Optimal Scheduling and Sequencing of Dredging Projects

Western Dredging Association
Pacific Chapter

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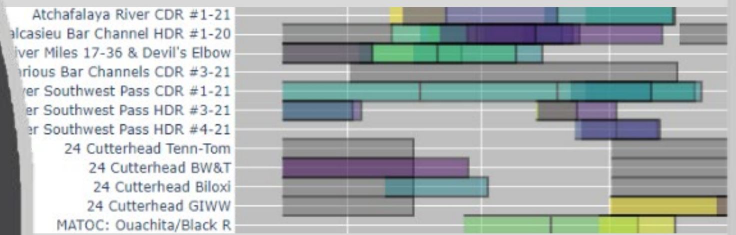
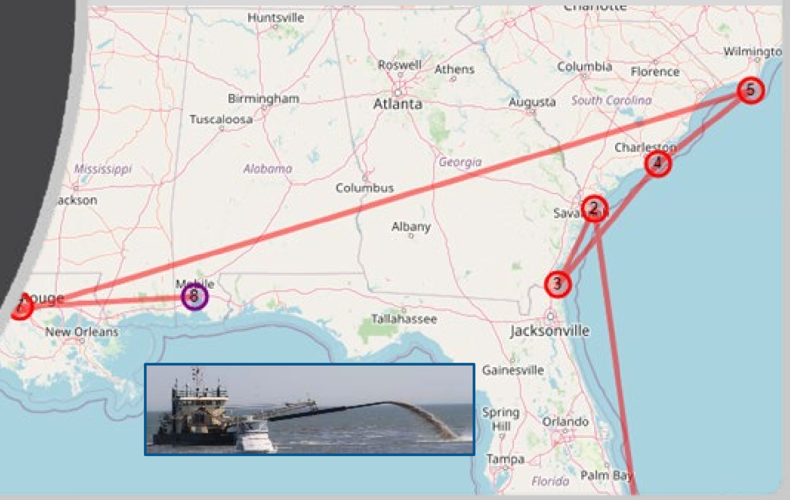
Analysis by USACE/ERDC/CHL and Woolpert, Inc.





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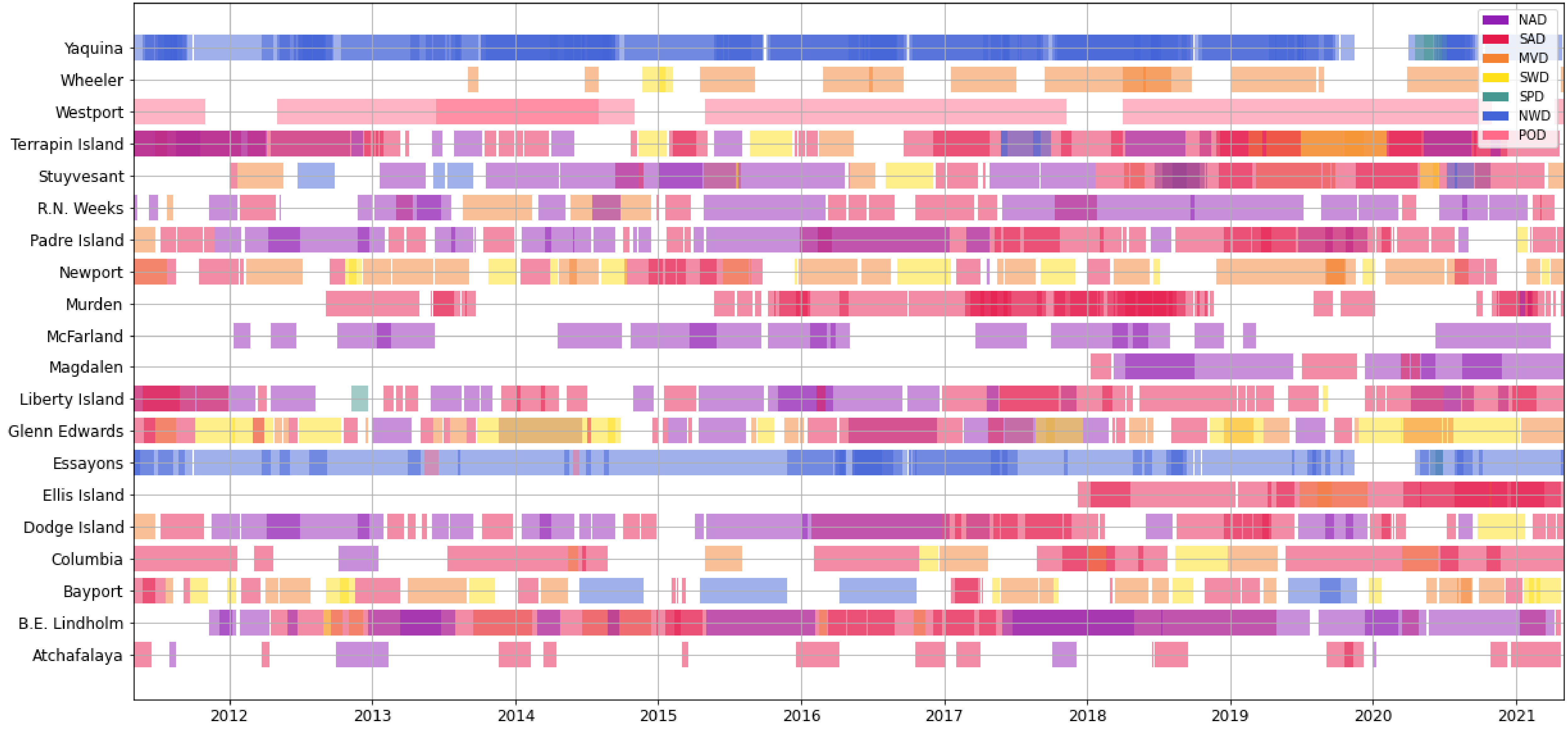
Background

- There are many projects that require maintenance dredging on an annual/semi-annual basis

- Every dredging project is unique and has unique requirements… but projects also compete for a limited number of dredges

- Dredges, in particular hoppers and cutterhead pipelines, are highly utilized and may not be available as each project needs them

Domestic Hopper Dredge Schedule 2011-2021



Source: Industry/Corps Forum for Discussion of Hopper Dredge Issues, January 2021; Woolpert and USACE analysis

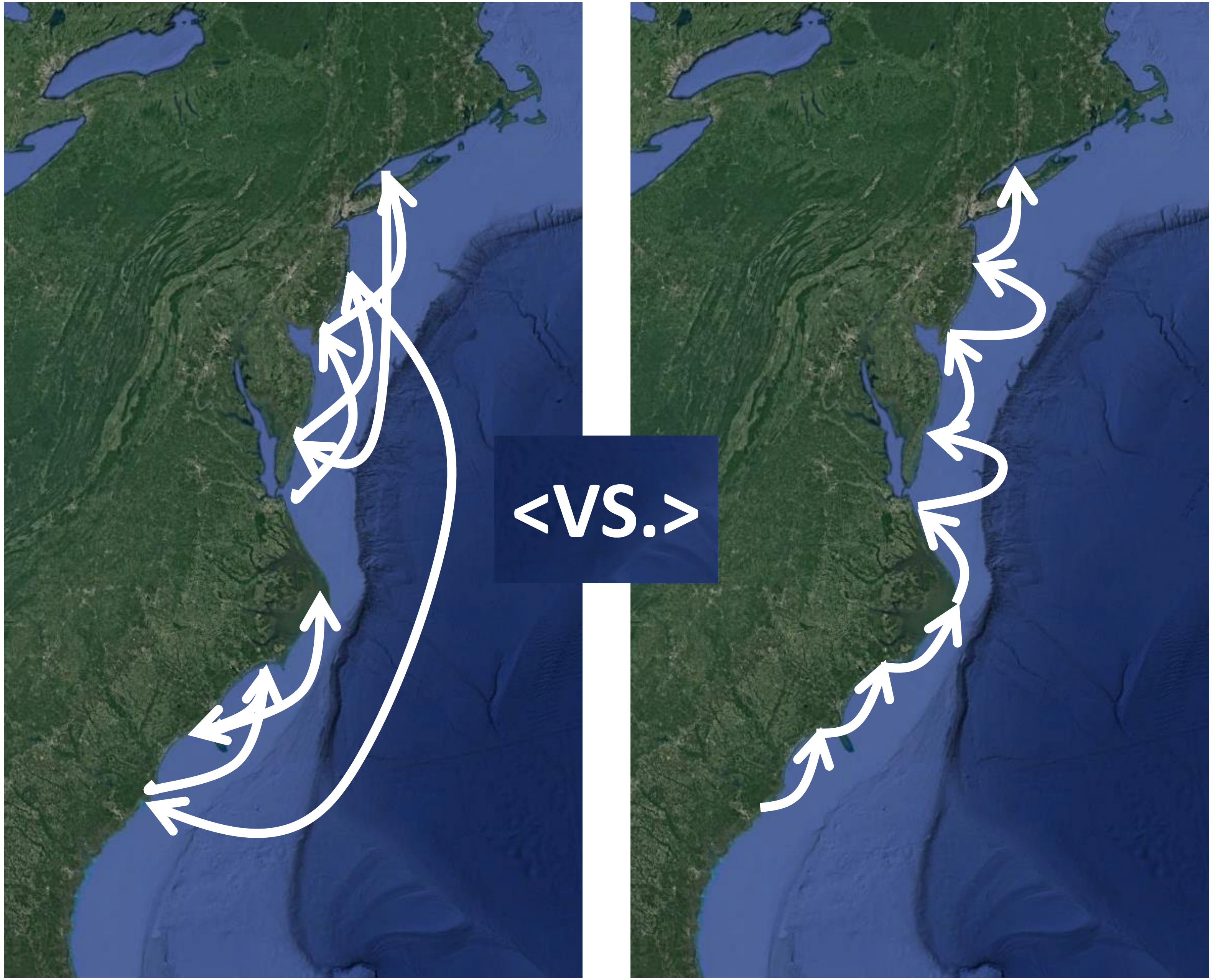
Anecdotal evidence

- Lack of bids, bids over IGE
- More travel time, high mobilization costs
- Long delays for priority projects
- Dredging during non-preferred periods
- Shallower channels, channels less than authorized & utilized depth
- More, smaller contracts
- Simultaneous… overworked and underutilized dredges

Schedule Optimization

Given a set of projects and a fleet of dredges, determine:

1. Which projects are dredged?
2. In what order?
3. On which dates?
4. By which dredges?



Source: Landsat/Copernicus, author's imagination

Key considerations

$$CY_s = Prod_{d_s j_s} \times \sum_{t=start_s}^{end_s} I_j(t) \; \forall \, s \in S \mid a_s = 1$$

- **Appropriateness of the dredge to the job**
- **Environmental Restrictions and Windows**

$$\{Seq_d\} = (d_S | a_s = 1)$$

$$start_{s_k} > start_{s_{k-1}}$$

$$start_{s_1} \geq tt_{d_s 0 j_{s_1}}$$

$$start_{s_k} \geq end_{s_{k-1}} + tt_{d_s j_{s_{k-1}} j_{s_k}}$$

- **Location and Travel Time**

Key considerations

$$e_m \leq e_n$$

$$e_n \times b_{dm} \leq b_{dn}$$

$$b_{dm} + b_{dn} \leq 1$$

$$e_m + e_n \leq 1$$

$$end_m \leq start_n$$

- **Contractual requirements**
- **Operational preferences and flexibility**
  - **Phasing**
  - **Multiple dredges**
  - **Split work**

Objectives

- **Dredge as much as possible**

$$Minimize \sum_{j \in J} UCY_j$$

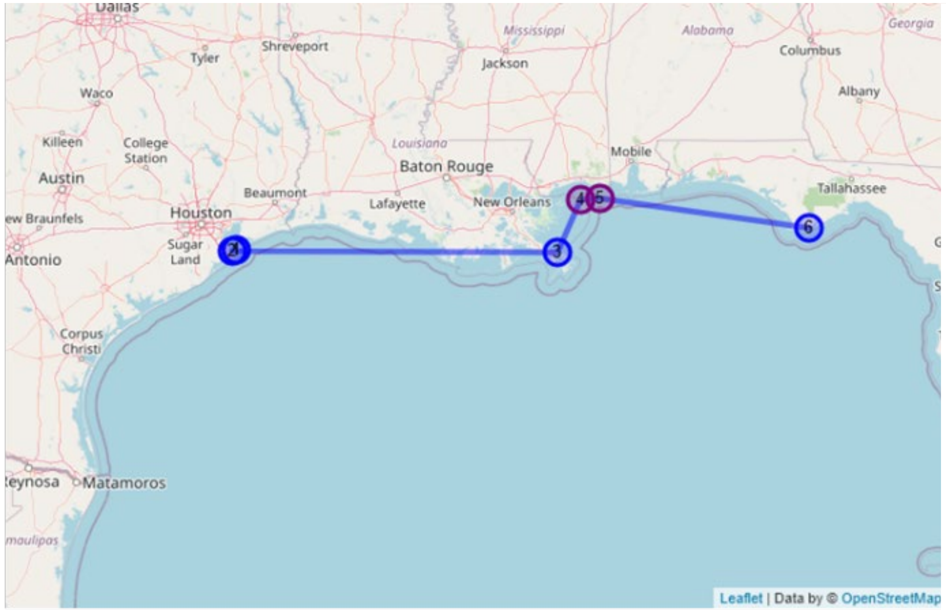
- **Dredge in a timely manner**

$$Minimize \sum_{j \in J} \left(PrefPen_j \times \left(jobend_j - prefjobend_j\right)\right)$$

- **Dredge reducing travel and mobilization costs**

$$\begin{aligned} Minimize \sum_{d \in D} (ActCost_d \times c_d) + \sum_{j \in J} \sum_{d \in D} \left(MobDemob_{dj} \times b_{dj}\right) \\ + \sum_{d \in D} \sum_{s_k \in Seq_d} \left(TravCost_d \times tt_{ds_{k-1}s_k}\right) \\ + \sum_{d \in D} \sum_{s \in d_S} \left(DrgCost_d \times (end_s - start_s)\right) + \sum_{j \in J} \left(CYPen_j \times UCY_j\right) \\ + \sum_{j \in J} \left(PrefPen_j \times \left(jobend_j - prefjobend_j\right)\right) \end{aligned}$$

Types of output: Tailored Schedules



Project	Size	Type	Start	End	Days	CY (k)
HOUST01 HOUST GALV NAV CH	Md	Cutter_Pipeline	11/16/2021	1/3/2022	49	501.9
TEXAS01 TEXAS CITY SHIP CH TX	Md	Cutter_Pipeline	1/4/2022	4/29/2022	116	1,202.6
MISSI01 MISS RIVER OUTLETS	Lg	Cutter_Pipeline	5/1/2022	5/14/2022	14	203.9
GULFP01 GULFPORT HARBOR MS	Lg	Cutter_Pipeline	5/15/2022	7/26/2022	73	1,129.4
PASCA01 PASCAGOULA HBR MS	Lg	Cutter_Pipeline	7/27/2022	10/28/2022	94	1,458.8
TOTAL			11/16/2021	10/28/2022	346	4,496.6

Source: OpenStreetMap, hypothetical projects, USACE and Woolpert analysis

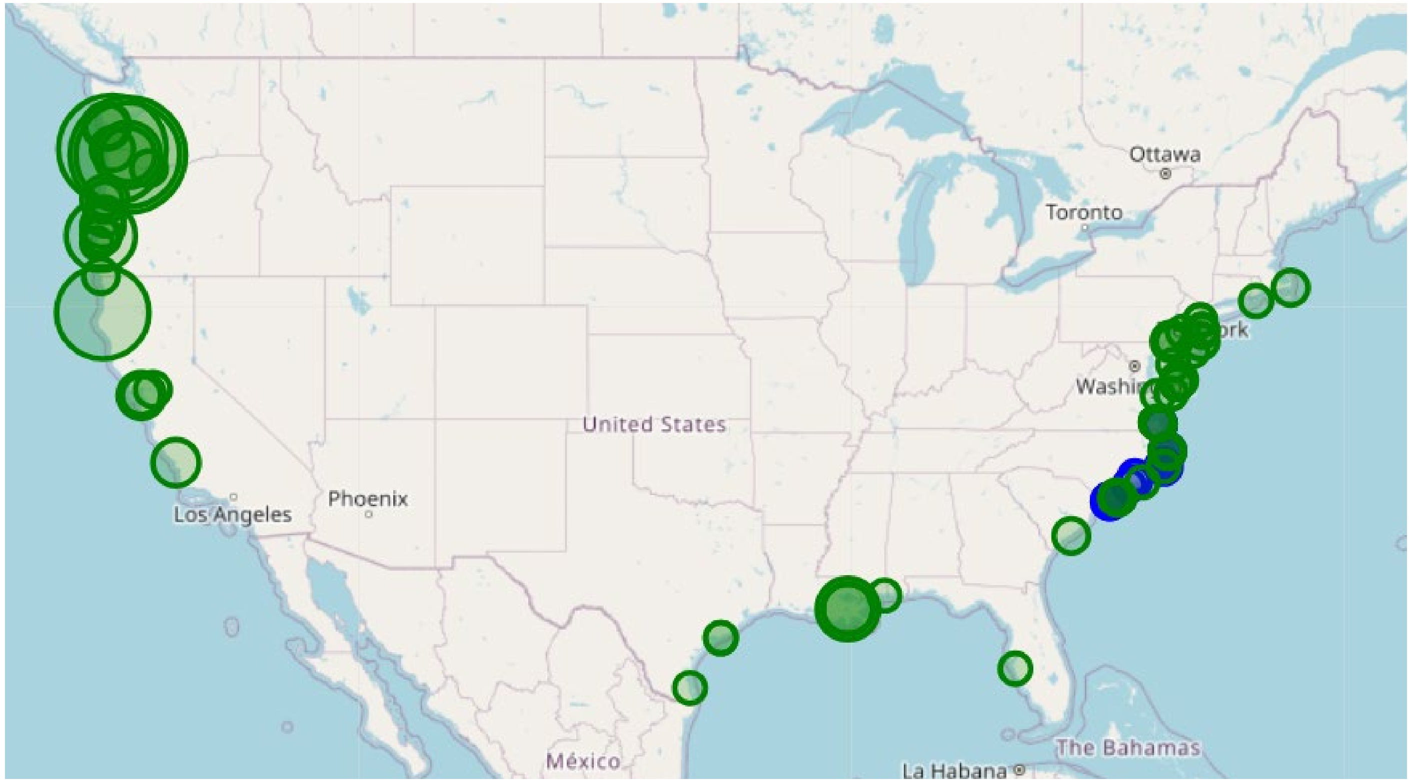
Challenge:

- Projects on the Florida panhandle had identified scheduling challenges due to other projects in the region

Outcome:

- Identified schedules that would enable all projects to be completed by available dredges

Example



Note: Radius is proportional to CY Dredged on the Job. Source: DIS, OpenStreetMaps, Author's Analysis

Dredge	Type	Size	Productivity CY/Day
Currituck	Hopper	Small	1,034
Murden	Hopper	Small	1,258
McFarland	Hopper	Medium	4,390
Yaquina	Hopper	Medium	8,137
Essayons	Hopper	Large	25,440
Wheeler	Hopper	Large	29,045
Merritt	Pipeline	Small	1,465

Types of output: Scenario and What-If Tests

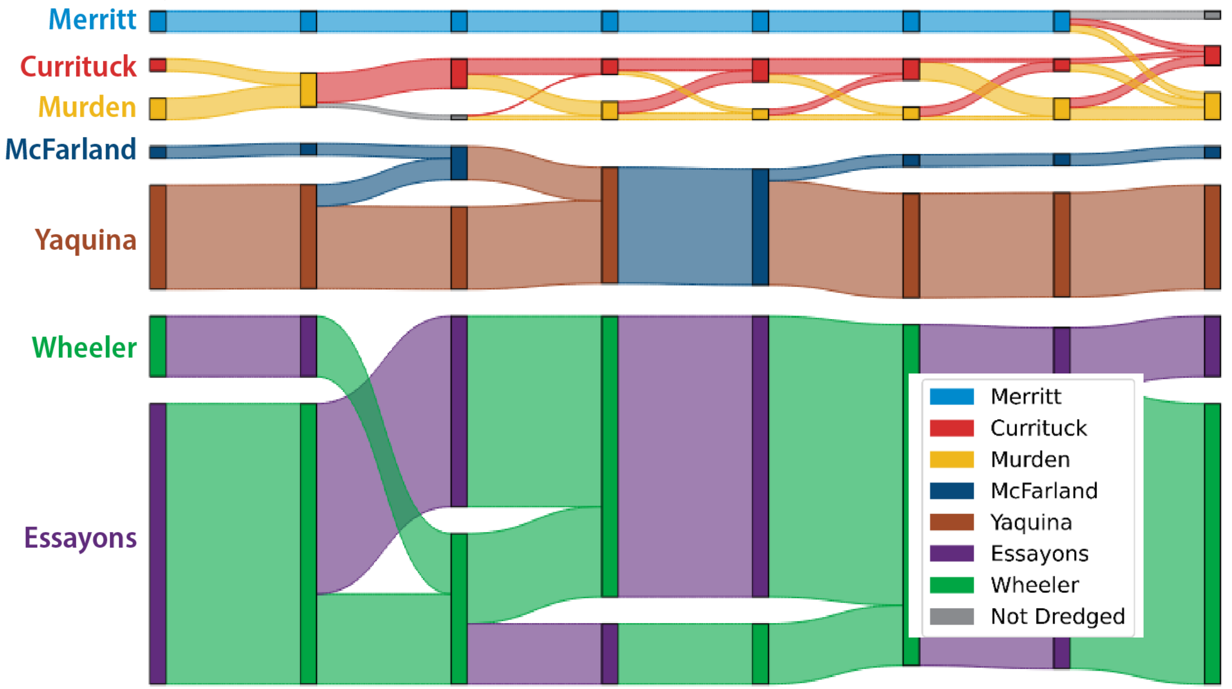
Challenge:

- Dredging fleet managers sought to develop contingency plans if a dredge became unavailable due to extended maintenance

Outcome:

- Developed alternative schedules to perform project work assuming various maintenance scenarios

Metric	Base	Ex-Currituck	Ex-Murden	Ex-McFarland	Ex-Yaquina	Ex-Essayons	Ex-Wheeler	Ex-Merritt
Obj. Value	18,496	31,536	7.6×10^7	24,854	32,803	24,937	23,847	3.7×10^8
Unmet CY	0	0	75,910	0	0	0	0	370,083
Penalty Days	389	1,494	5,039	442	1,290	627	321	271
Travel Distance	14,606	16,596	24,928	20,434	19,903	18,667	20,637	13,006



Applications

- Strategic work planning
- Tactical work planning and schedule development
- Regional contract opportunities
- Fleet maintenance planning
- Fleet capacity planning
- Hurricane/event response

Research Contributors

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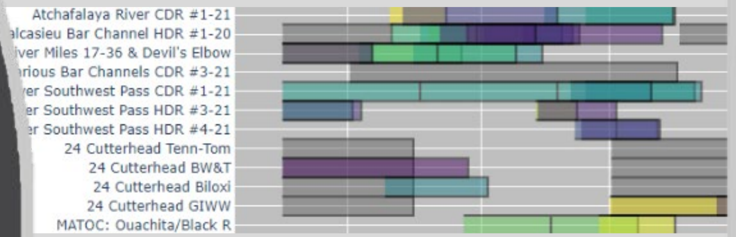

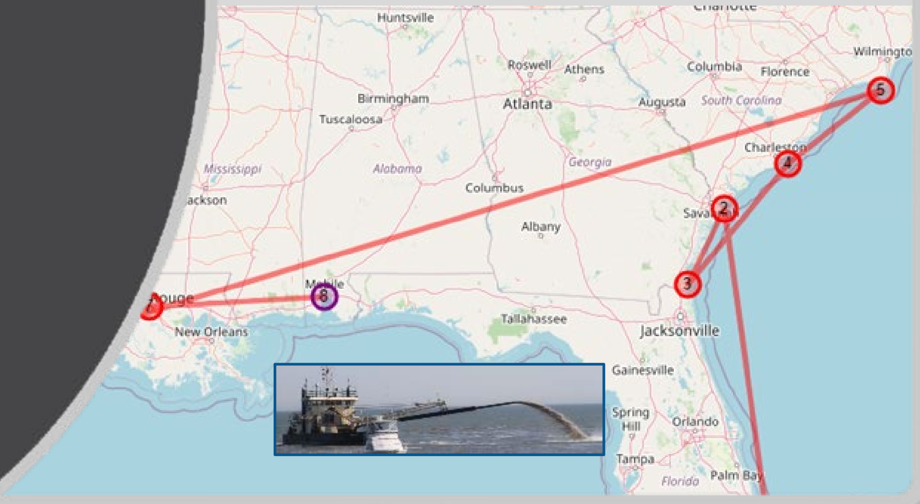

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Optimal Scheduling and Sequencing of Dredging Projects

To maintain the U.S. marine transportation system (MTS), the U.S. Army Corps of Engineers (USACE) conducts periodic maintenance dredging of navigable channels and waterways in order to remove accumulated sediment and restore channel depths. Dredging is a highly specialized activity performed by a small fleet of vessels and during periods of high demand, there may be more dredging work than the vessels can accommodate, resulting in delays to the performance of maintenance dredging and restrictions to vessel drafts within the MTS. To ensure the efficient use of available dredge resources, USACE maintains an operational model that identifies an optimal sequence and schedule of maintenance dredging projects considering project-specific dredge requirements, dredge fleet availability, network travel times, and time-based dredging restrictions. This presentation discusses the USACE dredge scheduling model and demonstrates how the model can be used to identify both an optimal schedule of projects and estimate dredging project delays that would occur when dredge vessels, themselves, require maintenance.