved economic justification of O&M dredging investments.

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