Dredging with Nature: The Strategic Sediment Pulse Dredging Approach to Marsh Nourishment Applied to Tidal Flood Control Channels in San Francisco Bay

**All slides and opinions are my own and may not represent official Marin County or Flood District Policies*

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August 22, 2025

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MARIN COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT

Historically, the Army Corps Turns Over Flood Control Channels to the Local Sponsor to Maintain

✓"Congratulations on your new flood control channel designed assuming no siltation"

✓Few years later as it silts in and DPW can't afford to dredge – "You are out of compliance and out of the program"

And What Our Residents Say…

Petaluma River dredge protest (above)

San Rafael Canal dredge protest (right)

Gallinas Creek, Marin County

Flooding Up Tidal Channels is Major SLR Impact

- Direct flooding up tidal creeks is a major SLR impact
- Many home and business are located adjacent to these tidal channel
- Backwater prevents drainage = backwater flooding

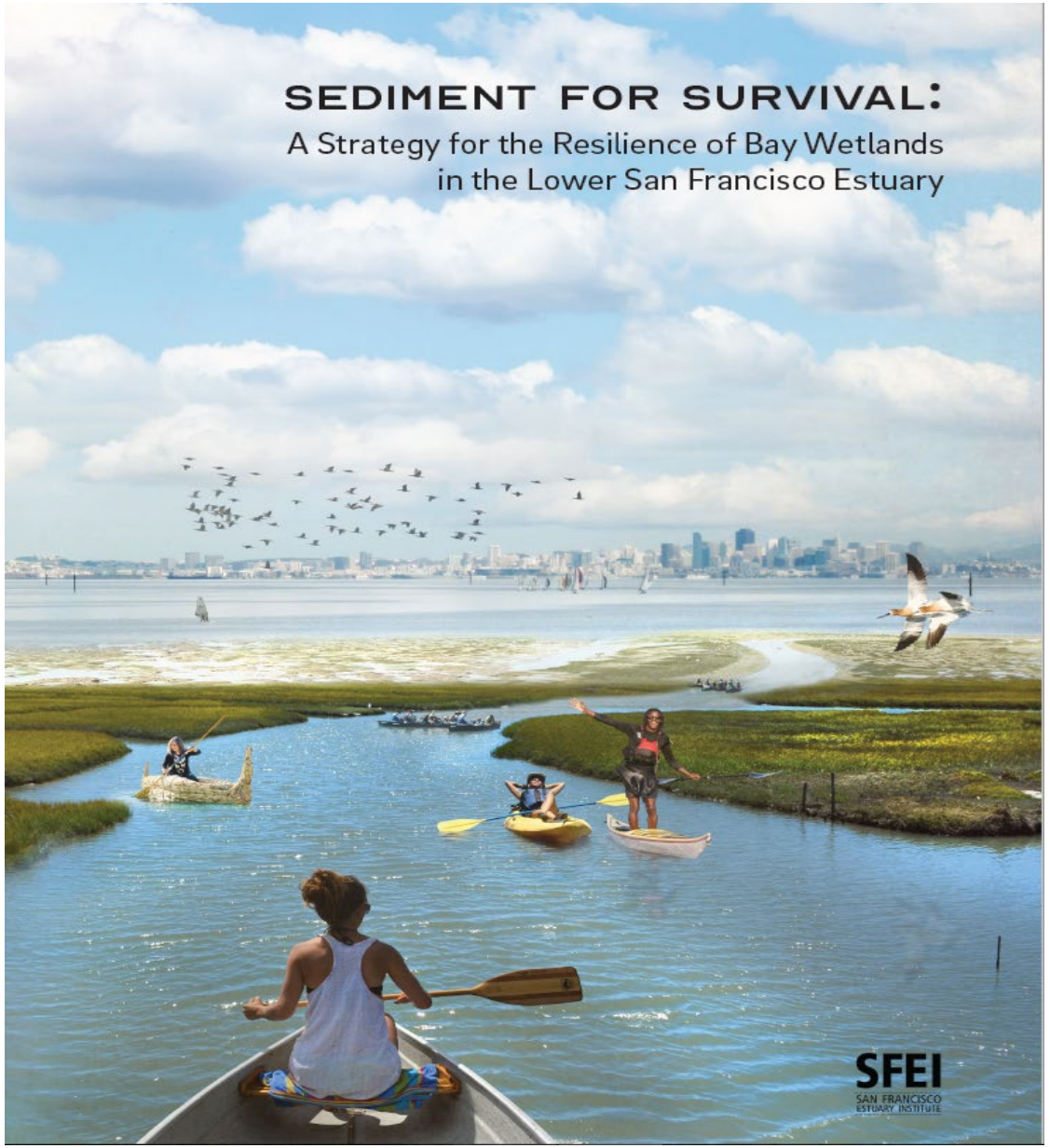
Why Do We Need a New Dredge Approach for Tidal Flood Control Channels?

- ✓Dredging tidal channels is impactful and difficult to permit
- ✓Major SLR flooding impact
- ✓It is expensive so that typical DPW flood agencies cannot afford to dredge
- ✓Generates huge amounts of GHGs
- ✓Marshes need the sediment

2020 Novato standard dredge – dewatered creek at downstream end

Bay Wide Awareness of Sediment Needs

- Estimate 5 to 10% of sediment tied up in tidal channels – not being beneficially reused (*estimate is low IMO*)
- Channels are located closest to marshes and mudflats
- Thorne et al (2022) confirmed research from Europe that episodic events such as ARs results in sediment deposition onto marshes and does the most to sustain marsh elevations – **critical finding!**
  - Pannozo et al (2023) - *"Majority of sediment supplied to marsh platform by storms likely generated by an increase in … resuspension of mudflat and tidal creek sediments."*

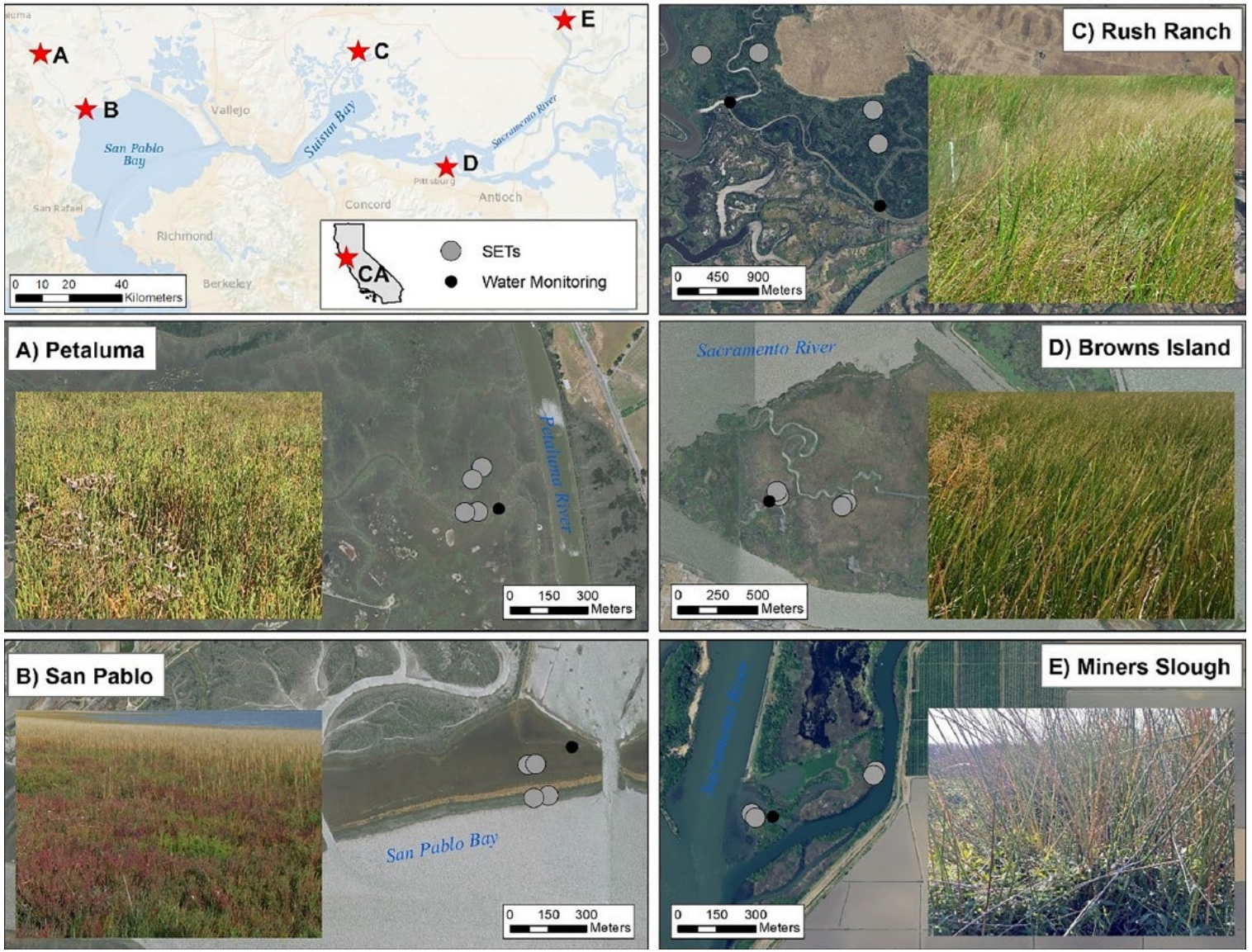


Storm Driven Depositions on Tidal Marshes

Recent studies document the importance of episodic storm driven deposition on tidal marshes (Thorne 2023 & Tognin 2021)

Thorne studies deposition due to an Atmospheric River (AR) event (2017)

ERDC staff used this same event for modeling in this project



The Science Shows the Way Sediment Moves

RESEARCH

Marsh Sediment in Translation: A Review of Sediment Transport Across a Natural Tidal Salt Marsh in Northern San Francisco Bay

Madeline R. Foster-Martinez*[1‡], Matthew C. Ferner[2‡], John C. Callaway[3‡], Brenda Goeden[4‡], Jessica R. Lacy[5‡]

the physical processes that we characterized there, key scientific conclusions, and proposed management implications. Key conclusions include (1) bay shallows are an important but variable source of marsh sediment, (2) flood tides and waves move sediment across the bay–marsh edge, (3) tidal creeks may not always import sediment to the marsh platform, and (4) protective effects of marsh vegetation depend on species and season. China Camp marsh is one of

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Geomorphology

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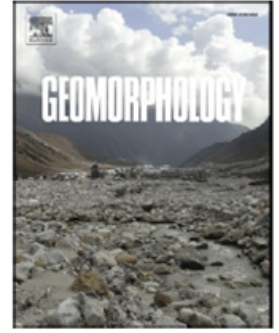

Storm sediment contribution to salt marsh accretion and expansion

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ABSTRACT

Salt marshes are ecosystems with significant economic and environmental value. However, the accelerating rate of sea-level rise is a significant threat to these ecosystems. Storms significantly contribute to the sediment budget of salt marshes, playing a critical role in salt marsh survival to sea-level rise. There are, however, uncertainties on the extent to which storms contribute sediments to different areas of marsh platforms (e.g., outer marsh vs marsh interior) and on the sediment sources that storms draw on (e.g., offshore vs nearshore). This study uses field analyses from an eight-month field campaign in the Ribble Estuary, North-West England, to understand storms' influence on the sediment supply to different marsh areas and whether storms can deliver new material onto the salt marsh platform which would otherwise not be sourced in fair-weather conditions. Field data from sediment traps indicate that storm activity caused an increase in inorganic sediment supply to the whole salt marsh platform, especially benefitting the marsh interior. Geochemistry and particle size distribution analysis indicate

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Estuarine Sediment Dynamics and the Importance of Storms in Moving (and Removing) Mud

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Abstract

Studies of sedimentation in low-elevation coastal zones often focus on long-term average sediment accumulation rates. Although decadal and centennial sedimentation rates are key to understanding resilience to relative sea-level rise, they overlook short-term (often seasonal or shorter) fluctuations that complicate impacts on ecosystems. Using a combination of field observations and hydrodynamic model results, we examined event- to seasonal-scale sediment dynamics and deposition rates in the Coos estuary, Oregon, a small, strongly forced system representative of estuaries along the U.S. Pacific Northwest coast. During rainfall events, peaks in turbidity are followed by up to 3 cm of mud deposition on tidal flats in the middle and upper estuary. Meanwhile, little or no deposition (0–1 cm) occurs in the lower estuary. The spatial pattern of sedimentation on tidal flats is consistent across timescales (event to centennial) but is inconsistent with sedimentation patterns in higher-elevation marshes. Whereas deposition on tidal flats in the middle and upper estuary occurs 2–3 times faster than deposition in the lower estuary, deposition in marshes appears to be slowest in the middle estuary. After a storm, the sediment deposited on tidal flats in the middle and upper estuary is reworked on the scale of weeks to a month and thus is not preserved in the long-term record. Projected climate-driven increases in the frequency and intensity of rainstorms will likely increase event-driven peaks in turbidity, bed stress, and sediment deposition, heightening the importance of short-term events as drivers of long-term estuary change from both ecological and sedimentological perspectives.

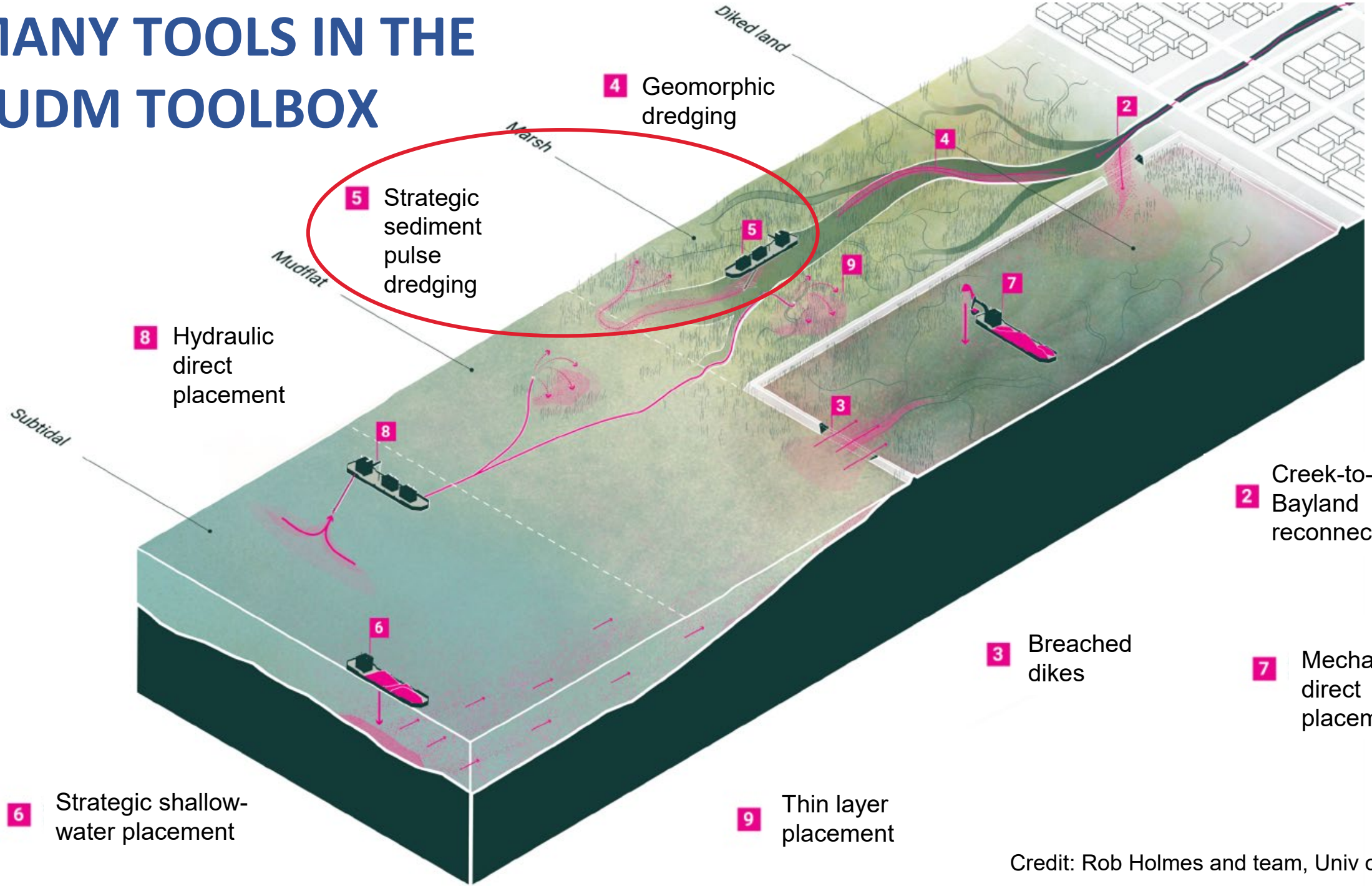
EWN Storm Driven Dredging - SSPD

- Marin proposal to naturally dredge tidal channels tied to episodic storm events when the Bay is naturally turbid – *a paradigm change in contracting*
- Limited to tidal channels
- Feeds the system with sediment when it's needed, that recent science shows does the most to sustain tidal marshes
- Low cost and low carbon

✓Very EWN, but difficult to permit in SF Bay

SF Bay in storm conditions

MANY TOOLS IN THE BUDM TOOLBOX



Credit: Rob Holmes and team, Univ of Auburn

FPMS Strategic Sediment Pulse Delivery Pilot Study

Program: USACE Floodplain Management Services

NFS + Project Partners:
Marin County Public Works, USACE ERDC

Study Duration: AUG 2023 – OCT 2024

Total Budget: $250,000 for report

Problem Statement: Traditional dredge approach in flood control tidal channels are cost-prohibitive and highly impactful, resulting in elevated flood risk to neighboring communities and up to 10% of Bay Area sediment supply trapped in out-of-compliance channels.

Proposed Solution: Low cost and low carbon hydrodynamic dredge method during times when Bay is naturally turbid (e.g. pre/post extreme event, summer high tides) **to achieve flood risk resilience by flood control tidal channels** and **feed Bay-wide sediment supply, which would bolster marsh and mudflat resilience to SLR.**

Roger Leventhal, PE

Tiffany Cheng, PE

Jessica Ludy

Julie Beagle

Seongjun Kim

Jade Ishii

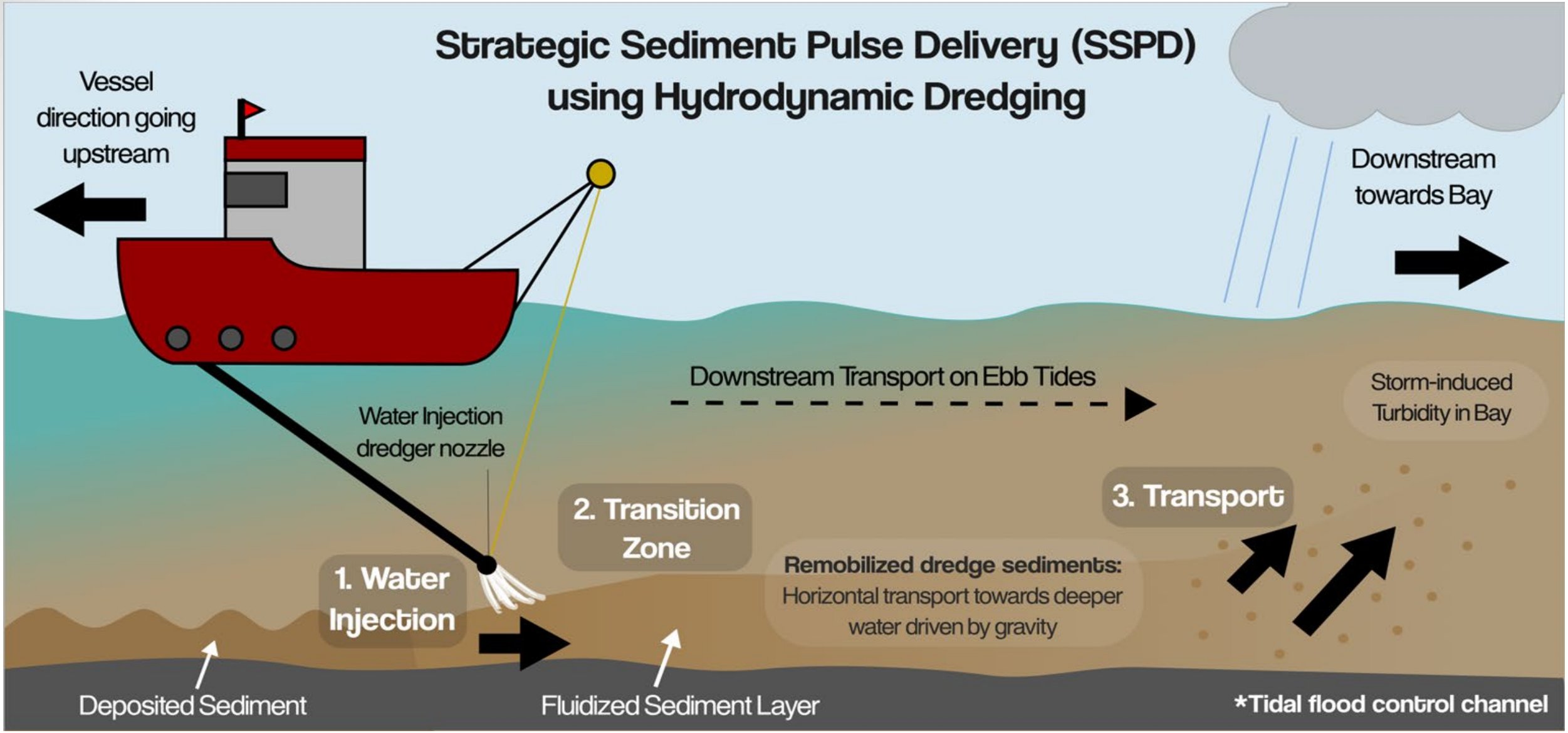
Jared Mcknight

Water Injection Dredge Vessel (Jetsed)

TECHNICAL WORKING GROUP – ROSTER & GOALS

- Technical working group membership meant to support feasibility of the SSPD approach from a scientific and engineering perspec tive

Name	Affiliation
Susan De La Cruz	USGS
Josh Gravenmeier	ERM
Jessica Lacy	USGS
Jeremy Lowe	SFEI
Michael MacWilliams	Anchor QEA
Jim McNally	Manson Construction
Karen Thorne	USGS
Zachary Tyler	ERDC
Joe Wagner	Black & Veatch
Isa Woo	USGS



Note: Vertical scale in graphic is exaggerated

GALLINAS CREEK – FORMER CORPS CHANNEL

Characteristics

Very Small Fluvial Input, All Bay Sediments (bookend to Coyote Creek)

Tidal Reach– approx. 14,000 lf – narrow at upstream end and around SM Island

Very Well Modeled with RAS (ESA)

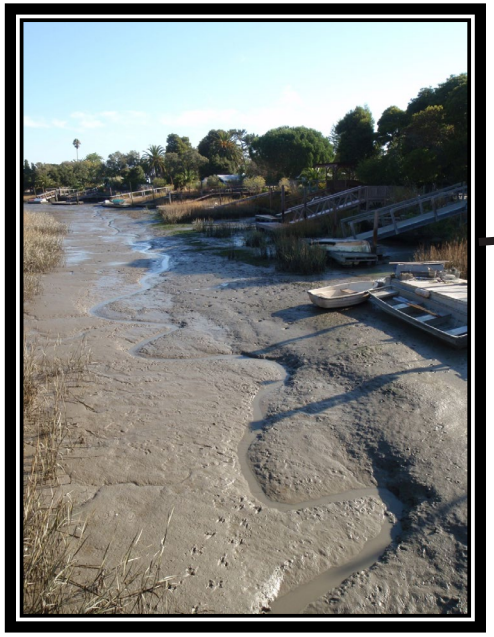
Adjacent to a **NERR site (China Camp**) Subject of Much Scientific Study of Marsh Deposition and Local Wave Energy

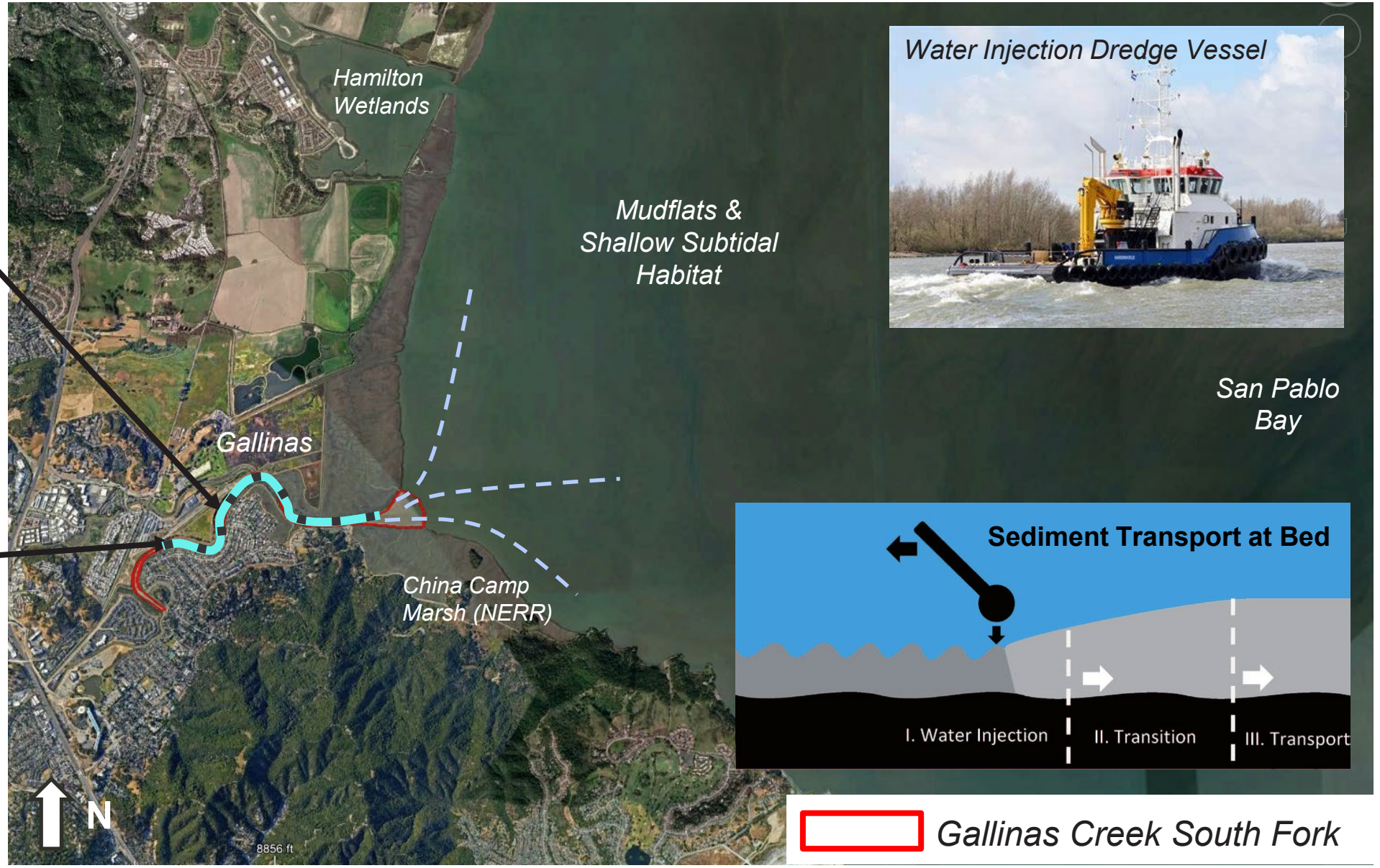
Full Time Water and Turbidity Sensor (NERR)

Very Concerned Community Over Lack of Dredging and Areas of High Flood Risk (Santa Venetia)

FPMS Strategic Sediment Pulse Delivery Pilot Study

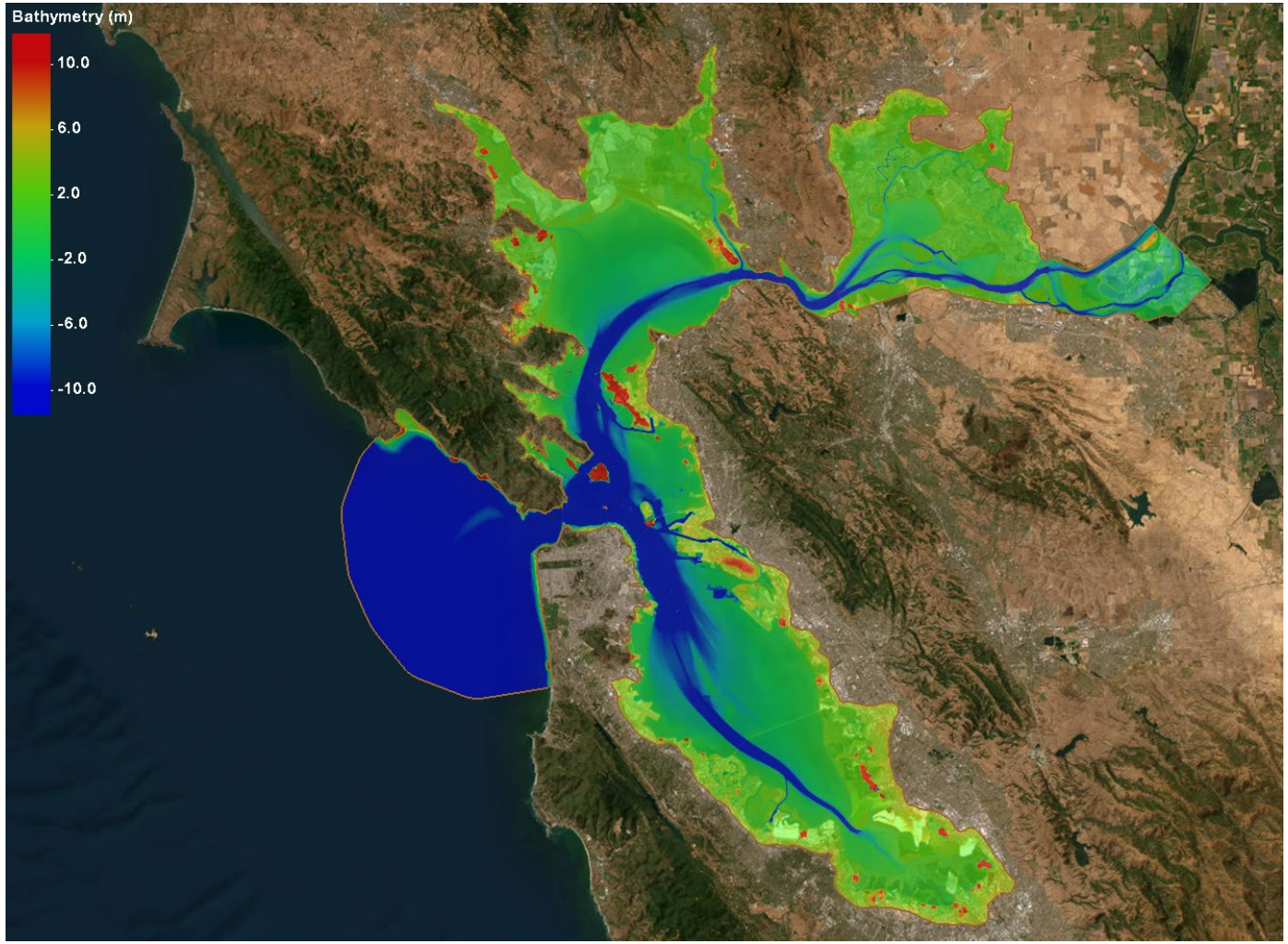
Excessive sedimentation in existing flood control channel





Conducted Full Hydrodynamic Sediment Modeling ADAPTIVE HYDRAULICS (ADH)

- USACE applied **Adaptive Hydraulics (AdH)**, a hydrodynamic and sediment transport model, to investigate the impacts of sediment pulse dredging on local morphologic changes and sediment fluxes into the system.
- Evaluated effectiveness of sediment pulse dredging assuming deployment in summer and winter to meet dredging and marsh/mudflat resilience goals
- Results show most sediment stayed within local marsh system



KEY MONITORING QUESTIONS

1

What are the potential impacts on the benthos and ecological communities nearby?

- *How long do the effects last?*
- *How far do the effects spread?*
- *What about eelgrass in the area?*

2

Where does the sediment end up? How do physical processes (tides and waves influence its transport?

- *Repeat bathymetric surveys*
- *What wave conditions move sediment?*
- *Use of a particle tracking study*
- *Understanding deposition in mudflats, marshes, breached ponds*

Environmental Effects of Hydrodynamic Dredging (Pledger et al. 2020, 2021)

- River Parrett, SW England
- Water Injection Dredging: spray bar mounted to the vessel stern
- Typical depths: 1.6-9.8 ft
- Bed elevation change: 1-3 ft for most dredged areas (3.5 mi)

Source: Somerset Rivers Authority

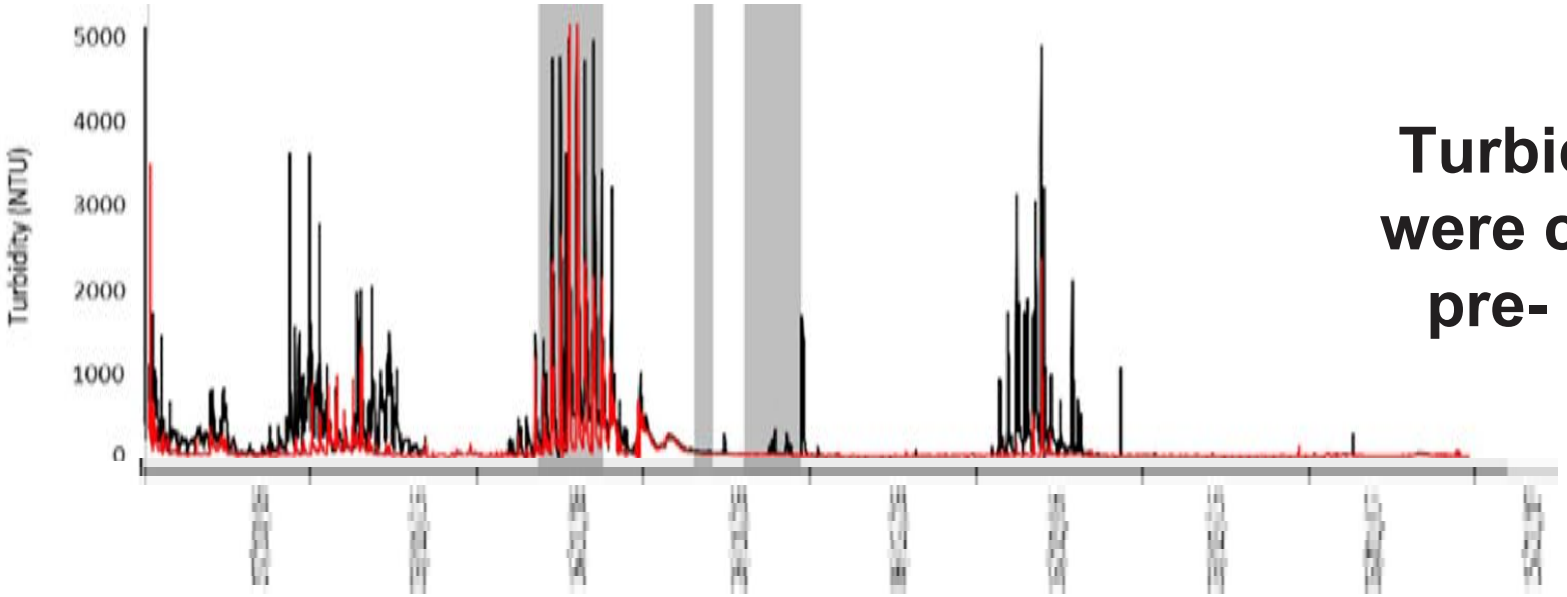
Water Quality Effects of Hydrodynamic Dredging (Pledger et al. 2020)

Changes in water quality parameters were short-lived (~1h) **and could not be isolated from effects of other processes/factors in tidal influenced, heavily modified systems.**

*statistically significant

Water Quality (Short-Term) Effects Summary: turbidity ↑*, salinity ↑, DO ↓*, pH ↓*

Grey bands = water injection dredging occurring, red=upstream, black=downstream.



Turbidity peaks during dredging were comparable in magnitude to pre- and post-dredge high tide peaks

Ecosystem Effects of Hydrodynamic Dredging (Pledger et al. 2021)

"Results suggest that mobile organisms and marginal communities were largely unaffected by thalweg water injection dredging"

Fish:

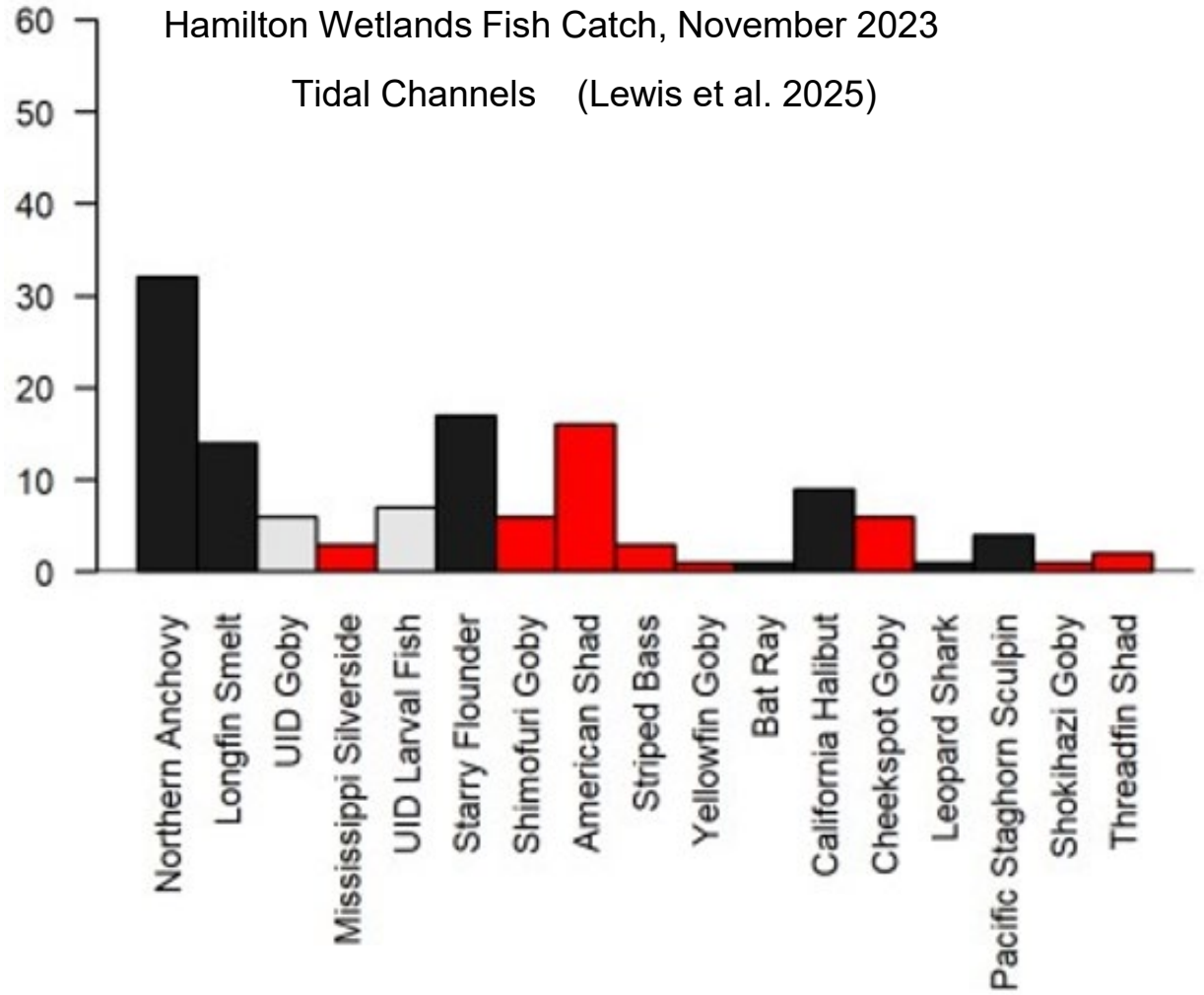
- **Low magnitude effects to fish community (no time dependence):**
  - Within dredge footprint: no *effects to fish
  - Downstream: abundance ↓, diversity ↓*, dominance ↑*, taxonomic richness ↓*
- **No effects on fish health and mortality:** all fish captured during dredging were alive and showed no obvious signs of distress, 3% had split/torn caudal fins

Macroinvertebrates:

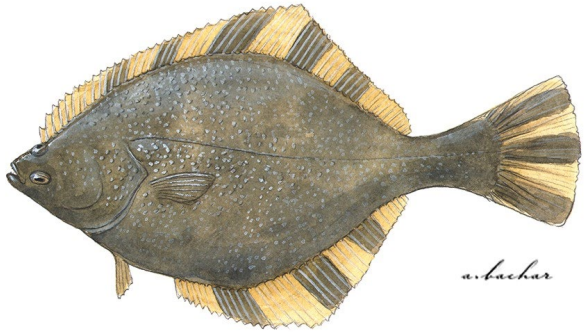
- **Temporary effects to benthic macroinvertebrates:**
  - Within dredge footprint and downstream: abundance ↓*, diversity ↓*, dominance ↑, and taxonomic richness ↓*
  - All recovered to control within 5 months

*statistically significant

Typical Fish Species



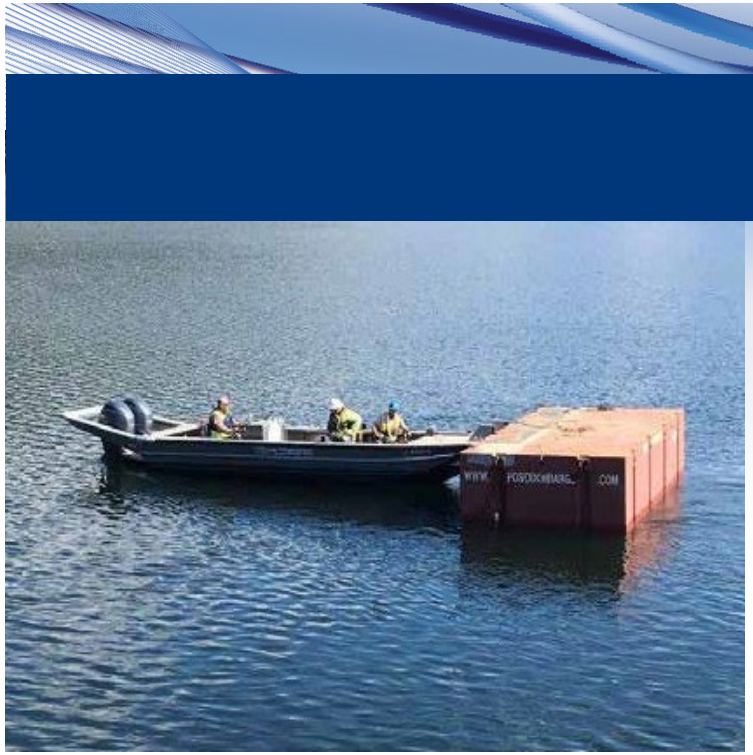
Longfin Smelt
Photo: USFWS 2022

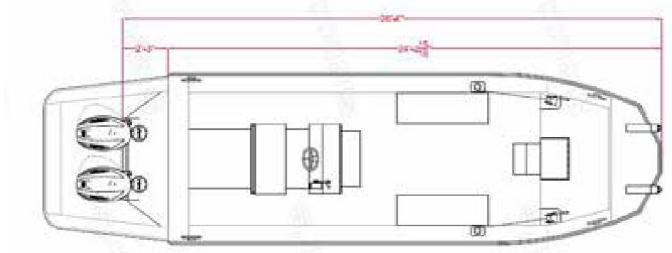


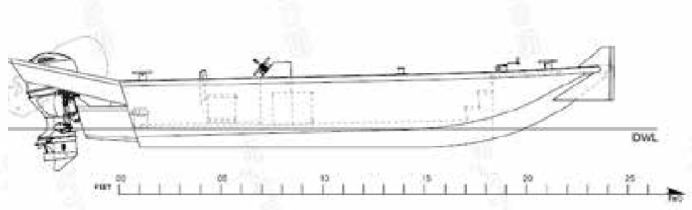
Starry Flounder
Drawing: CA Marine Species Portal

Pilot Study Proposal

- Two to three week study with full biological monitoring of benthos/WQ/fish is possible
- Dredge is limited to 3 to 6 hours per day (high tides)
- Design, Permitting, Bidding ~ $500k
- Pilot Unit Design and Fabrication ~$400k
- Field test (14 days) plus monitoring and reporting ~ $900k
- Approx $1.8M total







Final Report Completed January 2025

https://publicworks.marincounty.gov/documents/fpms-strategic-sediment-pulse-delivery-report/

THANK YOU! Time for Q&A

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