Empire Offshore Wind LLC

Empire Wind 2 Project

Appendix C

Sediment Transport Analyses

June 2022

TABLE OF CONTENTS

ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

Empire or the Applicant	Empire Offshore Wind LLC
EW 2	Empire Wind 2
NY Project	the portions of the EW 2 Project transmission system located within the State of New York
Tetra Tech	Tetra Tech, Inc.

C.1 INTRODUCTION

Empire Offshore Wind LLC (Empire or the Applicant) proposes to construct and operate the Empire Wind 2 (EW 2) Project as one of two separate offshore wind projects to be located within the Bureau of Ocean Energy Management-designated Renewable Energy Lease Area OCS-A 0512. This assessment is being submitted to the New York Public Service Commission for the portions of the EW 2 Project transmission system located within the State of New York (collectively the NY Project) pursuant to Article VII of the New York Public Service Law.

C.2 SEDIMENT TRANSPORT ANALYSES

This Appendix to the EW 2 Project Article VII Application presents the sediment transport analyses conducted by Empire and its contractors to support assessment of the potential water quality impacts of the New York Project, and compliance with the New York State Technical and Operational Guidance Series 5.1.9 for *In-Water and Riparian Management of Dredged Material* (NYSDEC 2004[1]). Technical and Operational Guidance Series 5.1.9 provides typical water quality standards for the mixing zone for suspended sediment discharge from dredging, dredged material placement, and effluent discharge.

Two analytical sediment transport models (the EW 2 Sediment Transport Study in **Attachment C-1** and the Sediment Transport Analysis in **Attachment C-2**) were developed and implemented for the NY Project to assess the suspended sediment water column concentrations and sediment deposition characteristics that would result from the submarine cable installation activities. A Sediment Transport Analysis using the publicly available Experimental System for Predicting Shelf and Slope Optics hydrodynamic model was conducted by Tetra Tech, Inc. (Tetra Tech) for the EW 2 Project to assess plume distances, suspended sediment concentration and sediment deposition (**Attachment C-2**). Additional refined hydrodynamic modeling for the NY Project, incorporating project-specific sediment sampling data, was then conducted by Deltares to assess suspended sediment concentrations, using the Delft3D hydrodynamic model (**Attachment C-1**). The submarine export cable routes presented in these analyses do not reflect some shifts to the submarine export cable routing that have been made in the Article VII application (Application), based on agency feedback and further design development. An updated analysis to reflect the routes filed in the Application is under preparation and will be filed with the New York State Public Service Commission once finalized.

Tetra Tech was contracted by Empire in support of its Construction and Operations Plan to evaluate the potential suspended sediment, transport and deposition associated with both the Empire Wind 2 and Empire Wind 1 Project construction activities, including installation of NY Project submarine export cables, as well as installation activities in federal waters. The sediment transport assessment by Tetra Tech covered a larger area than the EW 2 Article VII Project Area; a subset of the results relevant to the NY Project is provided in **Attachment C-2**. This assessment presents a representative submarine export cable route for the EW 2 Project, which is slightly different from the proposed NY Project submarine export cable route.

On November 1, 2021, Empire received informal comments from the New York State Department of Environmental Conservation requesting refinements to the sediment transport modeling for the NY Project Area.[2] Specifically, New York State requested "the model should be rerun incorporating the grain size analysis and chemical analysis results from the sediment sampling that was conducted along the route." Empire

[1] NYSDEC (New York State Department of Environmental Conservation). 2004. Technical and Operational Guidance Series 5.1.9, In-water and Riparian Management of Sediment and Dredged Material. Available at: https://www.dec.ny.gov/docs/water_pdf/togs519.pdf.
[2] Comments provided were specifically related to the Empire Wind 1 Project (21-T-0366); however, they also apply to the sediment transport modeling that was provided with the COP for the EW 2 Project.

contracted Deltares to conduct additional high-resolution hydrodynamic modeling of the NY Project submarine export cable route, using the Delft3D model and incorporating the project-specific sediment data. This EW 2 Sediment Transport Study is provided in **Attachment C-1**.

The EW 2 Sediment Transport Study relies on geotechnical data collected for Empire by Fugro in July and August 2019, including cone penetration tests and vibracore sampling as detailed in **Attachment C-1**.

Attachment C-1
EW 2 Sediment Transport Study

Deltares

Empire Wind 2 Sediment Transport Study

Modelling of trenching-induced sediment dispersion during the installation of the EW 2 export cables

Empire Wind 2 Sediment Transport Study

Modelling of trenching-induced sediment dispersion during the installation of the EW 2 export cables

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Empire Wind 2 Sediment Transport Study

Modelling of trenching-induced sediment dispersion during the installation of the EW 2 export cables

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Contact	Dennis Witteman
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Summary

Empire Offshore Wind LLC (Empire) proposes to construct and operate an offshore wind farm located in the designated Renewable Energy Lease Area OCS-A 0512 (Lease Area). The Lease Area is located approximately 14 statute miles (mi) (12 nautical miles [nm], 22 kilometers [km]) south of Long Island, New York and 19.5 mi (16.9 nm, 31.4 km) east of Long Branch, New Jersey. Empire proposes to develop the Lease Area in two wind farms, known as Empire Wind 1 (EW 1) and Empire Wind 2 (EW 2). Within the Lease Area, approximately 147 wind turbine generators at up to 176 locations will be connected through a network of inter-array cables. Each wind farm will connect via offshore substations to separate Points of Interconnection (POIs) at onshore locations by way of export cable routes and onshore substations. EW 1 and EW 2 will be electrically isolated and independent from each other.

Since the burial works could potentially be harmful to the marine environment due to the release of sediments, a comparison was made relative to standards provided in the NYSDEC Technical & Operational Guidance Series (TOGs). Specifically, Empire compared suspended sediment at the edge of a 1,500 ft mixing zone to the guidance value for the threshold of acute toxicity for suspended sediment from dredged material which has not undergone suspended phase toxicity testing, which is 100 ppm (100 mg/L) above ambient conditions.. Deltares was appointed to study the dispersion of sediment that is expected to be released into the water column during the burial activities for the EW 2 export cables in New York State (NYS) waters.

In order to meet the 6 ft. burial requirement, the burial works are anticipated to be carried out using jet plow equipment, with an anticipated maximum trenching speed of 188 m/hr. (617 ft./hr.) at a total required trenching depth of 8 ft (2.44 m). For locations where existing line assets (e.g., cables, pipelines) need to be crossed, the use of a Mass Flow Excavator (MFE) is foreseen. The SSC footprints are assessed by modelling the dispersion of the spilled sediment in a Delft3D far-field hydrodynamic model, with a high-resolution grid near the cable corridor, for a representative set of ambient conditions. The set of ambient conditions consists of different tidal periods, seasons, wind events and a significant wave height (H_s) up to 2 m (6.6 ft.). The sediment source terms in the far-field model are based on local sediment samples and a near-field assessment, which relies on the combination of a review of commonly reported values, expert interpretation as well as indicative numerical near-field computations. Based on the near-field assessment, a conservative sediment source term is included in the far-field modelling, which is introduced in the far-field model within 1 m (3.3 ft.) or 2 m (6.6 ft.) from the seabed. Only the associated release of fine sediment (silt and clay) is included in the far-field model, as it was found from the near-field assessment that the coarser sediment (sand and gravel) will either remain in the trench or settle within the near-field zone, which is well within the regulatory distance from the spill. Only for MFE, also the sand fraction was included since sand is expected to significantly contribute to the excess density of the plume due to the large release rates.

In the evaluation of the computed SSC footprints against the criteria, the near-bed SSC is mostly governing, as this typically represents the highest SSC in the water column (i.e., most conservative result). The different scenarios that were modelled showed that the compliance with the environmental criteria is sensitive to the ambient wave conditions. This evaluation is summarized for the different considered wave conditions.

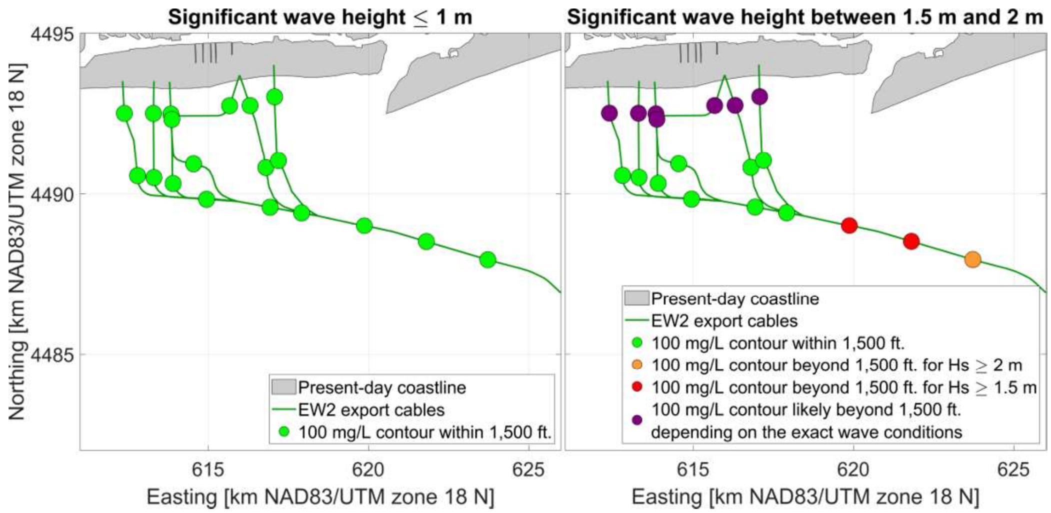

Figure 1 *Summary of the evaluation of the modelled excess SSC footprints against the environmental criteria for the Capjet operation. Left: All ambient conditions considered with significant wave heights up to 1 m. Right: In case of a 1.5 or 2 m significant wave height*

Figure 1 summarizes the evaluation of the Capjet operation. The modelled excess SSC at 1,500 ft. (457 m) is below 100 mg/L for all assessed release locations in case of significant wave heights up to about 1 m, which represents about 66% of the time (see Figure 4.8, based on DHI, 2021).

In case of a 1.5 m or 2 m significant wave height (wave heights exceeded about 12% and 4% of the time, respectively), the near-bed excess SSC at 1,500 ft. is expected to temporarily exceed 100 mg/L at the offshore stretches of the EW 2 export cables. At these locations, the modelled SSC footprints are larger because a relatively large fine sediment fraction is observed at these locations, based on the local sediment samples. At the near-shore release locations the exceedance of the 1,500 ft. zone strongly depends on the local wave *direction*. The most adverse conditions for the environmental criterion at these nearshore locations are the absence of a wave-induced longshore current (wave direction rather perpendicular to the local coastline orientation) in combination with mild tidal and wind-driven currents (i.e. neap tide and low wind speeds). In such situations, the 100 mg/L SSC footprint is expected to exceed beyond the 1,500 ft. mixing zone at the near-shore locations due to a lack of hydrodynamic activity that is able to dilute/mix the sediment plumes with ambient water. When the waves approach under a larger angle, the 100 mg/L SSC footprint is computed to remain within the 1,500 ft. mixing zone.

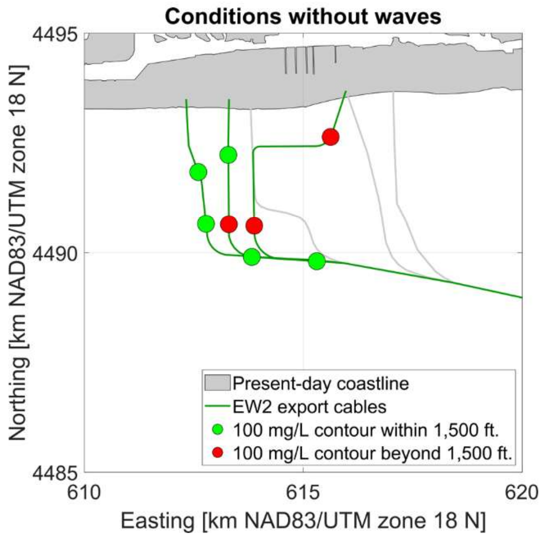

Figure 2 *Summary of the evaluation of the modelled excess SSC footprints against the environmental criteria for the MFE operation. Left: All ambient conditions considered with no (or low) waves. Right: In case of a 1 m or higher significant wave height.*

Figure 2 summarizes the evaluation for the MFE operations. At the offshore release locations, the 100 mg/L contour remains within 1,500 ft. for all considered conditions (i.e. with and without waves). For the other MFE locations, the 100 mg/L contour is beyond the 1,500 ft. zone in case of a significant wave height of 1 m or higher (maximum SSC at 1,500 ft. distance is in the range of 100 to 200 mg/L) and for some locations also in case of no (or low) waves. It is noted that in case of exceedance, the criterion is only exceeded up to about 20 minutes at 1,500 ft., given the short duration of the MFE operation.

For uncertain aspects of this study (e.g., spill rates during the burial works, sediment distribution along the entire cable) a conservative approach is followed. The actual excess sediment concentrations during the burial works are therefore likely smaller than the computed values. It is recommended to monitor the SSC during the burial works. The SSC could possibly be reduced by reducing the trenching speed (assuming that the jet intensity is reduced accordingly). Furthermore, it is recommended that adaptive management approaches and compliance should be based on monitoring and not on the provided estimations.

Contents

1 Introduction

1.1 Project background

Empire Offshore Wind LLC (Empire) proposes to construct and operate an offshore wind farm located in the designated Renewable Energy Lease Area OCS-A 0512 (Lease Area). The Lease Area is located approximately 14 statute miles (mi) (12 nautical miles [nm], 22 kilometers [km]) south of Long Island, New York and 19.5 mi (16.9 nm, 31.4 km) east of Long Branch, New Jersey (see Figure 1.1). Empire proposes to develop the Lease Area in two wind farms, known as Empire Wind 1 (EW 1) and Empire Wind 2 (EW 2). Within the Lease Area, approximately 147 wind turbine generators at up to 176 locations will be connected through a network of inter-array cables. Each wind farm will connect via offshore substations to separate Points of Interconnection (POIs) at onshore locations by way of export cable routes and onshore substations. EW 1 and EW 2 will be electrically isolated and independent from each other.

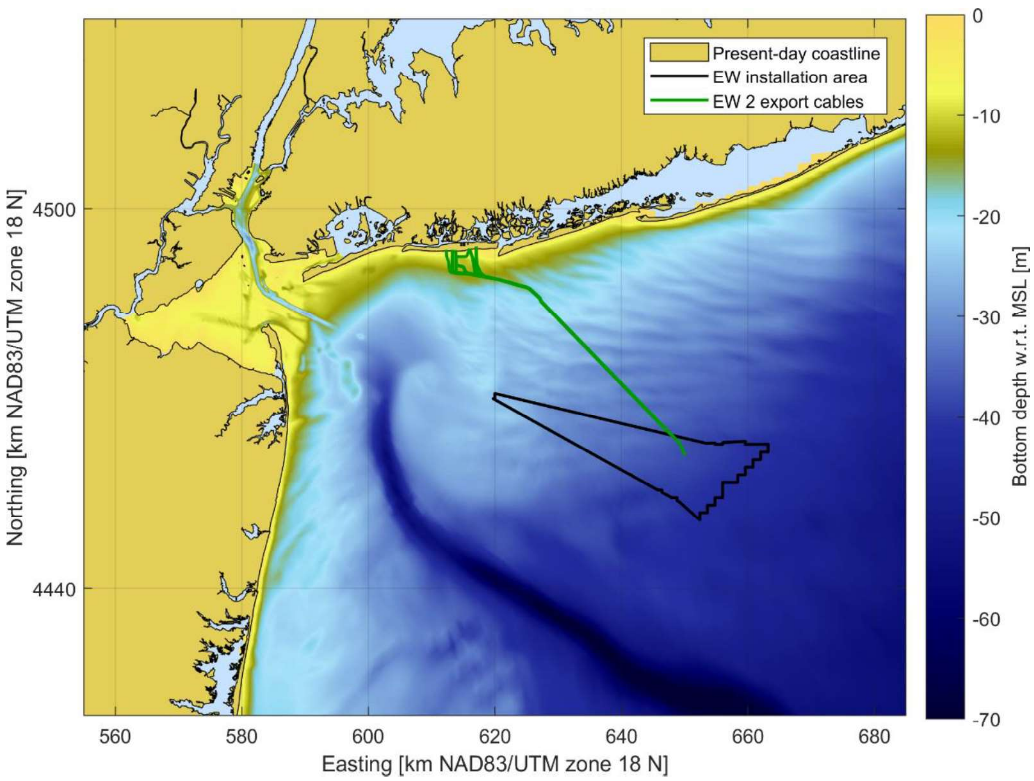

Figure 1.1 Overview of the Empire Wind project, including the main project components.

1.2 Study scope

The EW 2 submarine export cables will be buried, which causes the sediment to be agitated. This could cause sediment to be released into the water column. Subsequently, the sediment released into the water column will be dispersed (transported) by governing hydrodynamic conditions. This could potentially be harmful to the marine environment (e.g., due to a temporarily reduced light attenuation, smothering of organisms, etc.). Therefore, the sediment plumes during the burial works need to be assessed relative to the New York State Water Quality Standards, and certification under Section 401 of the Clean Water act.

This study focusses on the aspects introduced above, for the considered export cables of EW 2, within New York State Waters (which are located roughly from kilometer point (KP) 0 to about 14). This study considers six different EW 2 cable route alternatives, see Figure 1.2:

- Riverside Boulevard: in this report referred to as Cable Route A
- Monroe Avenue: in this report referred to as Cable Route B
- Lido Beach West: in this report referred to as Cable Route C1
- Lido Beach East: in this report referred to as Cable Route D
- Cable Route C3
- Cable Route E

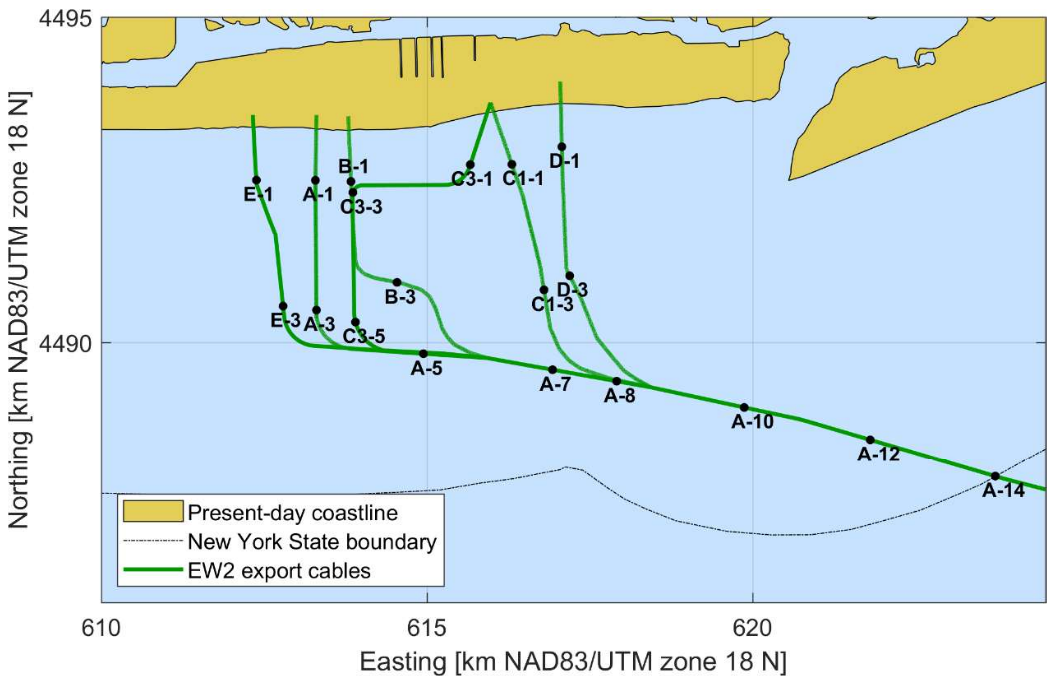

Figure 1.2 Overview of the EW 2 cable route alternatives, including indicative export cable kilometer points (KP's).

It is noted that the first kilometer of the export cable route alternatives (from KP 0 to 1) are not considered in this study, as these cable sections are installed deep within the subsoil using a trenchless installation method. Since this is completely executed within the subsoil, no sediment release into the water column is expected along these sections of the export cable routes.

1.3 Study objectives

The objective of this study is to compute the fate (dispersion, transport) and suspended sediment concentrations (SSC) of the released sediment as a result of the proposed burial activities, along the EW 2 export cable route in New York State waters as input to the environmental permitting procedures.

This study is prepared in support of the application for a Certificate of Environmental Compatibility and Public need under PSL Article VII submitted by Empire Offshore Wind LLC for the EW2 Project. The computed SSC is compared against the environmental criteria as described in the Technical & Operational Guidance Series (NYSDEC, 2004).

1.4 Study methodology

The present study is split into a near-field assessment, which focuses on the sediment behavior in the direct vicinity of the burial works, and a far-field assessment, which focuses on the larger-scale spreading of the sediment. In the near-field zone, the mixture density and non-hydrostatic behavior dictates the (initial) spreading behavior of the released sediment. As mixture densities reduce (by e.g. deposition, dilution, mixing), the spreading of the sediment becomes governed by advective and diffusive transport due to ambient hydrodynamic conditions, which is considered in the far-field assessment. A more detailed description of the sediment plume behavior and the typical terminology used in this field is described in Appendix A.

This study starts with an inventory on the available information with regard to the envisaged equipment for the burial of the EW 2 export cables, local sediment properties and the hydrodynamic characteristics of the project area.

A near-field assessment is carried out to assess the behavior of the sediment plumes in the direct vicinity of the trenching activities. The main objective of the near-field assessment is to determine the source terms (sediment release rate, vertical schematization, relevant sediment fractions, etc.) to be used in the numerical far-field modelling.

The far-field modelling is based on a Delft3D hydrodynamic model (Delft3D; Lesser et al, 2014) that covers a large part of the New York Bight as well as the Inner and outer Bay areas near New York City, with a high grid resolution near the EW 2 cable area. This model is coupled to a wave model (Delft3D-WAVE) that covers the same area as the hydrodynamic model. The models that are setup and utilized for this study are calibrated and validated against local water level, current, salinity and wave measurements.

To ensure a comprehensive plume dispersion assessment, all relevant hydrodynamic conditions should be considered. The modelled ambient conditions are selected with the aim to include the normative (i.e. worst case) conditions to assess the trenching activities for environmental compliance.

Sediment sources are introduced in the far-field model based on the near-field assessment results. The distribution of the release rate over the different sediment fractions (clay, silt, etc.) is based on the local sediment samples.

The far-field sediment dispersion modelling results have been evaluated against the environmental criteria as specified by the Technical and Operational Guidance Series of the New York State Department of Environmental Conservations (NYSDEC, 2004).

1.5 Reader

In line with the study methodology introduced above, the report also follows a structure in which first the near-field assessment is described (Chapter 3), followed by the far-field assessment (Chapter 4 and Chapter 5). Prior to these assessments, the available data and study input is firstly described in Chapter 2. The concluding remarks are provided in Chapter 6.

2 Study input data

This chapter provides an overview of the data analyses on the trenching equipment (Section 2.1), local sediment properties (Section 2.2) and environmental criteria (Section 2.3).

To better understand the hydrodynamics in the project area and to calibrate and validate the hydrodynamic and wave models, a large set of measurements have been analyzed. In addition, DHI (2021) provided modelled hindcast data for the period 2000 to 2019, consisting of water levels and velocity, salinity, and temperature at multiple vertical levels. A description of the data is given in Appendix B.

2.1 Burial and dredging equipment

All burial works within the New York State (NYS) waters (which represents the focus area of this study) are anticipated to be carried out using jet plow equipment (specifically, the Capjet from Nexans). Only for locations where existing line assets (e.g., cables, pipelines) need to be crossed, the use of a Mass Flow Excavator (MFE) is also foreseen. A spatial overview of the anticipated equipment is given in Figure 2.1. It is noted that MFE is only considered for three out of six export cable routes (A, C3 and E), as the remaining routes were no longer considered relevant once the MFE analysis was conducted. The different equipment is further elaborated on in the next subsections.

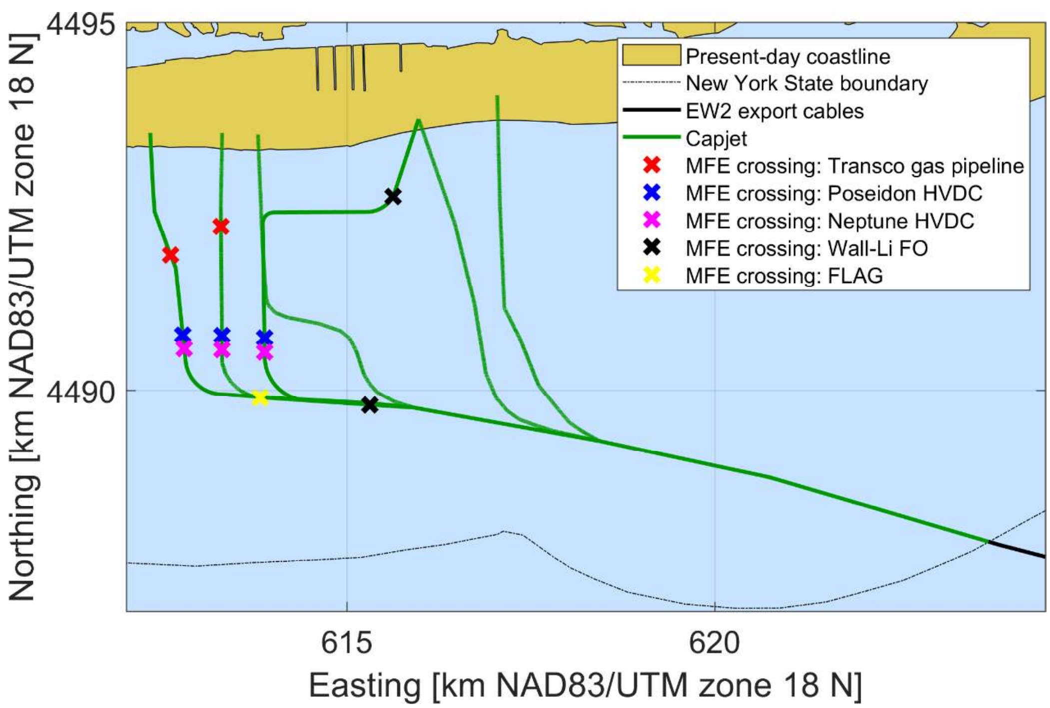

Figure 2.1 Spatial overview of the different anticipated equipment for the installation of the EW 2 export cables within NYS waters. Capjet trenching along the green lines, MFE at crossings (represented by crosses) with the indicated line object assets.

2.1.1 Capjet

For the burial of the EW 2 export cables (electric power cables within the New York State (NYS) waters (which is the focus area of this study) it is anticipated that the Capjet from Nexans will be used (from KP1 onwards), which is a type of jet plow equipment. The Capjet 1450 HP (Figure 2.2) is a remote-controlled hydraulic trenching machine, launched from a cable installation vessel (Figure 2.3), or a dedicated trenching vessel, with two jet swords guiding the cable to the required depth of lowering (minimal 6 ft. ≈ 1.83 m top of cable). The Capjet supports simultaneous cable lay and burial.

The trench is fully excavated by means of fluidization from hydropower jets. The installed hydraulic power consists of 2x400 kW LP water pumps, providing a flow rate of approximately 1300 m^3/hour at a pressure of 15 bar, 6 bar for backwash. The trenching depth including cable diameter (Ø 260 mm) is roughly 2 m. The anticipated distance between the jet swords is 300 mm, allowing the cable to pass through without friction, the thickness of each sword is 100 mm, meaning that the anticipated trench width is 0.50 m.

With remote operated jet-sword trench equipment such as Capjet, cable trenching can be performed with installation speeds reaching up to 250 m/hour (at a trenching depth of 6 ft.) in a sandy seabed (numbers provided by contractor). Achievable trenching speeds are defined by the technical and operational specifications of the trencher such as installed pump power, jet pressure, the type, number, diameter, and configuration of nozzles, pulling or propelling force and cable stiffness, as well as the seabed soil properties. For the present study it was assumed that the maximum installation speed scales linearly with the burial depth. Given the actual required burial depth of at least 6 ft. top of cable, a total trenching depth of 8 ft. (2,43 m) including cable diameter, has been adopted, with a maximum trenching speed of about 188 m/hour.

The seabed soil is excavated with high-pressure waterjets with nozzles placed on the front of the jet swords. With backward directed transport nozzles, the soil-water mixture is accelerated and flows backwards in the already excavated trench before the sediment settles and comes to rest, providing a backfill cover on top of the cable. In general, the backward flowing sediment plume, as observed relative to the trencher and accelerated by the transport jets, will not escape the trench. Although the excavated soil is diluted by turbulent mixing with the supplied jet water and ambient seawater, the flow will remain in the deepest sections of the trench and the local seabed until the particles have settled and the sediment flow relative to the seabed has decayed.

However, in the case of very fine sediment, during start-up or during slow progress speeds (for instance in firm sediment like clay ridges or insufficient backward transport capacity), the plume may escape the trench, causing near-bed turbidity as a fine sediment source.

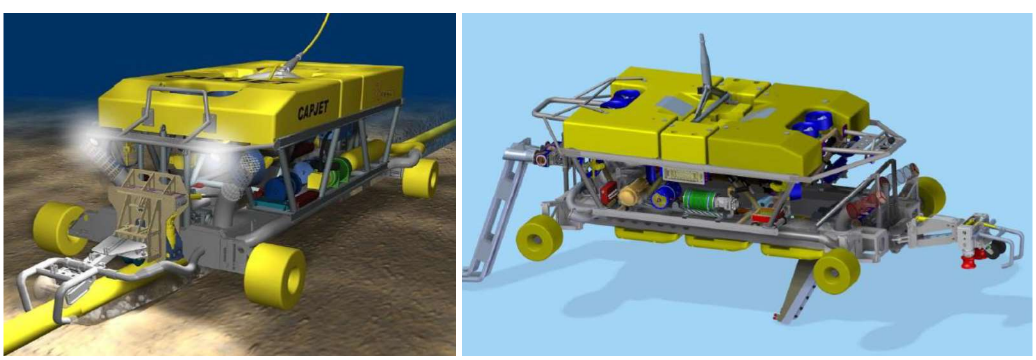

Figure 2.2 Capjet 1450 HP cable trencher (Nexans)

Figure 2.3 Cable installation support vessel Aurora (Nexans)

An assessment of the turbidity source and the near-field fine sediment behavior and distribution during Capjet operation (with project-specific operation characteristics as described in this section) is described in Chapter 3.

2.1.2 Mass Flow Excavator

The Mass Flow Excavator (MFE) will be deployed at some specific locations where crossings with existing cables or pipelines are foreseen, see Figure 2.1. With the MFE a high-momentum flow directed downwards can be generated that is very effective in removing sediment covering existing infrastructure without causing risk for mechanical damage.

The MFE is characterized by a vertical jet with a high flow rate and a relatively low pressure. The device, see Figure 2.4, can be operated from a vessel or pontoon and positioned at a certain level above the bed, excavating the seabed over one or more passes.

Figure 2.4 Examples of MFE (left: T4000 from James Fisher Subtech website, right: CCB-110 Excavator)

An assessment of the turbidity source and the near-field sediment behavior and distribution during MFE operation is presented in Chapter 3.3.

2.2 Sediment data

In July to August 2019, a geotechnical site investigation of the soil in the Empire Wind cable areas was performed (Fugro, 2020). The geotechnical site investigation included (thermal) cone penetration tests and Vibracore sampling. For the current study, the Vibracore samples were used to characterize the sediment composition of the near-bed layer in the vicinity of the considered EW 2 cable routes. Figure 2.5 and Figure 2.6 show the observed mud and sand fractions in the 12 Vibracore samples within the EW 2 cable area. The sediment composition derived from the sediment samples varies strongly in the project area. In the offshore part of the EW 2 cable routes (within the New York State boundary), as well as at the nearshore part of the western EW 2 cable alternatives, the sediment mainly consists of fine material. The mud content is minimal in the intermediate area. For 5 out of 12 sample locations, the mud fraction has been separated into a silt and clay fraction. The mud fraction mainly consists of silt (typically about 70%) and for a smaller part of clay (about 30%).

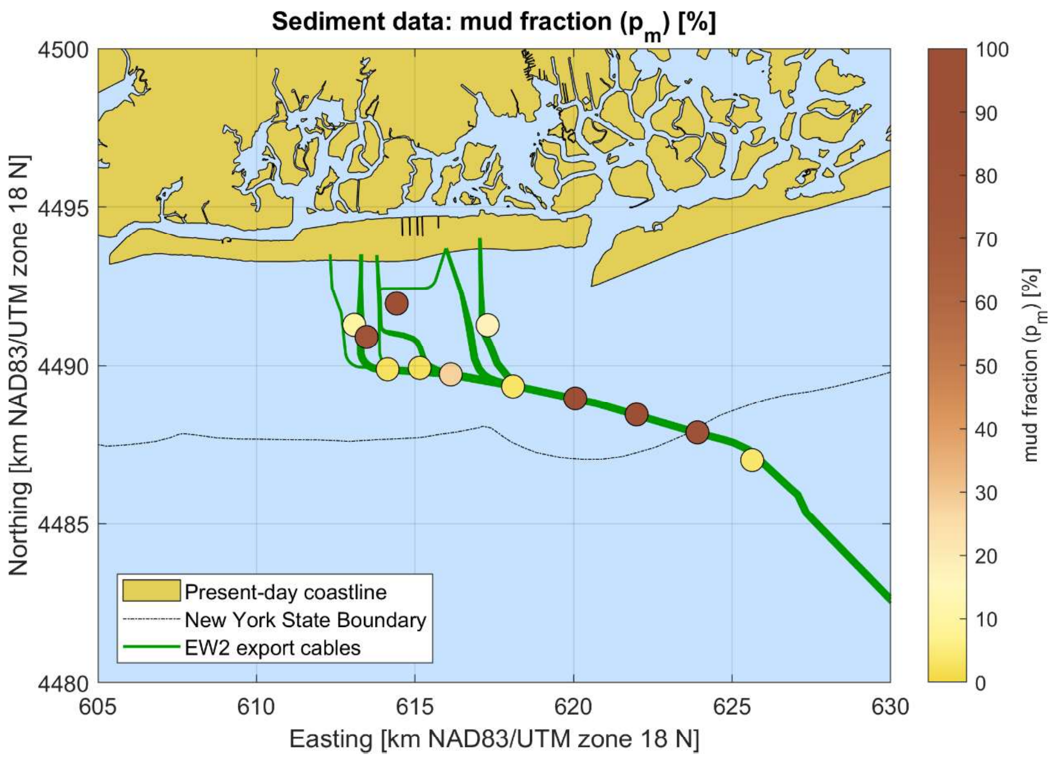

Figure 2.5: Overview of the mud fraction in the nearby Vibracore samples (Fugro, 2020)

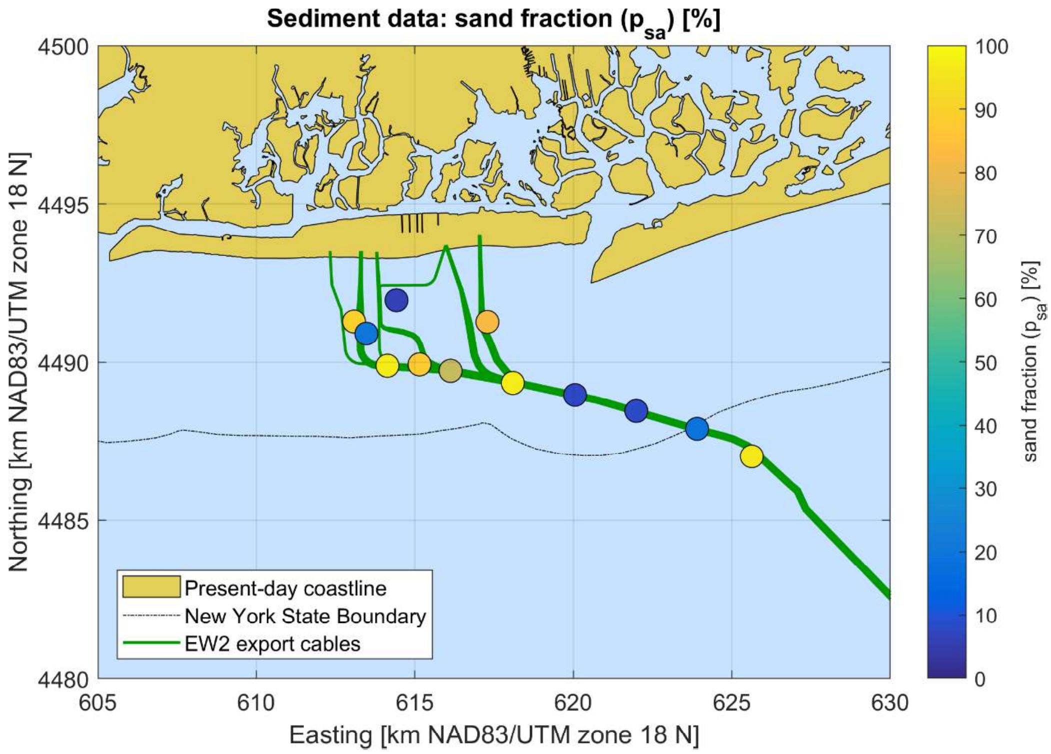

Figure 2.6: Overview of the sand fraction in the nearby Vibracore samples (Fugro, 2020)

2.3 Environmental criteria

The far-field modelling results, which are described in Chapter 5, are evaluated against the environmental criteria as described in the Technical and Operational Guidance Series of the New York State Department of Environmental Conservations (NYSDEC, 2004). As such, the suspended sediment concentration at the edge of a 1,500 ft mixing zone was compared to the guidance value for the threshold of acute toxicity for suspended sediment from dredged material which has not undergone suspended phase toxicity testing, which is 100 ppm (100 mg/L) above ambient conditions.

As indicated above, it is understood that the SSC limit of 100 mg/L refers to above-background (i.e., excess) concentrations. The background SSC is therefore not considered in this study.

3 Near-field assessment

3.1 Introduction & approach

To conduct the far-field sediment transport assessment, a near-field assessment is needed to determine the appropriate sediment source terms to implement (i.e., release) in the far-field model simulations. In this chapter, the near-field assessment conducted for this study are described for the different anticipated equipment (introduced in Section 2.1) while focusing on the yielding release rates (in kg/s). The near-field assessments rely on the combination of a review of commonly reported values, expert interpretation and judgement by Deltares' experts on trenching equipment and soil behavior during trenching activities, as well as applying indicative and informative numerical computations/simulations. These indicative near-field (model) computations are also utilized to obtain a reliable estimate of the spatial source term distribution to implement in the far-field model (primarily the vertical distribution). Uncertainties and variability associated with the source terms are considered by assessing the range from lower to higher estimates for the source terms. It is noted that based on the conservative near-field assessment also conservative sediment source terms are considered in the far-field sediment dispersion assessment.

The source terms presented in this chapter are linked to the production rate (m^3/hr.), defined by trench cross-section dimensions (m^2) and installation speed (m/hr.), the seabed soil composition as provided along the trenching trajectory from bore hole sampling, the envisaged spill rate (%) and release height. For the spill rate conservative estimates are used. Moreover, it is assumed that the excavated sediment, including clayey cohesive soil, will be fully dispersed (separated) into the composing fine particle fractions, which is a conservative assumption as well.

During the trenching operation and the spill of fines near the bed, a near-field spreading will take place caused by density effects. The plume will flow and disperse along the seabed as a density current before all the fine particles will be settled or resuspended by tidal currents to the far field. In this chapter this near-field redistribution is also addressed by means of indicative CFD-simulations.

The resulting release rates are used as input in the far-field simulations divided over representative sediment fractions included in the far-field model simulations, based on the local measured sediment distribution along the cable route.

3.2 Capjet

3.2.1 Sediment spill source

A description of the Capjet trencher is given in Section 2.1. As the Capjet advances forward along the cable route, a sediment plume directed behind the Capjet will flow backwards into the trench. In case the plume flows partly out of the trench over the adjacent seabed it can be assumed that due to its density, it will not disperse easily in the water column and will remain close to the seabed (up to approximately 1 m maximum, confirmed by near-field modelling). The operational parameters and resulting source terms for turbidity generation during the operation with the Capjet are given in Table 3.1.

The production rate is mainly defined by the trench speed. The maximum value will be defined by soil resistance and installed power, so this will be variable as shown in the table.

Only the fines in the seabed (generally silt and clay particles with a diameter smaller than 63 µm) will be subject to further entrainment. Coarser material and even fine sand will settle quickly when the plume migrates out of the trench because the plume is very close to the bed. The lower spill limit could be practically 0% if under optimal conditions the plume remains completely in the trench.

Literature gives spill rate numbers in the range of 10-35% for jet trenching operations, e.g., Tetra Tech, Appendix J, (2021), RPS ASA (2015), Table 3-3 Jet Plow, ESS Group (2013) and Vineyard Wind (2018). In these public documents, frequent reference is also made to Foreman, J. (2002), however, this document could not be retrieved for this study. A general overview of offshore jet trenching operation is given in Atangana Njock et al. (2020). A general overview of assessment of environmental impact of dredging is given in Laboyrie et al (2018).

In general, no conclusive monitoring data on turbidity during trenching is available, only model predictions. As observed by Nexans by video-inspection on other cable installation projects, after trenching often hardly any sediment deposition is found in the tracks of the Capjet after cable burial, suggesting, with some uncertainty, limited spill rates. For the Capjet it is assumed, based on literature and expert judgement, that at maximum 25% of the excavated seabed sediment will be subject to further entrainment in any present ambient seawater flow, as a conservative estimate. The resulting source flux in Table 3.1 has a range in magnitude to account for uncertainties and variability associated with the Capjet sediment spill processes.

The seabed in the offshore zone consists mainly of fine to coarse sands (Fugro, Table 4-3, 2020 and Tetra Tech, Appendix J, Table J-3, 2021). The unit bulk weight of moderate to densely packed sand is generally 2000 kg/m^3 consistent with lab data of soil samples, which implies a bed solids content of 1565 kg/m^3 (with sediment grain density of 2746 kg/m^3).

The maximum trenching speed follows from the 6 ft. trenching depth, which is assumed achievable up to a maximum of 250 m/hr., which implies a maximum of 188 m/hr. for the total trenching depth of 8 ft. (to account for a minimal 6 ft. 'top of cable' burial).

Table 3.1 Capjet operational properties and turbidity source

Capjet	Magnitude	Units
Trenching speed	75 – **188**	m/hour
Trench depth	8 ft. (2.44 m)	m below seabed (min. 6 ft. cover, top of cable)
Trench width	0.5	m
Seabed bulk weight	20	kN/m^3
Production	40 – **100**	kg/s solids
Spill factor	25	%, percent
Source term for model	9.9 – **24.9**	kg/s solids

It is noted that it is assumed that the Capjet will bury the export cable 6 ft below the seabed (top of cable). In case this depth would be increased, it is assumed that the trenching speed will also reduce proportionally, yielding identical source terms.

In the far-field model the source term is multiplied by the corresponding sediment fractions at the specific location along the cable route. Only the fines with particles < 63 µm will contribute to turbidity generation, coarser particles will settle in the near-field zone or remain in the trench and are therefore excluded from the sediment dispersion assessment.

3.2.2 Near-field computations

During release, the fines originating from the trencher tool starts as a plume with small dimensions and will flow as a density current near the seabed. Local bathymetry is important for the behavior of a density current, as a bed slope can steer its transport direction and influence its mixing. Those local so-called near-field effects manifest on spatial scales and include detailed turbulence processes that cannot be captured in a far-field model. Therefore, indicative near-field CFD (computational fluid dynamics) simulations with a realistically schematized input are used to assess the near-field mixing of the plumes released by a Capjet in the zone covering the first 50 m from the release location. The schematic near-field CFD simulations are used to investigate the initial vertical and horizontal mixing, which is used to establish an adequate representation of the sediment source term in the far-field model. Near-field CFD simulations are carried out with the following schematized realistic input, typical for the conditions to Empire Wind based on far field hydrodynamic model results and the bathymetry round the cable route (see Figure 1.1):

- Ambient depth of 10 m
- Ambient current of 0.2 and 1 m/s
- Three different bed-slopes:
    - No bed-slope
    - Bed-slope 1:10 perpendicular to ambient flow
    - Bed-slope 1:20 against ambient flow
- Two different source fluxes of 10 kg/s and 30 kg/s implemented between 0 – 1 m from the bed in a 0.5 m wide zone above the trench
- Sediment consists of fines with a settling velocity of 1 mm/s (representative for fine silt, about 30 – 40 µm grain size)

These cases are selected to envelop the bandwidth of Empire Wind conditions and investigate the potential range of near field plume characteristics. A total of 12 near-field CFD-simulations are carried out with TUDflow3D (De Wit 2015), based on all combinations of 2 ambient current speeds, 3 bed-slopes and 2 source fluxes. A grid size of Δx=Δy=0.5 m near the source, growing to 1 m at larger distances and uniform Δz=0.2 m is employed. The Large Eddy Simulation turbulence modelling approach is used to get adequate mixing of the sharp interface present at the edge of the near-field sediment plumes. TUDflow3D has been used successfully for near-field assessments of sediment plumes and density currents (De Wit 2015, Kirichek et al. 2021) in many projects. Details on TUDflow3D can be found in De Wit (2015).

The simulated 3D plume contours are shown in Figure 3.1 and Figure 3.2. These figures show the spreading of released sediment by the 3D 100 mg/L contour. Some of the simulated plumes hit a lateral edge of the computational domain. This only has a local impact on the plume distribution near such lateral edges and such local zone is omitted in assessing the plume distribution.

The 3D plume contours show that for the low ambient velocity of 0.2 m/s the plumes behave very much as a density current, transported along with the current and spreading in lateral direction near the bed. The 1:10 bed-slope in lateral direction forces the plume to shift in lateral direction down the slope but vertical mixing is hardly influenced. The 1:20 bed-slope against the current slows down the speed of the plume and vertical mixing is enhanced slightly. For the high ambient velocity of 1 m/s, the plume is taken along with the flow to a greater extent and lateral spreading is lower compared to the situation with 0.2 m/s ambient current. Also, the influence of both different bed-slopes is lower for the case with 1 m/s ambient current compared to the situation with 0.2 m/s ambient current. Vertical mixing of the plume is higher for the higher ambient current velocity, but in all the investigated cases most of the plume volume can be found very close to the bed in a zone of about 0 – 100 m from the source.

Details of the vertical and horizontal plume distribution have been subsequently assessed based on transects at x=50 m downstream of the source location.

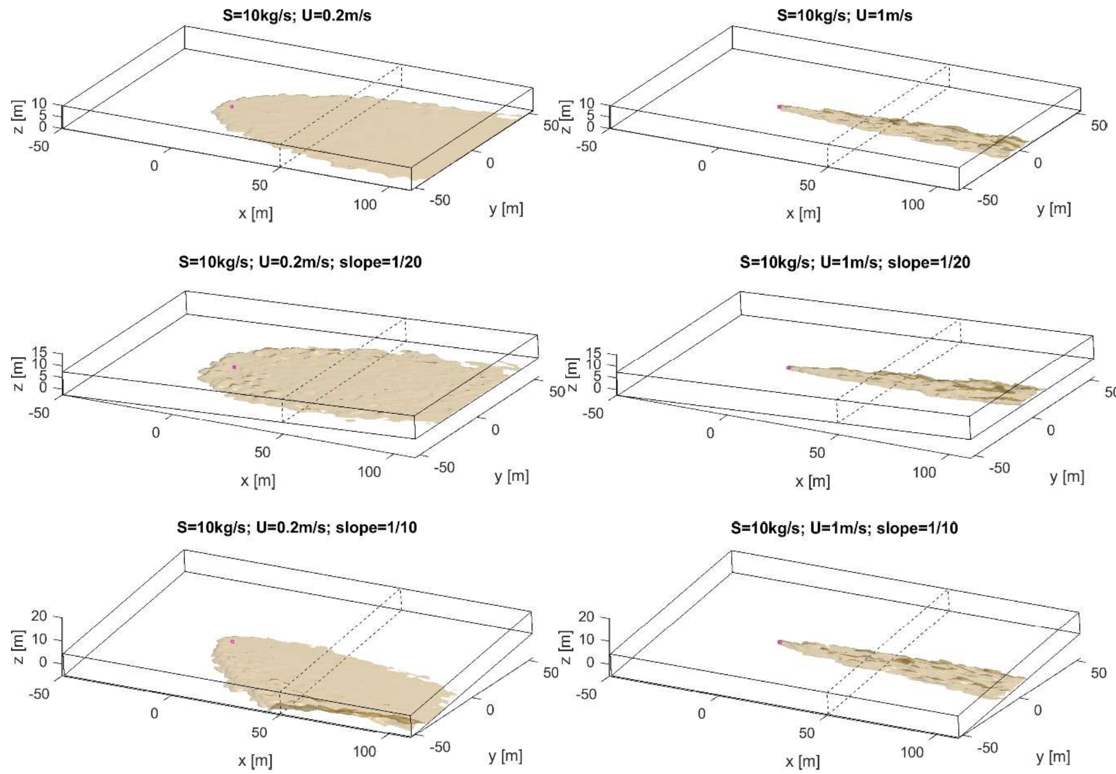

Figure 3.1 *Schematic CFD near-field 3D Capjet plume results for a source flux of 10 kg/s for two ambient velocities (0.2 m/s left column and 1 m/s right column) and three different bed slopes (no bed-slope top row; 1:20 bed-slope against ambient current middle row; 1:10 bed-slope perpendicular to ambient current bottom row). The plume source point (x = 0 m, y = 0 m) is indicated in magenta and the location of the cross section at x=50m used in Figure 3.3 - Figure 3.5 is indicated in black dashed lines.*

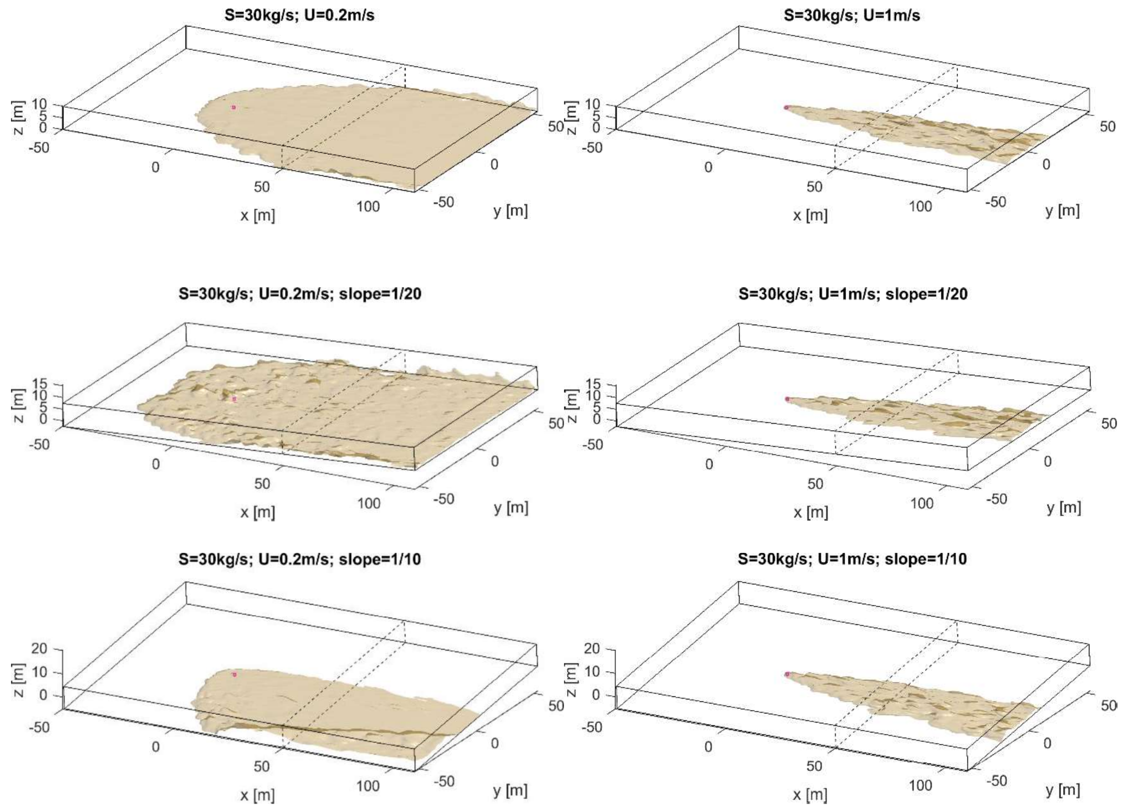

Figure 3.2 Schematic CFD near-field 3D Capjet plume results for a source flux of 30 kg/s for two ambient velocities (0.2 m/s left column and 1 m/s right column) and three different bed slopes (no bed-slope top row; 1:20 bed-slope against ambient current middle row; 1:10 bed-slope perpendicular to ambient current bottom row) The plume source point (x = 0 m, y = 0 m) is indicated in magenta and the location of the cross section at x=50m used in Figure 3.3 - Figure 3.5 is indicated in black dashed lines.

Simulated plume SSC (suspended sediment concentration) transects at x=50 m downstream of the source location are shown in Figure 3.3 – Figure 3.5. It confirms the observation from the 3D plume contours that the cases with high current velocity of 1 m/s are slightly more mixed in the vertical and much less dispersed in lateral direction. Maximum vertical up-mixing of the plume is observed for the cases with 1:20 bed-slope against the ambient current, since in that case the ambient flow and density effect work against each other. The cases with a 1:10 bed-slope perpendicular to the flow show very comparable lateral and vertical mixing compared to the cases without bed-slope. Comparing the plume fluxes for the different cases at x=50 m with the initial flux of 10 and 30 kg/s show that with the settling velocity of 1 mm/s, which is considered in the near-field simulations, almost ~10-75% of the sediment being released deposits in the zone 0-50 m from the release location.

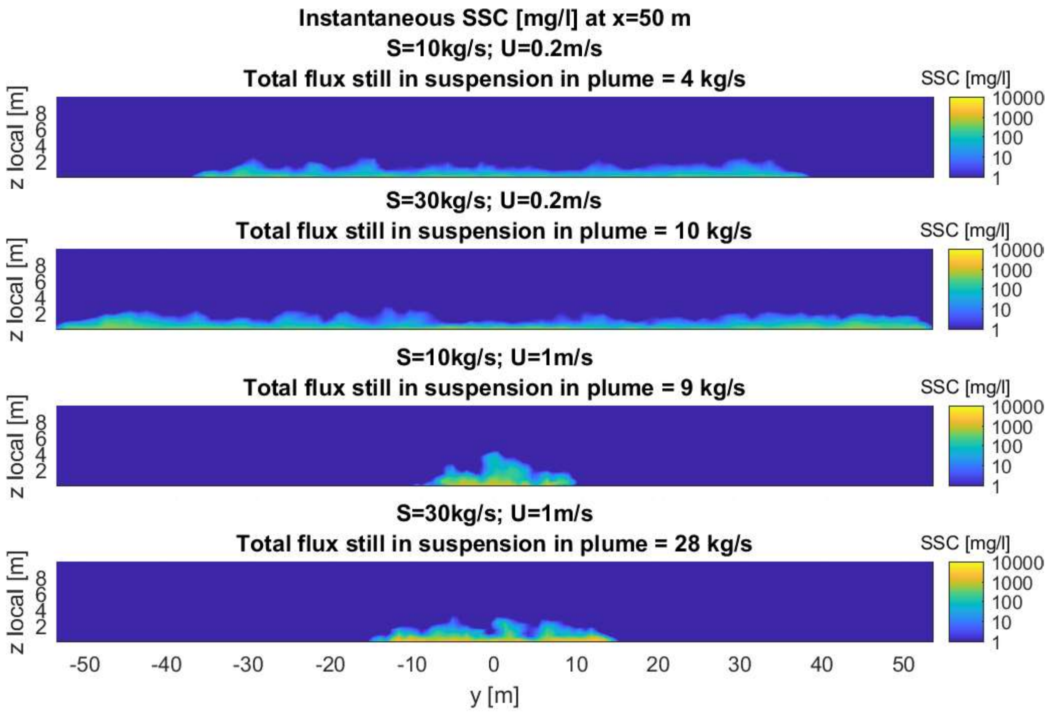

Figure 3.3 *Near-field Capjet plume cross sections at x=50 m downstream from the source location for the near-field CFD simulations without bed-slope and a source flux and ambient current of 10 kg/s and 0.2 m/s; 30 kg/s and 0.2 m/s; 10 kg/s and 1 m/s; 30 kg/s and 1 m/s respectively for the panels from top to bottom.*

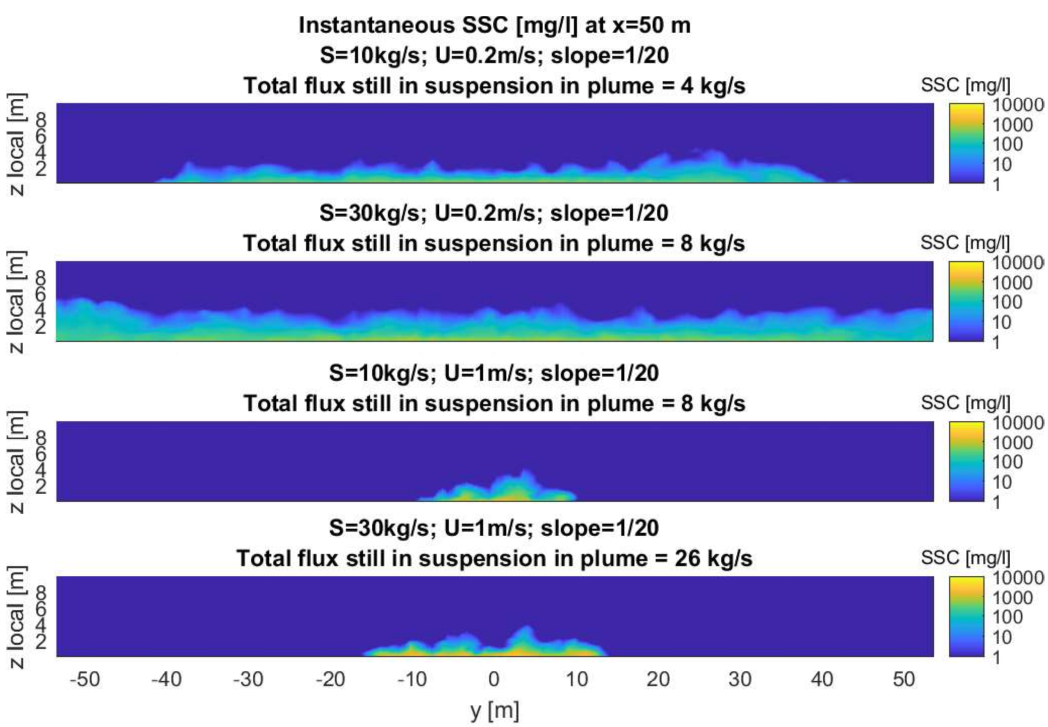

Figure 3.4 *Near-field Capjet plume cross sections at x=50 m downstream from the source location for the near-field CFD simulations with a 1:20 bed-slope against ambient current and a source flux and ambient current of 10 kg/s and 0.2 m/s; 30 kg/s and 0.2 m/s; 10 kg/s and 1 m/s; 30 kg/s and 1 m/s respectively for the panels from top to bottom.*

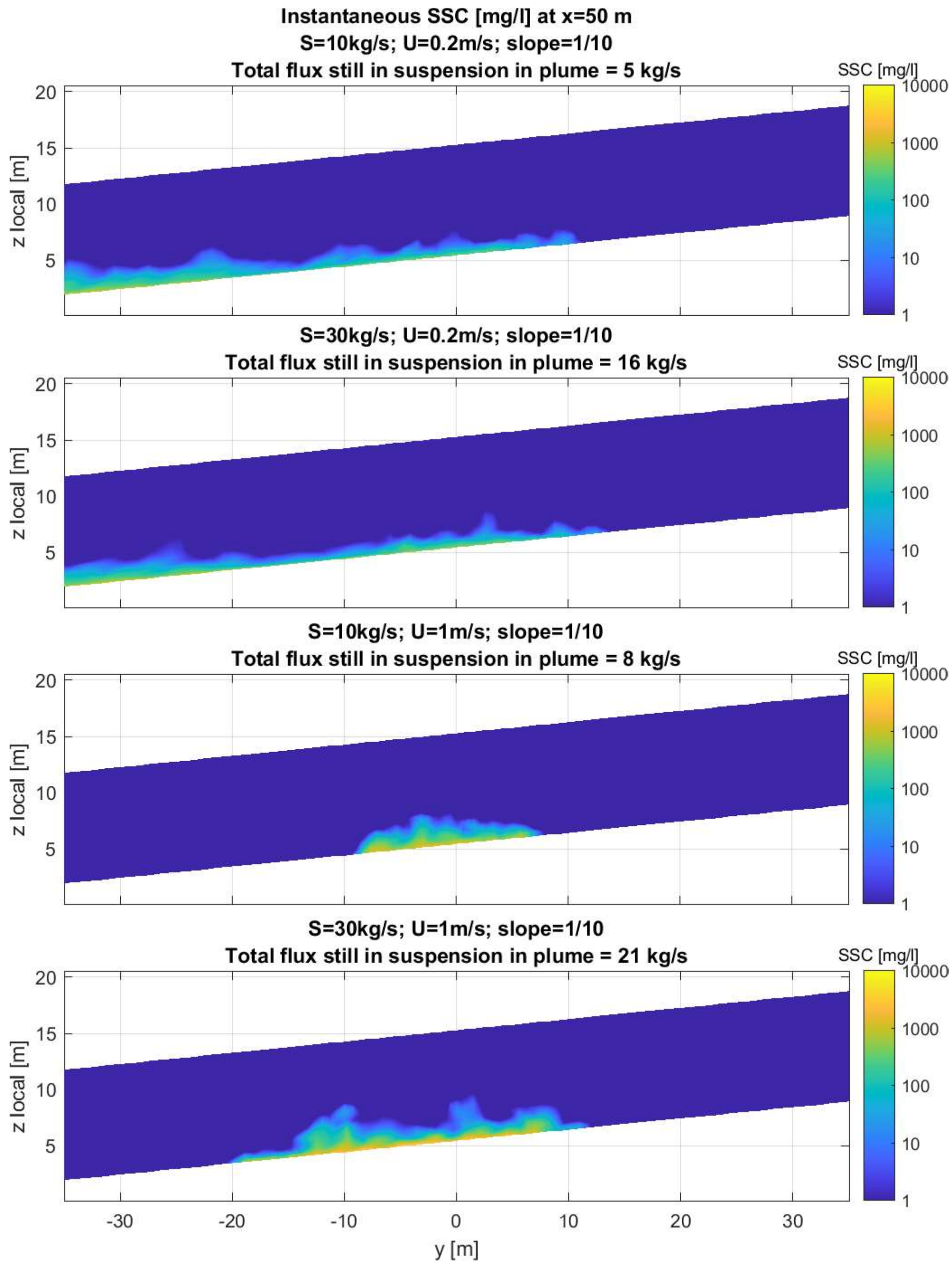

Figure 3.5 Near-field Capjet plume cross sections at x=50 m downstream from the source location for the near-field CFD simulations with a 1:10 bed-slope perpendicular to the ambient current and a source flux and ambient current of 10 kg/s and 0.2 m/s; 30 kg/s and 0.2 m/s; 10 kg/s and 1 m/s; 30 kg/s and 1 m/s respectively for the panels from top to bottom.

The schematic CFD simulations focusing on near-field plume mixing in the first 50 m from the release location for the Capjet lead to the following plume characterization to be used in the far field modelling:

- The driving force of gravity acting on the density difference between plume and surrounding water is important for the plume dispersion direction and lateral width. Therefore, the effect of sediment concentrations on water density (and hence its dynamics) is included in the far field modelling of this study.
- In the near-field zone there is limited vertical up-mixing and the majority of the plume can be found in the bottom 1 m. Only the case with a 1:20 bed-slope against the ambient current shows more vertical up-mixing, but even then, the majority of the plume can still be found in the bottom 4 from the seabed and the far-field model will also give extra vertical up-mixing in case of a bed-slope against an ambient current. Based on the near field assessment, the most appropriate schematization of the sediment source terms in the far-field model is released in the bottom 1m from the bed.
- Using a settling velocity of 1 mm/s in the near-field simulations already leads to ~10- 75% of the sediment being deposited in the first 50 m from the release location. However, to be on the conservative side, no reduction factor is applied on the source fluxes used in the far-field modelling of this study.

3.3 Mass flow excavation (MFE)

3.3.1 Sediment spill source

A description of the Mass Flow Excavator is given in Section 2.1.2. The MFE will be applied at locations where crossings with existing infrastructure are present. During operation, the excavated sediment will likely be suspended over the full water column, but only locally and temporarily.

To compute the potential turbidity source, it is assumed that a pit is to be dredged by the MFE. To create this pit, a layer of 6 ft. (1.83 m) will be removed over an area of 6 m (in the direction of the cable) by 1 m (perpendicular to the cable), with 1:6 side-slopes in the direction of the cable and 1:3 side-slopes perpendicular to the cable (see Figure 3.6 for a perpendicular cross-section).

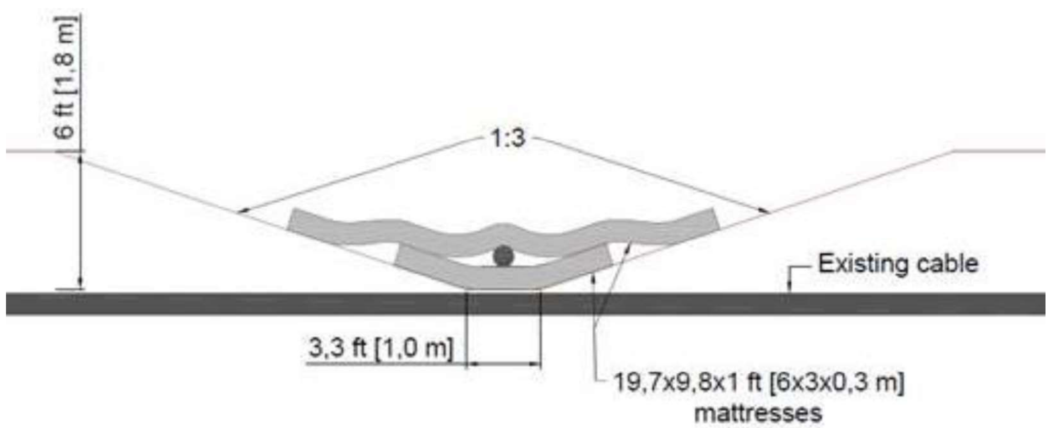

Figure 3.6 Cross-section (perpendicular to the Empire Wind export cable) showing the anticipated dredging pits created with the MFE operations. Along the Empire Wind export cable, the pit base is 6 m long and features more gentle 1:6 side-slopes.

Due to its high local vertical impact, it is anticipated that the MFE will stir up the removed volume completely over at least 10 m at the release location. A conservative spill factor of 100% and realistically high production rate of 1,000 m^3/hr. are used to assess the spill source term for MFE. So, the turbidity source is intense, but only during a short operation time window of 17 minutes (this is the time required to create the anticipated pit at a production of 1,000 m^3/hr.).

The operational parameters and resulting source term for the MFE are given in Table 3.2. In the far-field model the source term will be multiplied by the corresponding sediment fractions at the specific location along the cable route. For MFE, both the mud (< 63 μm) and sand particles will contribute to the excess density of the plume and are included in the MFE far-field source term, coarser (gravel) particles will settle directly in the near-field zone.

Table 3.2 MFE operational properties and turbidity source

Mass Flow Excavator- MFE		
Max flow rate	4	m^3/s
Max velocity	10	m/s
Power	200	kW
Distance from bed	3 – 10	m
Volume to be removed	287	m^3
Estimated production	1000	m^3/h
Operation time	17	min
Spill factor	100%	
Source	**435**	kg/s

3.3.2 Near-field computations

Results of a generic and schematic MFE near-field CFD computation are available in-house and some key results are shown in Figure 3.7 and Figure 3.8. This provides an indication of a typical near-field plume that can be expected as a result of the high flow rate of an MFE. The simulated near-field plume 50 m downstream of the MFE in Figure 3.8 is slightly more mixed in vertical direction as the Capjet plume at 50 m for a 1 m/s ambient current in Figure 3.3. The plume size and concentrations are however much higher because of the much higher sediment release that is brought into suspension by the MFE compared to the Capjet. Despite the high turbulent flow rate of the MFE, its resulting plume at 50 m distance from the release point can be found very close to the bed because of the high sediment concentrations that form a density current. Therefore, in the far field modelling the sediment source flux for an MFE will be injected in the bottom 2 m from the bed (representing the typical plume thickness at about 50 m from the point source, see Figure 3.8), with density effects included in the far-field model to be able to deal with the significant density differences between plume and surrounding waters.

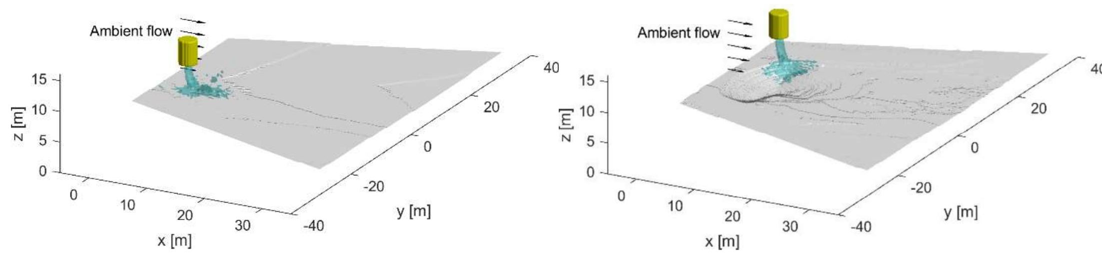

Figure 3.7 *Results from an indicative generic 3D MFE near-field CFD simulation with an ambient velocity of 1 m/s and ambient depth of approx. 12 m; left image shows the MFE flow jet at the start and the right image shows the MFE flow jet and eroded trench at the end of the simulation. It is noted that these figures do not show the suspended sediment plume.*

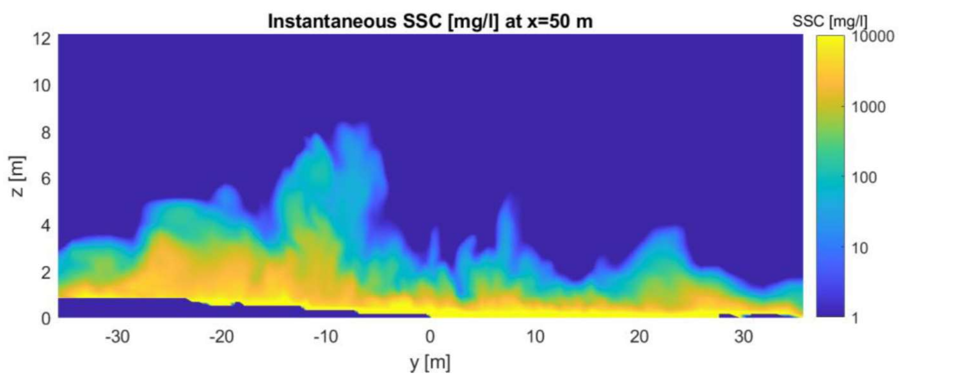

Figure 3.8 *Indicative, generic near-field MFE plume cross sections at x=50 m downstream from the MFE for an ambient velocity of 1 m/s.*

4 Far-field model setup

4.1 Introduction & approach

As described above, during the EW 2 cable burial works, sediment is expected to be released in the water column. The transport of the released sediment under the influence of different ambient flow conditions is studied in a far-field modelling assessment. The far-field assessment uses the a regional-scale hydrodynamic model of the New York – New Jersey Bight as a basis. This model was successfully validated against measured data and DHI (2021) hindcast data (see Appendix C). Several local refinements are incorporated in the model to cover the area in the vicinity of the cable in high resolution. This way, the boundary conditions and settings remained identical to the validated regional-scale model, while also representing the hydrodynamics and subsequent sediment plume dispersion in the vicinity of the cable route in a higher resolution. By introducing the sediment sources within the far-field hydrodynamic model, the effect of SSC on water density and hence hydrodynamics is explicitly accounted for.

The source terms established during the near-field assessment (Chapter 3) have been included in the far-field model as physically accurately as possible. This study only considers the excess (i.e., above background) suspended sediment concentrations due to the burial activities. For each considered release location, several combinations of ambient scenarios, associated with different tidal, wind, wave and seasonal condition, have been considered. The modelled dispersion of sediment has been analyzed by visualizing the maximum suspended sediment concentration footprints. For the Capjet, the far-field model considers a release location every 2 km along the cable route up to the New York State Boundary, see upper panel Figure 4.1. This coverage of the release locations ensures that the spatial variation in ambient conditions and sediment characteristics is well captured in the assessment. For the MFE, all crossing locations (as introduced with Figure 2.1) are included as release locations (see lower panel Figure 4.1), except for those crossing locations that are within 500 m distance from another crossing location. In that situation, a representative release location is selected instead (this applies to release locations A-2.9, C3-4.7 and E-2.9).

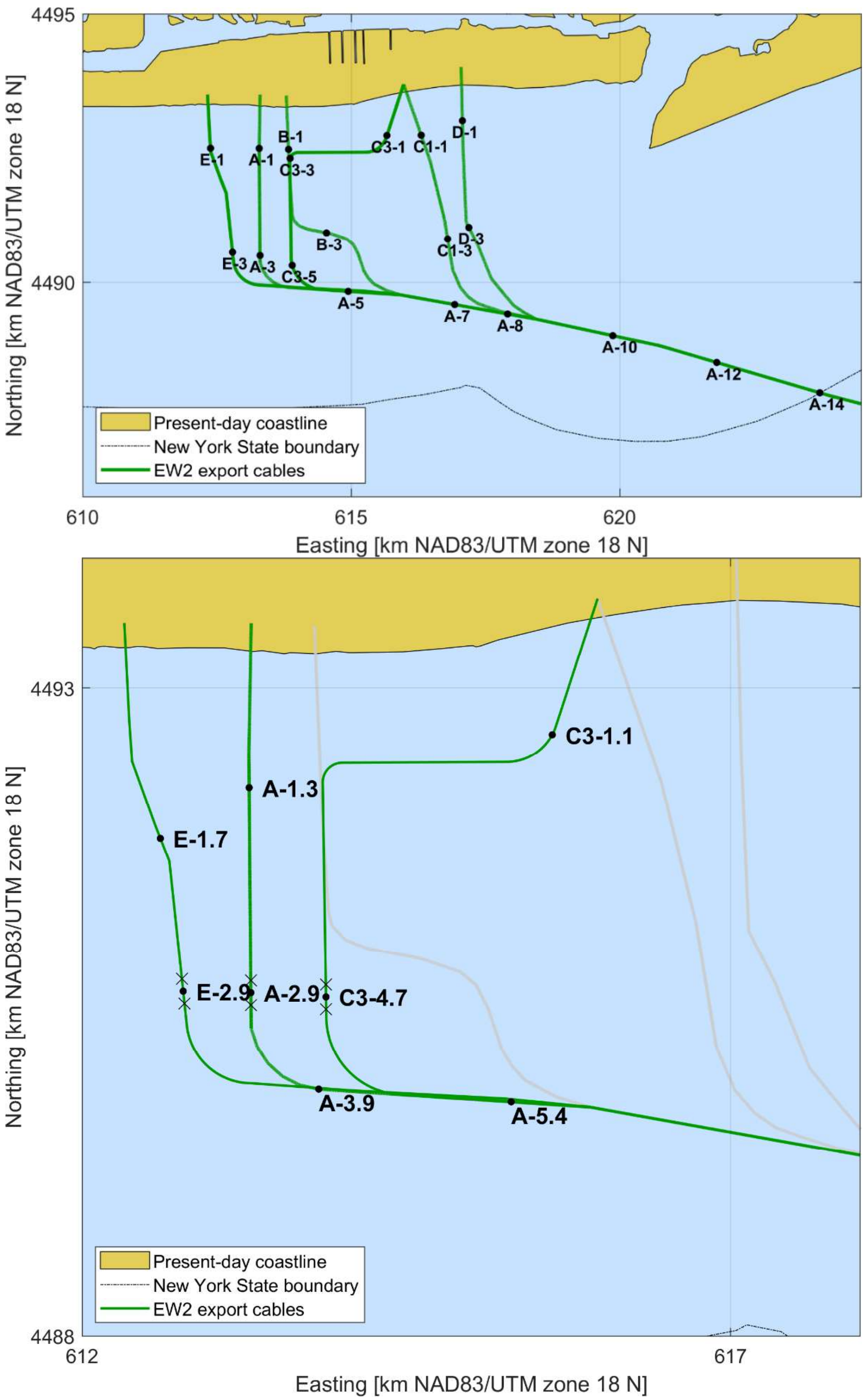

Figure 4.1 *Overview of the EW 2 export cable routes and the modelled release locations for the Capjet (top panel) and MFE (lower panel, focusing on only three out of the six routes).*

The setup of the refined hydrodynamic models is described in Section 4.2. The selection of a representative set of ambient conditions is discussed in Section 4.3. The modelled sediment properties and the sediment spills are described in Sections 4.4 and 4.5.

For a description of the setup and validation of the wave model, refer to Appendix D.

4.2 Hydrodynamic model setup

4.2.1 Regional-scale model

An overview of the computation grid of the regional-scale model is shown in Figure 4.2. The computational grid is set up such that the main hydrodynamic conditions near New York City, in the vicinity of the mouth of the Hudson River, and further offshore along the export cable routes are accurately represented. Therefore, the orientation of the grid follows the main flow patterns in these areas. The highest grid resolution is also applied in these cable areas (about 50 to 100 m in cross-flow direction and about 150 to 300 parallel to the main flow direction). The maximum grid size, near the offshore boundary, is about 3 km. The offshore extent of the grid is iteratively determined and optimized for an accurate representation of surface flows.

Over the vertical, a non-uniform 10 sigma-layer distribution is applied. The vertical resolution is increased near the bed to be able to simulate the near-bed sediment plumes in higher detail, see Figure 4.3. Also, a slightly increased vertical resolution is applied at the surface (at the expense of the mid-depth layers) to be able to adequately represent the surface flows. The thickness of the near-bed layer, which is 3% of the total water depth, varies from about 0.2 m to 0.5 m at the considered release locations.

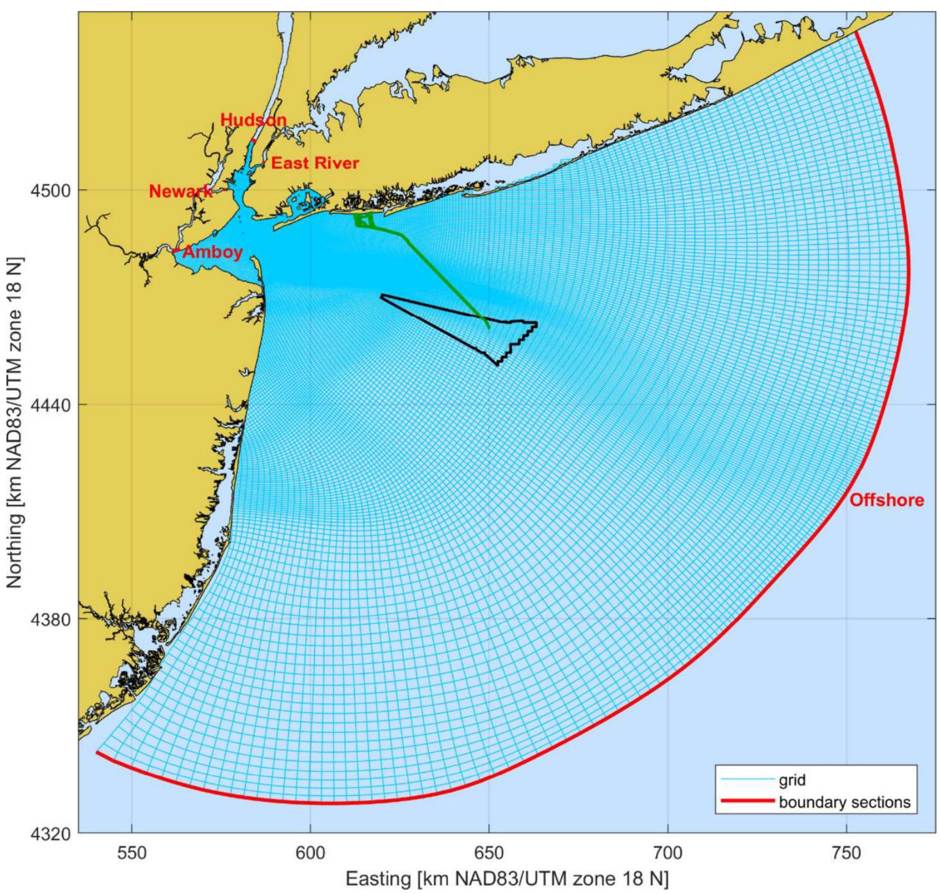

Figure 4.2 Overview model grid and boundary sections of the regional-scale model

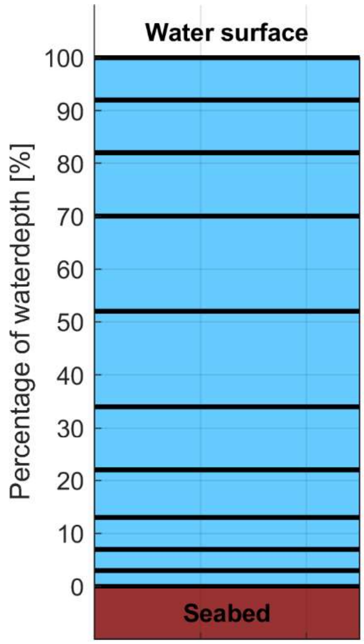

Figure 4.3 Illustration of the vertical grid resolution

The model bathymetry is aggregated from a composite set of bathymetric survey data, extended with bathymetry samples from the DHI (2021) wave model. Figure 4.4 gives an overview of the model bathymetry.

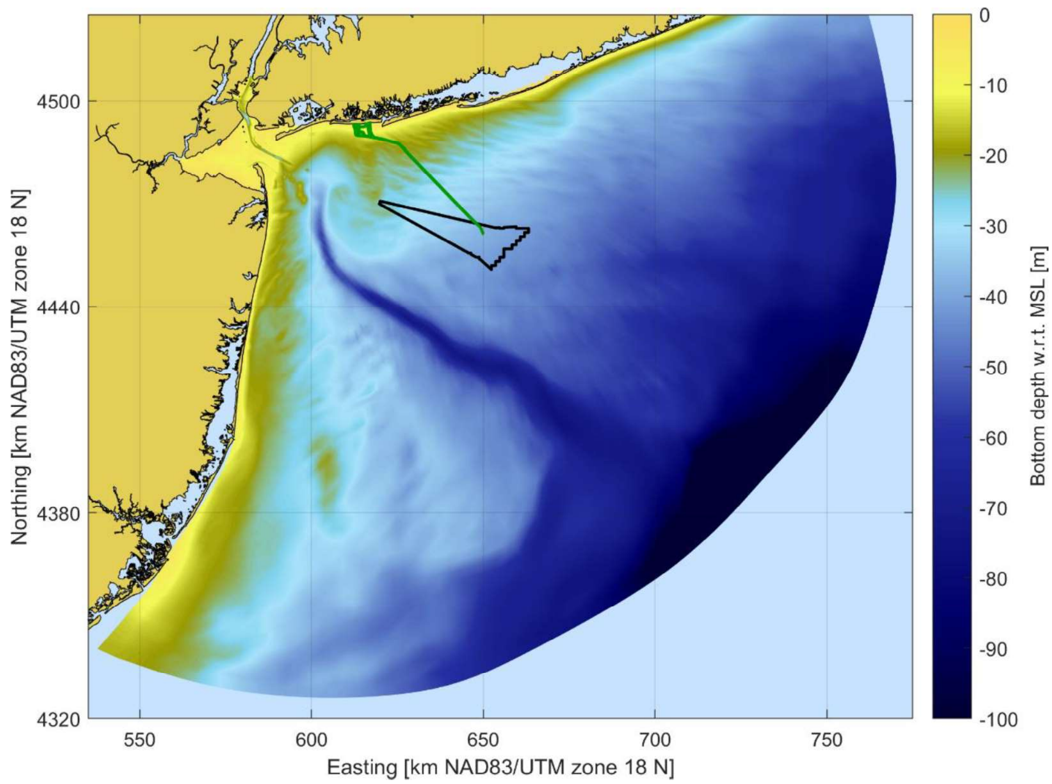

Figure 4.4 Overview of the regional-scale model bathymetry.

At the open boundaries (red lines in Figure 4.2), the model is forced with hydrodynamic conditions extracted from the DHI hydrodynamic model data (see Appendix B). At the offshore boundary, Riemann conditions are enforced, which both defines the temporal variation of the 3D velocity profile as well as the water level. At the inland boundaries (Hudson, Newark, Amboy and East River) 3D velocity timeseries were prescribed. For all boundaries also 3D salinity and temperature forcing are prescribed.

To limit the spin-up time of the model (i.e., the time the model needs to reach a dynamic equilibrium), also the initial conditions of the model are based on interpolation of the DHI data (water levels, temperature and salinity).

At the surface the model is forced with time and spatially varying wind data (u- and v-components of the wind speed). For the temperature modelling, also time- and spatially varying air temperature, humidity and cloud coverage fields are used. The meteorological forcing was also provided by DHI and originates from the NOAA's NCEP CFSR data[1].

Consistent with the DHI hindcast study, the bed roughness is based on the White-Colebrook formulation, with spatially varying Nikuradse values of 0.1 and 0.001 m.

4.2.2 Local refinements near the EW 2 cables

To accurately represent the dispersion of the sediment plumes during the cable burial, a local high resolution is required. Since it would not be computationally feasible (i.e., too long computation times) to include a resolution of about 20 m along the entire length of the considered EW 2 cable routes, several local refinements are generated and incorporated in the regional scale model covering the different release locations.

Figure 4.5 shows the different high-resolution domains that were set up, each representing 2 or 4 release locations. A resolution of about 20 m was applied within a radius of about 1 km from the release locations (see example in Figure 4.6). Subsequently, an intermediate zone was defined to facilitate transitions between the high-resolution and typical regional-scale resolution. This intermediate domain typically has a 3 times lower resolution and acts as a 1 km buffer zone in between the high-resolution model and the outer part of the regional-scale model to ensure numerical stability of the models.

[1] https://climatedataguide.ucar.edu/climate-data/climate-forecast-system-reanalysis-cfsr

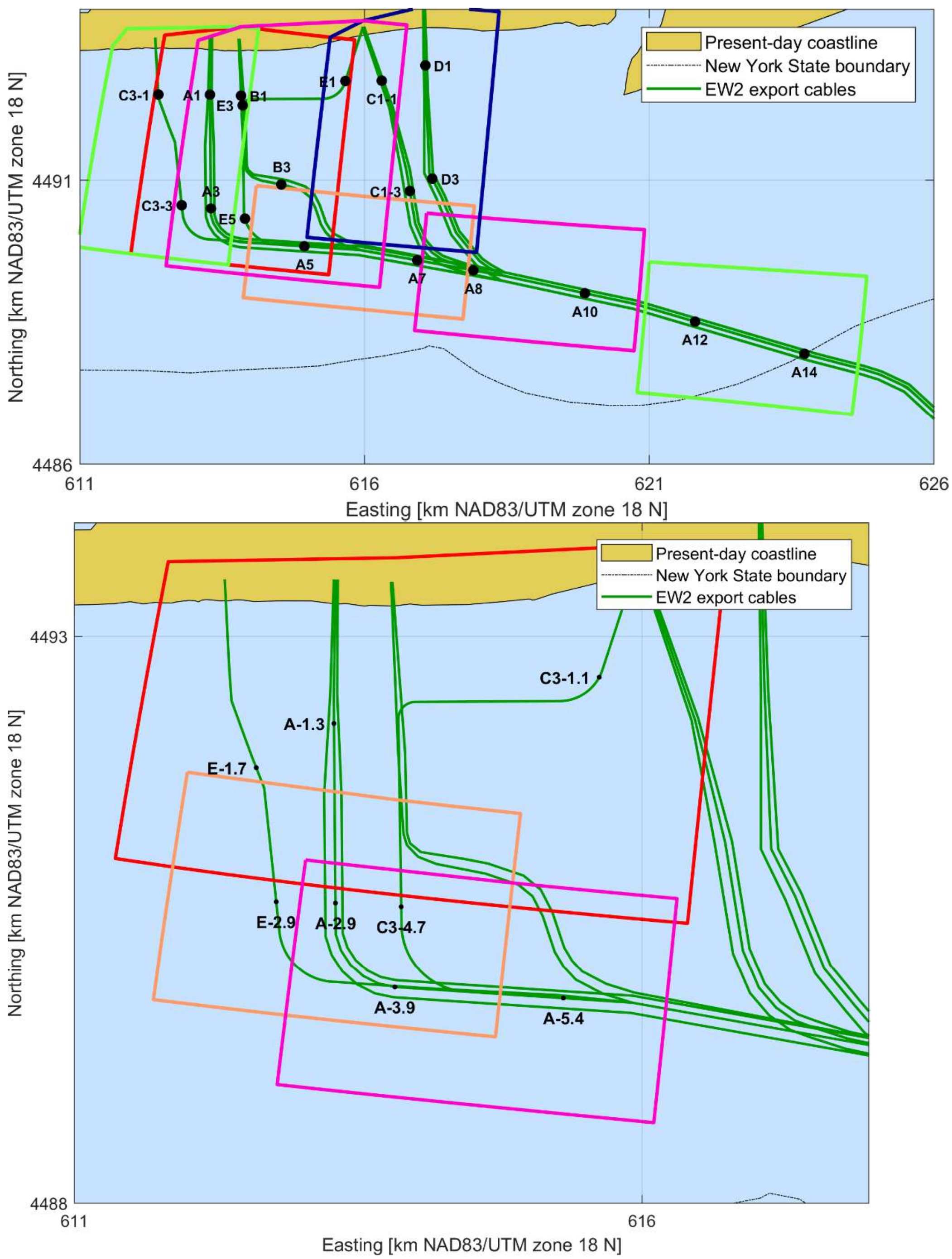

Figure 4.5: Overview of the different high-resolution domains (± 20 m resolution) that have been applied in this study. Upper panel: domains that have been used to assess the Capjet operations. Lower panel: domains that have been used to assess the MFE operations.

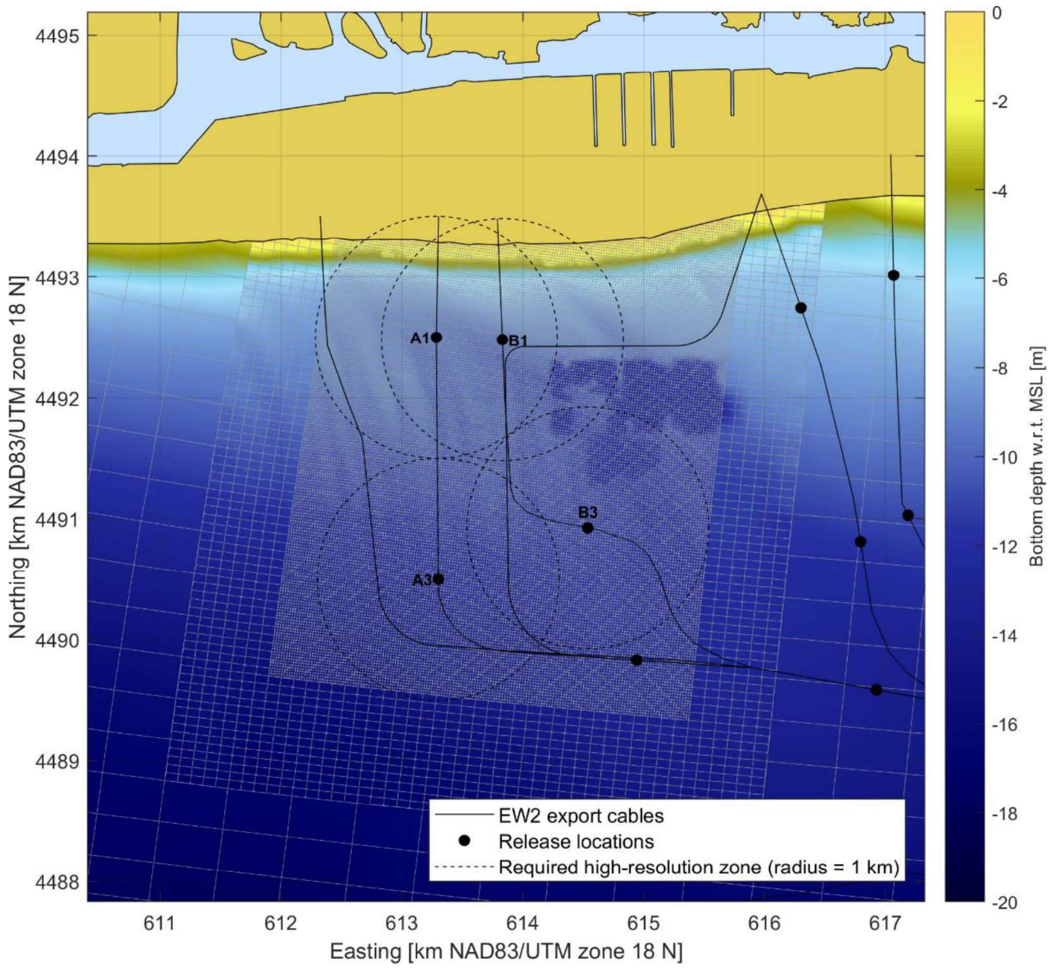

Figure 4.6: Detail of bathymetry and computational domains of the model applied for Release location A1, A3, B1 and B3.

4.3 Modelled ambient conditions

The dispersion of the released sediment plumes depends on the burial method, the local sediment characteristics, and the hydrodynamic conditions during the burial works. To ensure a comprehensive plume dispersion assessment, all relevant hydrodynamic conditions should be considered. The modelled ambient conditions are selected with the aim to include the normative (i.e., worst case) conditions to assess the trenching activities for environmental compliance. To make sure that the modelled ambient conditions are as realistic as possible, historic periods have been hindcasted that contain the envisaged ambient conditions.

Figure 4.7 shows the variation of the Hudson River discharge, wind speed, water level and near-bed current velocity near Release Location A7 (center of the EW 2 cable area) in the DHI hindcast database for the year 2019. Figure 4.8 shows a statistical analysis of the hindcasted significant wave height at the offshore end of the EW 2 cables within State Waters (near Release location A14).

The sediment spills during the jet plow operations are introduced within 1 m from the seabed. Therefore, mainly the near-bed hydrodynamics are of importance. The near-bed flow velocity mainly depends on the tidal variation (which shows a clear spring-neap variation), wind and waves.

The influence of the tide on the sediment dispersion is included by modelling periods during spring tide (relatively high flow velocities) and neap tide (relatively low flow velocities), see Conditions A to D in Figure 4.7 and Table 4.1. Two different seasons (wet and dry) are included to account for any seasonality. The seasonal effects on the sediment plumes are expected to be limited, since the EW 2 cable area is relatively far away from the Hudson River.

To assess the sediment dispersion during strong wind events, a period in mid-October 2019 is included, with wind speeds up to 18 m/s (Condition E in Figure 4.7). Note that waves (which likely have been relevant in this historic period) have not been considered for Condition E (see Table 4.1). This conditions therefore mainly shows the sensitivity of the sediment footprints to the influence of wind-driven currents.

Additionally, based on the selected hindcast periods, more schematic (but still realistic) ambient conditions have been generated by adjusting the wind speed to reduce/increase the dynamics as part of the sensitivity analyses. Ambient condition F represents a neap tidal period during the dry season (as Condition D) with a very weak wind forcing (1 m/s), which is expected to result in the lowest dynamics in the project area (which could concentrate the sediment spill around the release location). On the other hand, ambient Condition G represents typical maximum dynamics that could be expected in the project area (persistent strong NW wind during spring tide, which could significantly the transport of the sediment spill).

For these more schematic ambient conditions (F and G) also the influence of waves was tested. Based on the statistical wave height analysis (Figure 4.8), three different significant wave heights have been selected: 1 m (exceeded about 34% of the time), 1.5 m (exceeded about 12% of the time) and 2 m (exceeded for about 4% of the time).

The resulting set of modelled ambient scenarios is summarized in Table 4.1. Each simulation starts with initial conditions based on the DHI database, followed by a one-day spin-up period. Subsequently, the sediment spills are included for a period covering 4 tidal cycles (50 hours).

Table 4.1: Modelled ambient scenarios

Condition	Tide	Wind	Waves	Season
A	Spring	Normal	n/a	Wet
B	Neap	Normal	n/a	Wet
C	Spring	Normal	n/a	Dry
D	Neap	Normal	n/a	Dry
E	Average	Strong	n/a	Intermediate
F	Neap	Weak (1m/s)	n/a	Dry
F-Wave1m	Neap	Weak (1m/s)	1 m significant wave height (near Release location A14)	Dry
F-Wave1.5m	Neap	Weak (1m/s)	1.5 m significant wave height (near Release location A14)	Dry
F-Wave2m	Neap	Weak (1m/s)	2 m significant wave height (near Release location A14)	Dry
G	Spring	Persistent NW strong wind	n/a	Wet
G-Wave1m	Spring	Persistent NW strong wind	1 m wave (near Release location A14)	Wet
G-Wave1.5m	Spring	Persistent NW strong wind	1.5 m wave (near Release location A14)	Wet
G-Wave2m	Spring	Persistent NW strong wind	2 m wave (near Release location A14)	Wet

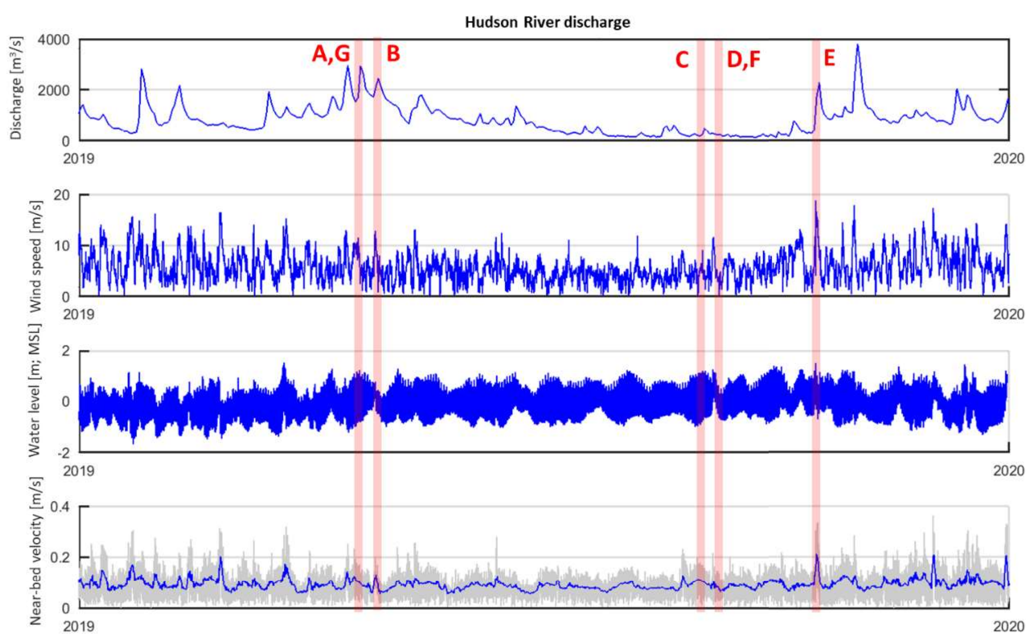

Figure 4.7: Main ambient conditions in the EW 2 cable area in the year 2019. Upper panel: Hudson River discharge, 2nd panel: CFSR wind speed, 3rd panel: hindcasted water level (w,r,t, to MSL) by DHI, lower panel: hindcasted near-bed velocity by DHI (in gray). The blue line shows the daily-averaged near-bed velocity.

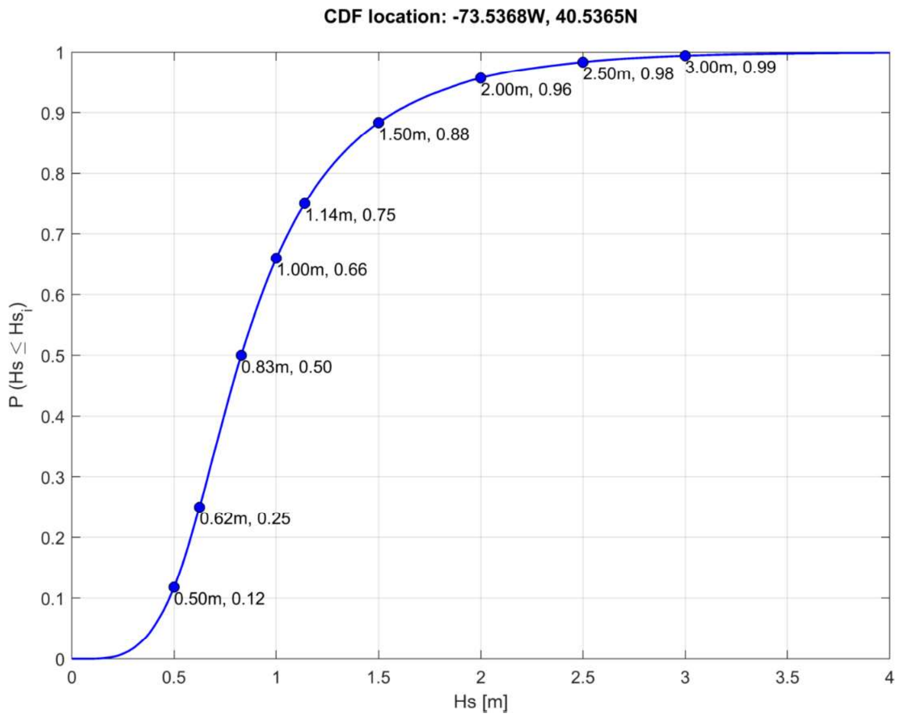

Figure 4.8 *Cumulative Density Function (CDF) of the hindcasted significant wave height at the offshore end of the considered EW 2 cables (near Release Location A14).*

4.4 Sediment properties

The available core data (see Section 2.2) suggests that the sediment composition strongly varies along the EW 2 cable route. The sediment along the intermediate section of the EW 2 cables in State Waters (Release Location A5 to A8) mainly consists of sandy material, whereas at the near-shore and offshore parts of the cables a lot of fine sediment is found. This fine material is separated in a silt fraction that typically represents 70% of the fines and a clay fraction that represents the remaining fine material (about 30%). Based on the near-field analysis, sand is expected to settle very close to the trench and is not expected to have an effect on the suspended sediment concentrations in the far-field zone. Only in case of MFE, sand is expected to be relevant due to the large release rates (see Section 3.3). The far-field modelling therefore also considers sand in case of MFE, next to finer silt and clay. The finer silt and clay fractions are included for all trenching/dredging methods and are further discussed in the next sections.

4.4.1 Clay

The settling velocity of clay depends on the degree of flocculation. When present at the seabed, it is important to distinguish between fine sediment in an upper fluff layer and consolidated sediment in underlying strata. Sediment in the upper fluff layer (several mm thick, just above the seabed) is poorly consolidated and forms a loose floc structure (individual particles that have clumped together). This sediment is regularly resuspended and dictate typical ambient suspended sediment concentrations. Sediment in underlying layers is more strongly consolidated, forming compact flocs which are only eroded during extreme events (storms, high waves, etc.).

During trenching, the fine sediment present in the top 0.5 – 1 meter is mobilized through water injection. The mobilization partly destroys the compact floc structure of the clay. Subsequently, part of the resulting primary clay particles will coagulate again in a saline environment, forming flocs.

Based on literature (Smith and Friedrichs (2011) and USACE (2015)) it is expected that a few percent of the compact floc structures will be destroyed after mobilization. In the present study 10% of the released clay is assumed to de-flocculate into primary clay particles, which is a conservative assumption (i.e., upper bound). These primary particles have a very low settling velocity (~0.01 mm/s) and negligible critical shear stress against erosion (0.05 Pa).

The remaining 90% of the released clay is expected to remain as compact clay flocs, with an average settling velocity of about 1 mm/s. Freshly deposited (after being transported by the local currents) particles will deposit in the fluff layer from which they are eroded fairly easily (critical shears stress around 0.1 Pa).

4.4.2 Silt

The settling velocity of silt ranges from 0.01 to 2.7 mm/s (grain diameter range between 4 and 63 µm) but is typically 1 mm/s (~40 µm). Coarse silt particles at the bed follow the Shields curve for initiation of erosion (0.1 Pa at 63 µm).

The erodibility of finer silt particles reduces because of pseudo-cohesive properties related to the permeability of the material, but will be between 0.1 and several tenths Pa. In the present study a critical erosion rate of 0.2 Pa is assumed.

The silt particle behavior is not influenced by the trenching process and keep the same erosion and settling properties as discussed above.

4.4.3 Summary of modelled sediment properties

Table 4.2 gives a summary of the modelled sediment fractions and their properties.

Table 4.2 Modelled sediment properties

Sediment type	Sand (only in case of MFE)	Silt	Clay	
			Flocs/ aggregates	Primary particles
Amount		See Figure 4.9	90% of clay in Figure 4.9	10% of clay in Figure 4.9
Critical bed shear stress for erosion ($\tau_{cr,ero}$) [Pa]	1	0.2	0.1	0.05
Settling velocity (W_s) [mm/s]	20	1	1	0.01

4.5 Source terms

Based on the near-field assessment (Chapter 3), the total release rate during the jet plow operation is expected to be about 24.9 kg/s (upper range). This release rate considers all sediment fractions present at the release locations (i.e., gravel, sand, silt, clay, etc.). For the Capjet operations, the far-field modelling only considers the release of the finer silt and clay fractions, as the other fractions will deposit within the near-field zone (in close vicinity of the release). Only for MFE, also the sand fraction was included since sand is expected to significantly contribute to the excess density of the plume due to the large release rates. The sediment releases are distributed over the lower 1 m near the seabed for the Capjet operation and over the lower 2 m near the seabed for MFE.

The sediment composition at the considered release locations is obtained by a distance-weighted interpolation of the available Fugro sediment samples (Figure 4.9). Only the sediment data down to the total trenching depth was considered. Note that for a number of sediment samples (see Figure 4.9, indicated with red outline around the markers), only the total silt and clay content (mud) was given (no separate silt and clay fraction). The assumed ratio between silt and clay for these samples was based on the average silt-clay ratio of the samples that included the separate silt and clay fractions: 70% silt and 30% clay.

Table 4.3 shows for all release locations, the release rate per modelled sediment fraction. The total amount of released sediment is highest for MFE (typically about 435 kg/s). For the Capjet operations, the total amount of released fines is highest (20 to 23 kg/s) in the offshore sections of the cables (Release location A10 to A14) and lowest (0.5 to 5 kg/s) in the southwestern part of the cable area (Release location A5 to A8). In the near-shore part (first 1 to 3 km of each cable route), the release rate is about 5 to 16 kg/s.

Table 4.3 Release rate per sediment fraction at the considered release locations

Release location	Trenching/ dredging method	Local bed level [m MSL]	Release rate [kg/s]				
			Sand	Silt	Clay (flocs)	Clay (Primary particles)	Total
A1	Capjet	-9.2	-	9.0	3.5	0.4	12.8
A1.3	MFE	-9.8	225.8	146.5	56.5	6.3	435.0
A2.9	MFE	-11.9	180.6	178.1	68.7	7.6	435.0
A3	Capjet	-12.5	-	7.7	3.0	0.3	11.1
A3.9	MFE	-13.3	346.9	61.4	23.7	2.6	434.7
A5	Capjet	-12.5	-	0.4	0.2	0.0	0.6
A5.4	MFE	-12.6	370.4	22.0	8.5	0.9	401.8
A7	Capjet	-13.3	-	3.7	1.4	0.2	5.3
A8	Capjet	-14.1	-	1.0	0.4	0.0	1.5
A10	Capjet	-14.8	-	14.6	5.6	0.6	20.9
A12	Capjet	-15.7	-	19.7	2.9	0.3	22.9
A14	Capjet	-16.5	-	13.8	6.0	0.7	20.5
B1	Capjet	-9.3	-	11.1	4.3	0.5	15.9
B3	Capjet	-11.1	-	6.1	2.3	0.3	8.7
C1-1	Capjet	-7.4	-	9.3	3.6	0.4	13.2
C1-3	Capjet	-11.6	-	4.0	1.5	0.2	5.7
C3-1	Capjet	-7.5	-	11.0	4.2	0.5	15.8
C3-1.1	MFE	-7.6	156.2	195.2	75.3	8.4	435.0
C3-3	Capjet	-10.2	-	11.4	4.4	0.5	16.3
C3-4.7	MFE	-11.8	217.9	151.9	58.6	6.5	434.8
C3-5	Capjet	-12.4	-	5.9	2.3	0.3	8.4
D1	Capjet	-6.5	-	8.1	3.1	0.3	11.6
D3	Capjet	-10.6	-	3.4	1.3	0.1	4.9
E1	Capjet	-8.5	-	7.6	2.9	0.3	10.8
E1.7	MFE	-9.7	286.8	103.7	40.0	4.4	435.0
E2.9	MFE	-12.4	242.7	134.6	51.9	5.8	435.0
E3	Capjet	-12.6	-	7.9	3.1	0.3	11.4

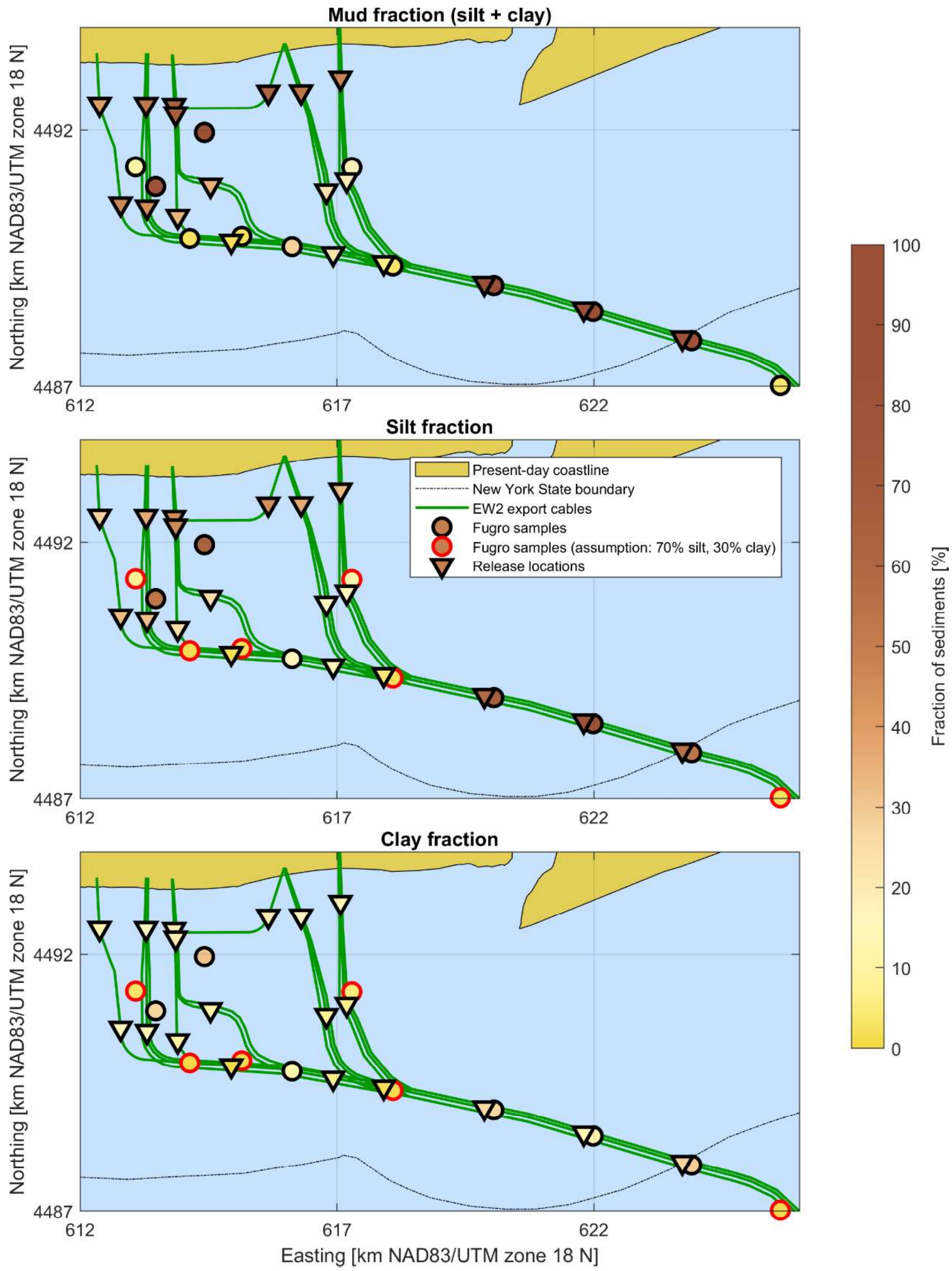

Figure 4.9 Overview of the measured mud, silt and clay content (Fugro, 2020) and, based on that, the assumed content at the considered release locations for the Capjet operation.

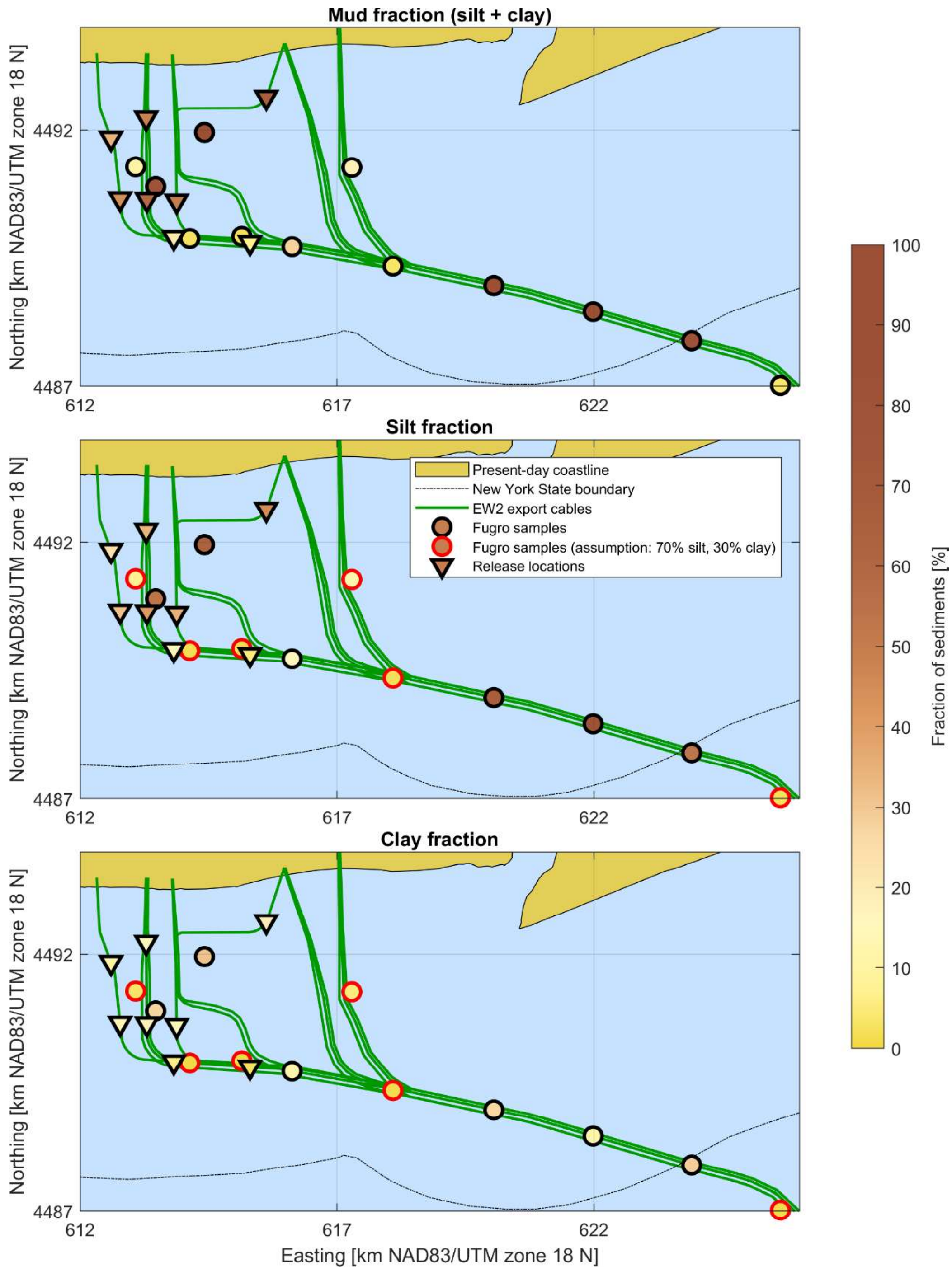

Figure 4.10 *Overview of the measured mud, silt and clay content (Fugro, 2020) and, based on that, the assumed content at the considered release locations for the MFE operation.*

5 Far-field modelling results

This chapter describes the sediment plume dispersion modelling results. The section starts with a description of the general plume behavior (Section 5.1). Subsequently, Section 5.3 gives an overview of the sediment footprints for all release locations in relation to the environmental criteria. Section 5.2 describes the sediment plume footprints at different levels and along a vertical plane for selected representative release locations. The modelling results for the remaining release locations are included in Appendix E for Capjet and Appendix F for MFE.

5.1 General sediment plume behavior

5.1.1 Sediment behavior in the direct vicinity of the release location

Following the near-field assessment (Chapter 3), the sediment released during the EW 2 cable burial works is introduced in the bottom 1 m of the water column. In the far-field sediment release, only the fine sediment fractions (silt and clay) are included, as the coarser sediment fractions (sand, gravel, etc.) are expected to settle in the direct vicinity of the trenching activities and will therefore not contribute to the suspended sediment concentrations (SSC) in the far-field zone. The released silt and clay fractions will slowly settle towards the bed, after which they will deposit. Due to the flow and wave-induced shear stresses, the deposited sediment may be resuspended shortly after deposition.

In the sections below, the modelled plume behavior is described based on Release location A12. The observed plume behavior for Release location A12 is rather representative for the other release locations. The objective of the sections below is to gain understanding of the temporal variability of the sediment footprints (Section 5.1.2), and to describe the relevant vertical levels (Section 5.1.3) and ambient conditions (Section 5.1.4 and 5.1.5) with regard to the environmental criteria.

5.1.2 Instantaneous snapshots versus footprints

Directly after the release, but also after resuspension, sediment entrained in the water column is transported by the local flow conditions. Figure 5.1 shows a couple of snapshots of the computed excess SSC (i.e., concentration above background conditions) at Release location A12 at different tidal phases. Figure 5.2 presents a timeseries of SSC and further shows that the elevated concentrations vary with the phase of the tide. Peak concentrations typically persist for a couple of hours, after which the turning tidal flows transport released sediment to different areas.

The behavior of the sediment plume can be summarized by generating a composite image of all these separate snapshots, resulting in the plume footprint that shows the maximum SSC values that have been computed throughout the entire simulation independent of time, see Figure 5.3. In this figure, and in the rest of this report, the 98-percentile excess SSC is visualized, meaning that the visualized concentration is only exceeded during 2% of the simulation period. This approach is adopted to filter out any numerical outliers. For the sake of readability, the 98-percentile footprint will be referred to as the maximum footprint in the remainder of this report.

According to the environmental criterion, the maximum excess SSC at 1,500 ft. from the release location should be lower than 100 mg/L. All footprints in this report, therefore, include a dashed blue circle that indicates a distance of 1,500 ft. from the release location.

Furthermore, the 100 mg/L plume concentration contour is indicated in light-blue in each of the figures.

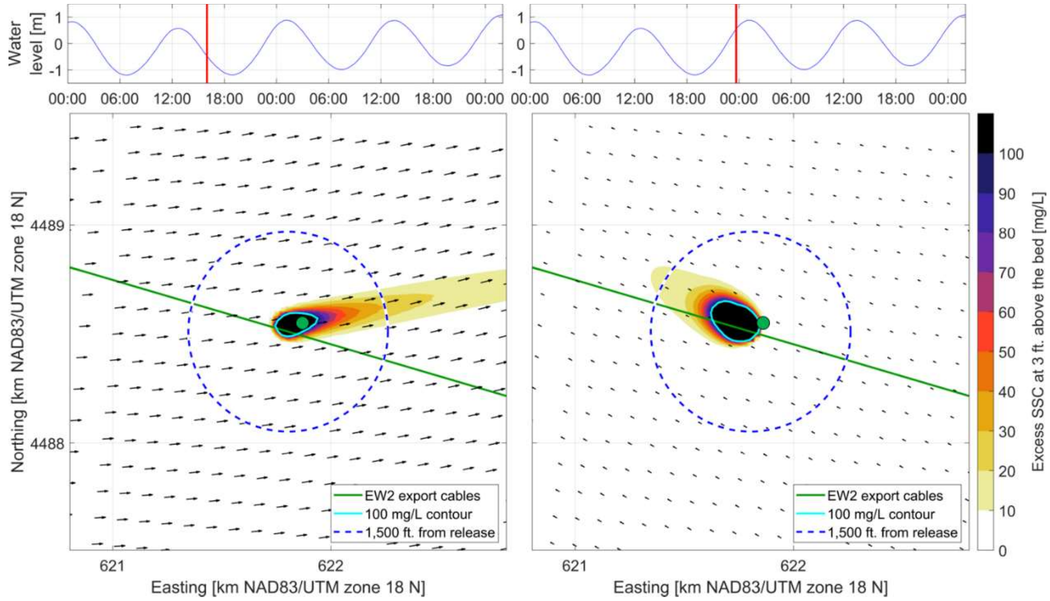

Figure 5.1 *Snapshots of the excess suspended sediment concentrations during ebb tidal conditions (left) and during flood tidal conditions (right). Release location A12, ambient condition G. The green dot indicates the location used for the timeseries plot in Figure 5.2.*

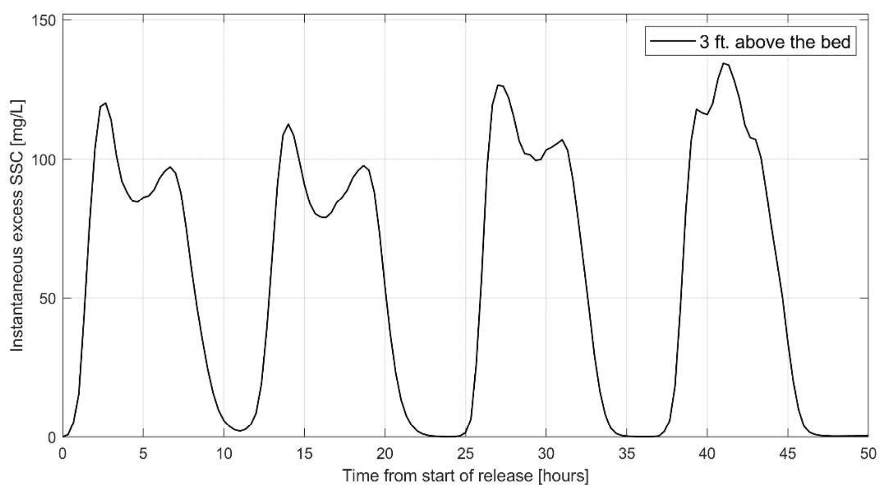

Figure 5.2 *Timeseries of the excess suspended sediment concentration near the release location. Actual location is indicated in Figure 5.1. Release location A12, ambient condition G.*

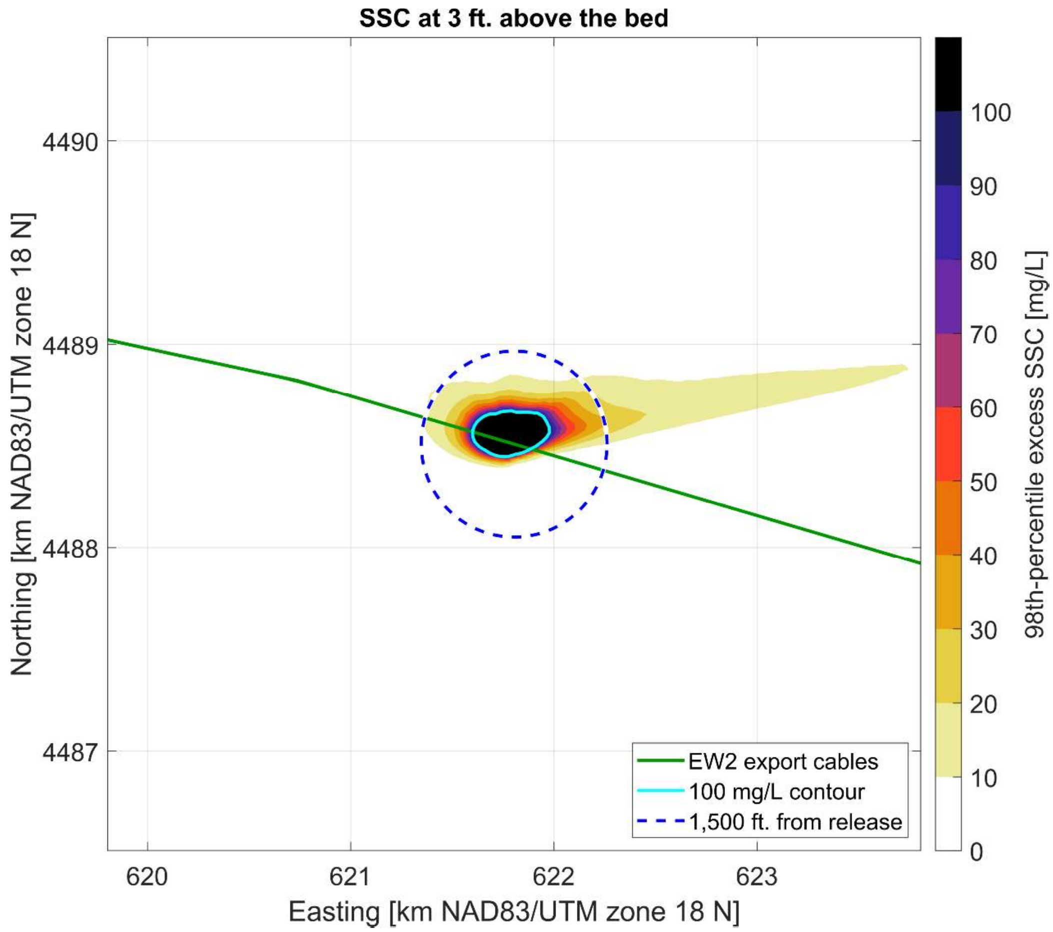

Figure 5.3 *98-percentile excess suspended sediment concentration at 3 ft. above the bed. Release location A12, ambient condition G. The blue dashed circle indicates the distance of 1,500 ft from the release location (as per the environmental criterion) and the light-blue contour indicates the 100mg/L SSC contour of the plume.*

5.1.3 Variation of the footprint over the vertical

As sediment is released near the bed (within 1 m of the bed) and the sediment is settling (because the particles have a higher density compared to ambient waters), the largest suspended sediment concentrations are found near the bed. This is also observed in Figure 5.4. The remainder of the report, therefore, focuses on the near-bed footprints. The footprints for the middle of the water column and near the water surface are included in Appendix E.

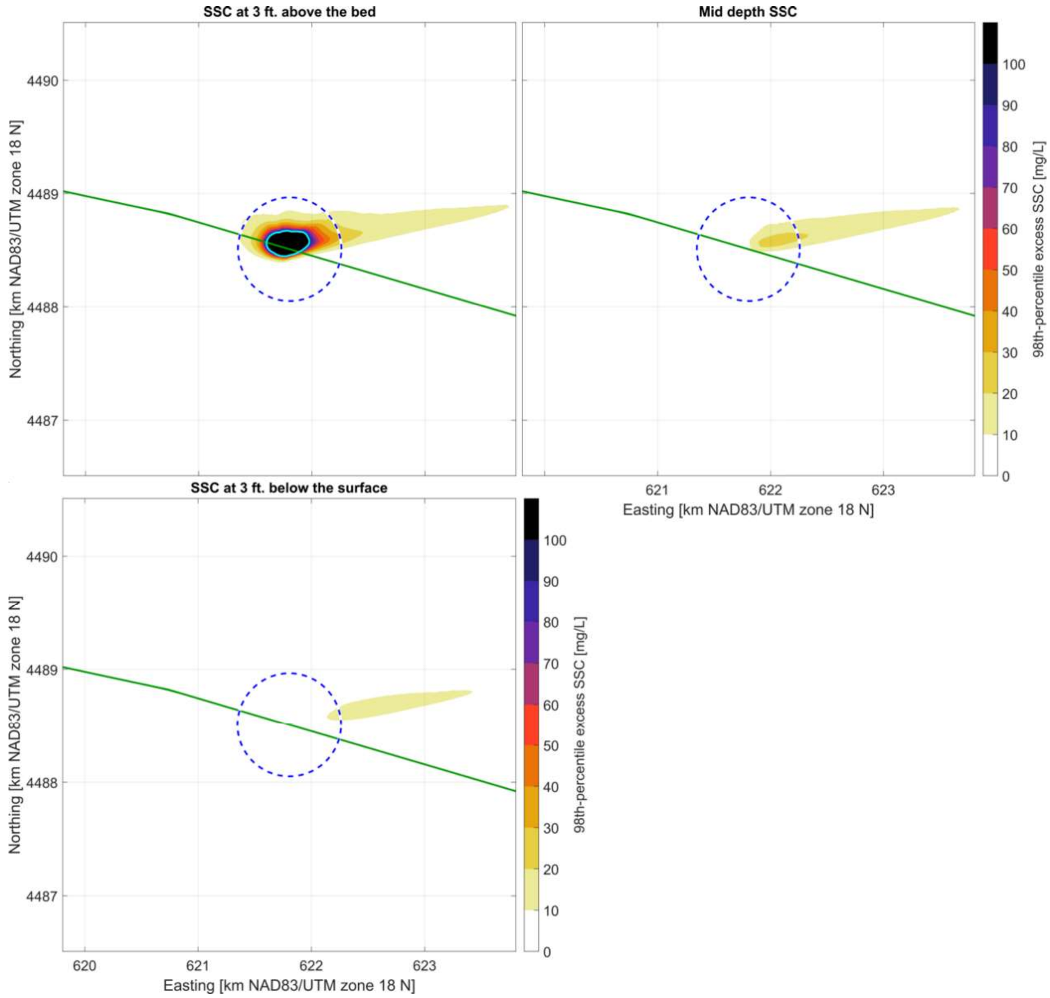

Figure 5.4 98-percentile excess suspended sediment concentration at 3 ft. above the bed (top left), middle of the water column (at about -8 m MSL, top right) and 3 ft. below the water surface (bottom left). Release location A12, ambient condition G.

5.1.4 Influence of tide, wind and seasons

Ambient conditions A to G cover a wide range of tidal, seasonal, and meteorological conditions (waves are not yet included in these ambient conditions). Although the shape of the maximum excess SSC footprint is different for each ambient condition, the extent of the 100 mg/L contour line is hardly influenced by differences in tidal, wind or seasonal conditions. This is shown by Figure 5.5, which compares the individual maximum excess SSC footprints per ambient condition to the combined footprint for Release location A12, by taking the maximum concentration from all individual footprints. The same conclusion holds for the other release locations.

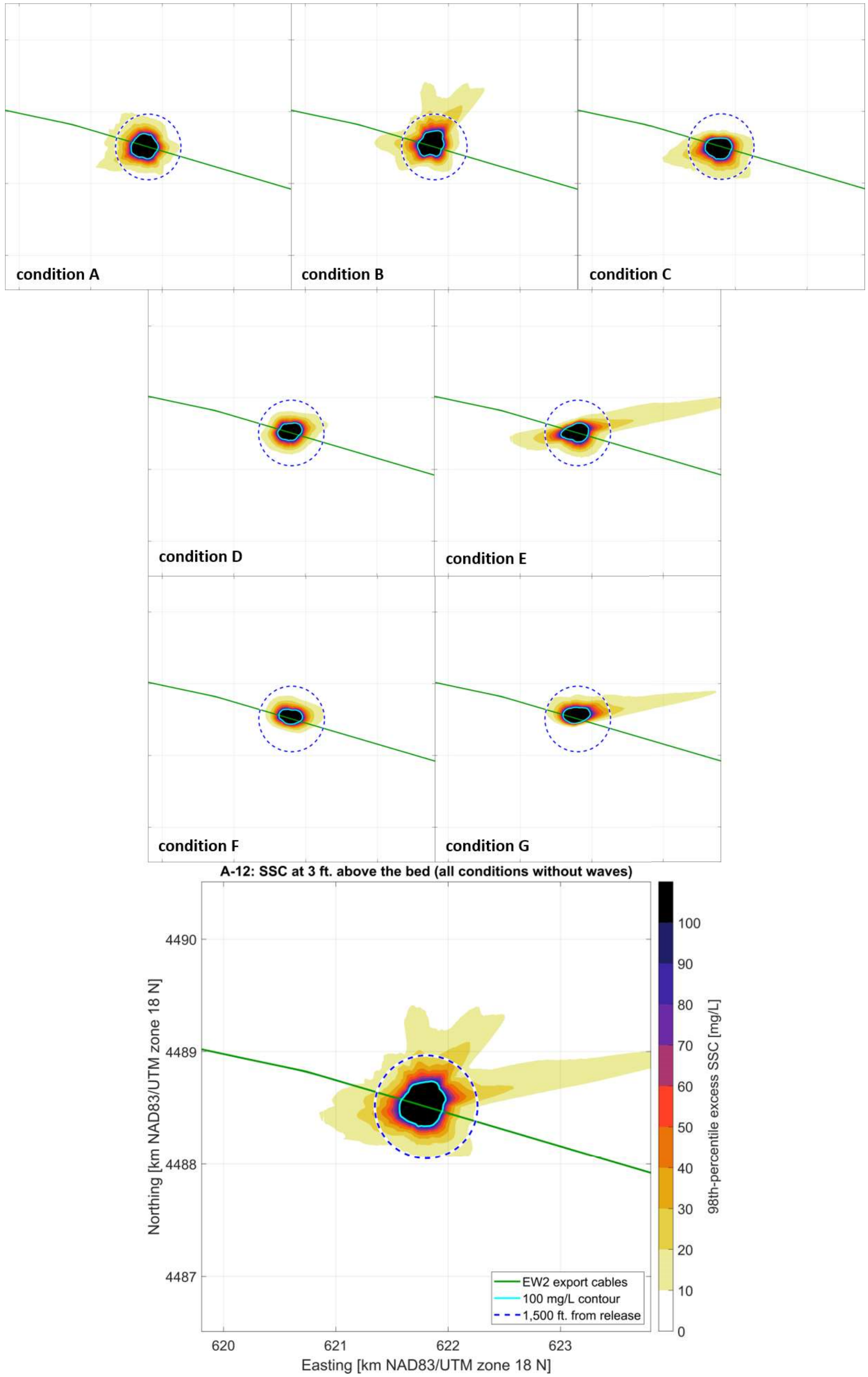

Figure 5.5 98-percentile excess suspended sediment concentration at 3 ft. above the bed for all ambient conditions combined (excluding the modelled wave conditions). Release location A12.

5.1.5 Influence of waves for Capjet operations

Figure 5.6 compares the footprints for condition F and G with and without waves for the Capjet operation at Release location A12. The maximum excess SSC footprint remains rather similar up to a significant wave height of 1 m. For wave heights up to this range, the wave-induced mixing and re-suspension of sediment is limited. This implies that the results for ambient conditions without waves (A to G) are therefore also representative for waves lower than 1 m (occurring about 66% of time).

In case of significant wave heights above 1 m (occurring about 34% of time), the wave-induced re-suspension increases. Furthermore, when the waves approach the coastline obliquely, a longshore wave-induced current develops, which could transport and dilute the released sediment. The 100 mg/L contour therefore depends on a delicate balance between the wave-induced resuspension (locally increasing the amount of sediment in the water column), the wave-induced longshore current (transporting and diluting suspended sediment away from the release location), as well as remaining ambient dynamics as introduced in Section 5.1.4.

The wave-induced longshore current is rather weak in the offshore areas (e.g. Release location A12), which is why the sediment footprint mainly depends on the wave height (see Figure 5.6).

At the nearshore release locations (e.g. A1, B1, C1 and D1), the effect of the longshore current is more pronounced. The sediment footprint at these locations therefore strongly depends on both the wave height and the wave direction. The most adverse conditions for the 100 mg/L footprint are the absence of a wave-induced longshore current (wave direction rather perpendicular to the local coastline orientation) and mild tidal and wind-driven currents (i.e., neap tide and low wind speeds). In this case, the 100 mg/L SSC footprint is expected to exceed the 1,500 ft. mixing zone at the near-shore locations (see Appendix E). When the waves approach the coast increasingly obliquely, the SSC footprint is expected to possibly remain within the 1,500 ft. mixing zone.

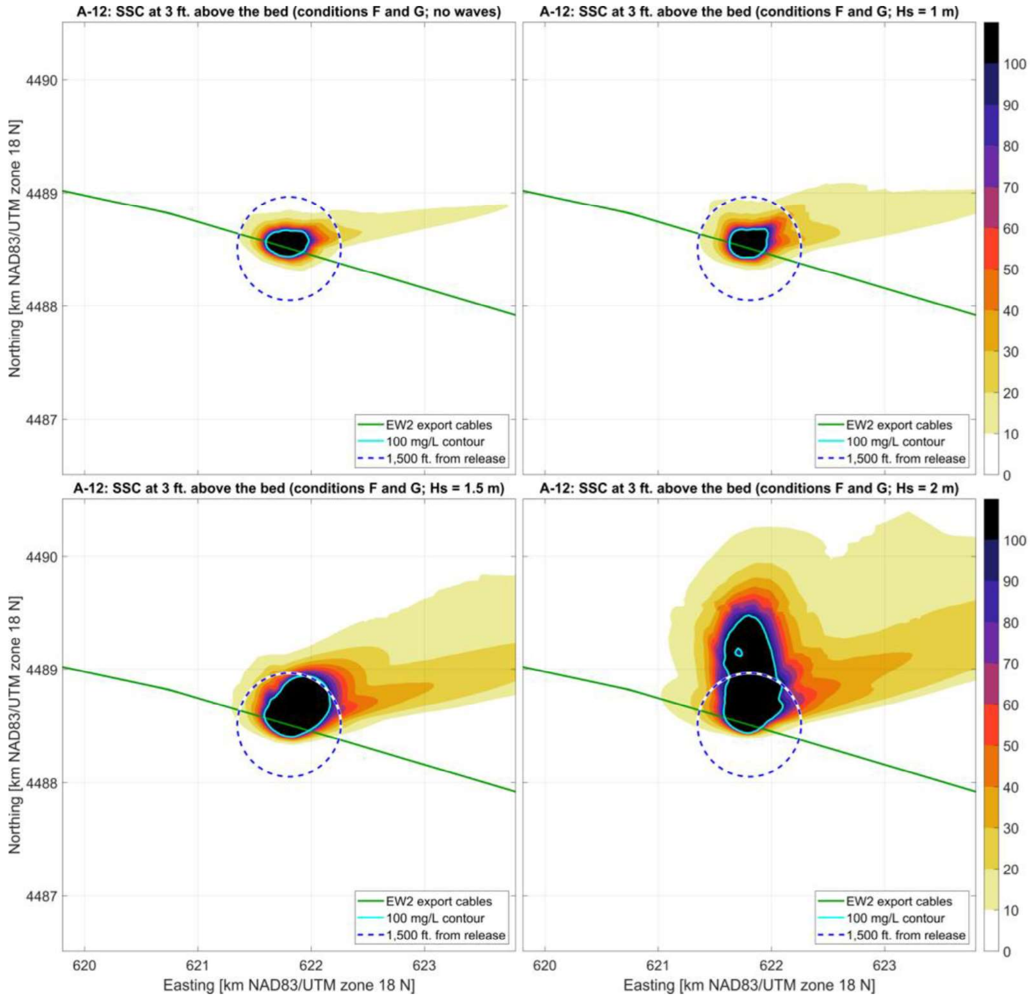

Figure 5.6 98-percentile excess suspended sediment concentration 3 ft. above the bed without waves (top left), with 1 m high waves (top right), 1.5 m high waves (lower left) and 2 m high waves (lower right). Release location A12, Capjet.

5.1.6 Influence of waves for MFE operations

The previous section describes the influence of waves on the sediment plumes during the Capjet operation. In this section, the influence of waves is described in case of the MFE. The general effects of waves on the sediment plumes during the MFE operations are similar as discussed above. Waves will resuspend sediments and will additionally generate a longshore wave-induced current (depending on the wave direction) transporting the released sediments away from the release location. However, for the MFE operations, the influence of waves already becomes apparent for a significant wave height of about 1 m (compared to H_s > 1.5 m for Capjet operations). This is illustrated in Figure 5.7 for the MFE operation at Release location A1.3. The figure shows that the 100 mg/L contour line remains within 1,500 ft. in case of no waves and exceeds 1,500 ft. from the release location for a significant wave height equal or larger than 1 m. It is noted that in all assessed ambient conditions, the 100 mg/L contour line is close to the 1,500 ft. zone. Any minor change in ambient conditions could therefore temporarily influence the compliance against the criteria. In case of Release location A1.3, the 1 m significant wave height results in a slightly increased sediment resuspension without causing a significant wave-induced current, which results in a slightly higher SSC. For larger wave heights, stronger wave-induced currents can be observed, which transport and dilute the sediments away from the release location, thereby partially compensating the effect of the increased resuspension.

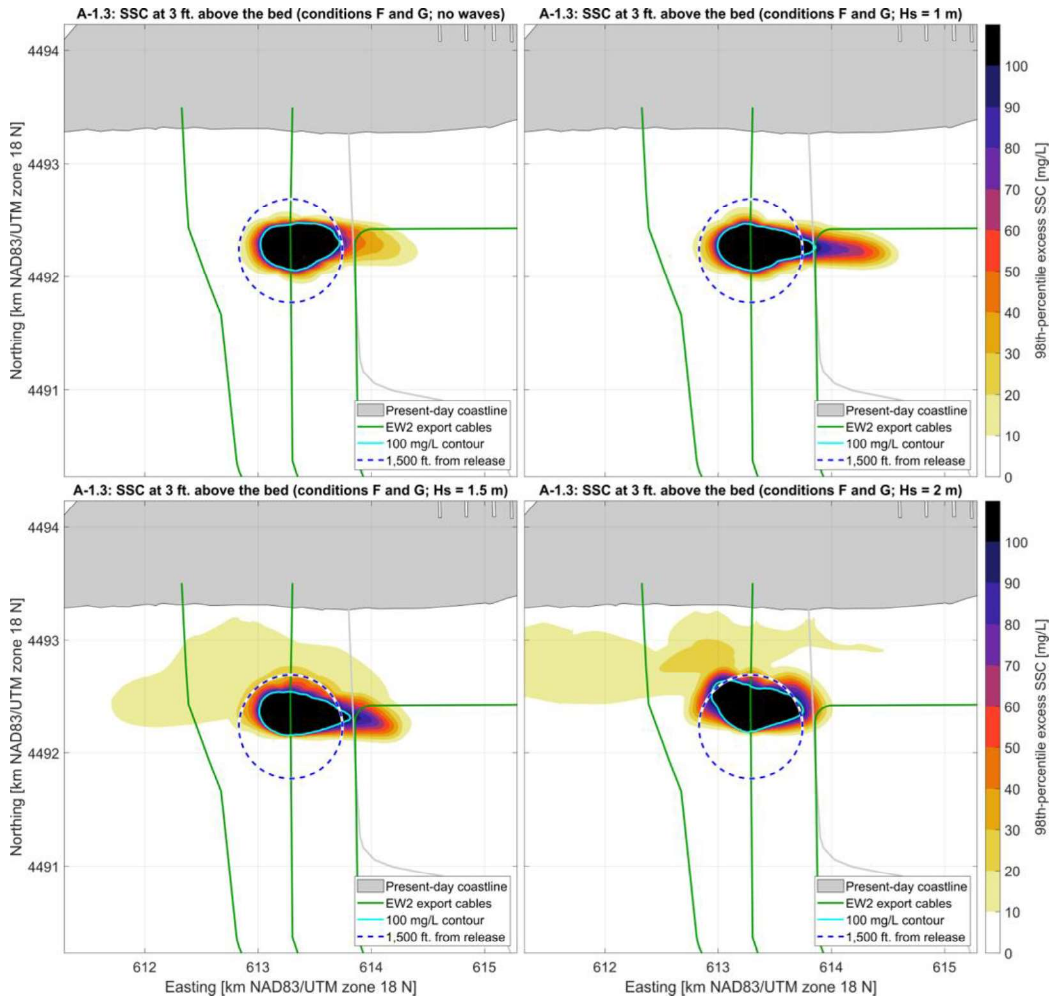

Figure 5.7 98-percentile excess suspended sediment concentration 3 ft. above the bed without waves (top left), with 1 m high waves (top right), 1.5 m high waves (lower left) and 2 m high waves (lower right). Release location A1.3, MFE.

5.2 Sediment footprints

In this section the main SSC modelling results are described. For Capjet, 2 release locations have been selected and for the MFE operation, 1 release location. The modelling results for the other release locations are included in Appendix E for Capjet and Appendix F for MFE. A summary of the evaluation for all release locations for Capjet and MFE is given in Section 5.3.

5.2.1 Release location A12 (Capjet)

This section describes the main modelling results for Release location A12 (see Figure 5.8). The seabed at this location is expected to contain a relatively large fine sediment fraction (92%, based on the survey data). A similarly large fine fraction is expected near Release locations B1, A10 and A14, which therefore results in similar footprints.

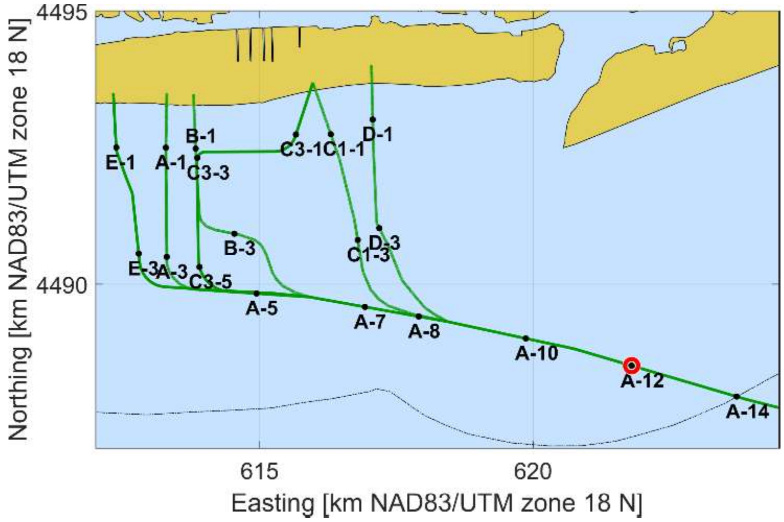

Figure 5.8: Map showing the location of Release location A12

Figure 5.9 shows the main modelling results for Release location A12 for a significant wave height up to about 1 m. The 100 mg/L contour line remains well within the 1,500 ft. zone. The computed maximum sediment concentration at 1,500 ft. is about 30 mg/L. The largest sediment concentrations can be found within 1 to 2 m from the bed.

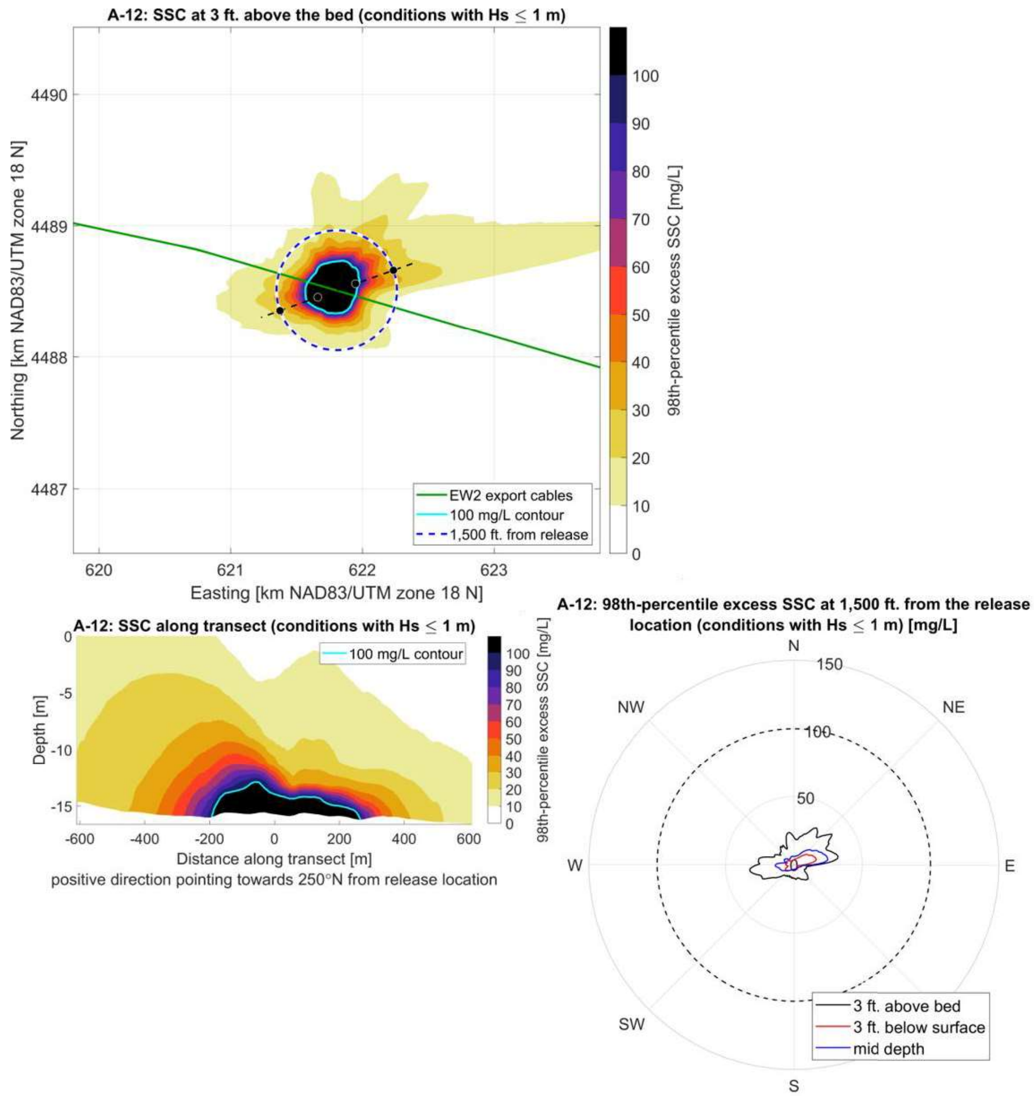

Figure 5.9 *Main modelling results for Release location A12 for H_s ≤ 1 m. Upper left: 98-percentile excess SSC footprint 3 ft. above the bed. Lower left: 98-percentile excess SCC vertical footprint along the cross-section indicated by the black dashed line in the upper left plot. Lower right: The 98-percentile excess SSC at 1,500 ft. at 3 ft. above the bed, middle of the water column and 3 ft. below the surface. The results of all ambient conditions have been combined by taking the maximum concentration of these individual simulations.*

Figure 5.10 shows the main modelling results for Release location A12 for a significant wave height of about 2 m (frequency of exceedance is roughly 4%). During these conditions, the computed maximum excess SSC at 1,500 ft. exceeds the 100 mg/L criterion (maximum excess SSC is about 160 mg/L). Figure 5.11 shows that the 100 mg/L criterion at 1,500 ft. is exceeded for a couple of hours.

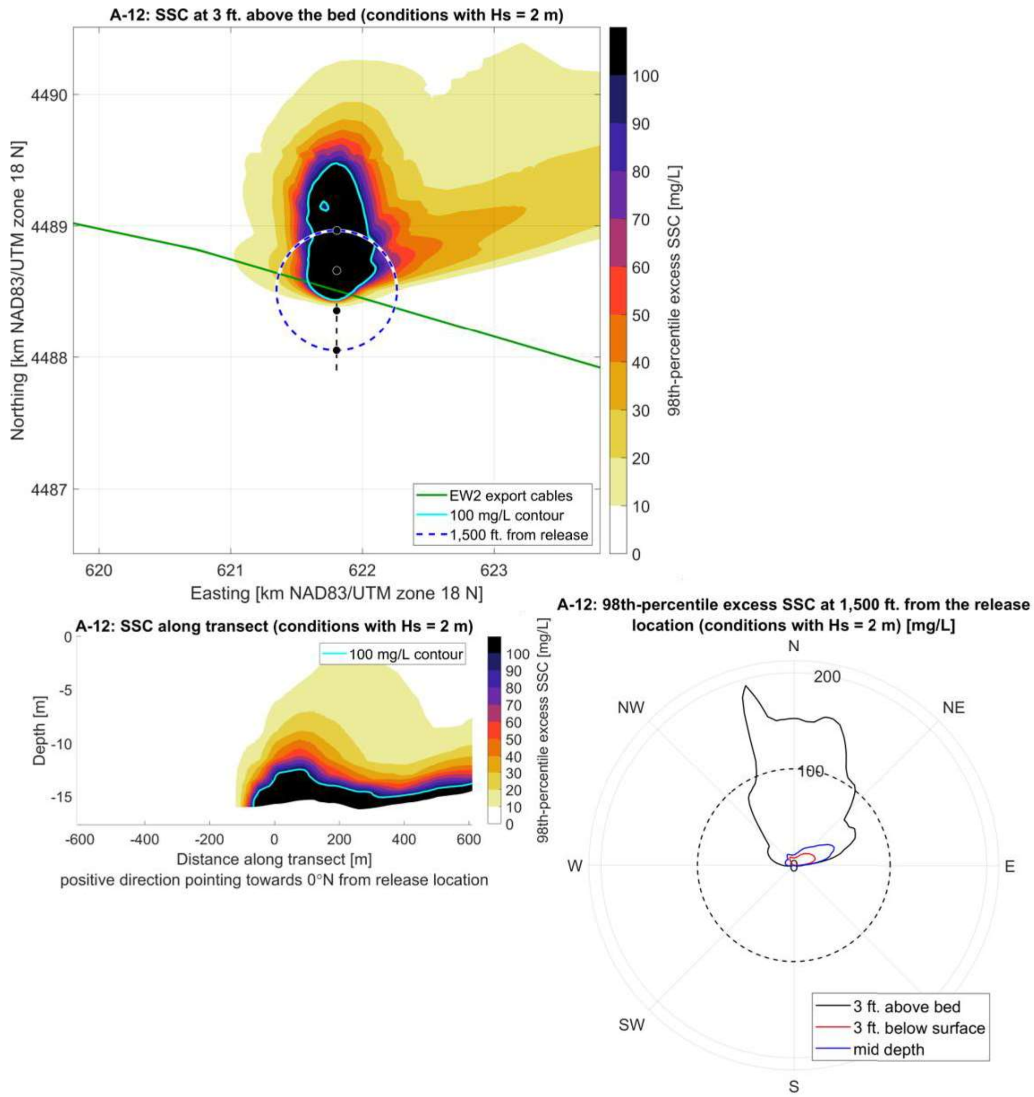

Figure 5.10 *Main modelling results for Release location A12 for $H_s \approx 2$ m. Upper left: 98-percentile excess SSC footprint 3 ft. above the bed. Lower left: 98-percentile excess SCC vertical footprint along the cross-section indicated by the black dashed line in the upper left plot. Lower right: The 98-percentile excess SSC at 1,500 ft. at 3 ft. above the bed, middle of the water column and 3 ft. below the surface. The results of all ambient conditions have been combined by taking the maximum concentration of these individual simulations.*

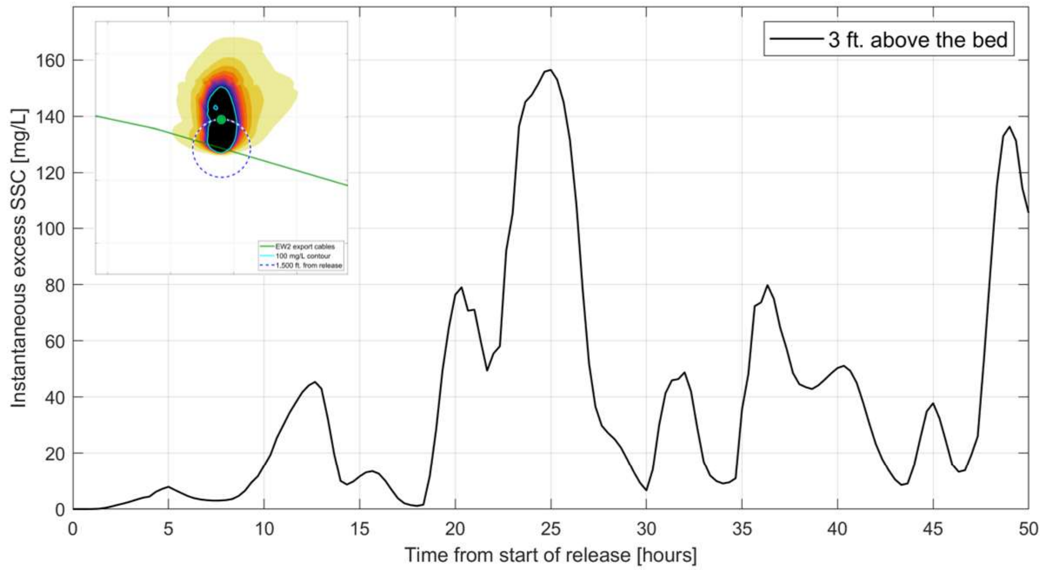

Figure 5.11 Instantaneous excess SSC timeseries at 1,500 ft. for ambient condition F including 2 m waves. The location corresponding to these timeseries is indicated by a green dot in the upper left panel.

5.2.2 Release location A3 (Capjet)

This section describes the main modelling results for Release location A3 (see Figure 5.12). The seabed at this location is expected to contain a fine sediment fraction of about 45%. This implies that the release rate in the far-field model is 12.1 kg/s (out of the total source term of 24.9 kg/s). The relatively small fine fraction is the main reason why the sediment footprints are significantly smaller compared to Release location A12, which is discussed in the previous section.

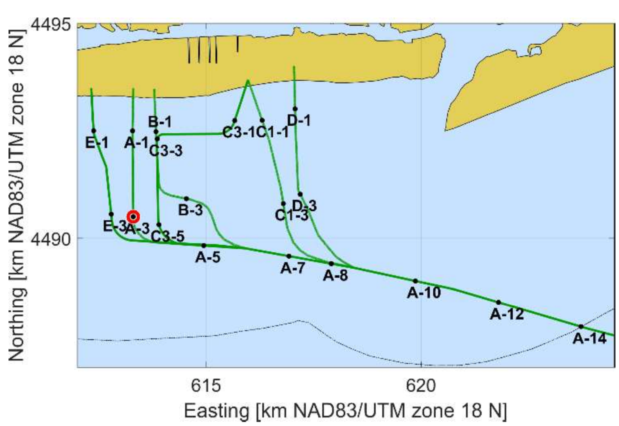

Figure 5.12: Map showing the location of Release location A3

Figure 5.13 shows the main modelling results for Release location A3 for a significant wave height up to about 1 m. The 100 mg/L contour line remains well within the 1,500 ft. zone. The computed maximum sediment concentration at 1,500 ft. is about 20 mg/L. The largest sediment concentrations can be found within 1 to 2 m from the bed.

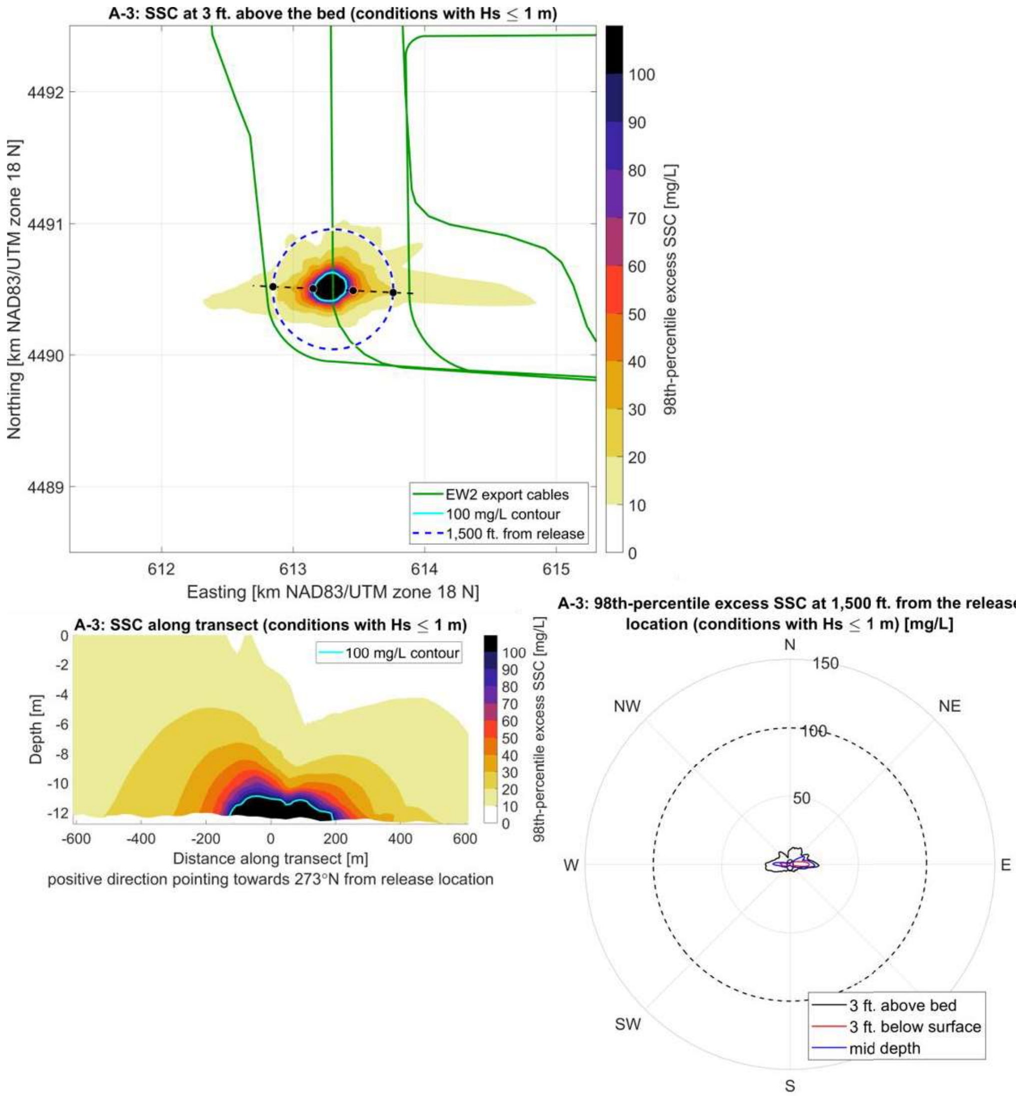

Figure 5.13 Main modelling results for Release location A3 for $H_s \leq 1$ m. Upper left: 98-percentile excess SSC footprint 3 ft. above the bed. Lower left: 98-percentile excess SCC vertical footprint along the cross-section indicated by the black dashed line in the upper left plot. Lower right: The 98-percentile excess SSC at 1,500 ft. at 3 ft. above the bed, middle of the water column and 3 ft. below the surface. The results of all ambient conditions have been combined by taking the maximum concentration of these individual simulations. .

Figure 5.14 shows the main modelling results for Release location A3 for a significant wave height of about 2 m. During low waves, the orientation of the sediment footprint was mainly in east-west direction. The higher waves result in a slightly stronger north-going residual flow. The 100 mg/L contour is still well within the 1,500 ft. mixing zone. The computed maximum sediment concentration at 1,500 ft. increases to about 60 mg/L. Note that the orientation of the cross-section in Figure 5.14 (south to north) is different than in Figure 5.13 (east to west).

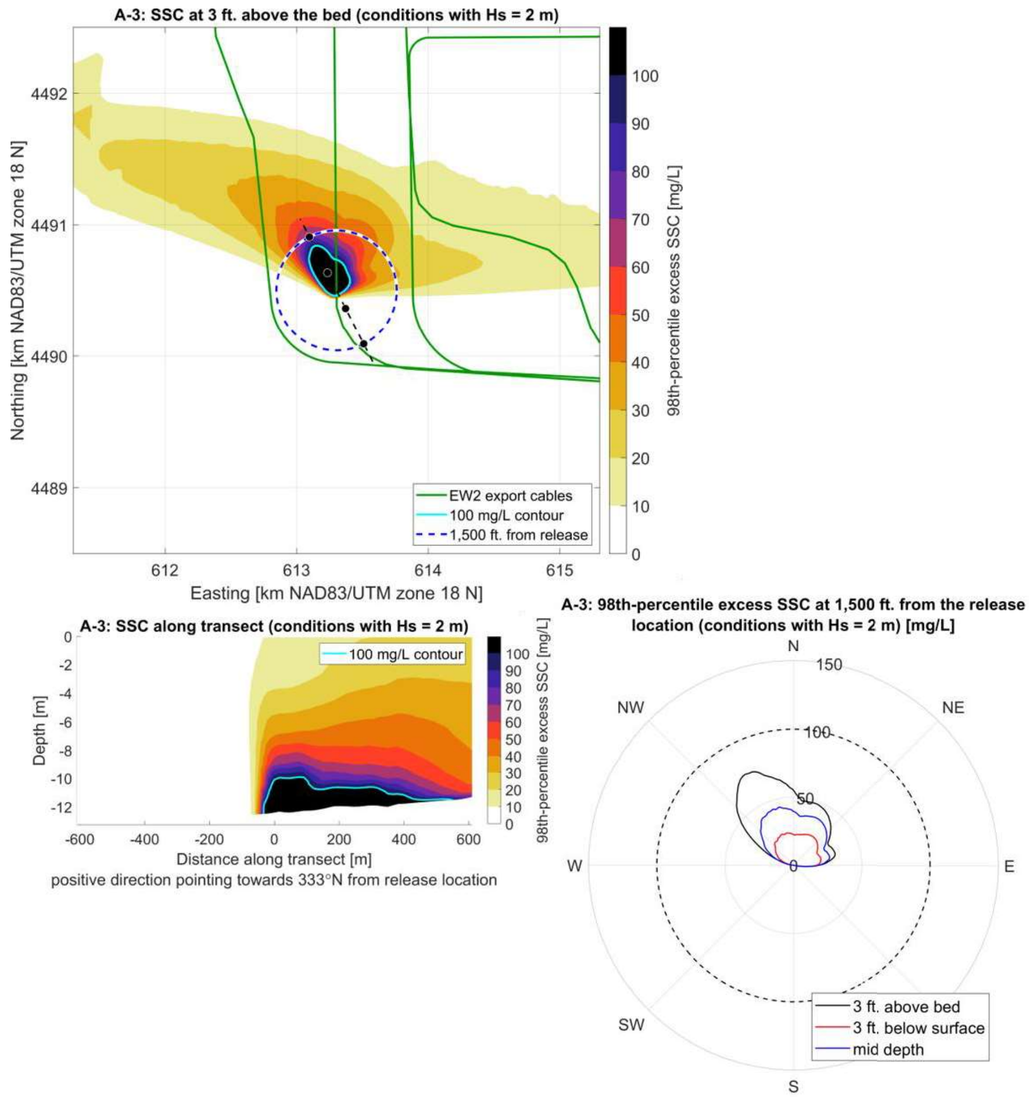

Figure 5.14 *Main modelling results for Release location A3 for $H_s \approx 2$ m. Upper left: 98-percentile excess SSC footprint 3 ft. above the bed. Lower left: 98-percentile excess SCC vertical footprint along the cross-section indicated by the black dashed line in the upper left plot. Lower right: The 98-percentile excess SSC at 1,500 ft. at 3 ft. above the bed, middle of the water column and 3 ft. below the surface. The results of all ambient conditions have been combined by taking the maximum concentration of these individual simulations.*

5.2.3 Release location A2.9 (MFE)

This section describes the main modelling results for the MFE operation at Release location A2.9 (see Figure 5.15 and Figure 5.16).

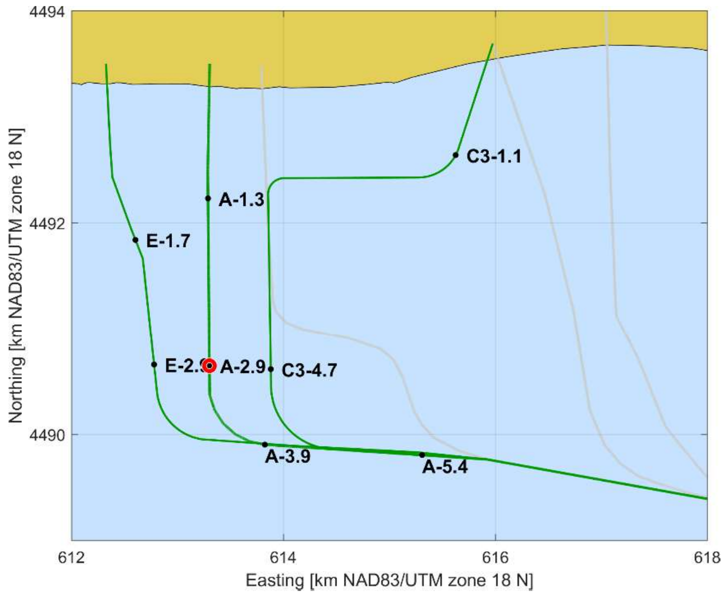

Figure 5.15: Map showing the location of Release location A2.9

For this location, the computed maximum 100 mg/L contour just extends beyond the 1,500 ft. zone, with a maximum SSC of about 110 mg/L at 1,500 ft. It is noted that the MFE operation is expected to only take 17 minutes (see Section 3.3), after which the released sediment quickly settles to the seabed (particularly the sand fractions). The SSC concentration therefore exceeds the 100 mg/L criterion for a short period, which is shown by Figure 5.17. The SSC exceeds the 100 mg/L criterion at 1,500 ft. only for about 20 minutes. Furthermore, it is noted that the criterion is only exceeded during one ambient condition (Condition H).

The SSC at a specific location depends on the tidal and wind-driven flows at the time of release. The four individual MFE operations in the simulation, have been distributed such that they occur during different phases of the tide (peak flood, low water slack, peak ebb, and high water slack tide).

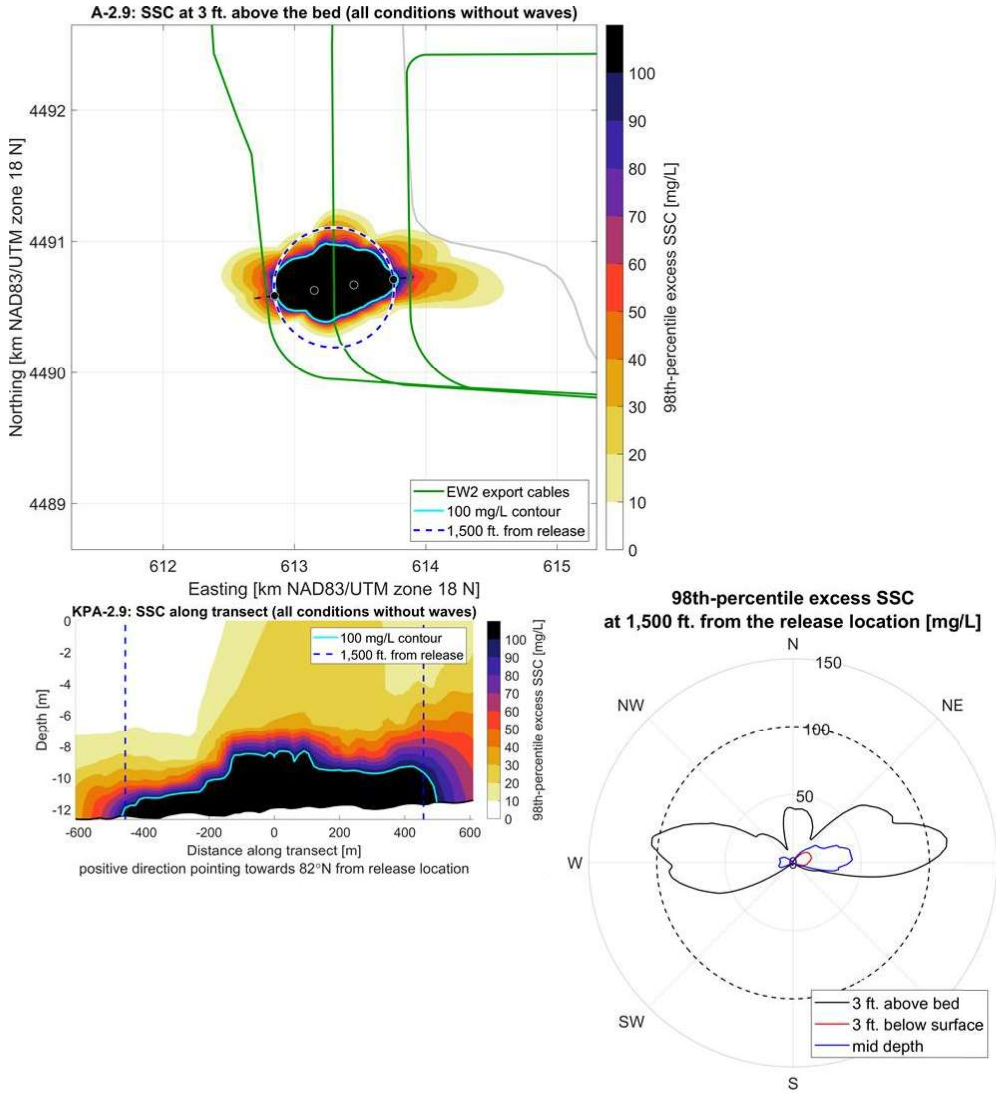

Figure 5.16 *Main modelling results for the MFE operation at Release location A2.9 in case of no waves. Upper left: 98-percentile excess SSC footprint 3 ft. above the bed. Lower left: 98-percentile excess SCC vertical footprint along the cross-section indicated by the black dashed line in the upper left plot. Lower right: The 98-percentile excess SSC at 1,500 ft. at 3 ft. above the bed, middle of the water column and 3 ft. below the surface. The results of all ambient conditions have been combined by taking the maximum concentration of these individual simulations.*

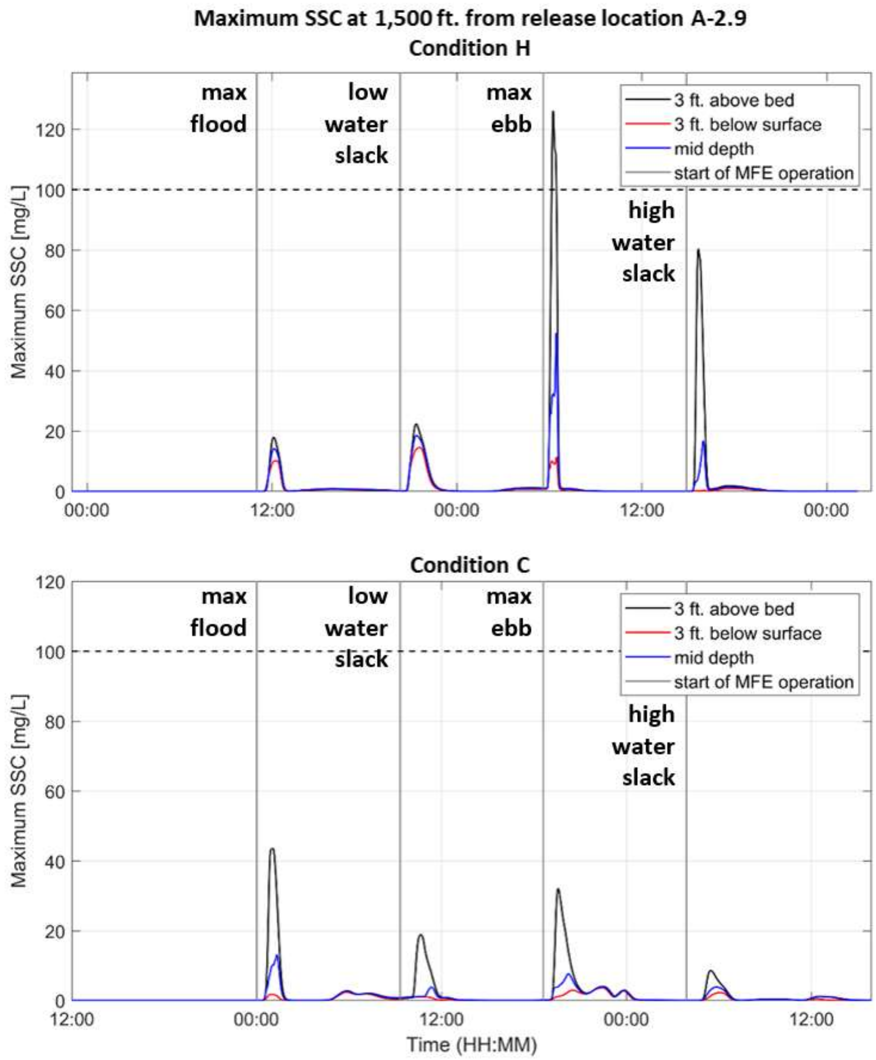

Figure 5.17 Timeseries of the maximum SSC at 1,500 ft. from Release location A2.9 during the MFE operation, during ambient condition H (upper) and ambient condition C (lower). The grey lines indicate the 4 individual MFE operations that have been considered in the simulation.

Figure 5.18 shows the main modelling results for Release location A2.9 for a significant wave height of about 1 m and higher (frequency of exceedance is roughly 34%). For these conditions, the maximum SSC at 1,500 ft. increases to about 200 mg/L.

The sediment plume behavior is very similar for the other release locations at which MFE is considered (except for the offshore Release locations A3.9 and A5.4). The maximum SSC at 1,500 ft. is typically in the range of 70 mg/L to 120 mg/L in case of no (or low) waves and in the range of 100 to 200 mg/L in case of a significant wave height of about 1 m or higher (see Section 5.1.6 for more details on this observation). For all these locations, the 100 mg/L SSC contour line is therefore close to 1,500 ft. zone.

At the offshore Release locations A3.9 and A5.4, the 100 mg/L SSC contour remain within the 1,500 ft. for all considered conditions (i.e. with and without waves). This is mainly related to the small fine sediment fractions at these locations (15% to 20%) and the limited influence of waves due to the larger water depth (about 13 m) compared to the other considered MFE release locations.

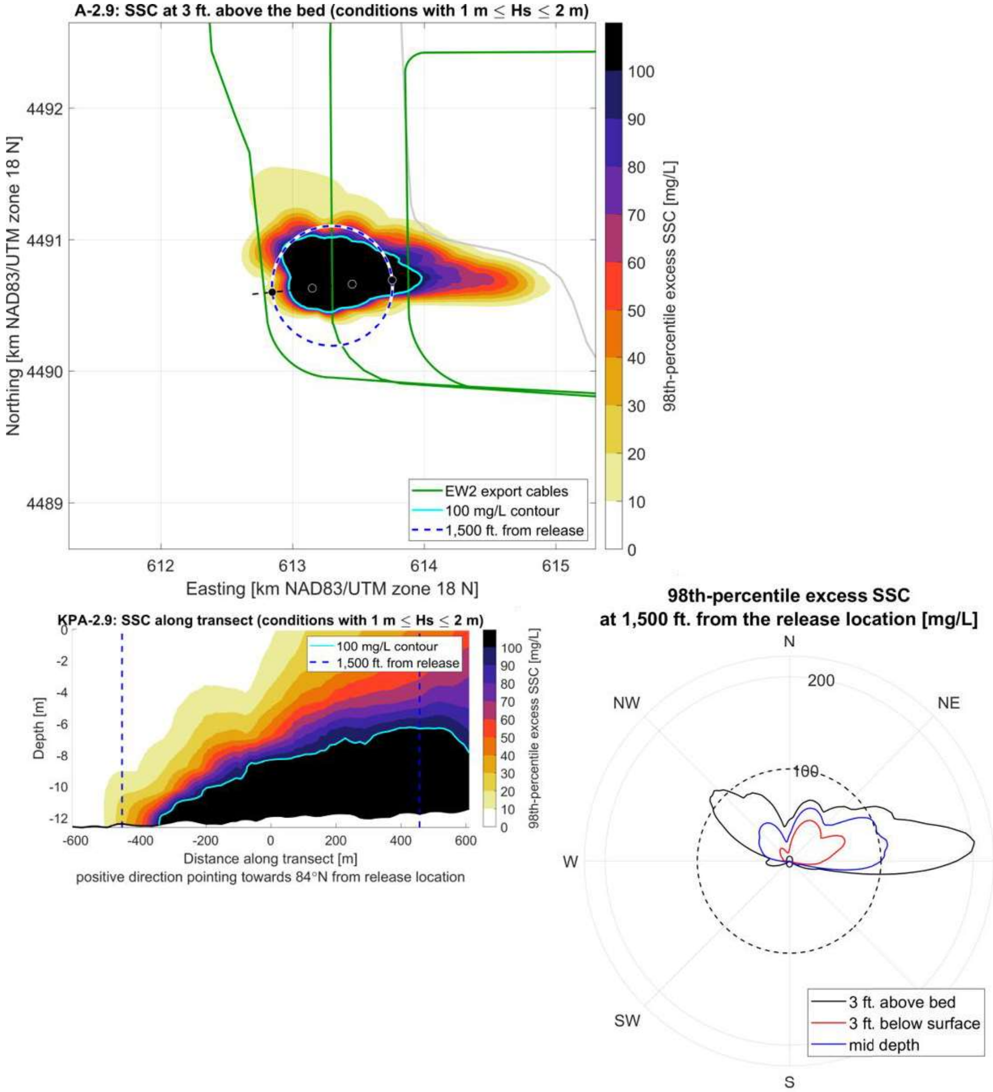

Figure 5.18 Main modelling results for the MFE operation at Release location A2.9 for H_s >= 1 m . Upper left: 98-percentile excess SSC footprint 3 ft. above the bed. Lower left: 98-percentile excess SCC vertical footprint along the cross-section indicated by the black dashed line in the upper left plot. Lower right: The 98-percentile excess SSC at 1,500 ft. at 3 ft. above the bed, middle of the water column and 3 ft. below the surface. The results of all ambient conditions have been combined by taking the maximum concentration of these individual simulations.

5.3 Overview of computed sediment footprint results

5.3.1 Capjet

In this section, the computed results of all Capjet release locations are summarized. As discussed in the previous section, the dispersion of released sediment in relation to the environmental criterion largely depends on the wave height and less on other ambient conditions. For a significant wave height[2] lower than 1 m, the excess suspended sediment footprint remains well within the criteria (<100 mg/L at 1,500 ft), see Figure 5.19 and Table 5.1.

In case of a significant wave height of about 1.5 m, the 100 mg/L contour of the plume exceeds beyond 1,500 ft. at a couple of locations. The main reason for the exceedance at the offshore Release locations (A10, A12) is the large fine sediment content at these locations (Figure 4.9). At the nearshore Release locations (A1, B1, C1 and D1), the footprints largely depend on the wave direction (explained in detail in Section 5.1.5). The most adverse conditions for the 100 mg/L footprint at these nearshore locations are the absence of a wave-induced longshore current (wave direction rather perpendicular to the local coastline orientation, as illustrated in Figure 5.20) and mild tidal and wind-driven currents (i.e., neap tide and low wind speeds). In this case, the SSC footprint is expected to exceed a distance of 1,500 ft. at the near-shore locations (see Appendix E). When the waves approach the coast obliquely, the SSC footprint is expected to possibly remain within the 1,500 ft. mixing zone. Given these sensitivities, it is recommended to monitor the actual sediment dispersion (and wave conditions) during the burial, especially at the near-shore locations.

When a significant wave height of 2 m is considered, the 100 mg/L contour line of the plume exceeds a distance of 1,500 ft. from the release at the offshore Release locations (A10 to A14). The sediment footprints at the near-shore locations still depend on the wave direction, as explained above.

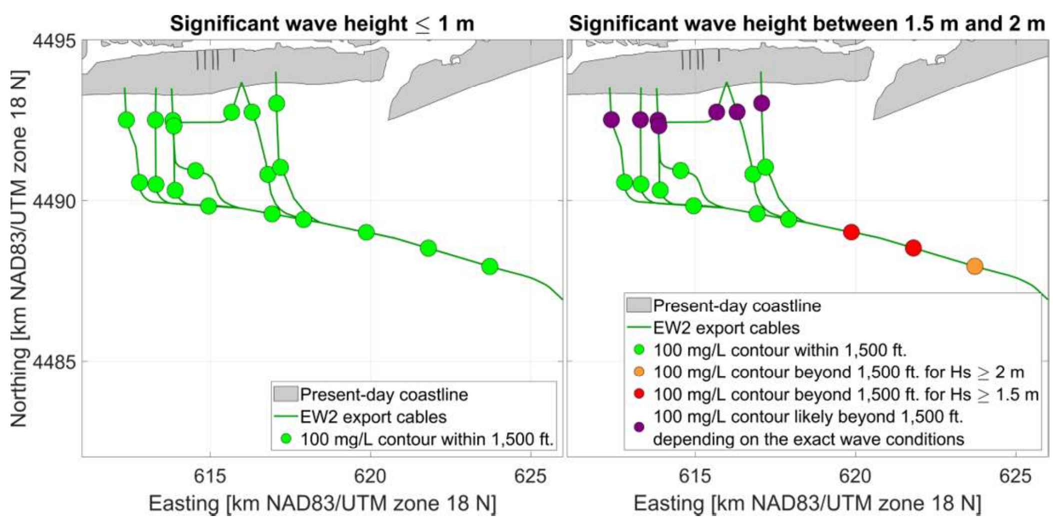

Figure 5.19 Summary of the evaluation of the modelled excess SSC footprints against the environmental criteria for the Capjet operation. Left: All ambient conditions considered with significant wave heights up to 1 m. Right: In case of a 1.5 or 2 m significant wave height.

[2] The significant wave height in the far-field model slightly varies within the considered EW2 cable area. The referred wave heights are the typical wave height that is observed at an offshore location, where the EW2 cables cross the New York State border (-73.5368 °W, 40.5365 °N).

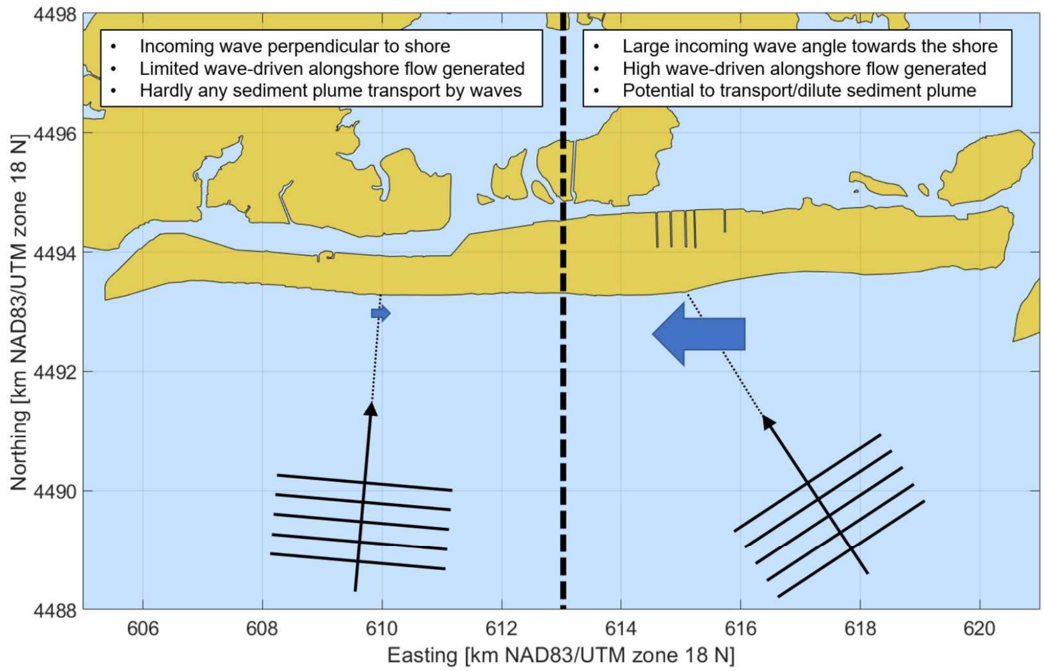

Figure 5.20 *Schematic showing the effect of wave direction (black lines represent wave crests, relevant for waves larger than 1 m) on flows generated alongshore (blue arrows), which influences the dilution of the sediment plumes. As noted in the text, also the combination of tidal and wind-driven current conditions are of importance in this context.*

It is noted that the modelled excess SSC footprints correspond to an assumed trenching speed of 188 m/hour, given a total trenching depth of 8 ft. In case the SSC footprint is expected to exceed the criteria (e.g., while installing the offshore part of the cables during high waves), it is recommended to temporarily reduce the release rates. This could potentially be achieved by reducing the trenching speed (if the jet power can be reduced accordingly). Note that from the numerical model results, it is found that the excess SSC scales rather linearly with the release rate.

Table 5.1 *Maximum SSC at 1,500 ft and the maximum distance to the 100 mg/L contour for all Capjet Release Locations. Distinction is made between three different significant wave height classes (H_s< 1 ml, H_s ≈ 1.5 m and H_S ≈ 2 m). The colors in this table are consistent with the colors used in Figure 5.19.*

** The maximum concentration in the far-field model is lower than 100 mg/L. The 100 mg/L is therefore only expected to be exceeded in the direct vicinity of the release.*

Release location	Hs ≤ 1 m		Hs ≈ 1.5 m		Hs ≈ 2 m	
	Maximum SSC at 1,500 ft. [mg/L]	Maximum distance to 100 mg/L contour [m]	Maximum SSC at 1,500 ft. [mg/L]	Maximum distance to 100 mg/L contour [m]	Maximum SSC at 1,500 ft. [mg/L]	Maximum distance to 100 mg/L contour [m]
A1	39	199 (654 ft.)	91	403 (1,123 ft.)	116	578 (1,896 ft.)
A3	21	145 (477 ft.)	85	343 (1,125 ft.)	75	380 (1,245 ft.)
A5	1.9	<50 (164 ft.)*	3.8	<50 (164 ft.)*	3.0	<50 (164 ft.)*
A7	16	116 (382 ft.)	58	304 (998 ft.)	34	208 (683 ft.)
A8	4.9	<50 (164 ft.)*	12	<50 (164 ft.)*	12	<50 (164 ft.)*

A10	49	265 (868 ft.)	116	485 (1,590 ft.)	161	801 (2,629 ft.)
A12	36	242 (794 ft.)	112	478 (1,569 ft.)	193	968 (3,177 ft.)
A14	34	233 (764 ft.)	77	405 (1,327 ft.)	157	866 (2,842 ft.)
B1	44	180 (589 ft.)	158	1592 (5,225 ft.)	146	822 (2,696 ft.)
B3	18	129 (422 ft.)	76	181 (594 ft.)	62	292 (959 ft.)
C1-1	79	296 (971 ft.)	192	1067 (3,500 ft.)	107	508 (1,668 ft.)
C1-3	17	108 (355 ft.)	41	215 (704 ft.)	33	142 (467 ft.)
C3-1	39	156 (513 ft.)	179	1353 (4,437 ft.)	185	1285 (4,217 ft.)
C3-3	30	173 (571 ft.)	149	1168 (3,830 ft.)	143	816 (2,677 ft.)
C3-5	16	122 (400 ft.)	77	394 (1,293 ft.)	47	249 (817 ft.)
D1	87	417 (1,367 ft.)	93	399 (1,309 ft.)	62	223 (732 ft.)
D3	13	95 (313 ft.)	33	160 (524 ft.)	31	123 (403 ft.)
E1	39	145 (477 ft.)	103	473 (1,551 ft.)	85	347 (1,139 ft.)
E3	22	153 (503 ft.)	100	457 (1,500 ft.)	71	369 (1,209 ft.)

5.3.2 MFE

Figure 5.21 summarizes the evaluation of the modelled SSC footprints for the considered MFE operations against the environmental criteria. The figure shows that the 100 mg/L criterion at 1,500 ft. is exceeded at 3 out of 8 locations in case of no (or low) waves (maximum SSC at 1,500 ft. is about 120 mg/L) and at 6 out of 8 release locations when a significant wave height of 1 m or higher is considered (maximum SSC at 1,500 ft. is about 200 mg/L). Only at the offshore MFE locations (A3.9 and A5.4), the 100 mg/L criterion always remains within the 1,500 ft. zone because of the relatively small fine sediment fraction at these locations and the fact that waves only have a limited influence on the sediments at these deeper locations.

It is noted that the MFE operation is expected to only take 17 minutes (see Section 3.3), after which the released sediment quickly settles to the seabed (particularly the sand fraction). The SSC concentrations therefore exceed the 100 mg/L criterion for a short period (typically up to about 20 minutes at 1,500 ft.).

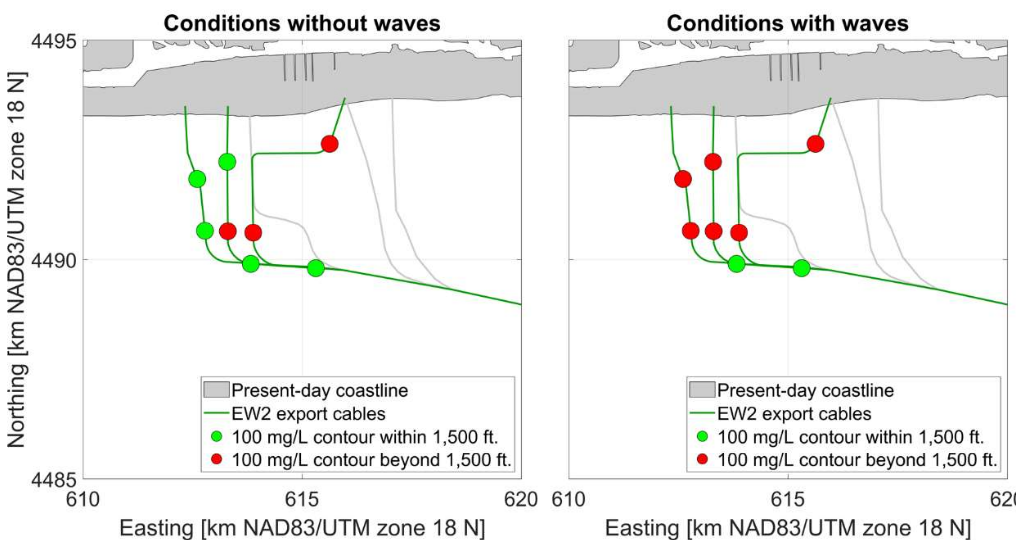

Figure 5.21 Summary of the evaluation of the modelled excess SSC footprints against the environmental criteria for the MFE operation. Left: All ambient conditions considered with no (or low) waves. Right: In case of a 1 m or higher significant wave height.

Table 5.2 *Maximum SSC at 1,500 ft and the maximum distance to the 100 mg/L contour for all MFE Release Locations. Distinction is made between four different significant wave height classes (No waves, $H_s \approx 1$ m, $H_s \approx 1.5$ m and $H_S \approx 2$ m). The colors in this table are consistent with the colors used in Figure 5.21.*

Release location	No waves		Hs ≈ 1 m		Hs ≈ 1.5 m		Hs ≈ 2 m	
	Maximum SSC at 1,500 ft. [mg/L]	Maximum distance to 100 mg/L contour [m]	Maximum SSC at 1,500 ft. [mg/L]	Maximum distance to 100 mg/L contour [m]	Maximum SSC at 1,500 ft. [mg/L]	Maximum distance to 100 mg/L contour [m]	Maximum SSC at 1,500 ft. [mg/L]	Maximum distance to 100 mg/L contour [m]
A-1.3	87	437 (1,435 ft.)	137	575 (1,886 ft.)	114	534 (1,753 ft.)	117	488 (1,601 ft.)
A-2.9	114	490 (1,608 ft.)	202	683 (2,239 ft.)	161	544 (1,784 ft.)	122	548 (1,798 ft.)
A-3.9	75	387 (1,270 ft.)	83	411 (1,347 ft.)	81	377 (1,237 ft.)	72	339 (1,111 ft.)
A-5.4	34	279 (916 ft.)	33	199 (653 ft.)	32	210 (687 ft.)	31	205 (773 ft.)
C3-1.1	119	501 (1,644 ft)	123	580 (1,902 ft.)	156	591 (1,937 ft.)	136	517 (1,697 ft.)
C3-4.7	106	477 (1,564 ft.)	184	690 (2,264 ft.)	151	632 (2.073 ft.)	122	540 (1,770 ft.)
E-1.7	75	405 (1,329 ft.)	121	526 (1,724 ft.)	100	459 (1,506 ft.)	104	474 (1,556 ft.)
E-2.9	90	432 (1,418 ft.)	165	610 (2,000 ft.)	135	544 (1,784 ft.)	99	455 (1,493 ft.)

6 Conclusions & recommendations

6.1 Conclusions

The objective of this study is to compute the fate (dispersion, transport) and suspended sediment concentrations of the released sediment as a result of the proposed burial activities, along the EW 2 export cable route in New York State waters as input to the environmental permitting procedures.

This is achieved by means of high-resolution 3D hydrodynamic and wave modelling (far-field models), in which representative conservative sediment source terms are introduced, which are obtained from a near-field assessment.

The suspended sediment concentration (SSC) footprints, resulting from the far-field modelling, are evaluated against the standards provided in the NYSDEC Technical & Operational Guidance Series (TOGs). As such, suspended sediment concentration at the edge of a 1,500 ft. mixing zone was compared to the guidance value for the threshold of acute toxicity for suspended sediment from dredged material which has not undergone suspended phase toxicity testing, which is 100 ppm (100 mg/L) above ambient conditions (excess concentrations). The evaluation is summarized in the figures below, for different wave conditions. The study results are clustered for different wave heights, since it is found that the sediment footprints are most sensitive to the wave height (and less sensitive to the considered variations in tide, wind and seasons), in relation to the conclusions of this study.

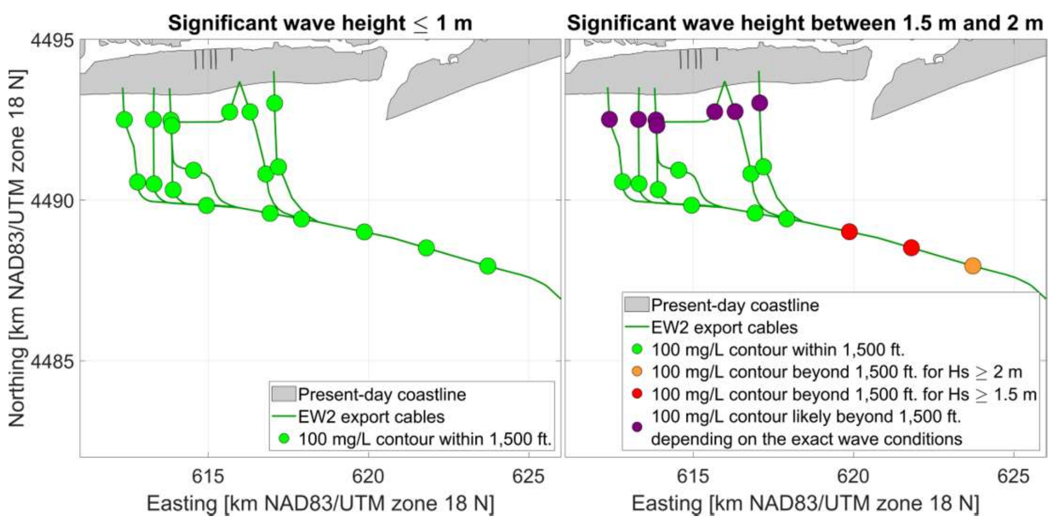

Figure 6.1 Summary of the evaluation of the modelled excess SSC footprints against the environmental criteria for the Capjet operation. Left: All ambient conditions considered with significant wave heights up to 1 m. Right: In case of a 1.5 or 2 m significant wave height

Figure 6.1 summarizes the evaluation for the Capjet operation. The computed excess SSC at 1,500 ft. is below 100 mg/L at all assessed release locations in case of significant wave heights up to about 1 m (3.3 ft.), which represents about 66% of the time.

In case of a 1.5 (4.9 ft.) or 2 m (6.6 ft.) significant wave height (wave height exceeded about 12 and 4% of the time, respectively), the near-bed excess SSC at 1,500 ft. is expected to temporarily exceed 100 mg/L at the offshore stretches of the EW 2 export cables. At these locations, the modelled SSC footprints are larger because a relatively large fine sediment fraction is observed at these locations, based on the local sediment samples. At the near-shore release locations (A1, B1, C1 and D1), the exceedance of the 1,500 ft. zone strongly depends on the local wave direction. The most adverse conditions for the environmental criterion at these nearshore locations are the absence of a wave-induced longshore current (wave direction rather perpendicular to the local coastline orientation) in combination with mild tidal and wind-driven currents (i.e., neap tide and low wind speeds). In this case, the 100 mg/L SSC footprint is expected to exceed beyond 1,500 ft. at the near-shore locations. When the waves approach under a larger angle, the SSC footprint is computed to remain within the 1,500 ft. mixing zone, as the sediment is better dispersed by alongshore wave-induced currents.

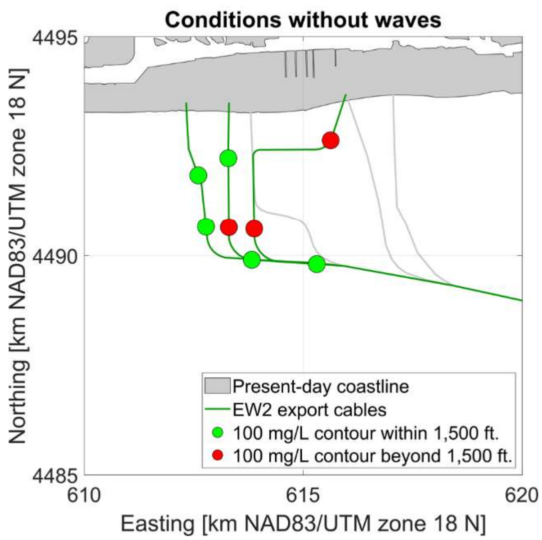

Figure 6.2 Summary of the evaluation of the modelled excess SSC footprints against the environmental criteria for the MFE operation. Left: All ambient conditions considered with no (or low) waves. Right: In case of a 1 m or higher significant wave height.

Figure 6.2 summarizes the evaluation for the MFE operation. At the offshore release locations, the 100 mg/L contour remains within 1,500 ft. for all considered conditions (i.e. with and without waves). For the other MFE locations, the 100 mg/L contour is beyond the 1,500 ft. zone in case of a significant wave height of 1 m or higher (maximum SSC in the range of 100 to 200 mg/L) and for some locations also in case of no (or low) waves. It is noted that in case of exceedance, the criterion is only exceeded up to about 20 minutes at 1,500 ft., given the short duration of the MFE operation (assumed 17 minutes).

For uncertain aspects of this study (e.g. spill rates during the burial works, sediment distribution along the entire cable) a conservative approach is followed. The actual excess sediment concentrations during the burial works are therefore likely smaller than the computed values. It is recommended to monitor the SSC during the burial works (see below). The SSC could possibly be reduced by reducing the trenching speed (assuming that the jet intensity is reduced accordingly).

The results presented in this study report are aligned with the cable routes and associated representative release locations as indicated in Figure 1.2. These considered routes do not reflect some shifts to the submarine export cable routing alternatives that have been made in the filed Article VII application, based on agency feedback and further design development. An updated analysis to reflect the routes filed in the Application is under preparation and will be filed with the Commission once finalized. It is however noted that with the minor anticipated route changes (maximum route shifts of up to 250 m), also minor differences in the updated study results are expected. Hence, any changes to study conclusions are not anticipated.

6.2 Recommendations

Following the activities and conclusions of this study, it is recommended to:

- monitor the suspended sediment concentrations during the burial. This is especially recommended along sections of the cables where relatively large fine sediment fractions are expected, and at the near-shore zone, where the sediment footprints depend on the local wave characteristics.
- investigate how conservative model assumptions linked to e.g., spill rates and installation characteristics may be further optimized.
- adopt an adaptive trenching strategy that uses input from the monitoring, possibly in combination with operational model forecasts, to adapt the trenching speed and other operations to ensure environmental compliance at all times.
- install the cables preferably during periods with mild waves, since this will result in the smallest suspended sediment footprints.

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A Introduction on sediment plume modelling

When sediment plumes are released into the water column by e.g. dredging or trenching activities, the plume behavior transitions from a dynamic to passive phase. The dynamic plume phase is observed close to the source (typically within a 100-metre radius from the activity), while passive plume behavior is typically observed beyond.

Within the dynamic plume phase, mixture density and non-hydrostatic behavior dictate the (initial) spreading behavior of the released sediment. As mixture densities reduce (by e.g. deposition, dilution, mixing), this transitions into passive plume behavior, which is governed by advective and diffusive transport due to ambient hydrodynamic conditions. Thus, during this transition, the relevance of settling velocities and other sediment characteristics increasingly dominate plume behavior, while the relevance of mixture densities reduces.

The above may be summarized as follows:

- **Near-field phase**: Dynamic plume behavior
    - Non-hydrostatic behavior
    - Relevance of mixture density
    - Typical spatial scales < 100 m

- **Far-field phase**: Passive plume behavior
    - Advective and diffusive transport (dependent on ambient hydrodynamics)
    - Relevance of settling, flocculation, deposition (potential re-entrainment)
    - Typical spatial scales > 100 m

For dredging activities this is also visualized in Figure A.1.

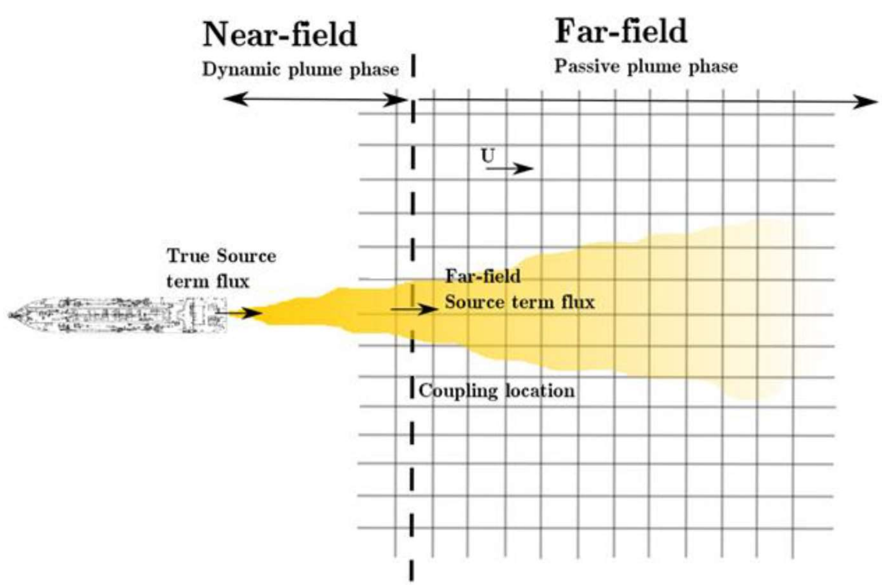


Figure A.1 Overview of near-field and far-field plume behavior, along with the definition of associated source term fluxes

As near-field (dynamic) and far-field (passive) plume behavior is governed by different physical processes, different assessment techniques and numerical modelling approaches are available. Typically, a near-field assessment is first conducted, in which the ‘true source term fluxes’ are first estimated (Figure A.1), and the near-field plume behavior is assessed. From this near-field assessment, ‘far-field source term fluxes’ are obtained. These fluxes are subsequently utilized for the far-field assessment. Both near- and far-field assessments may rely on literature review, expert judgement, tailored routines and/or numerical modelling.

B Hydrodynamic and wave data

B.1 Hydrodynamics data

For understanding the system and validation of the hydrodynamic model the following observations have been gathered:

- Water levels:
  - Long-term water level measurements at 3 locations (see Figure B.1). Extracted from NOAA's National Data Buoy Center.
- Velocity timeseries:
  - Measurements at different vertical levels (typically near-surface and near-bed) for different periods at 9 locations in the Upper Bay and Lower Bay area (see Figure B.1). Data was extracted from NOAA's National Data Buoy Center Velocity measurements at the EW lease area, specifically measured for this project, referred to as 'Equinor' (see Figure B.1 as well).
- Salinity timeseries:
  - Near-surface salinity measurements in the period June to October 2019 at 5 locations in the Hudson River (Figure B.1) obtained from the USGS National Water Information System.

In addition, DHI provided hindcast data for the period 2000 to 2019, consisting of water levels and at multiple vertical levels velocity, salinity and temperature. The hindcast data was provided for every grid cell of the numerical model that DHI used for the hindcast modelling Figure B.2). Additionally, DHI provided the main input used in the hindcast modelling, like:

- Time and spatially varying meteo fields (based on CFSR)
- Discharge timeseries at the Hudson and other rivers

DHI (2021) provides a detailed overview of the validation of the DHI hindcast modelling. In this section only some characteristic hydrodynamic data will be visualized to help understanding the system and verify whether the main hydrodynamic processes can be observed in the data.

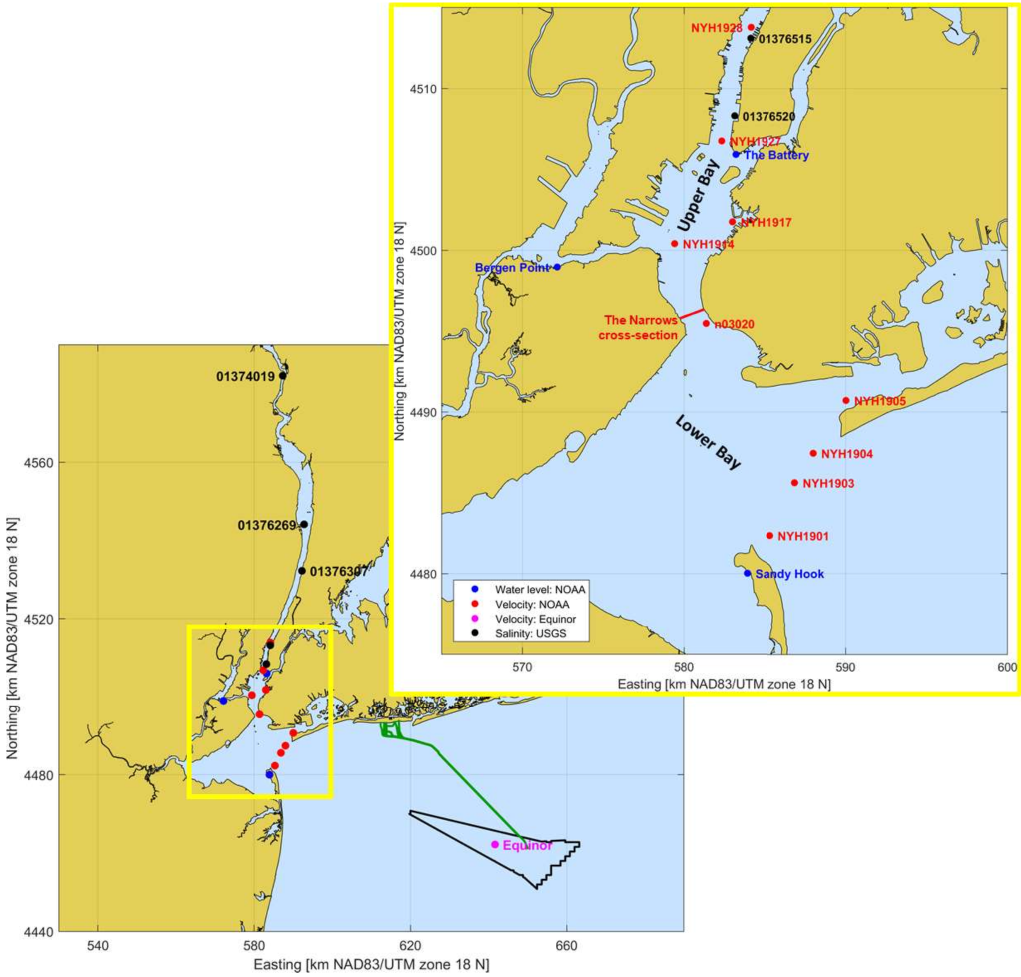


Figure B.1 *Overview of available water level, velocity and salinity measurement data in the project area*

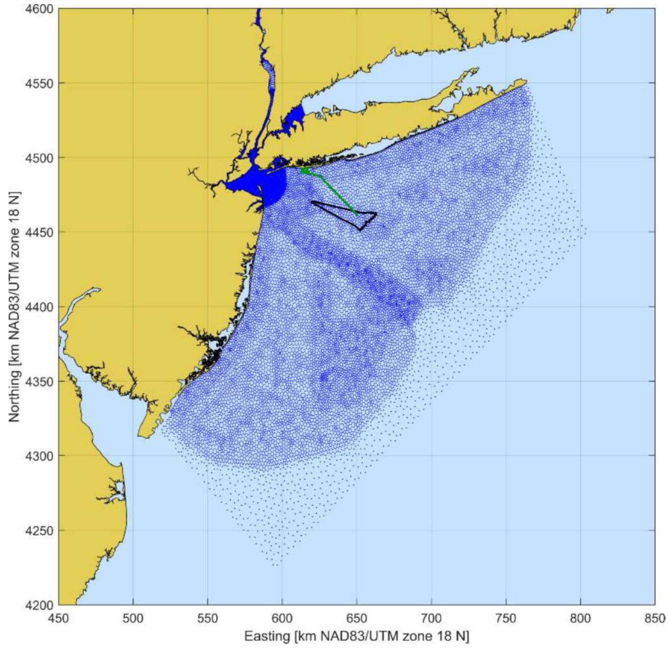


Figure B.2 Overview DHI hindcast hydrodynamic data output locations (grid covering).

Figure B.3 shows the total Hudson discharge as provided by DHI and included in their hindcast modelling. The peak river discharge (2000-3000 m^3/s) typically occurs in March/April, after which the discharge decreases towards a constant low discharge (100 – 400 m^3/s) in the period of July to October.

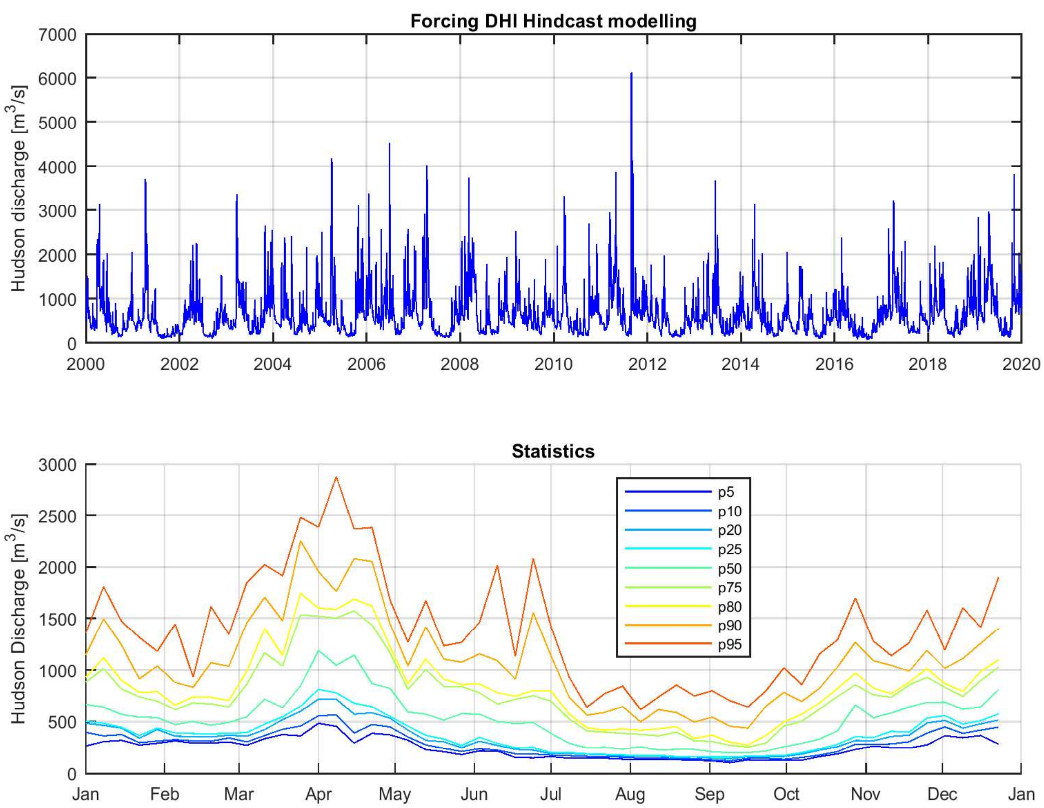


Figure B.3 Total Hudson discharge as provided by DHI and included in their hindcast modelling. Upper plot: Hudson discharge timeseries as used in the DHI hindcast modelling. Lower plot: statistics derived from the Hudson discharge timeseries.

Figure B.4 shows a comparison of the observed and DHI hindcasted water level timeseries at Sandy Hook. The observed water variation is reasonably captured by the DHI hindcast model. The tide is governed by a semi-diurnal pattern. During spring tide, the tidal range is in the order of 2 m, while during neap tide the tidal range is about 1 to 1.5 m.

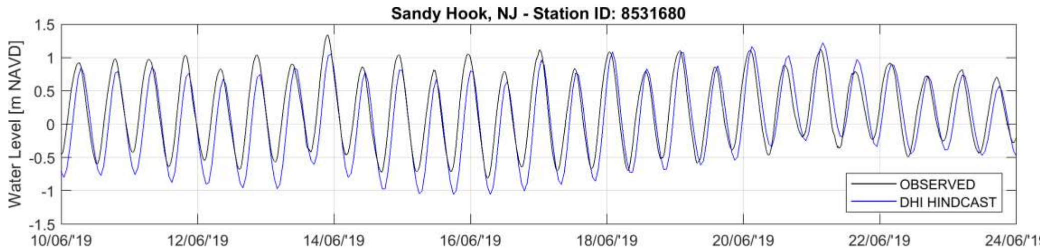


Figure B.4 Comparison of observed and DHI Hindcast water levels at Sandy Hook

Figure B.5 shows a comparison of observed and DHI hindcasted velocity timeseries at The Narrows (location n03020). The temporal variation as well as the variation of the vertical is generally well represented by the DHI Hindcast modelling. At the surface, the peak tidal flow is typically about 1 to 1.3 m/s, whereas the near-bed peak tidal flow is typically about 0.5 to 0.8 m/s.

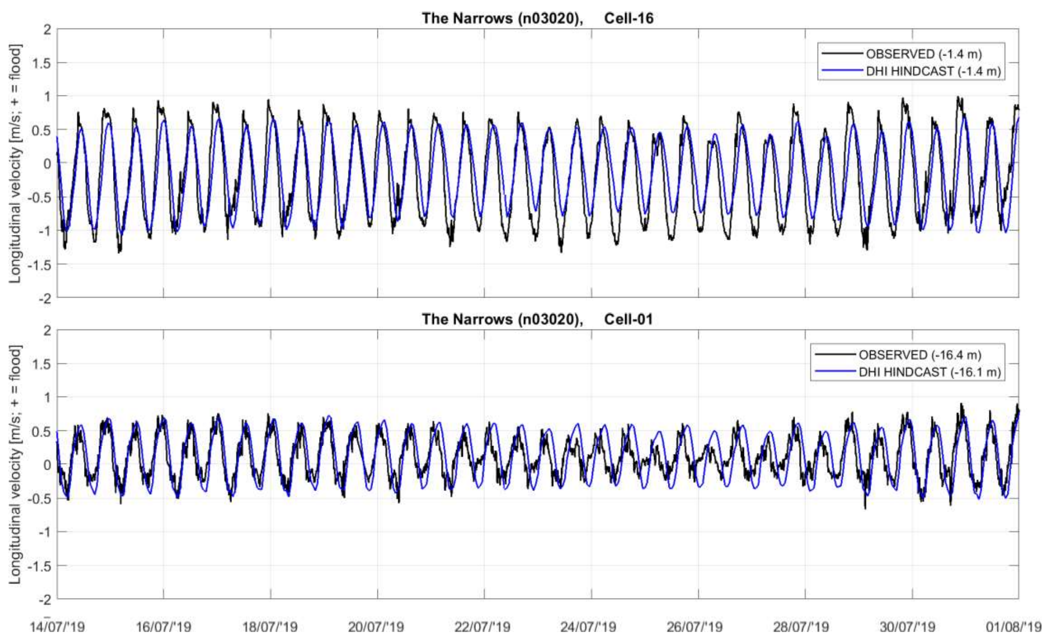


Figure B.5 Comparison of observed and DHI Hindcast velocity timeseries at The Narrows (location n03020). Only the main velocity component in line with the channel orientation is shown here. Upper: near-surface velocity, Lower: near-bed velocity

Figure B.6 shows the seasonal variation of the near-surface and near-bed residual flow at The Narrows across the width of the channel. The presence of the estuarine circulation is clearly indicated by the opposing directions of the near-surface and near-bed residual flows. Near the surface, the residual flow is typically towards the south due to the fresh water inflow from the Hudson. During the peak Hudson discharges (March-April), the southerly near-surface residual is strongest. Near the bed, the residual flow is typically in northwards direction due to the difference in fresh and saltwater difference, which forces the heavier salt water towards the Upper Bay along the seabed. The fact that the near-surface residual is strongest in the western part of the cross-section, whereas the near-bed residual is strongest in the eastern part, is mainly related to the local geometry. Due to the bended shape of the channel at The Narrows, a secondary flow will develop, which pushes the near-surface flows towards the outer bend (west) and the near-bed flow towards the inner bend (east).

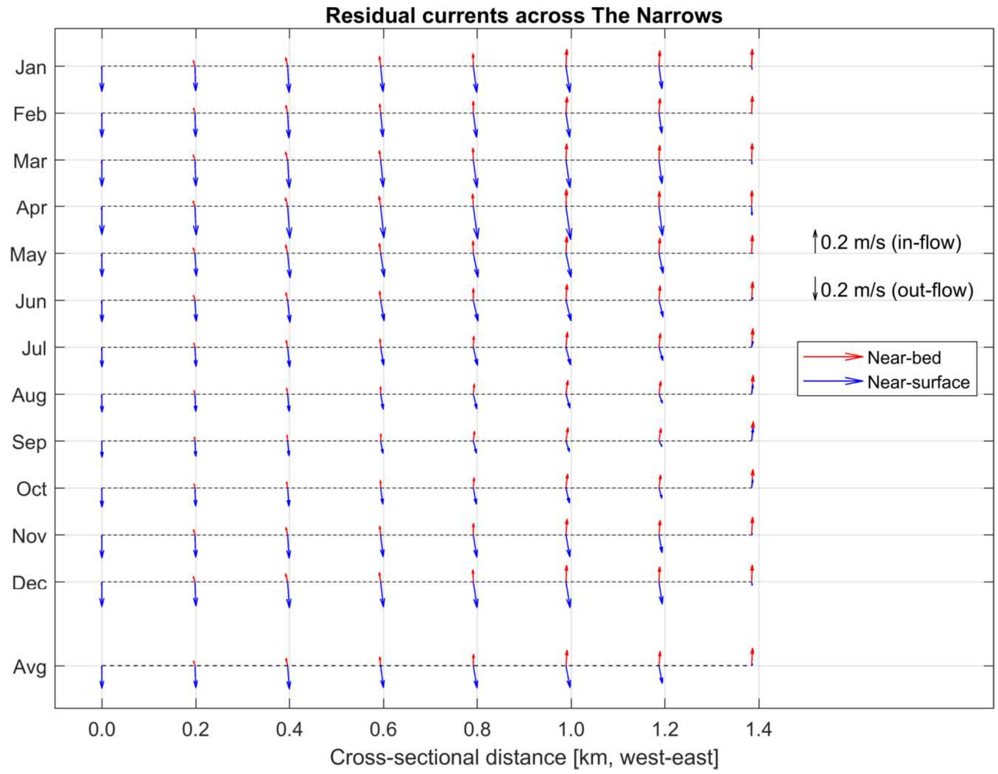


Figure B.6 Seasonal variation of residual currents at The Narrows across the width of the channel, based on the DHI Hindcast data. Red: the residual flow near the bed, Blue: the residual flow near the surface.

B.2 Wave dynamics data

Information on local wave conditions is available from observation (buoy) wave data and literature. In addition to the wave data from measurements and literature, DHI provided their model input (time and spatially varying wind) and model output (wave parameter output, grid covering). The DHI wind and wave hindcast data covers the period from 2000 to 2020.

The observation wave data consists of specific project-measured wave data and wave data from NOAA's National Data Buoy Center, https://www.ndbc.noaa.gov/.

Figure B.7 gives an overview of the locations of the available wave measurement data in the area. The table below gives an overview of the time coverage for these individual wave data stations where the data was used from January 1, 2000 onwards only, limiting it in overlap with the DHI hindcast data starting time.

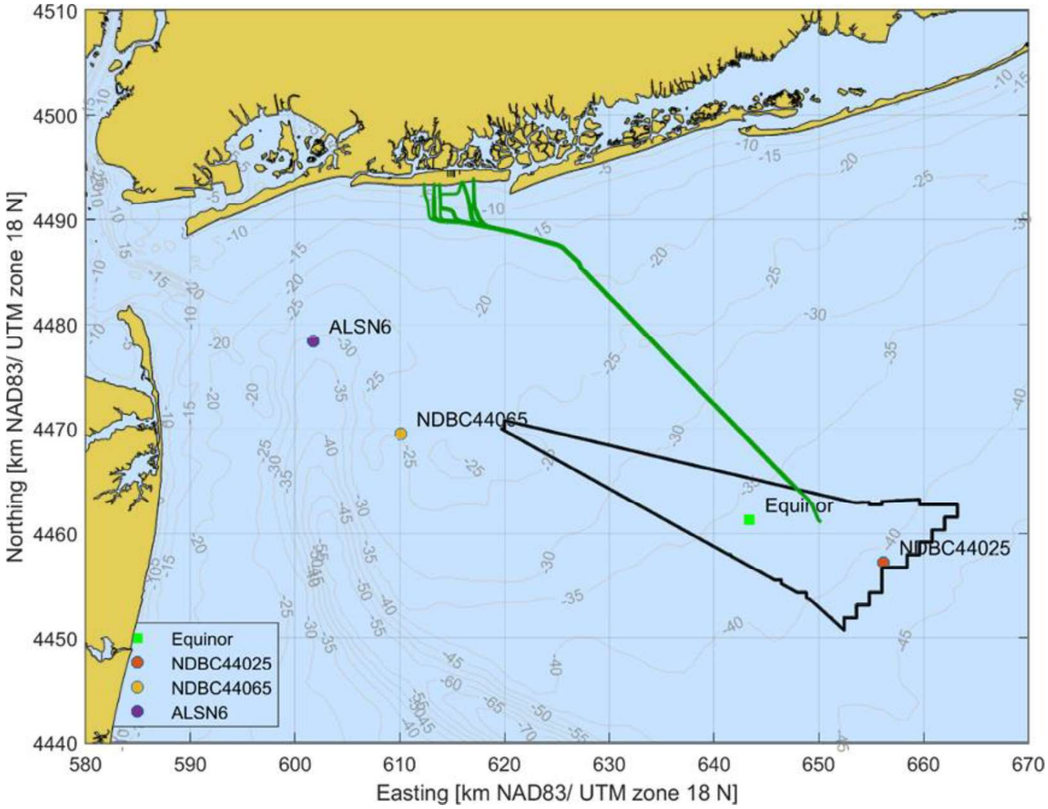


Figure B.7 Overview of available wave measurement data in the project area.

	Available data period [yyyy/mm/dd]
Equinor	2018/12/01 – 2020/11/27
NDBC 44025*	2000/01/01 – 2019/01/31
NDBC 44065*	2008/10/30 – 2019/02/28
ALSN6**	2000/01/01 – 2008/07/28

** delivered by DHI*

*** obtained from https://www.ndbc.noaa.gov/*

The project-measured wave data, located in the center of the OWF development zone, referred to as *Equinor* wave data were collected in the period between December 2018 and end of November 2020, for an almost consecutive period of 2 years. The data consists of various parameters of wave height, wave period and direction for total, wind-sea and swell partions. Figure B.8 gives and overview of the Equinor wave data, with a recorded average wave height of 1.25 m and a maximum recorded wave height of 6.4 m. The recorded wave period was on average 7.4 s and peaked at 18.3 s. Representing a mixture of local wind-generated and higher period swell waves. Wave directions are dominantly from the 2nd quadrant, with directions between 90 (East) and 180 (South) degrees, coming from. Figure B.9 and Figure B.10 present the wave roses of the significant wave height (total) and peak wave period (total) for the Equinor wave data.

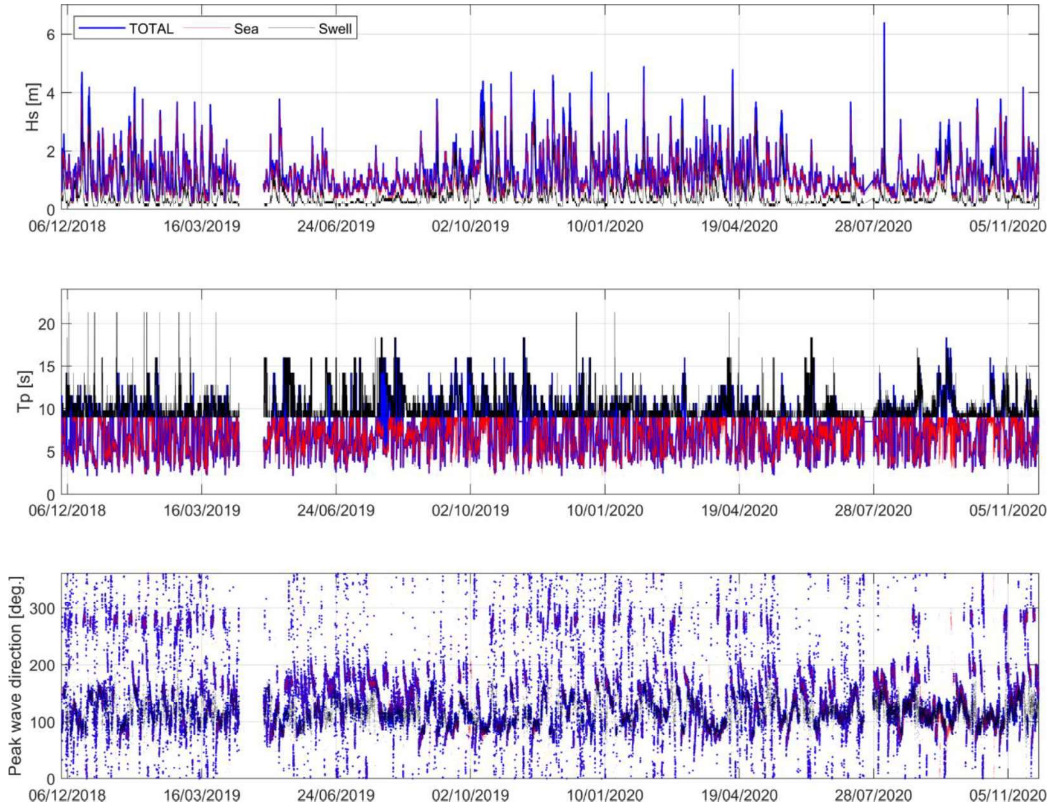


Figure B.8 Equinor wave data timeseries.

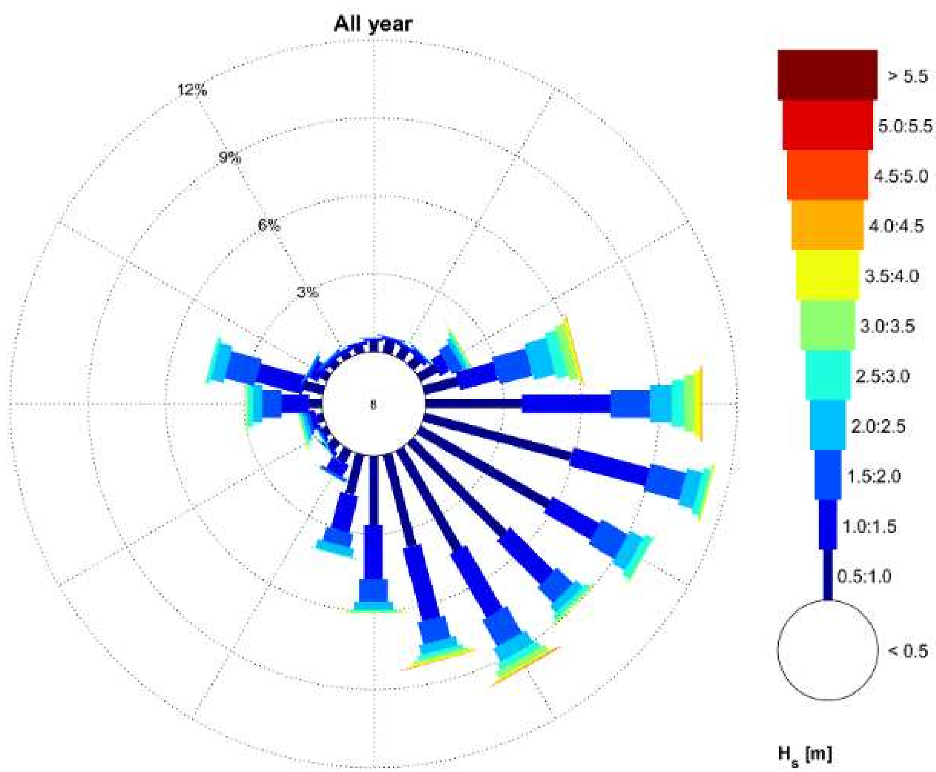


Figure B.9 Wave rose, Equinor wave data, Significant wave height.

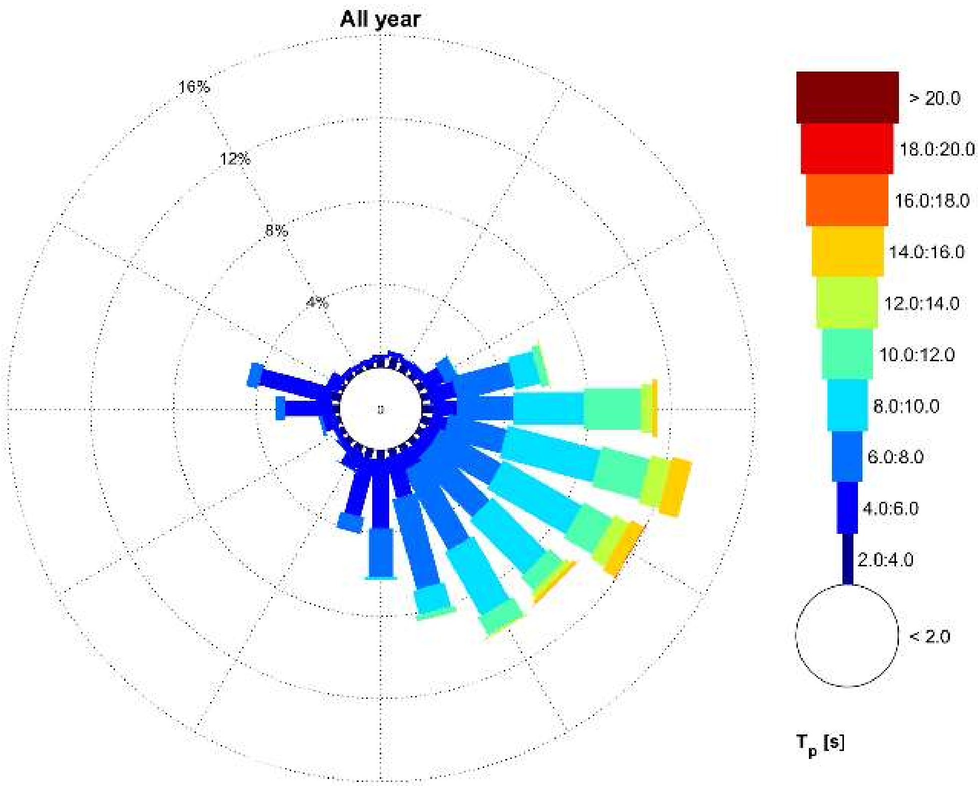


Figure B.10 Wave rose, Equinor wave data, peak wave period.

As stated, in addition to the wave data from measurements, DHI provided their model input (time and spatially varying wind) and output (grid covering wave parameter output). The DHI wind and wave data covers the period from 2000 to 2020. Figure B.11 gives an overview of the available DHI hindcast wave data locations, with in red highlighted a reference location for the Equinor wave data location. The DHI model output was validated against both the Equinor wave data and NDBC wave buoy data. Following requirements and based on the good performance found in the DHI wave data validation, the DHI model input and output data is used in this study, without alterations as forcing conditions for the dedicated local wave model developed here. The wave model setup is presented in Subsection D.1. The validation of this study's wave model against the wave observation data is discussed in Subsection D.2.

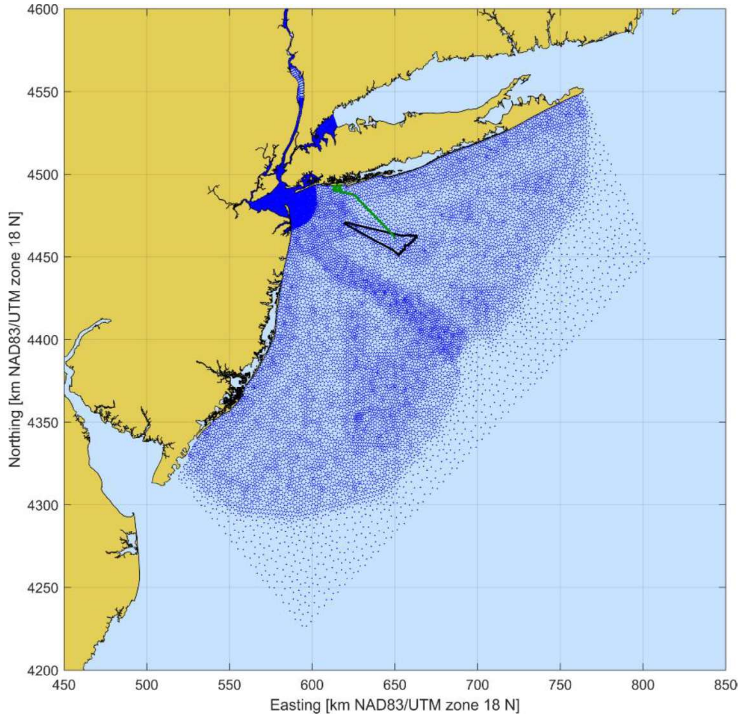


Figure B.11 Overview DHI hindcast wave data output locations (grid covering).

C Validation of the hydrodynamic model

The hydrodynamic model was validated by comparing the hindcast results against measured data and the DHI hindcast data. Since the forcing of the hydrodynamic model is fully based on the DHI hindcast data, a similar performance as the DHI hydrodynamic model is expected.

In this section, some representative comparisons will be shown for water levels, salinity and current velocity.

Water levels
Figure C.1 shows a comparison of observed and computed water level timeseries at Sandy Hook. The water levels in the Delft3D4 model exactly match the water levels as computed by the DHI Hindcast model, which is a consequence of using the DHI Hindcast data as forcing for the Delft3D4 model. The observed water levels are reasonably well represented in the DHI Hindcast and therefore as well in the Delft3D4 model.

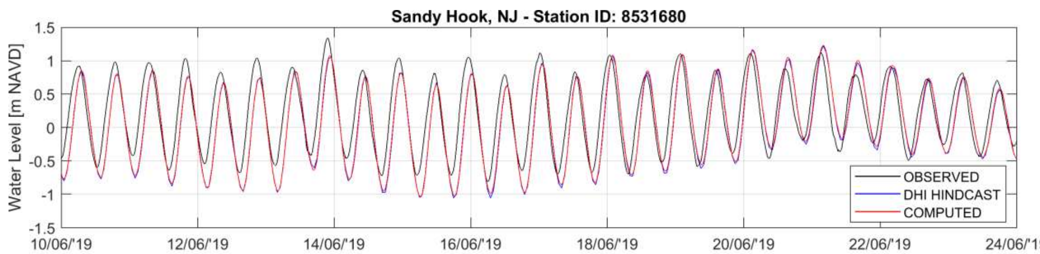


Figure C.1 Comparison of observed versus computed water level timeseries at Sandy Hook

Velocity timeseries
An overview of the available velocity measurement locations is given in Appendix B.1. In this section velocity comparisons will be shown at The Narrows (n03020), Ambrose Channel (NYH1903) and at the EW lease area (Equinor).

Figure C.2 and Figure C.3 present the timeseries comparison of the observed versus computed flow velocity at Ambrose Channel (NYH1903) near the surface and near the bed. The current velocity has been split up in a main component (upper plot), with positive magnitudes for flood and negative for ebb, and the remaining transversal velocity component (lower plot). The figures show that the Delft3D model is capable of reproducing the flow dynamics at this location. The increased performance compared to the DHI Hindcast is mainly related to the higher grid resolution in the Delft3D4 model. Since the NYH1903 measurement location is close to the slope of the channel, large velocity gradients can be expected at this location, which can be better represented by a higher resolution grid.

Figure C.4 and Figure C.5 show the comparison for The Narrows (n03020) at the surface and near the bed. The results show that the Delft3D4 model is very consistent with the DHI Hindcast and in agreement with the observed tidal dynamics.

Figure C.6 presents the comparison of flow velocity at the Equinor measurement location near the bed. The Delft3D4 model results are again very consistent with the DHI Hindcast. The computed flow velocity typically follows the observed longer-term trends as well as the typical tidal peak velocities. However, some events are not captured by the model. It is noted that these events were also absent in the DHI Hindcast, which is the boundary conditions of the Delft3D model.

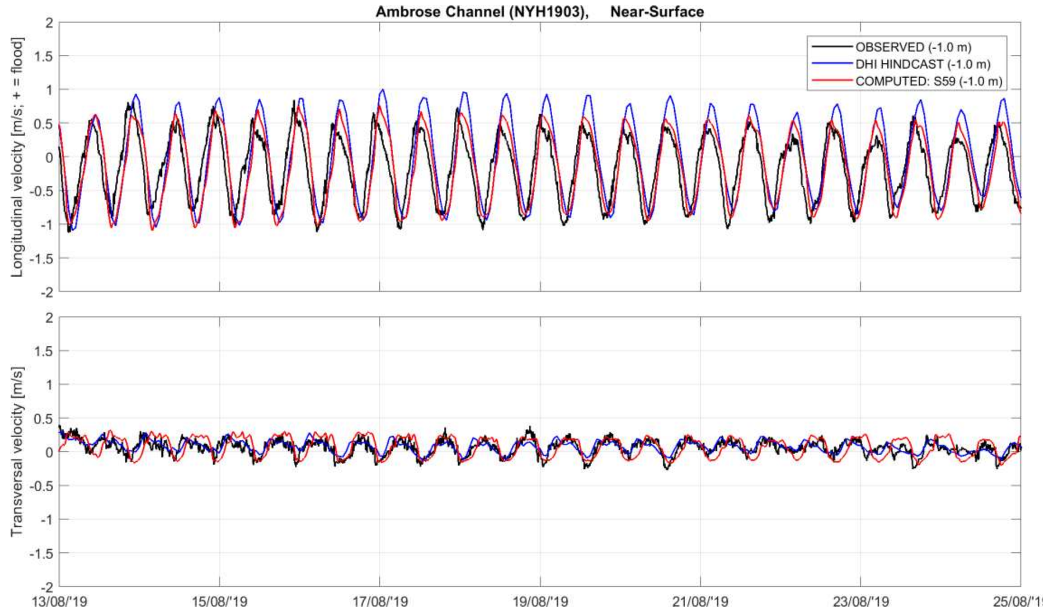


Figure C.2 Comparison of observed versus computed velocity magnitude at Ambrose Channel (NYH1903), near-surface.

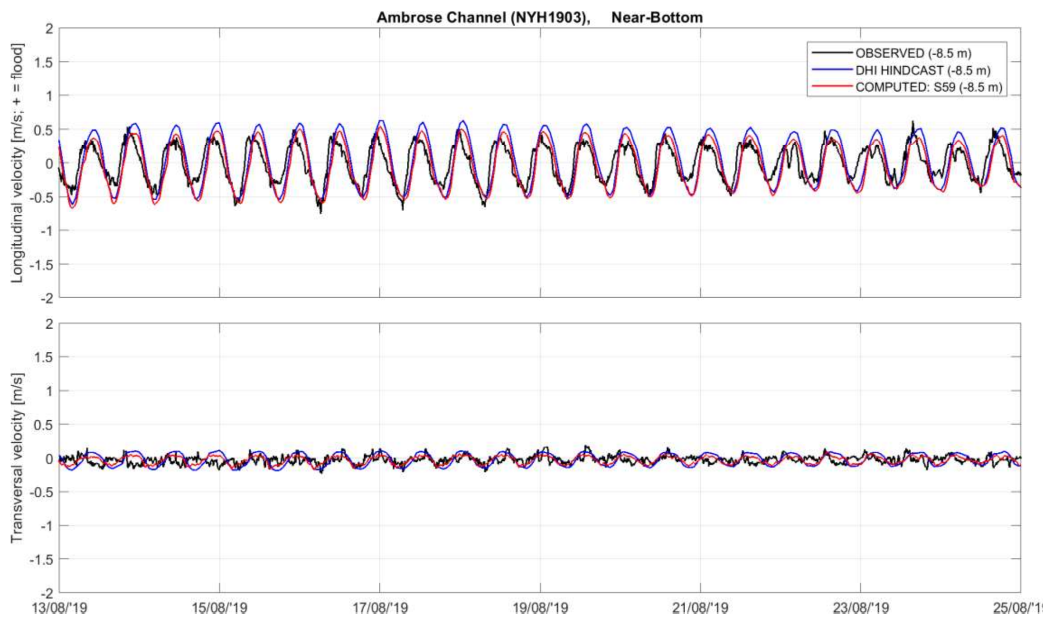


Figure C.3 Comparison of observed versus computed velocity magnitude at Ambrose Channel (NYH1903), near-bed.

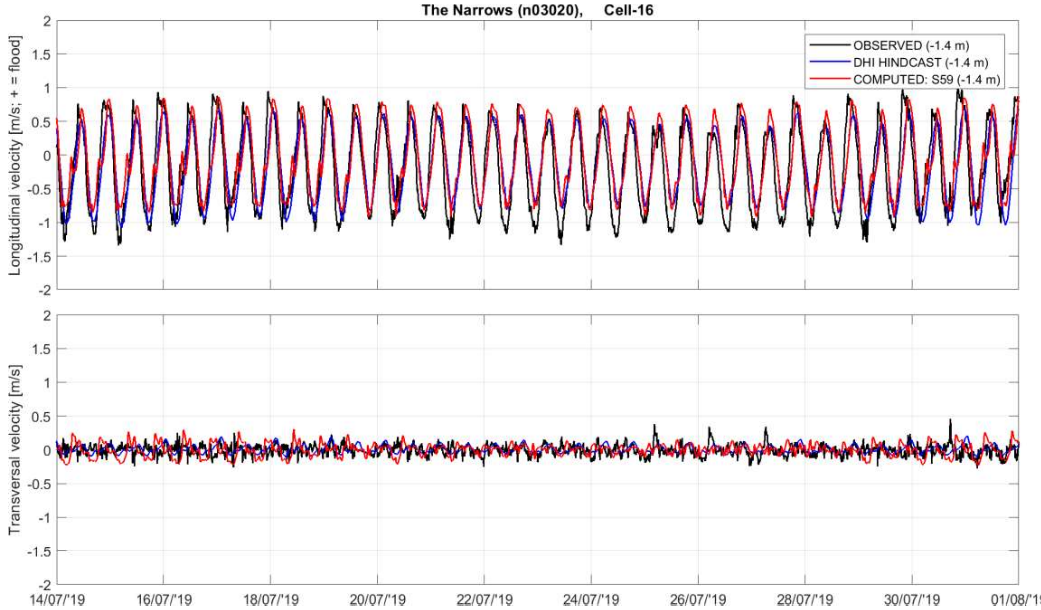


Figure C.4 Comparison of observed versus computed velocity magnitude at The Narrows (n03020), near-surface.

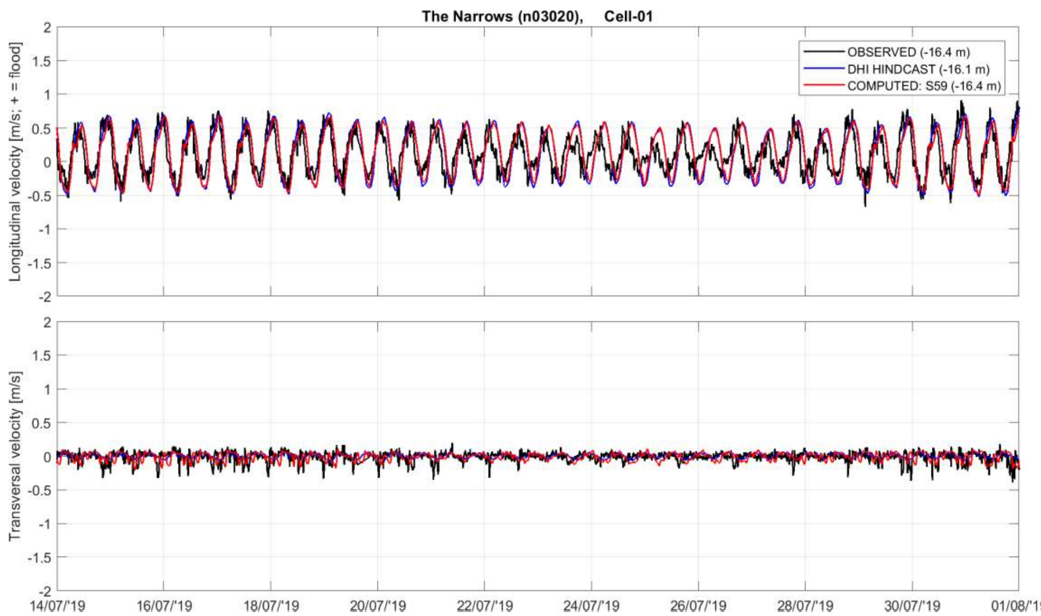


Figure C.5 Comparison of observed versus computed velocity magnitude at The Narrows (n03020), near-bed.

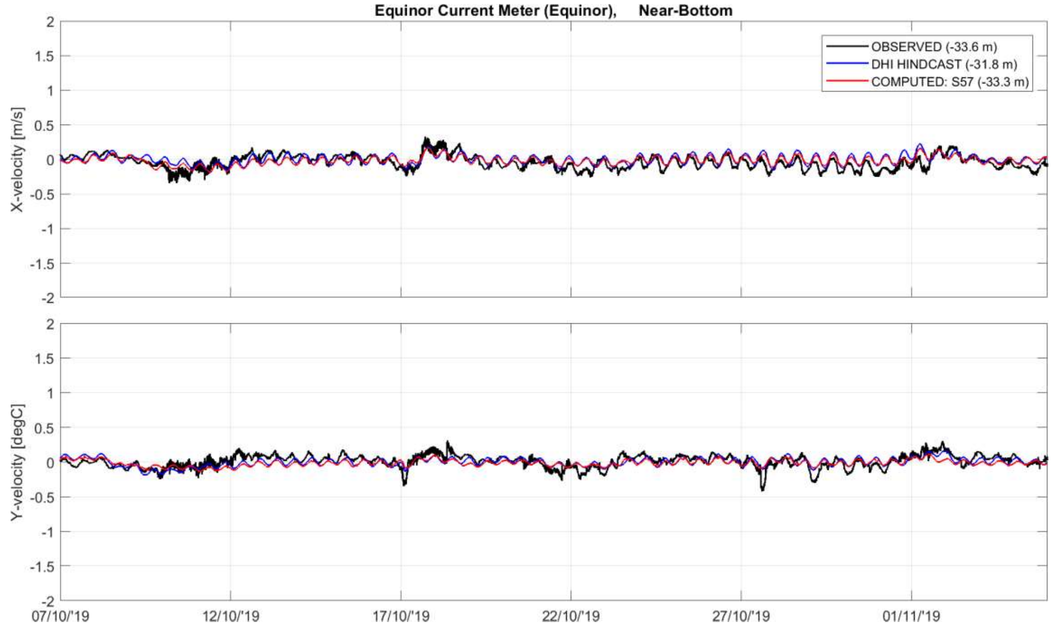


Figure C.6 Comparison of observed versus computed velocity magnitude at Equinor, near-bed.

Salinity

Figure C.7 presents the timeseries comparison against measured near-surface salinity levels at 5 locations in the Hudson River for the period of June to October 2019 by HRECOS (see Appendix B.1). Even though the upper 3 plots refer to locations which are not included in the Delft3D4 model, these plots are still valuable, since they indicate the validity of the DHI hindcast model that was used as a source for the boundary conditions. The comparison shows that Delf3D model is consistent with the DHI hindcast model (see lower 2 plots), which basically validates the nesting procedure. The comparison against the measured data shows that the DHI hindcast model (and therefore also the Delft3D model) are capable of simulating the trends in the salinity timeseries as well as the spatial variation along the Hudson river. It is noted that the measurements in the lowest plot do not seem reliable, given the large differences compared to the neighboring location.

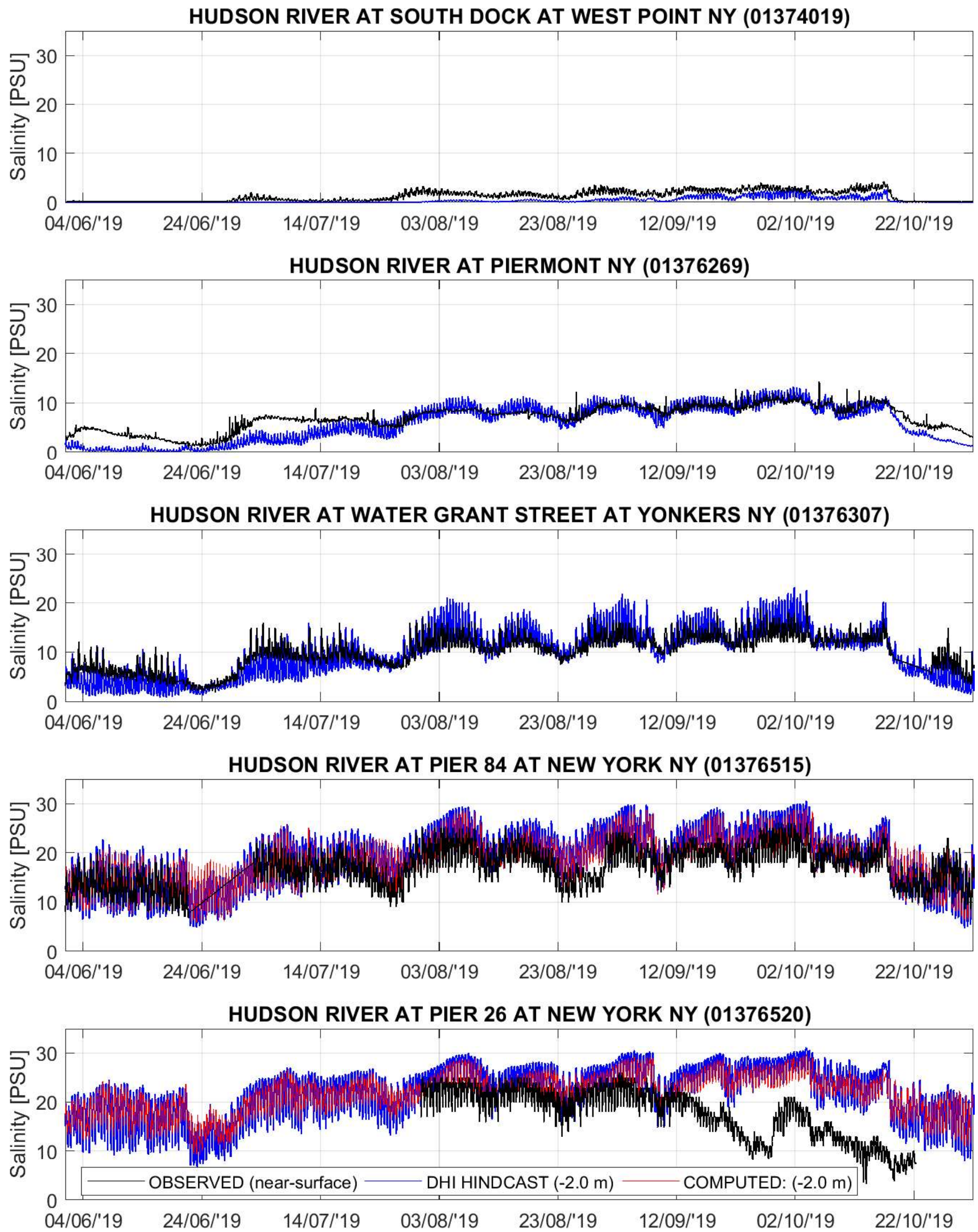


Figure C.7 Overview of salinity validation at Hudson River

D Wave model setup and validation

A local wave model (Delft3D-WAVE) has been set-up that will provide the wave forcing input to the sediment transport model. The Delft3D-WAVE module makes use of the numerical wave model SWAN. SWAN is widely used for nearshore wave modelling in the international coastal engineering community and has been successfully validated under a large variety of field cases and conditions.

The wave model forcing conditions (offshore wave boundary forcing and surface wind forcing) are taken from the data provided by DHI (2021, see Appendix B.2) and was validated by comparing hindcast model results against observed local wave measurement data. In Subsection D.1 an overview is given of the model set-up. In Subsection D.2 the calibration and validation of the wave model is presented.

D.1 Model setup

The wave model applies the same grid as the hydrodynamic model. At the offshore side the wave grid was extended with a single row of cells, which is common practice to facilitate a smoother transition between the hydrodynamic and wave model, once coupled.

At the offshore boundary the model is forced with parametric wave conditions (significant wave height, H_s, peak wave period, T_p, mean wave direction, MWD, and directional spreading, DSpr). The source data for this is model output from the DHI wave model (Appendix B.2). The spectral shape, γ, was assumed to be constant for all computations, being a JONSWAP shape (Hasselmann et al., 1973) with a value of $\gamma = 3.3$. The exact value of γ prescribed along the boundary is not critical, since the model will automatically properly redistribute the wave energy in the frequency domain and in balance with the wind forcing. The offshore boundary is divided in 46 sections (every 4 cells) where for each of the subsection's corner points data from the closest DHI output point is taken. Figure D.1 gives an overview of the wave model grid and offshore boundaries.

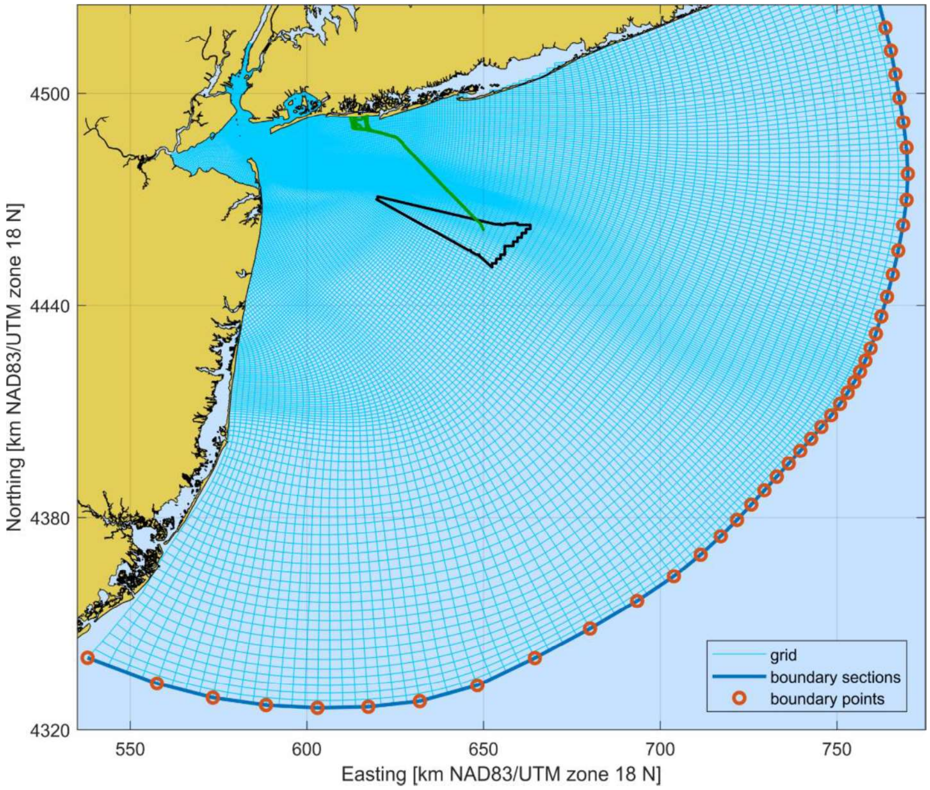


Figure D.1 Overview wave model grid and boundary sections

At the surface the model is forced with time-and spatially varying wind data (u- and v-components of the wind speed). The surface wind forcing was also provided by DHI and originates from the NOAA's NCEP CFSR data[3].

The model's bathymetry is made up out of a composite set of the bathymetric survey data, extended with bathymetry samples from the DHI wave model. Figure D.2 gives an overview of the wave model bathymetry.

[3] https://climatedataguide.ucar.edu/climate-data/climate-forecast-system-reanalysis-cfsr

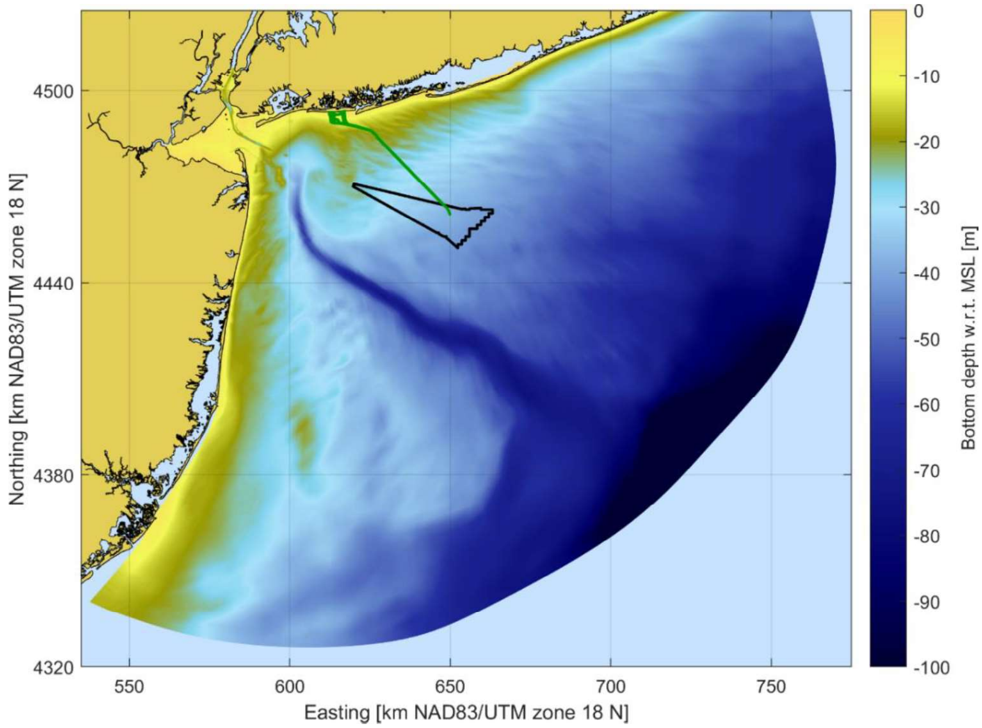


Figure D.2 Overview wave model bathymetry.

For the validation of the wave model a hindcast (2000-2020) of the wave conditions has been performed from which a comparison is made of the model results with wave data from observations, both in a qualitative and quantitative matter. The model validation is discussed in Subsection D.2. The model was run in non-stationary mode for the model validation (i.e., taking the evolution of the wave conditions in time into account under the changing forcing conditions, which is in contrast to a stationary mode in which the model runs iterations for each individual time point until a steady state is reached for the active forcing conditions at that time point, which leads to fully developed sea state for each time point). The model uses a timestep of one hour, which is equal to the time step of the wave boundary data and input wind fields (DHI, 2021).

This section lists detailed settings for physical parameters and numerical aspects within the SWAN model that followed from wave model calibration. Several settings were tested to find the most optimal results. It is primarily included here for recording purposes, e.g. for possible future interpretation or reproduction of results. General readers may opt to skip this section.

The modelling was carried out using SWAN, version 41.20. The most relevant applied wave physics settings in the computations are:

- Dissipation of wave energy by bottom friction and wave breaking (wave steepness-induced and depth-induced) have both been applied in the computations.
- Dissipation by bottom friction the JONSWAP formulation (Hasselmann et al., 1973) with a friction coefficient of 0.038 m^2s^{-3} (Zijlema et al., 2012) has been applied.
- Dissipation by depth-induced wave breaking the Battjes-Janssen formulation (Battjes and Janssen, 1978) with a proportionality coefficient of 0.73 has been applied.
- For representing the effects of white-capping, the formulations by Rogers et al. (2003) have been applied, which is default setting since SWAN version 40.91.
- For the wind drag the default Wu (1982) approximation of the Charnock relation has been applied.

The criteria for numerical accuracy thresholds were set as follows:

- The directional grid in SWAN covers the full circle (360°). The number of directional bins was set to 45, resulting in a directional resolution of 8°.
- The spectral grid of the numerical model covers a frequency range from 0.03 Hz to 0.6 Hz, allowing for representation of wave periods ranging from 1.67 s to 33.33 s. The distribution of the frequencies, f, is logarithmic with a constant relative resolution, Δf/f, close to 0.1. This results in a total number of frequency bins of 32. This way of distributing the modelled frequencies over the extent of the considered frequency range ensures that the resolution at lower frequencies is not as coarse as it would have been if an equidistant distribution of frequencies had been applied.
- the computation is finished in case of changes in the second derivative of the iteration curve of the significant wave height are less than 1% and the absolute (relative) change in significant wave height from one iteration to the next is less than 1 cm (1%) at 99% of the grid points, and
- a maximal number of 60 iterations is allowed.

These settings mean that the computation will continue until a stable outcome has been reached for the modelled moment in time, with a maximum of 60 iterations to reach the result for that time step. Typically, 60 iteration steps will be sufficient, if not then often a setting in the model is incorrect or the computational grid is not optimal. In the computations performed for the present study, all timesteps after the two days spin-up period have been verified to have converged within 60 iterations, i.e., the computation has reached accurate numerical outcomes.

Spatial and time varying fields of multiple wave (-related) parameters (H_s, T_p, other spectral wave periods and MWD) were produced by the model as output at a time step of 1 hour (i.e. the computational time step). In addition, location-specific timeseries of the same set of parameters were generated in the numerical model to allow for a detailed validation of the model outcomes. Comparing measured and computed values at those locations gives an indirect verification of the accuracy of the results in the full domain modelled.

D.2 Model calibration & validation

For the validation of the wave model a hindcast of the wave conditions has been performed from which a comparison is made of the model results with wave data available from observations (3 stations, within the model domain, i.e., Equinor, NDBC44025, NDBC44065, see Appendix B.2), both in a qualitative and quantitative matter. For the qualitative comparison a visual comparison is made, plotting observed and modelled timeseries for the main wave parameters (H_s, T_p and MWD) for the periods for which observation data is available. Timeseries comparison are made presenting the full observation wave data periods and inspecting individual peaks. For the quantitative comparison density scatter and percentile comparisons including the main statistics of the data comparisons such as the correlation coefficient, root-mean-square errors, bias and standard deviation are presented. The results for the Equinor wave data location are presented below.

Figure D.3 present the timeseries comparison of the observed versus computed wave parameters for the full Equinor wave data period (December 2018 – November 2020). In Figure D.4 a density scatter plot is presented including the main statistics for the significant wave height. In Figure D.5, plots are presented for the periods around the 5 highest significant wave height peaks in the observation data to allow for a better visual assessment of the performance of the model. Included in these plots are also the DHI hindcast data.

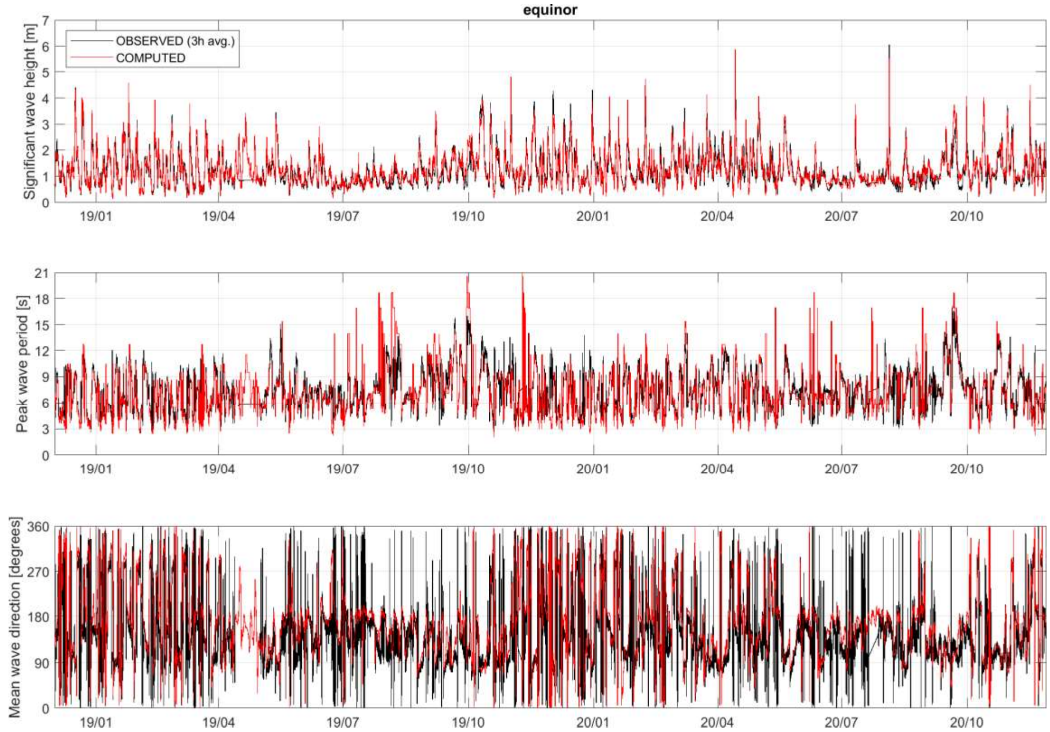


Figure D.3 *Comparison observed versus computed significant wave height (upper panel), peak wave period (middle) and mean wave direction (bottom).*

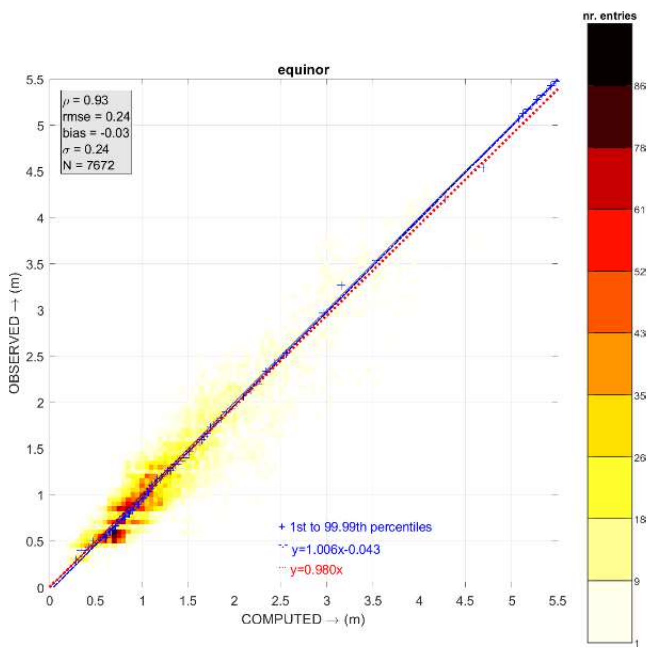


Figure D.4 *Density scatter plot computed versus observed significant wave height, including main statistics.*

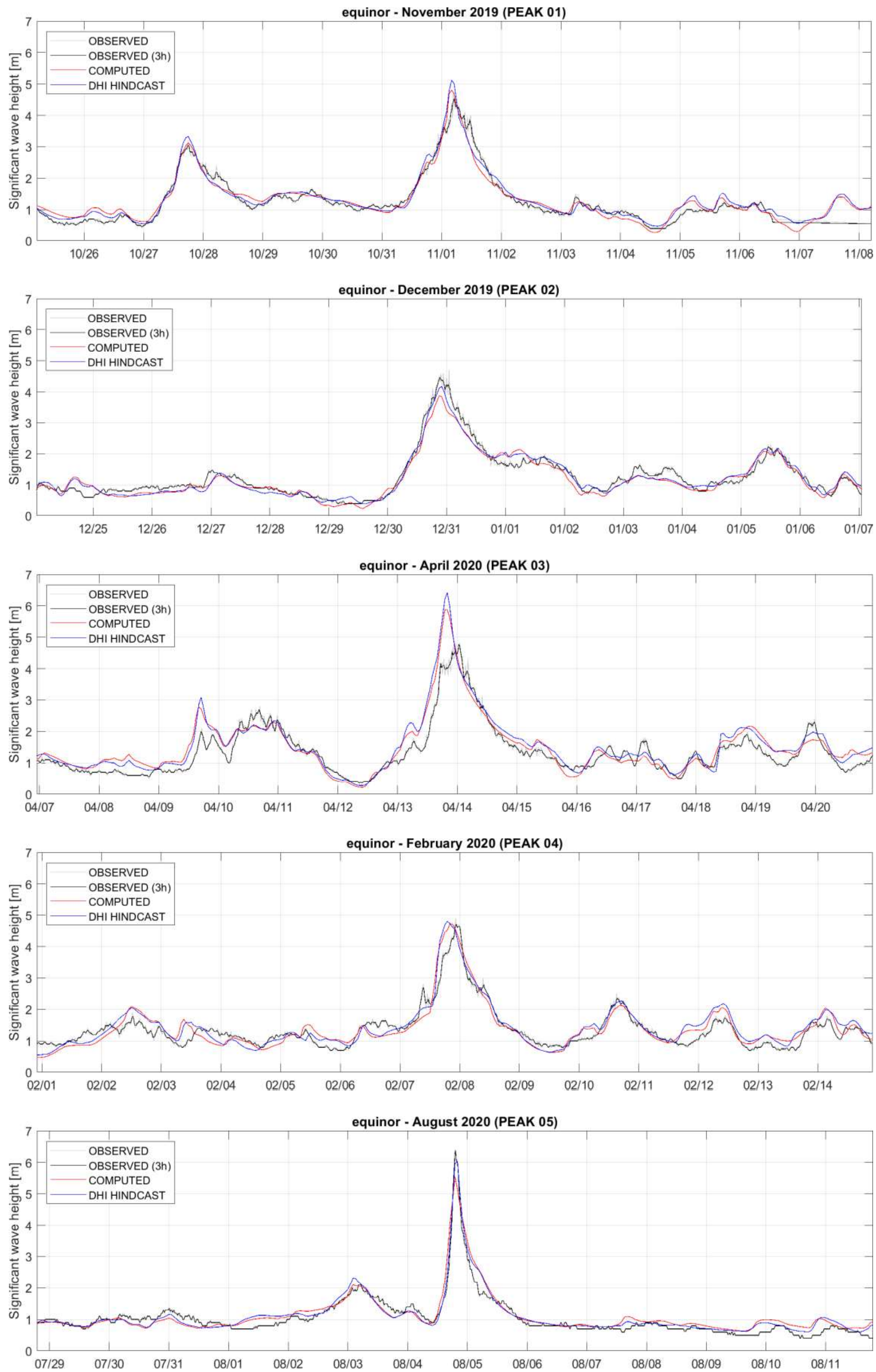
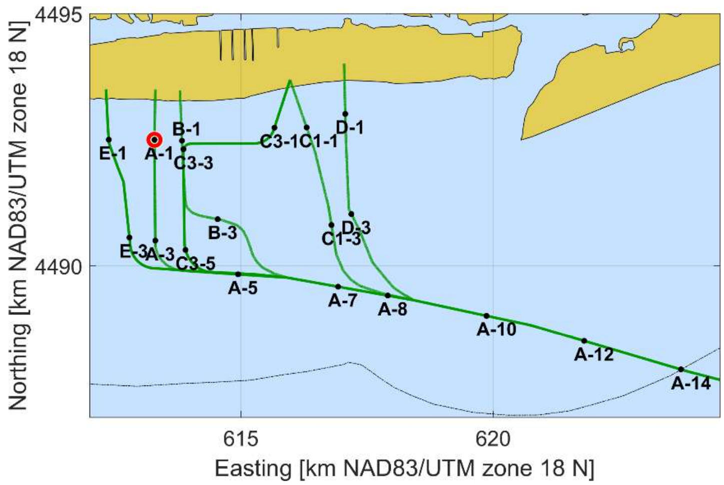


Figure D.5 Comparison observed versus computed significant wave height peaks.

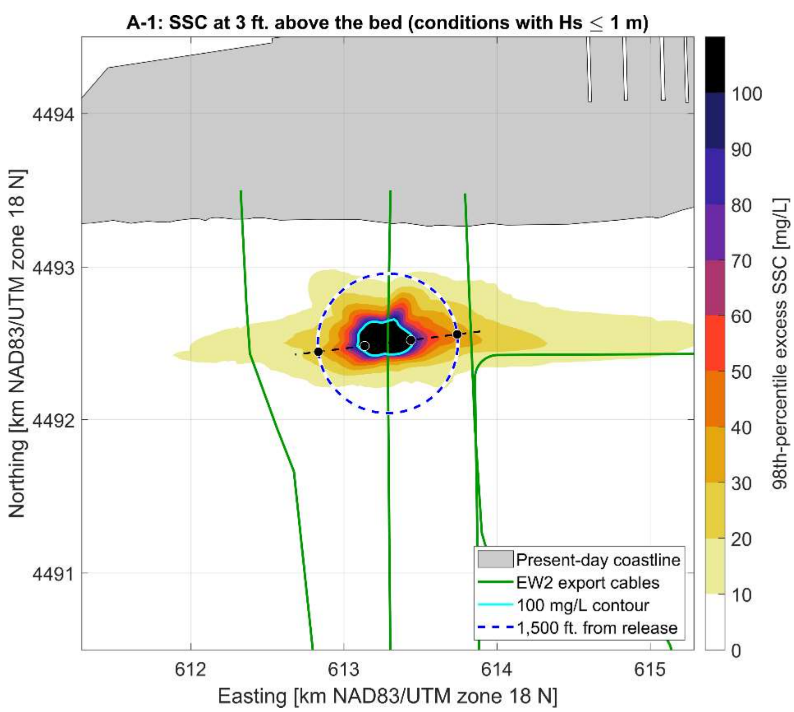
From the comparison of the wave model results with measurements it shows that the model is well capable of simulating the wave conditions in the area. On average an equal performance as the DHI output was reached with a correlation coefficient of 0.93, and RMSE of 0.24 m.

E Far-field modelling results (Capjet)

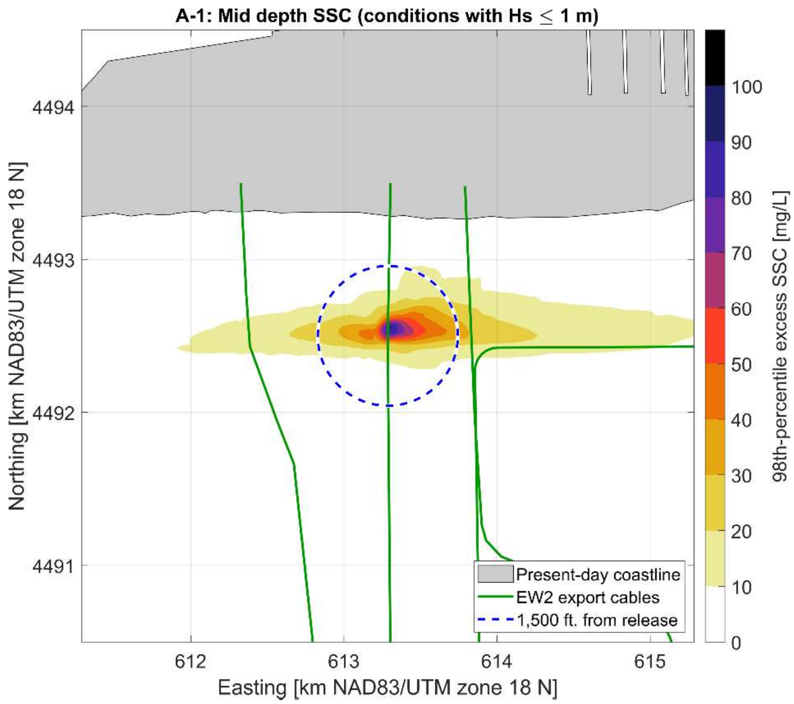
E.1 Release location A-1



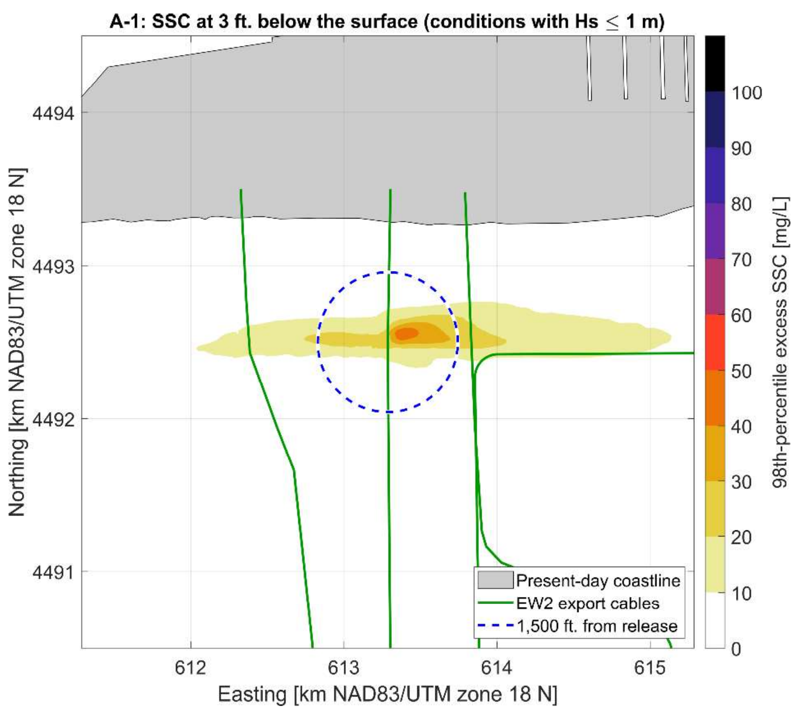
E.1.1 Sediment footprint with significant wave height ≤ 1 m



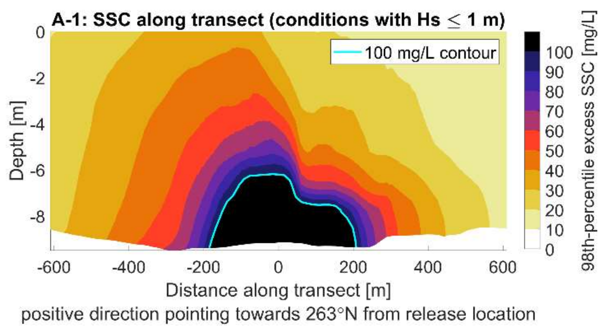
Deltares

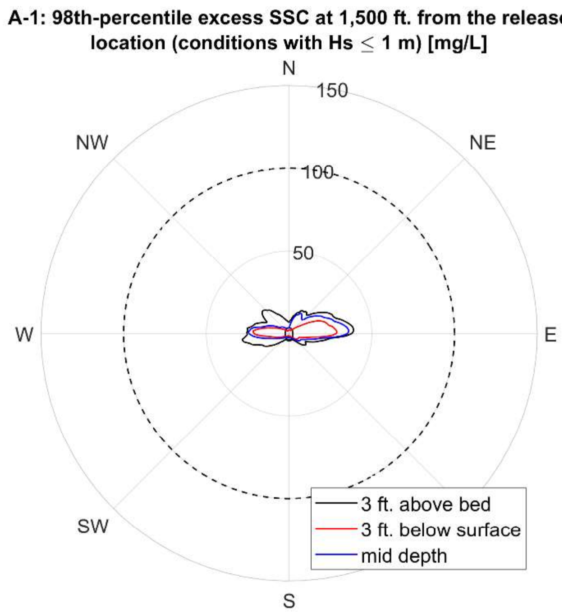


A-1: Mid depth SSC (conditions with Hs ≤ 1 m)
4494
4493
4492
4491
Northing [km NAD83/UTM zone 18 N]
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
Present-day coastline
EW2 export cables
1,500 ft. from release
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

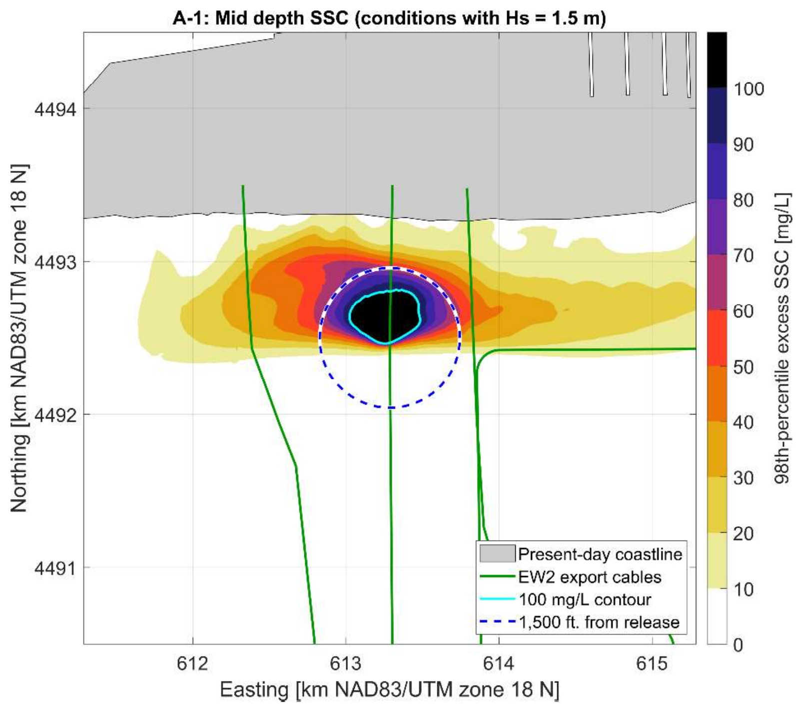


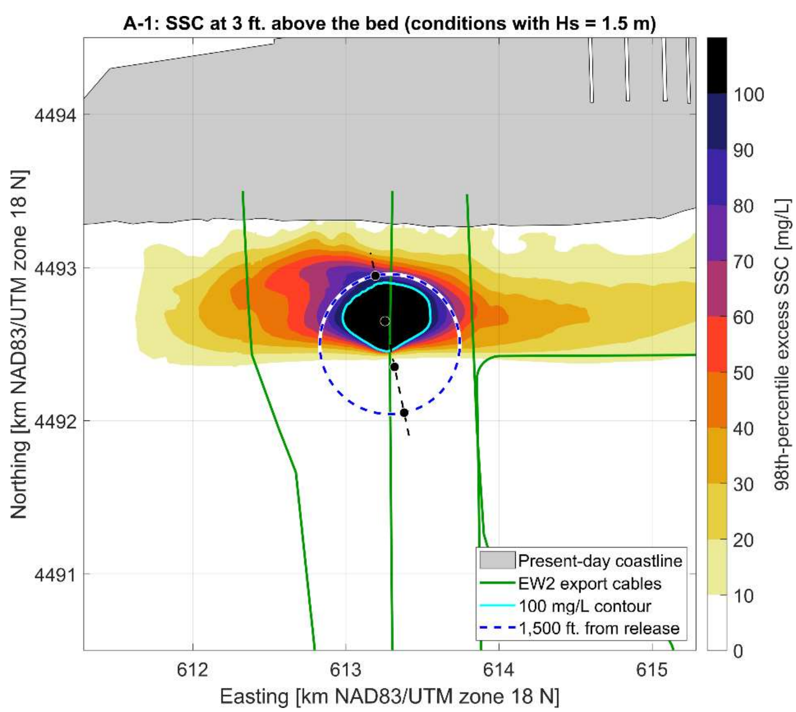
A-1: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
4494
4493
4492
4491
Northing [km NAD83/UTM zone 18 N]
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
Present-day coastline
EW2 export cables
1,500 ft. from release
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

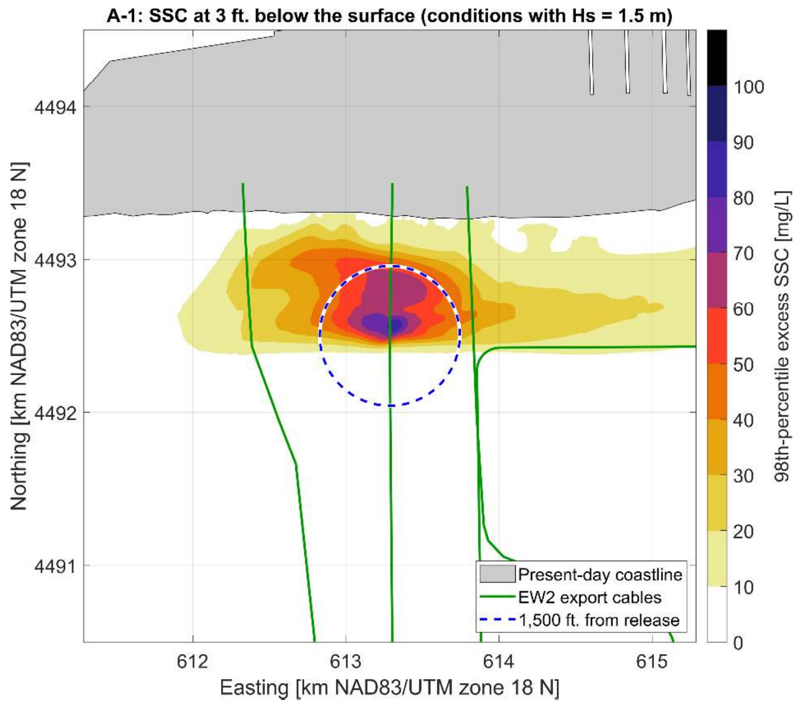

A-1: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 263°N from release location
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]


A-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
SW
S
NW
W
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

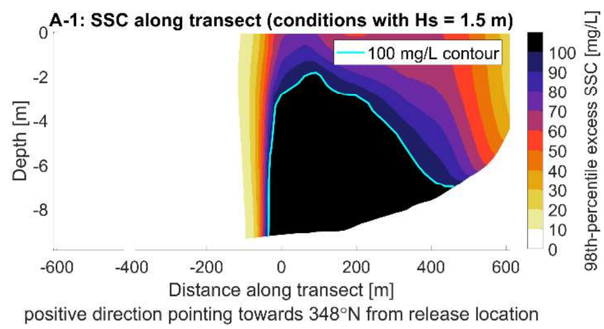
E.1.2 Sediment footprint with significant wave height ≈ 1.5 m



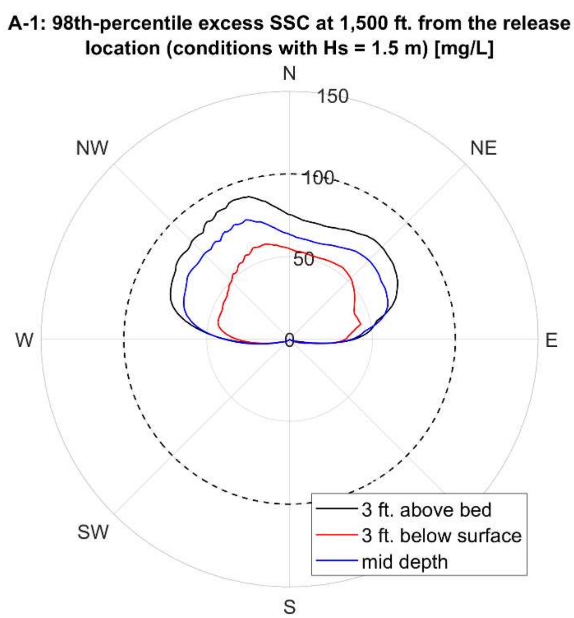




A-1: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
Present-day coastline
EW2 export cables
1,500 ft. from release

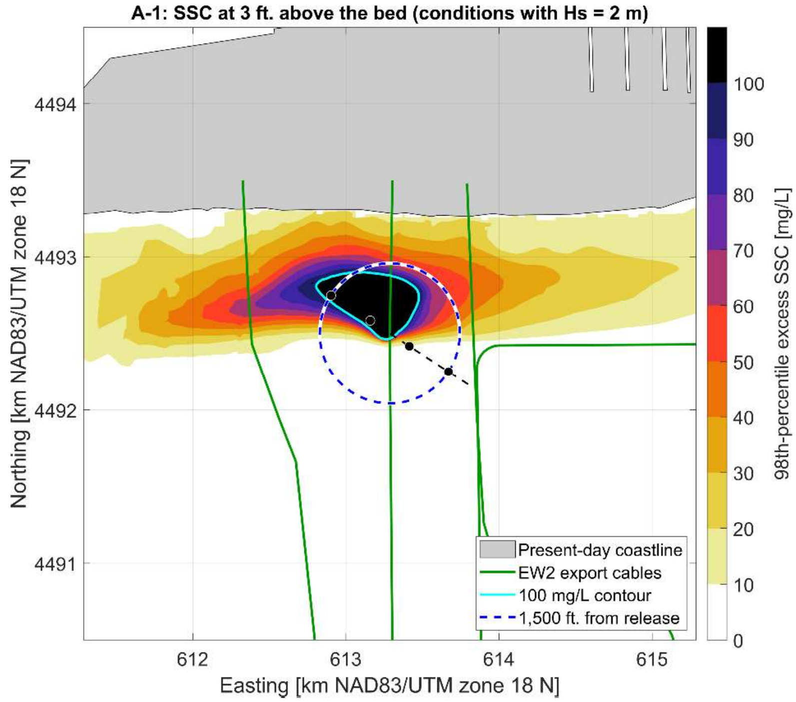


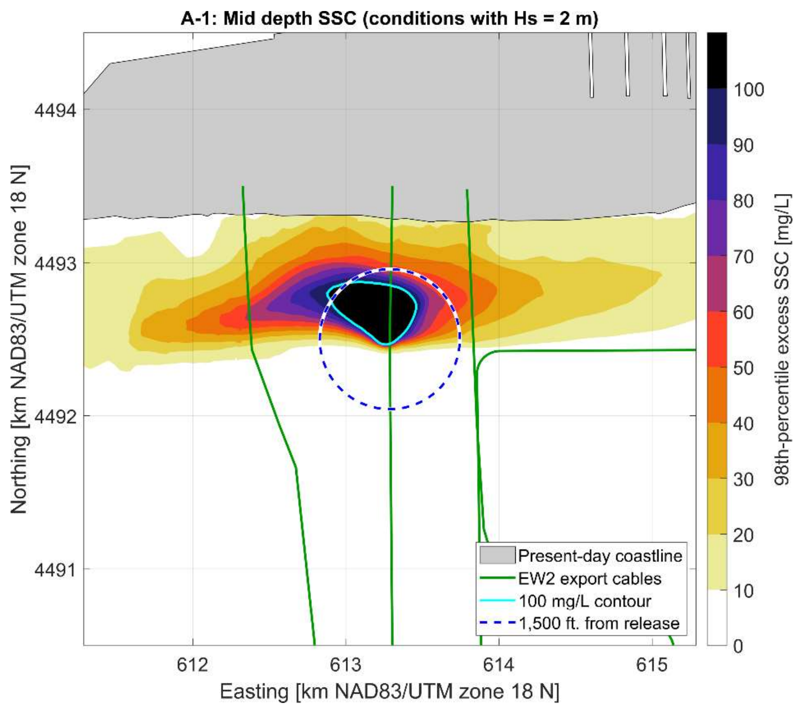
A-1: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 348°N from release location
98th-percentile excess SSC [mg/L]

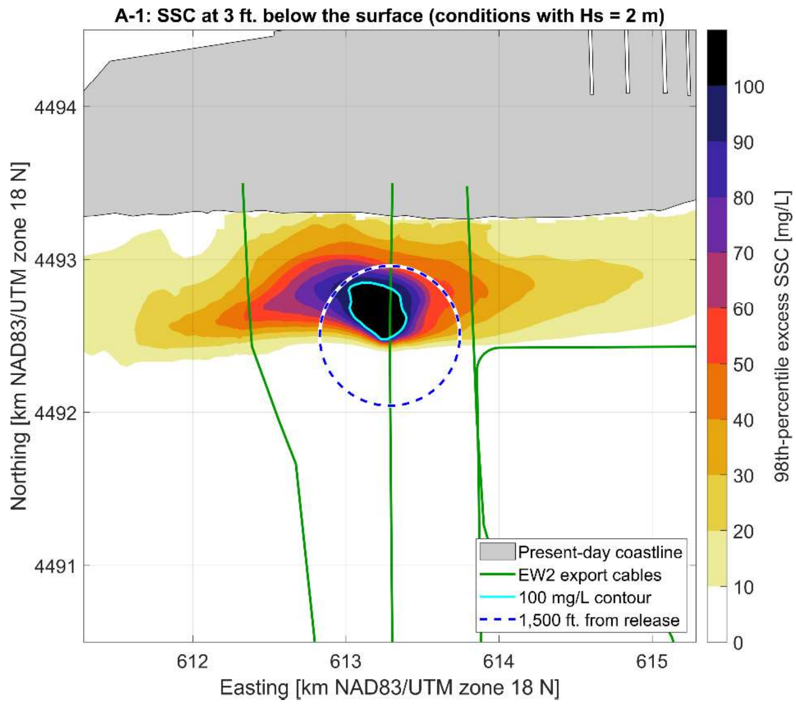


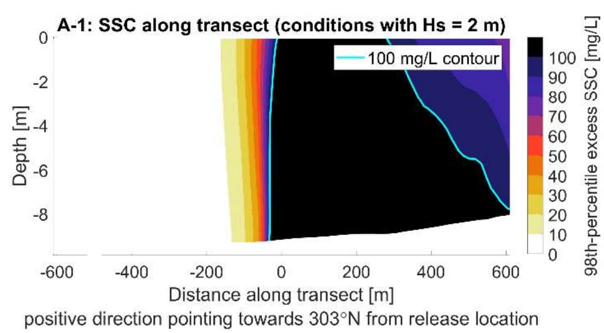
A-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
SW
S
W
NW
3 ft. above bed
3 ft. below surface
mid depth

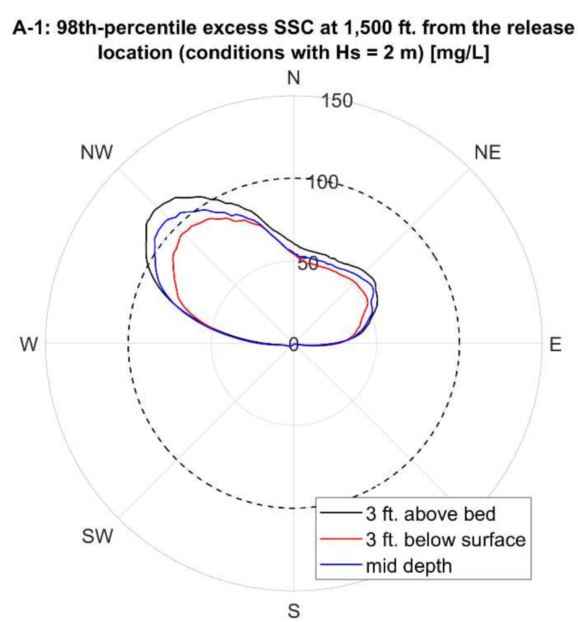
E.1.3 Sediment footprint with significant wave height ≈ 2 m



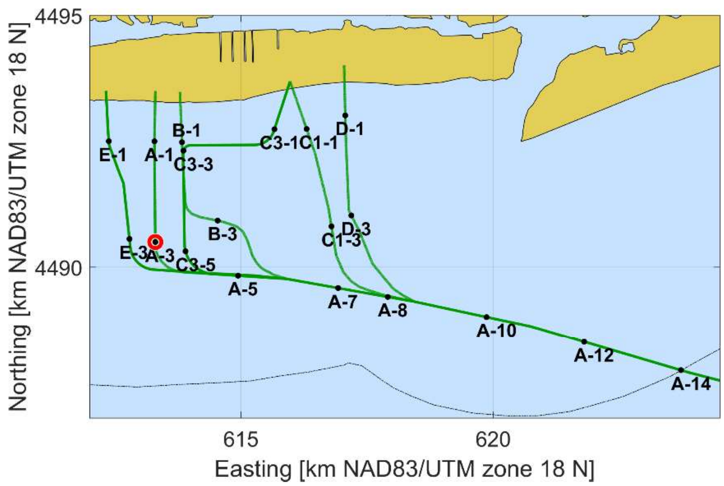



A-1: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
Present-day coastline
EW2 export cables
100 mg/L contour
1,500 ft. from release

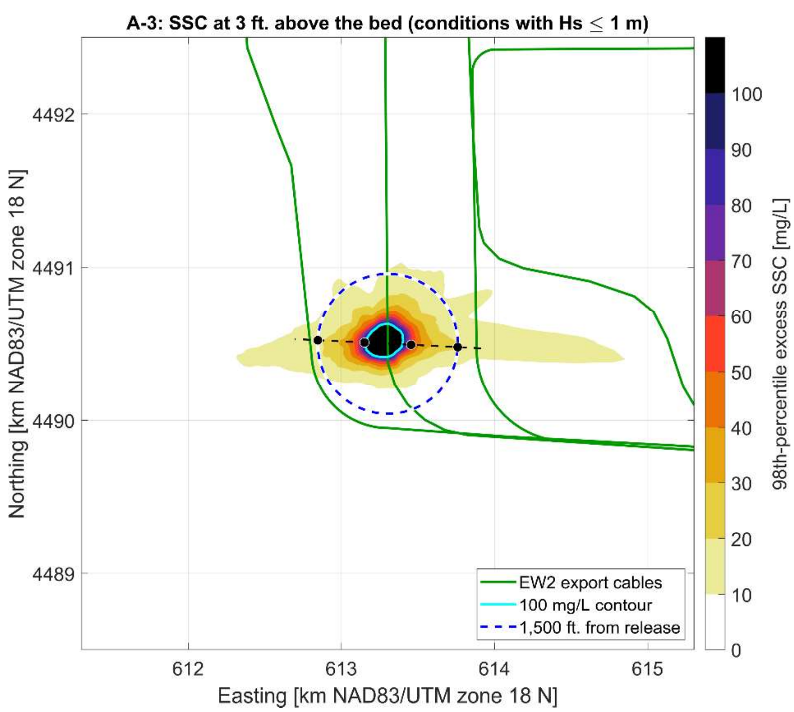

A-1: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
98th-percentile excess SSC [mg/L]
Distance along transect [m]
positive direction pointing towards 303°N from release location

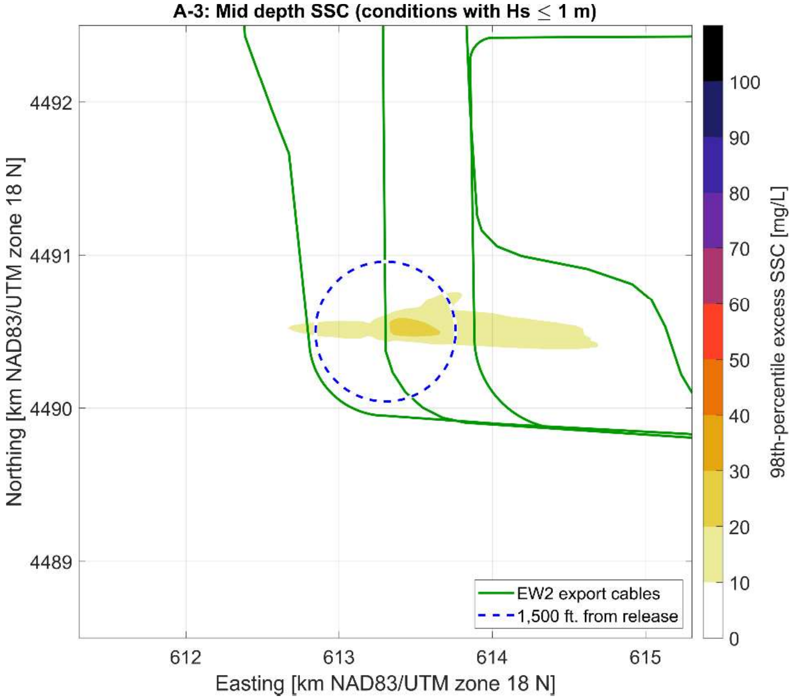

A-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
3 ft. above bed
3 ft. below surface
mid depth

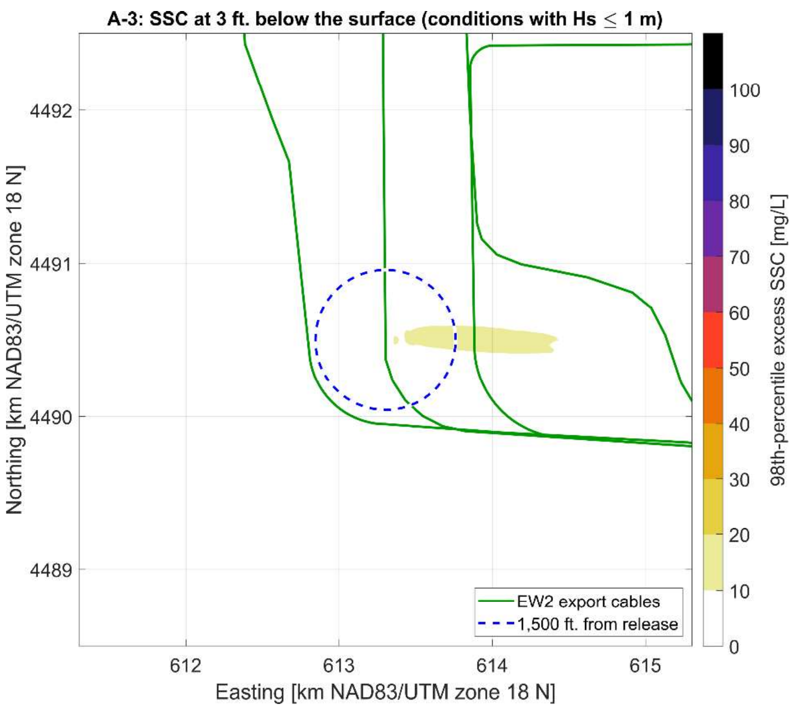
E.2 Release location A-3

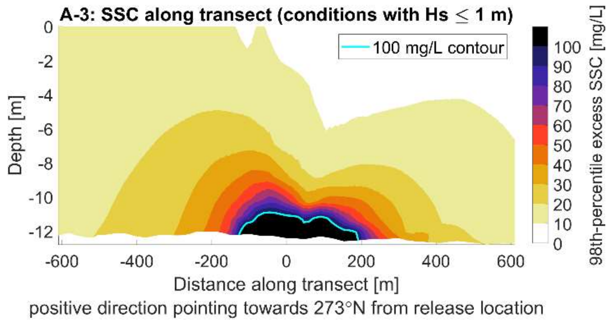


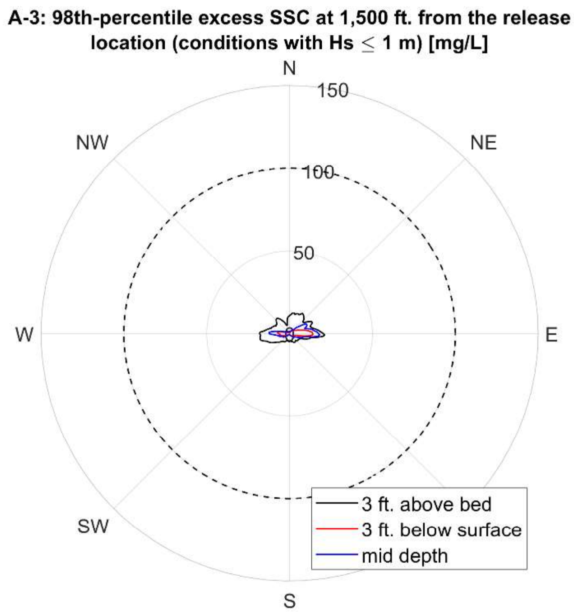
E.2.1 Sediment footprint with significant wave height ≤ 1 m



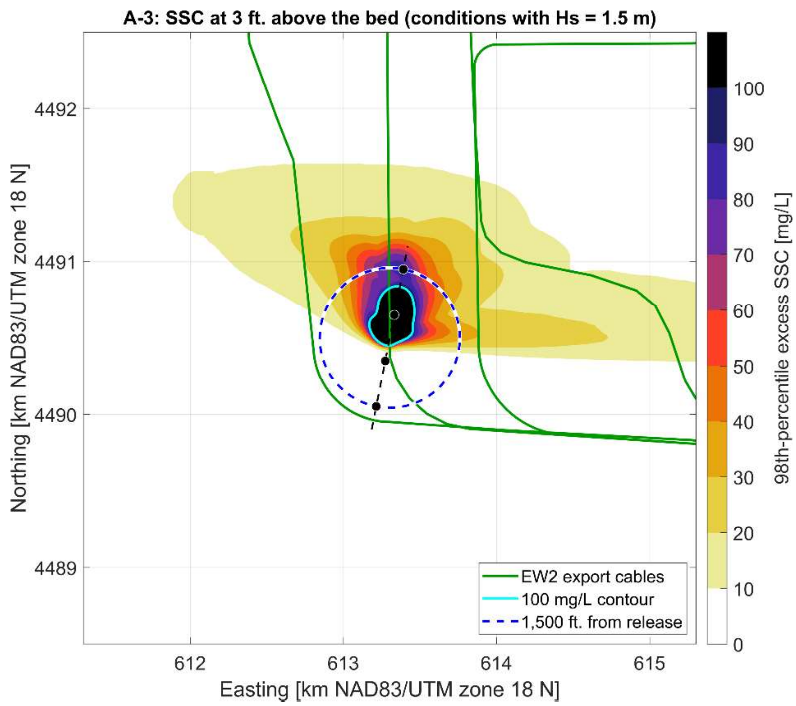

A-3: Mid depth SSC (conditions with Hs ≤ 1 m)
4492
4491
4490
4489
Northing [km NAD83/UTM zone 18 N]
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
0
10
20
30
40
50
60
70
80
90
100
98th-percentile excess SSC [mg/L]

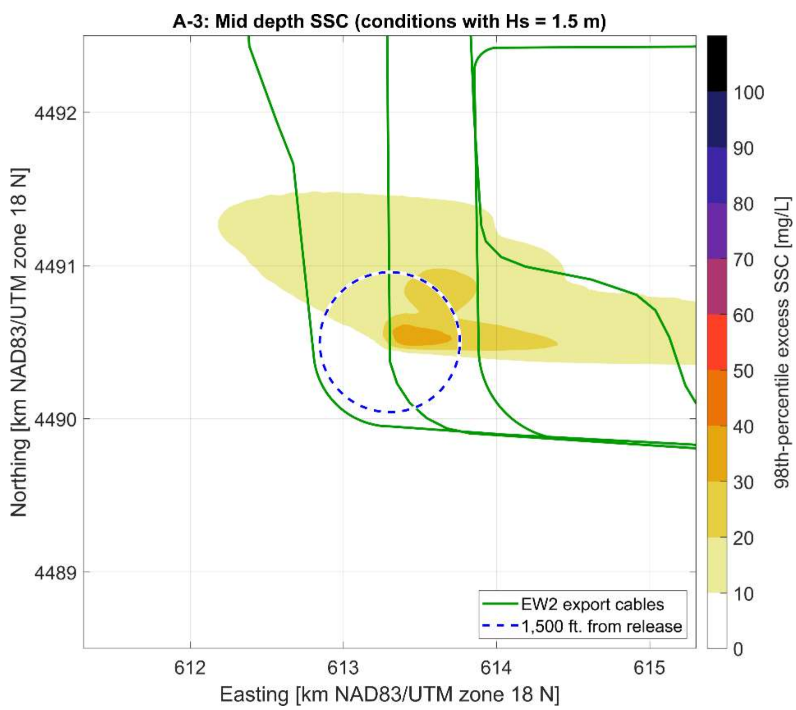

A-3: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
4492
4491
4490
4489
Northing [km NAD83/UTM zone 18 N]
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
0
10
20
30
40
50
60
70
80
90
100
98th-percentile excess SSC [mg/L]

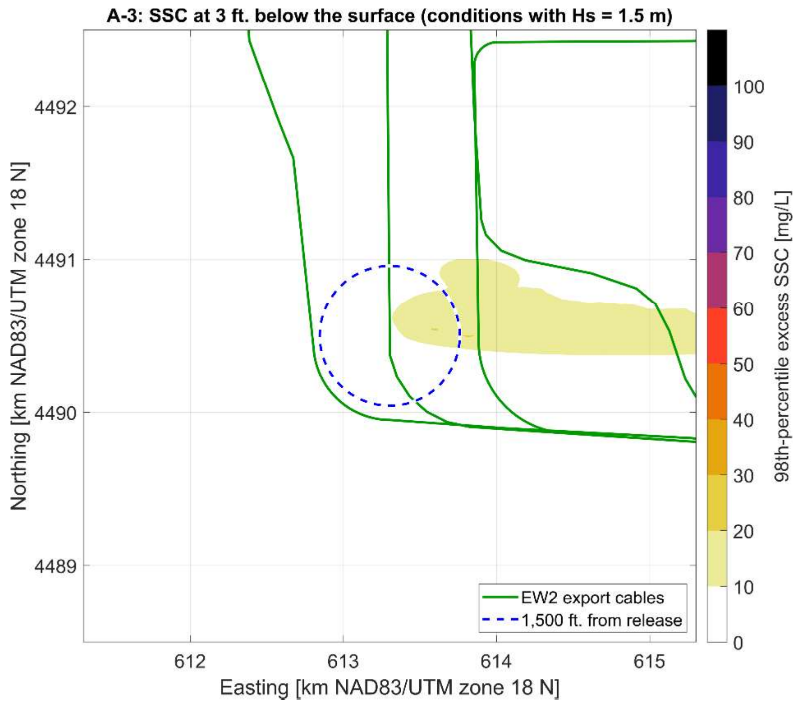

A-3: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 273°N from release location
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]


A-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

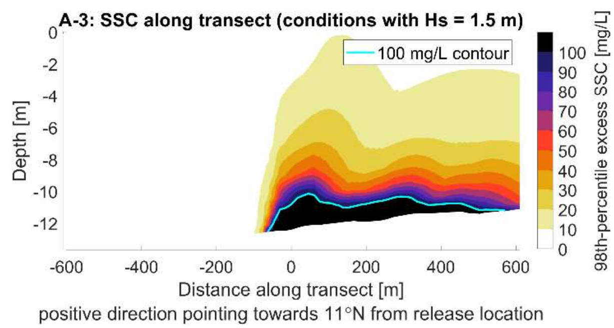
E.2.2 Sediment footprint with significant wave height ≈ 1.5 m



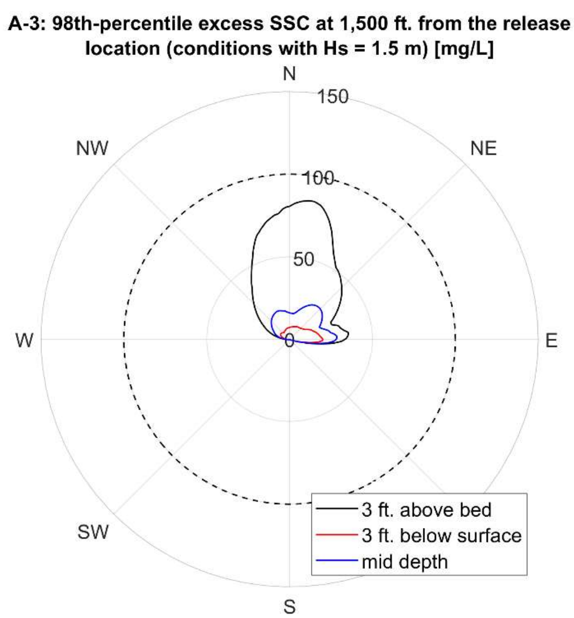




A-3: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
612
613
614
615
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100

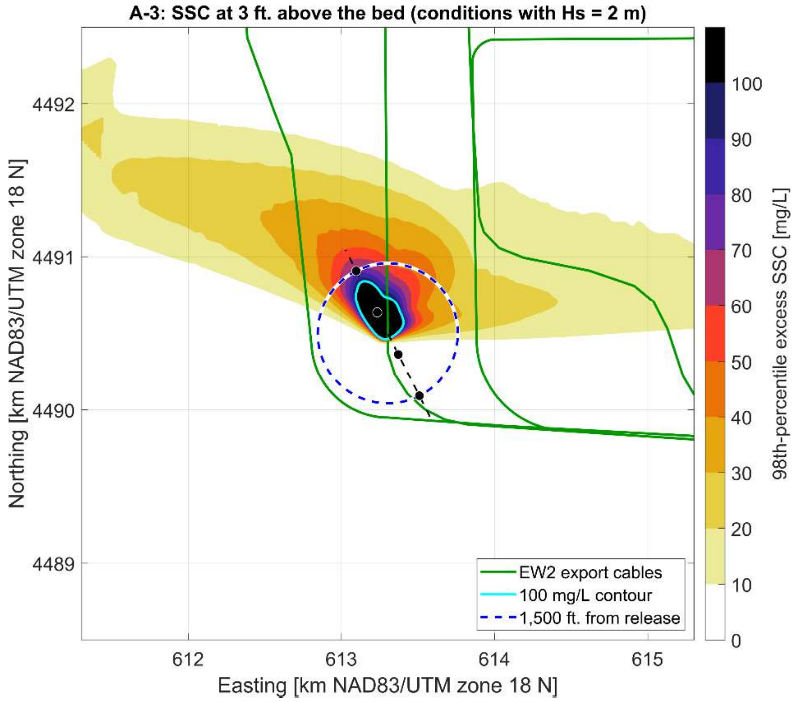


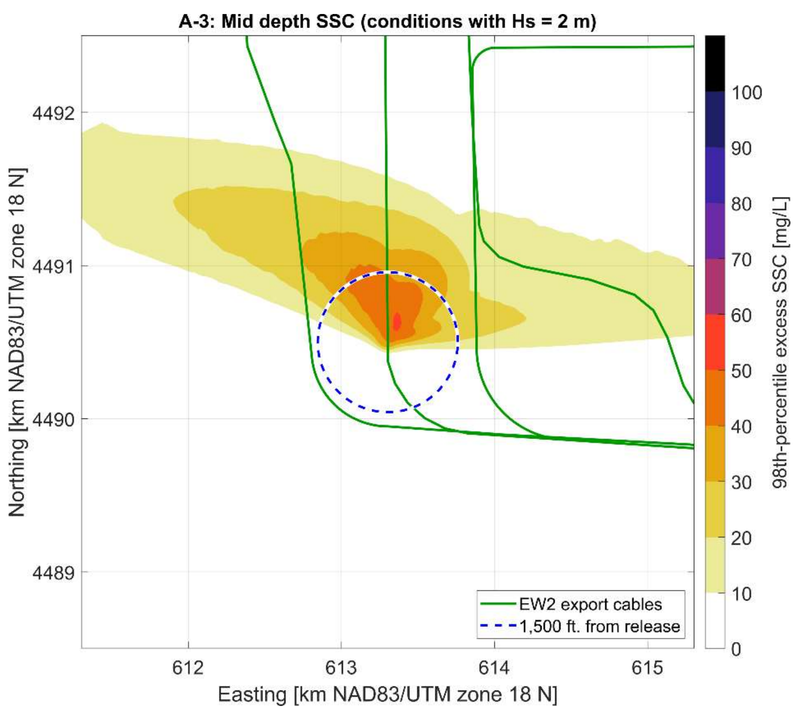
A-3: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 11°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

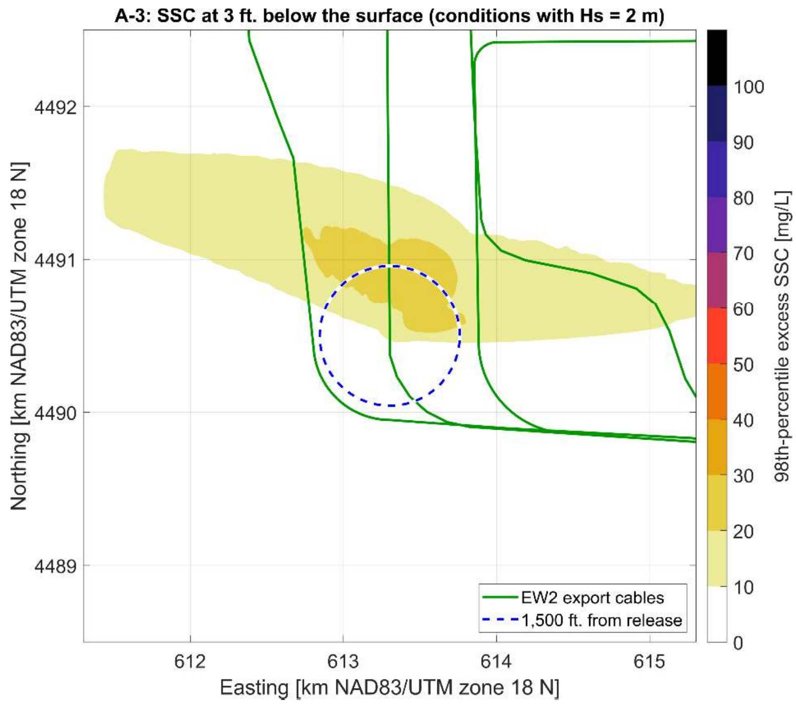


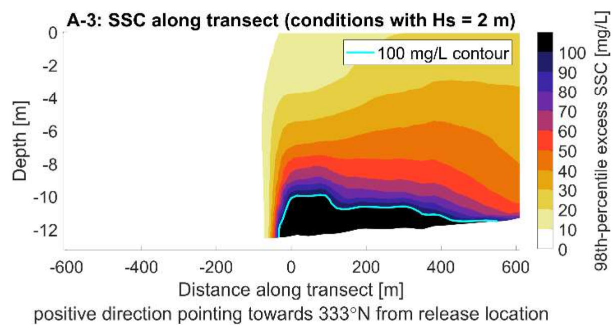
A-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

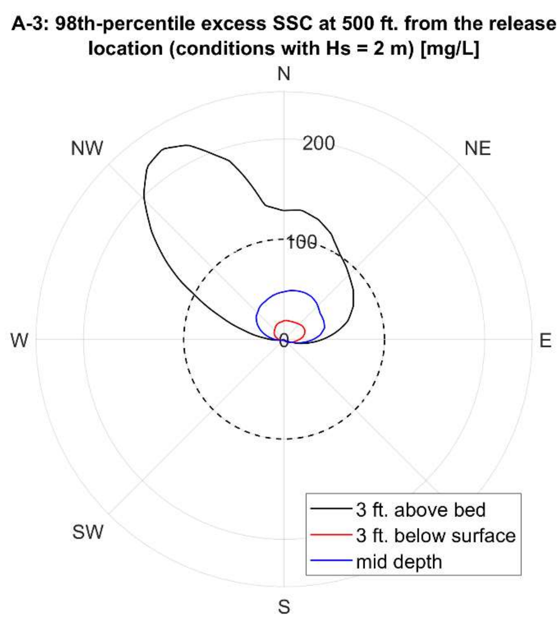
E.2.3 Sediment footprint with significant wave height ≈ 2 m



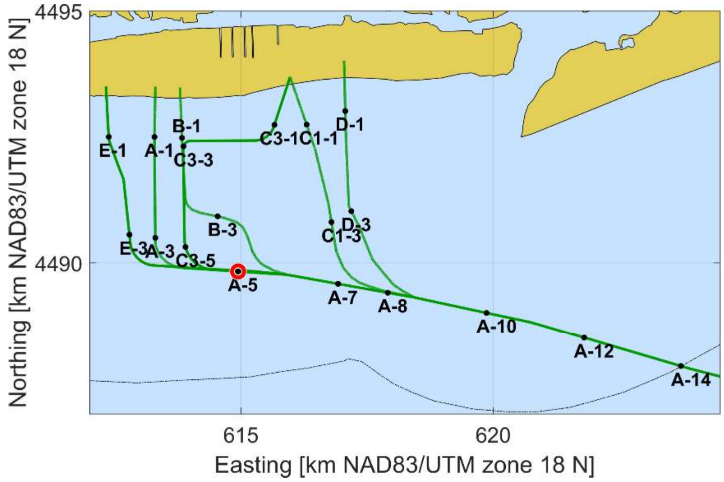



A-3: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release

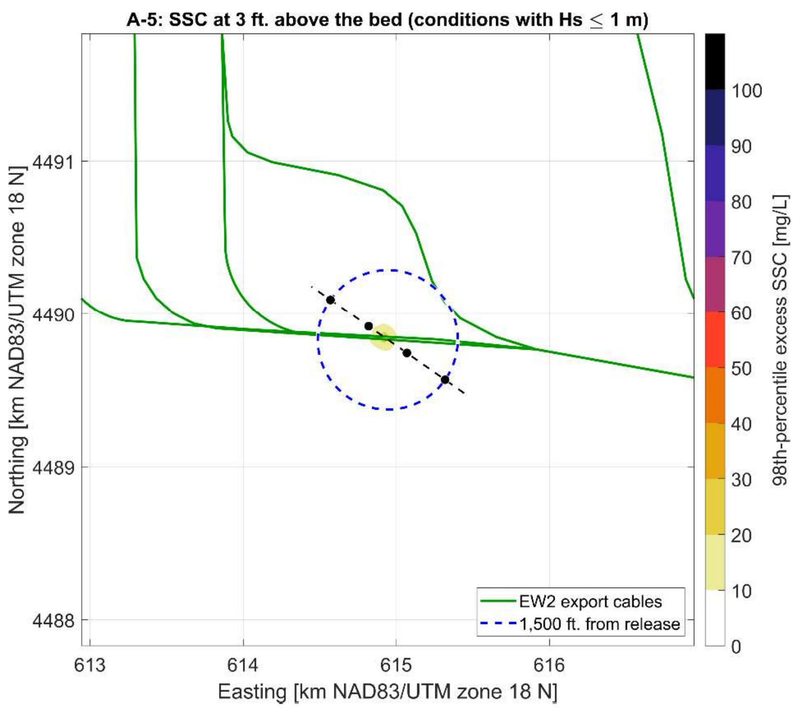

A-3: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 333°N from release location
98th-percentile excess SSC [mg/L]

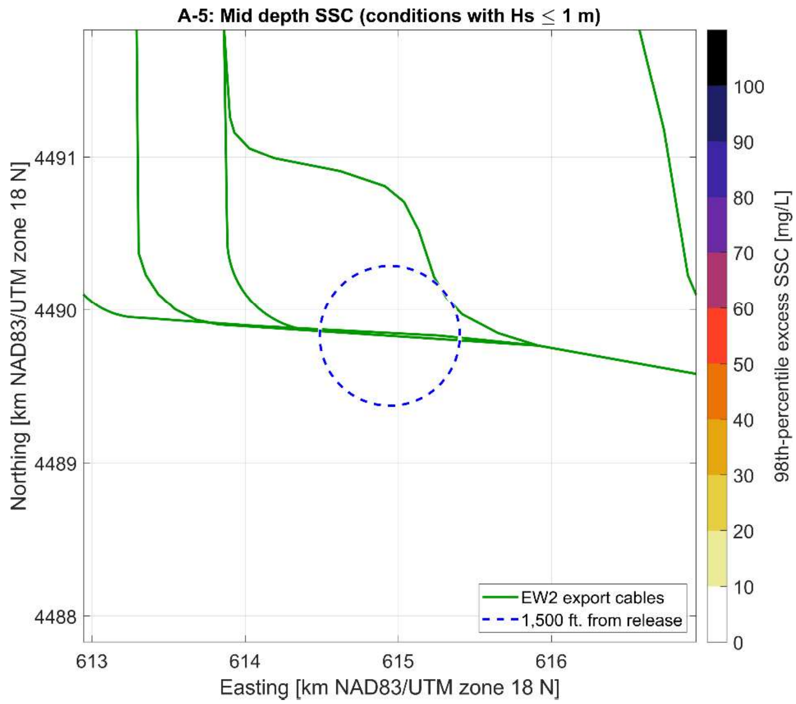

A-3: 98th-percentile excess SSC at 500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
SW
S
W
NW
3 ft. above bed
3 ft. below surface
mid depth

E.3 Release location A-5

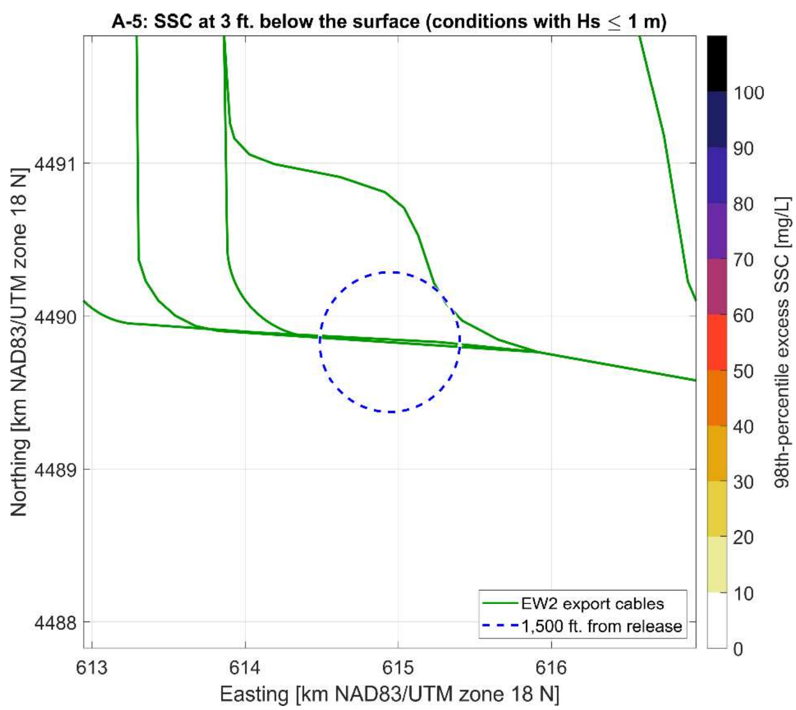


E.3.1 Sediment footprint with significant wave height ≤ 1 m

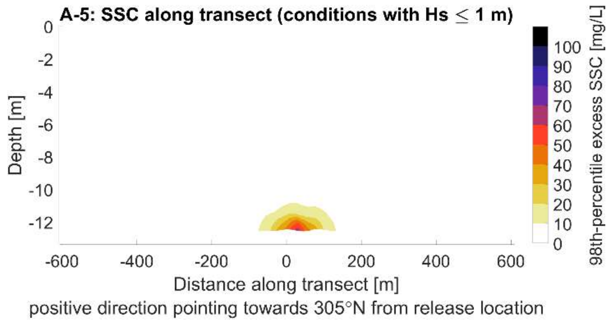


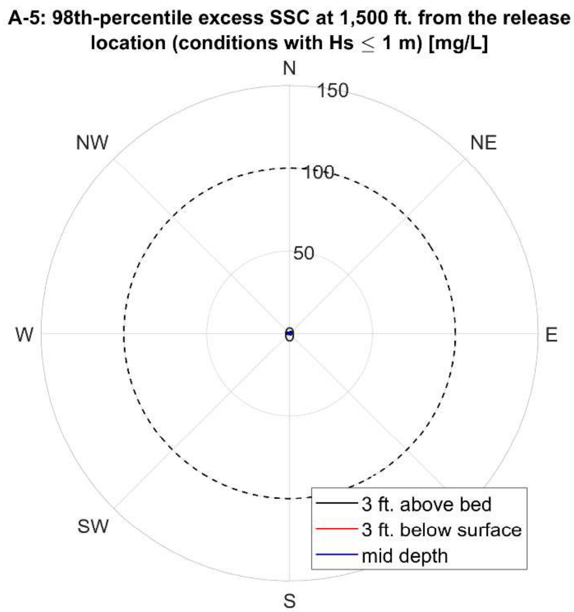


A-5: Mid depth SSC (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release
4491
4490
4489
4488
613
614
615
616
0
10
20
30
40
50
60
70
80
90
100

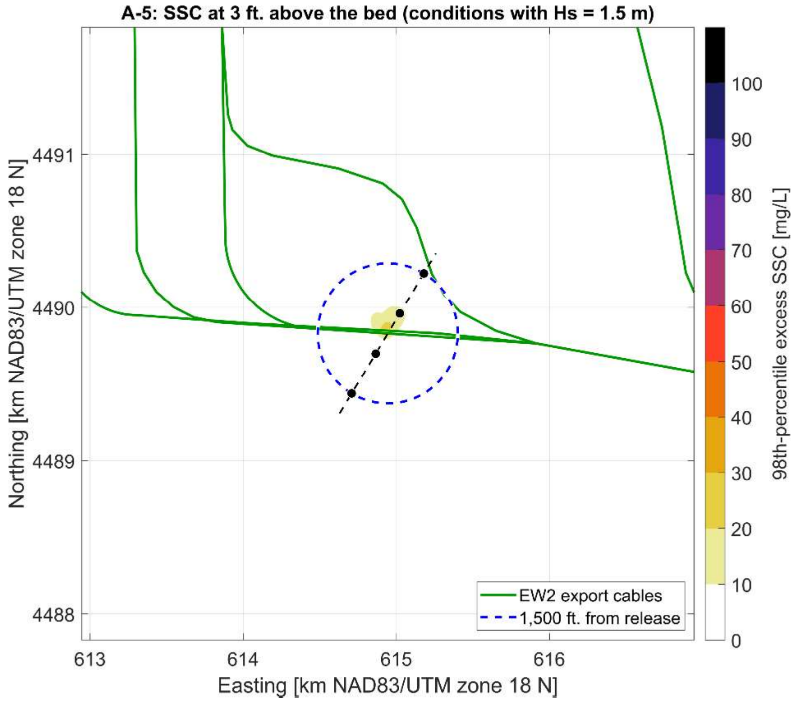


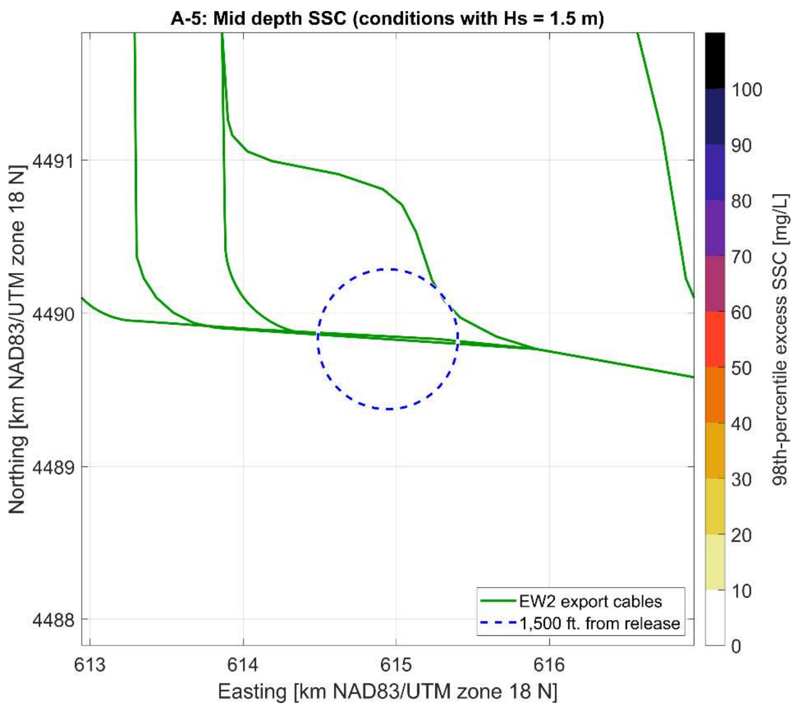
A-5: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release
4491
4490
4489
4488
613
614
615
616
0
10
20
30
40
50
60
70
80
90
100

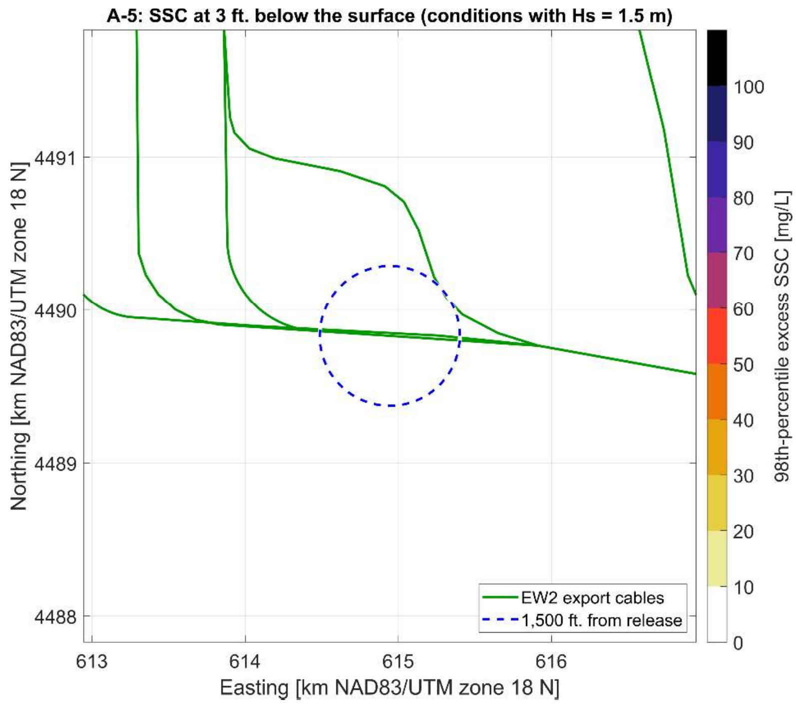

A-5: SSC along transect (conditions with Hs ≤ 1 m)
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 305°N from release location
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

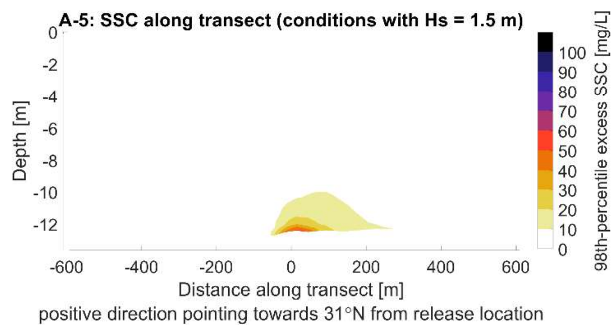

A-5: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

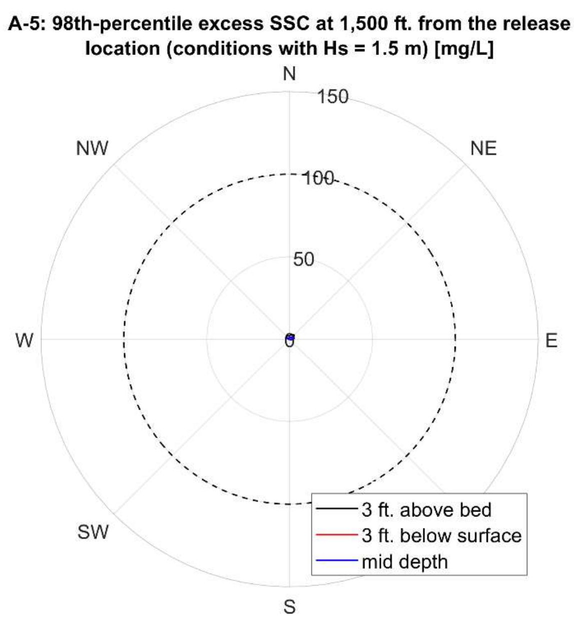
E.3.2 Sediment footprint with significant wave height ≈ 1.5 m



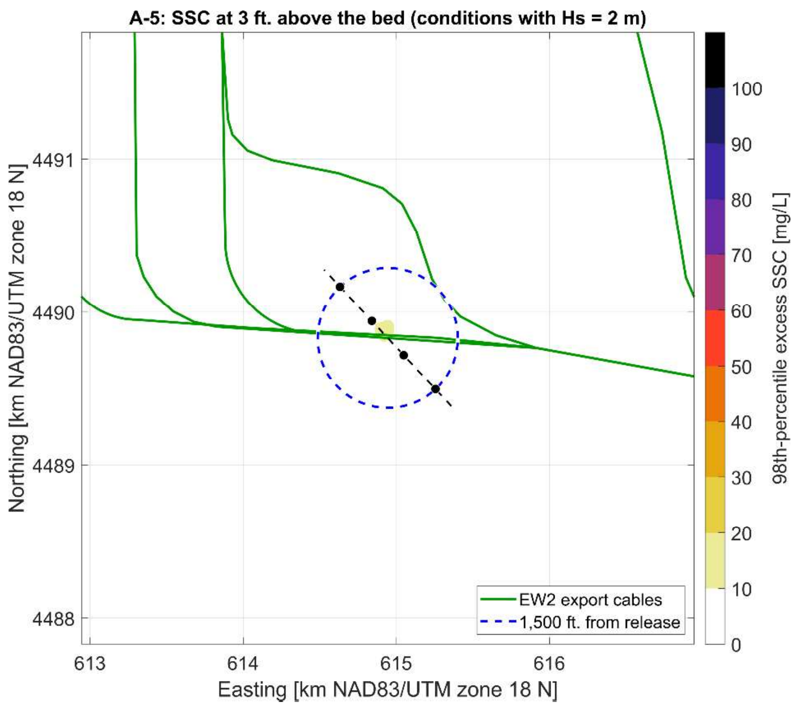


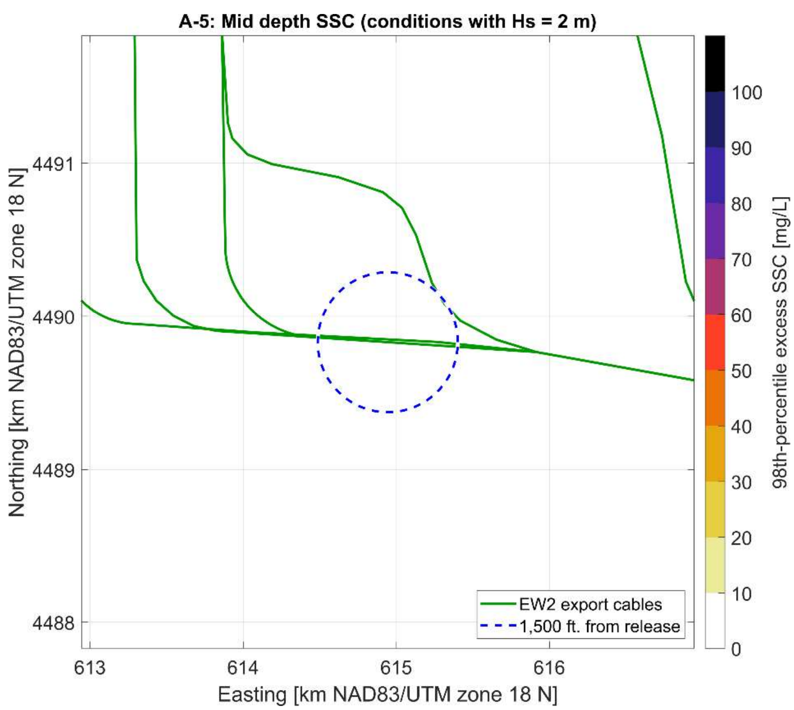

A-5: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release
613
614
615
616
4488
4489
4490
4491
0
10
20
30
40
50
60
70
80
90
100

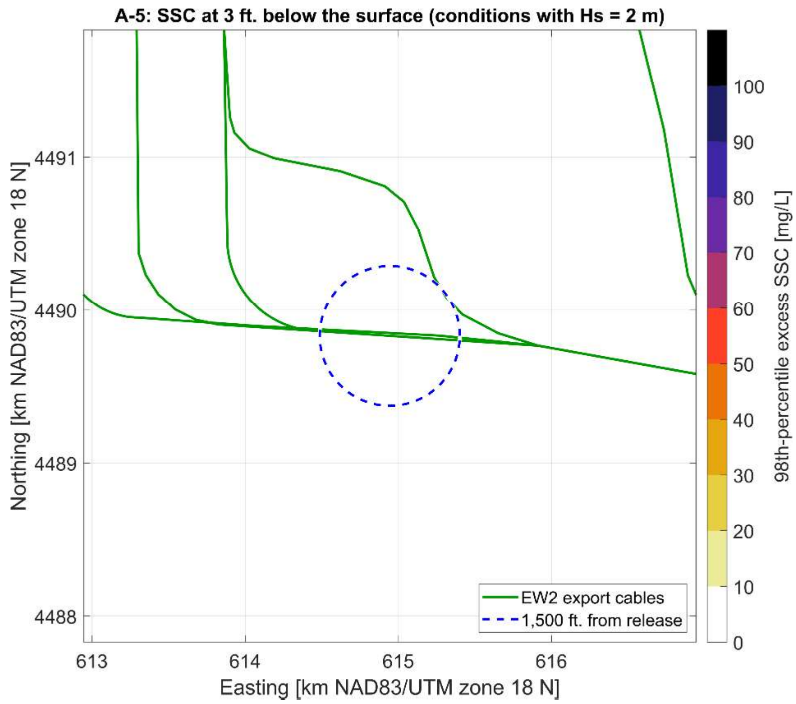

A-5: SSC along transect (conditions with Hs = 1.5 m)
Depth [m]
Distance along transect [m]
positive direction pointing towards 31°N from release location
98th-percentile excess SSC [mg/L]
-600
-400
-200
0
200
400
600
0
-2
-4
-6
-8
-10
-12

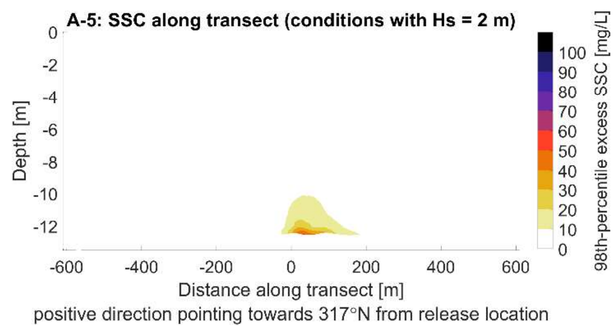

A-5: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

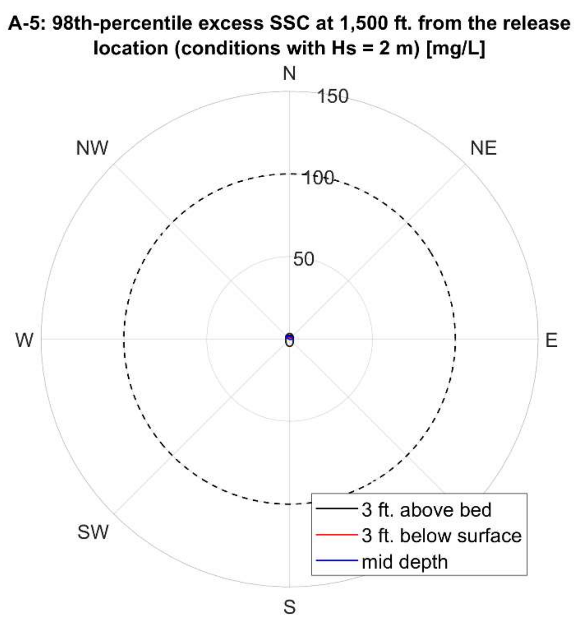
E.3.3 Sediment footprint with significant wave height ≈ 2 m



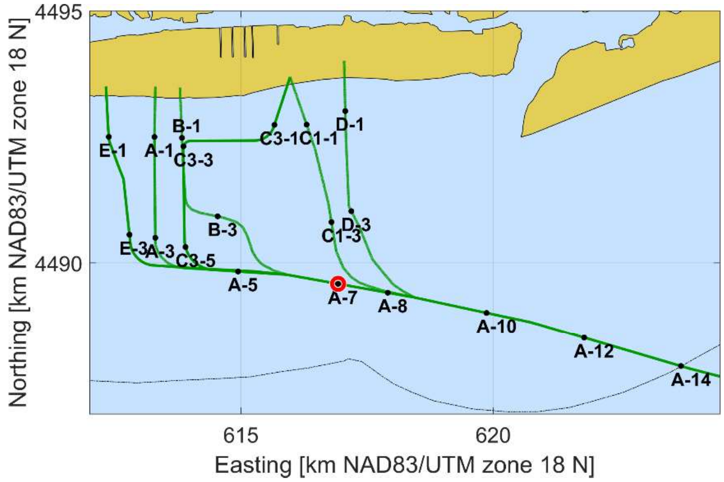



A-5: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4491
4490
4489
4488
613
614
615
616
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

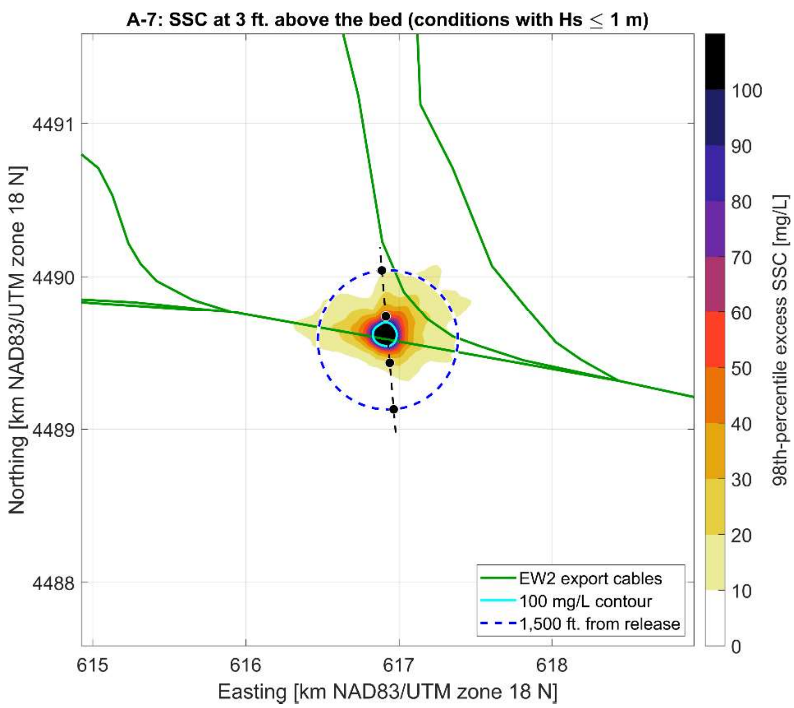

A-5: SSC along transect (conditions with Hs = 2 m)
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 317°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

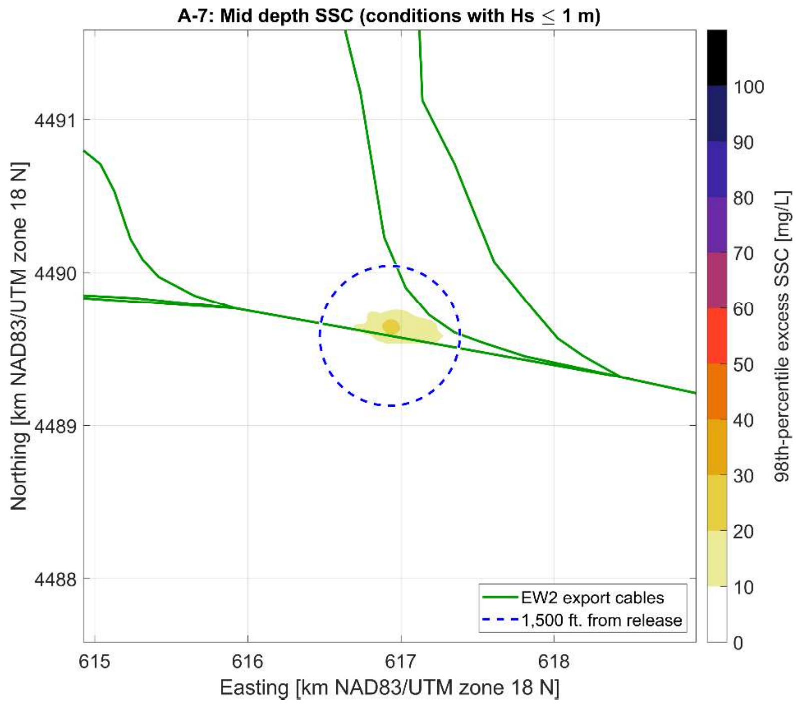

A-5: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

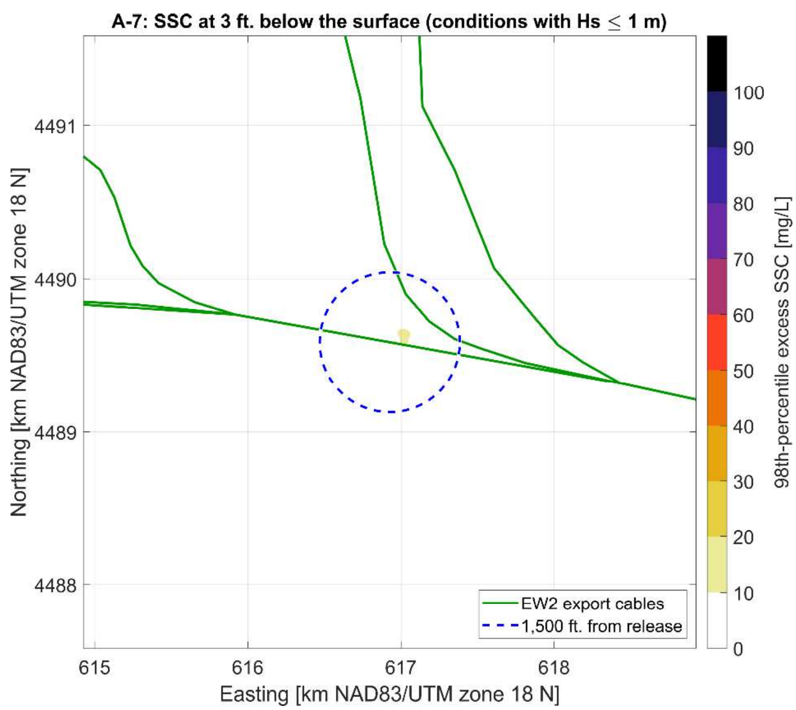
E.4 Release location A-7

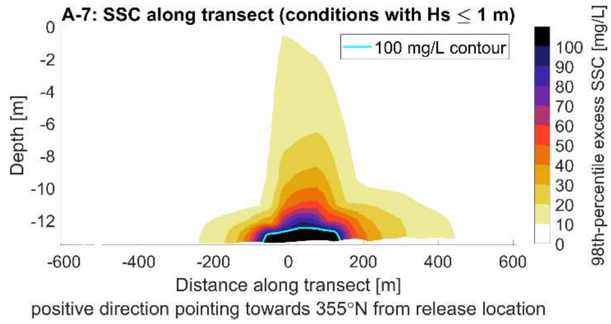


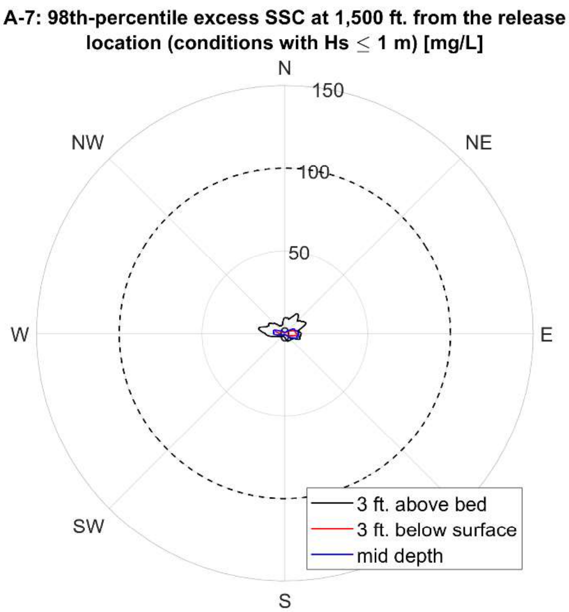
E.4.1 Sediment footprint with significant wave height ≤ 1 m



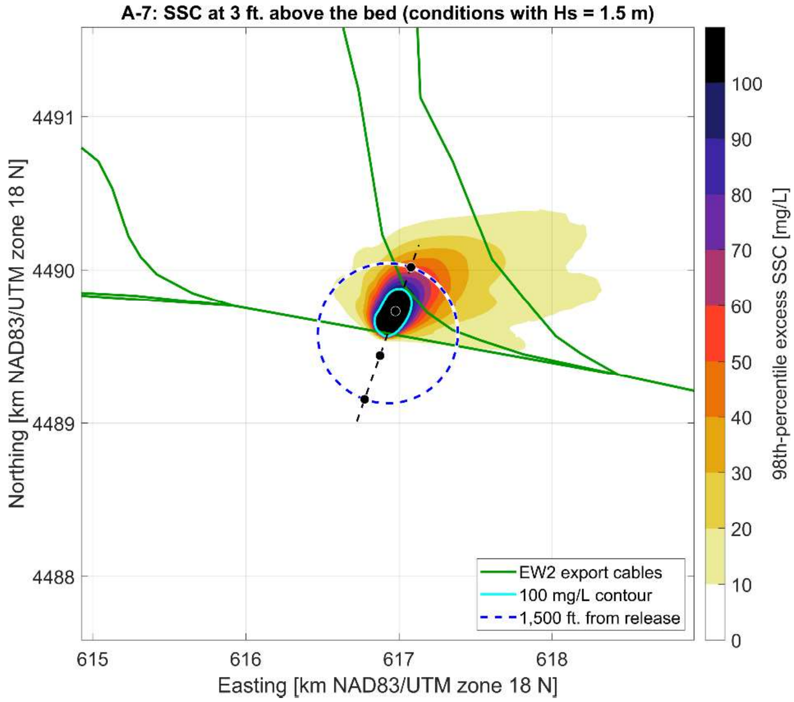

A-7: Mid depth SSC (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
4491
4490
4489
4488
Easting [km NAD83/UTM zone 18 N]
615
616
617
618
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

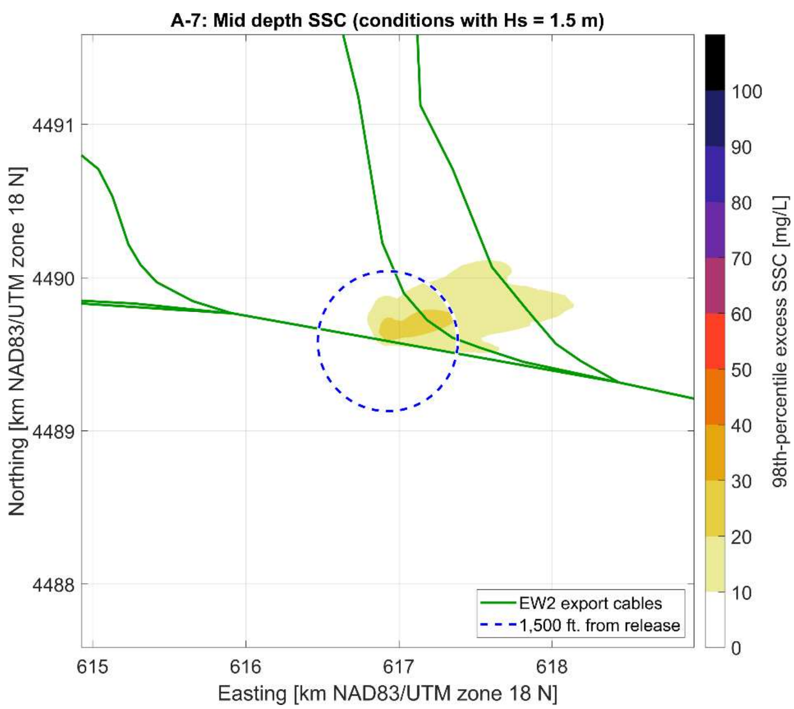

A-7: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
4491
4490
4489
4488
Easting [km NAD83/UTM zone 18 N]
615
616
617
618
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

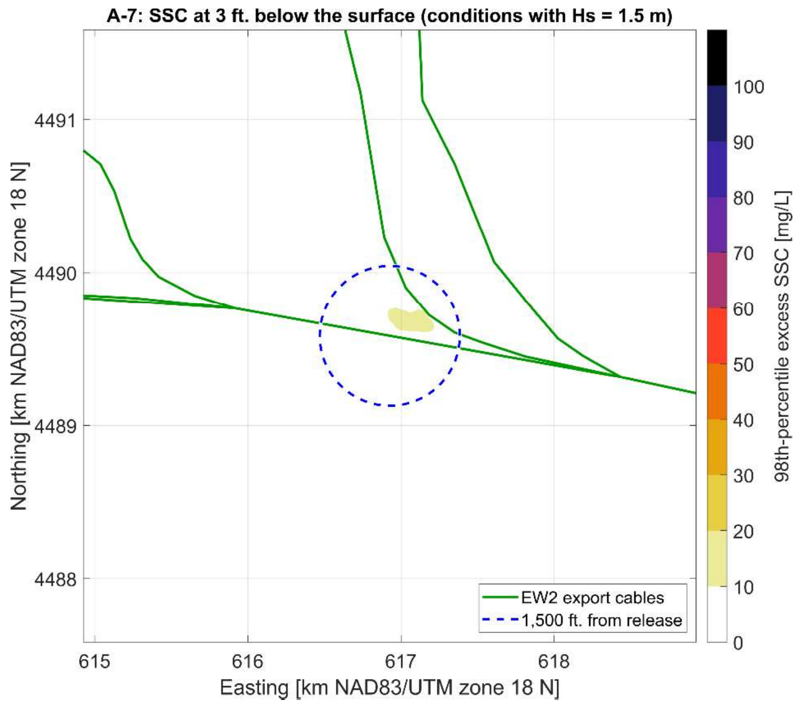

A-7: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 355°N from release location
98th-percentile excess SSC [mg/L]

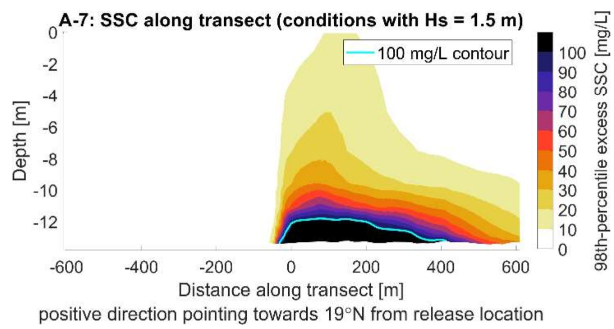

A-7: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

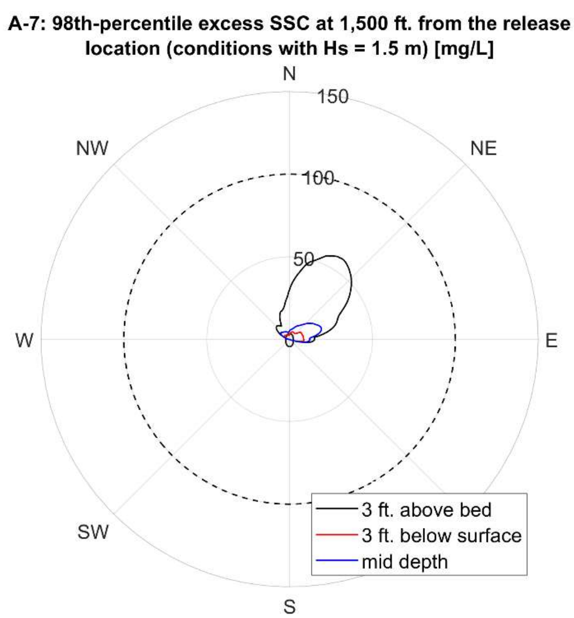
E.4.2 Sediment footprint with significant wave height ≈ 1.5 m



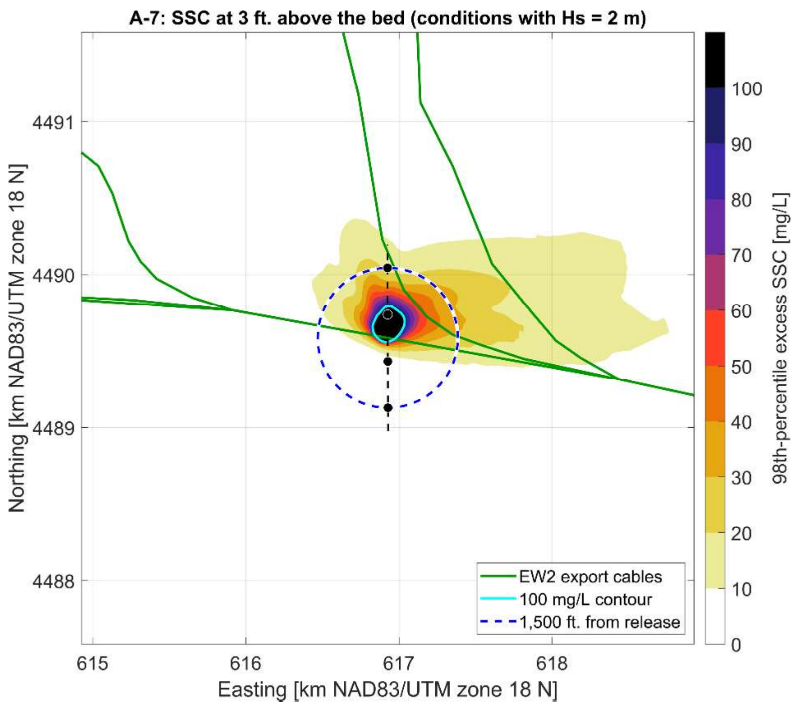


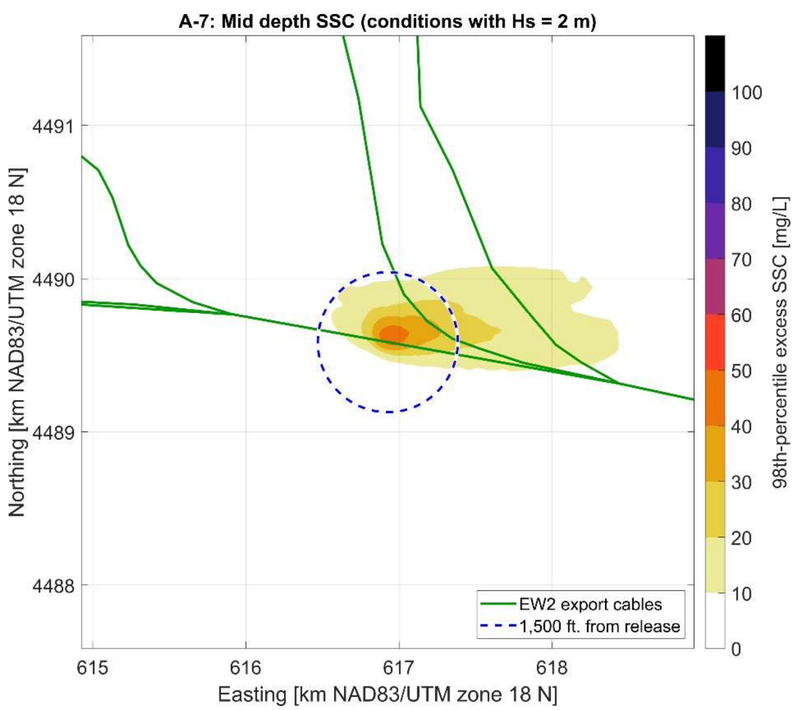

A-7: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4491
4490
4489
4488
615
616
617
618
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

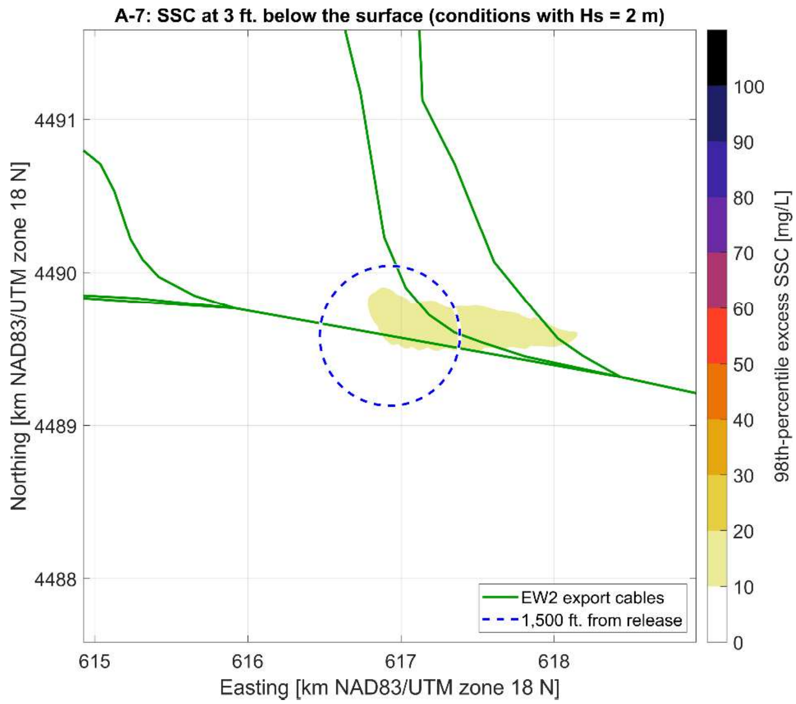

A-7: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 19°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0


A-7: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

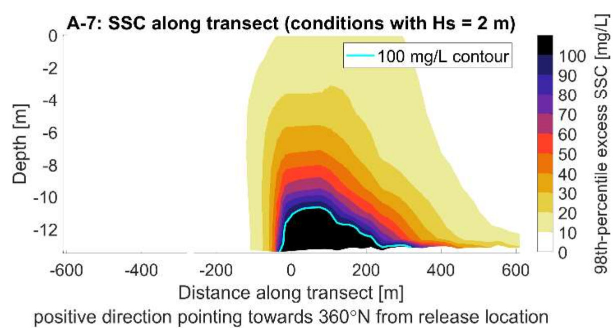
E.4.3 Sediment footprint with significant wave height ≈ 2 m



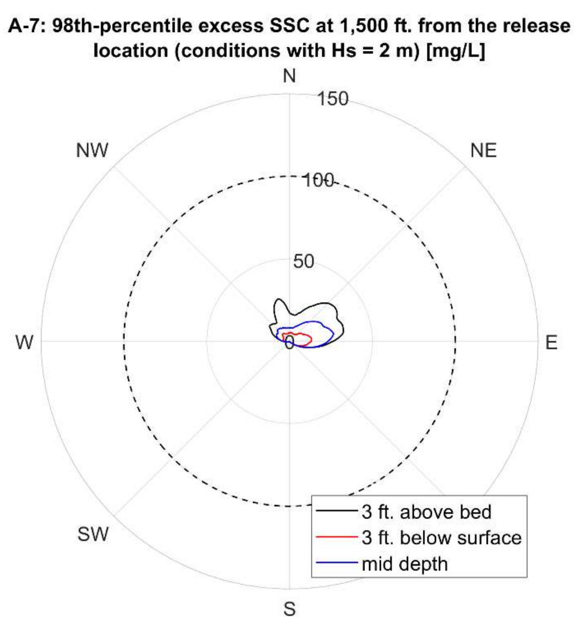




A-7: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release

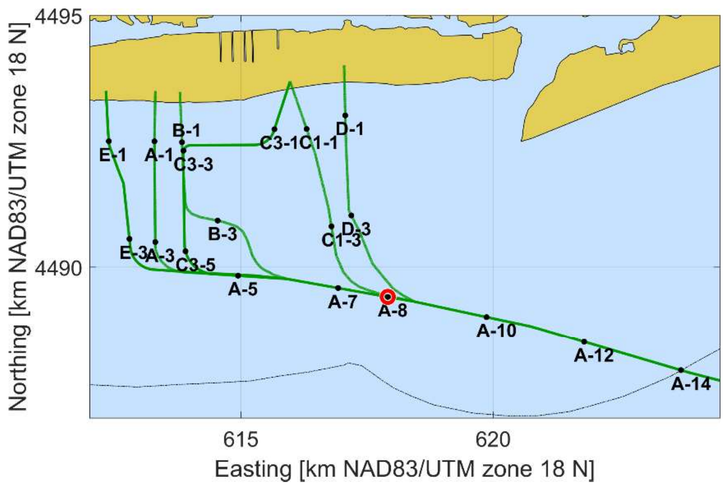


A-7: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 360°N from release location
98th-percentile excess SSC [mg/L]

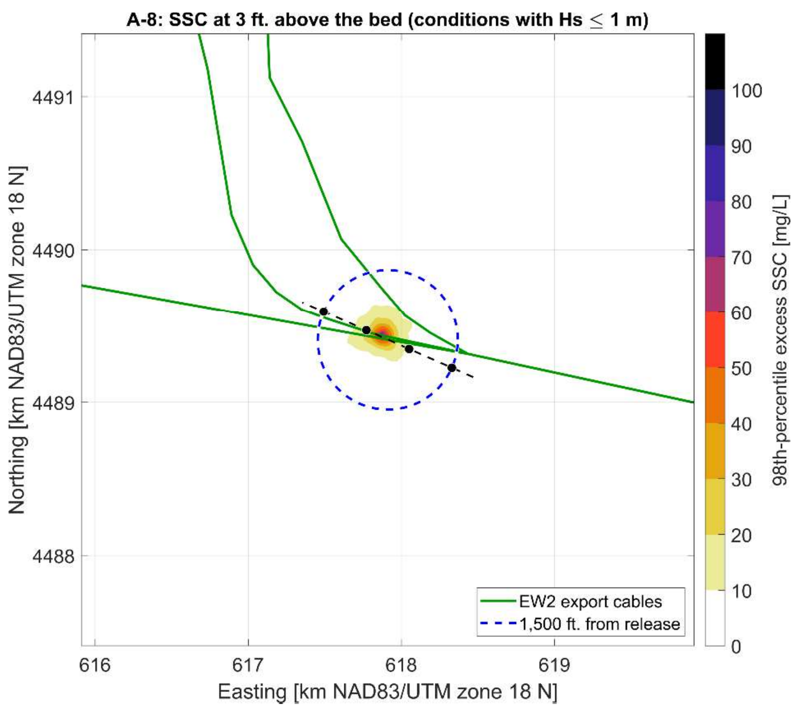


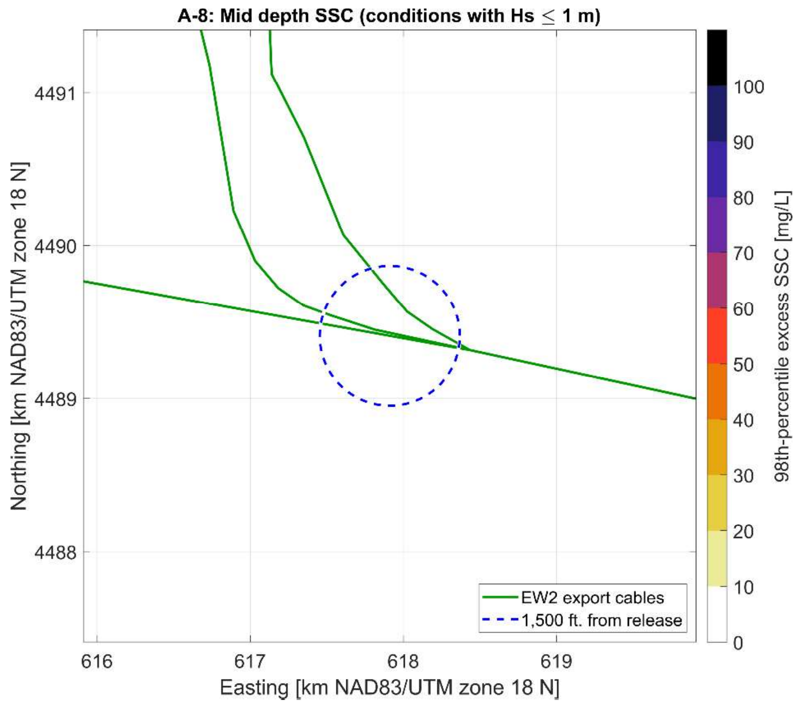
A-7: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

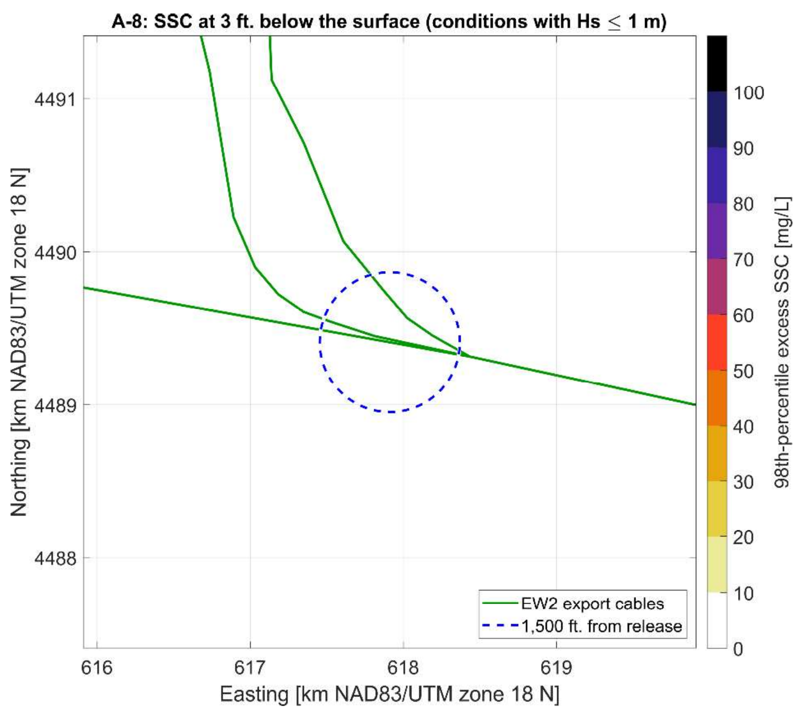
E.5 Release location A-8

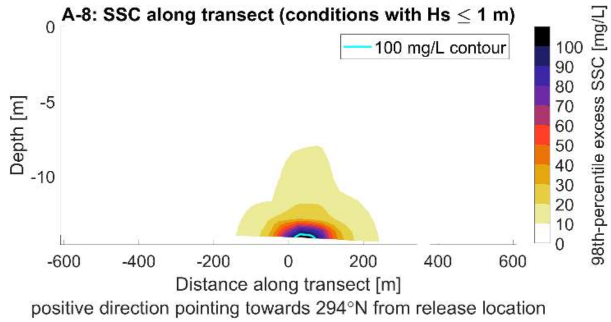


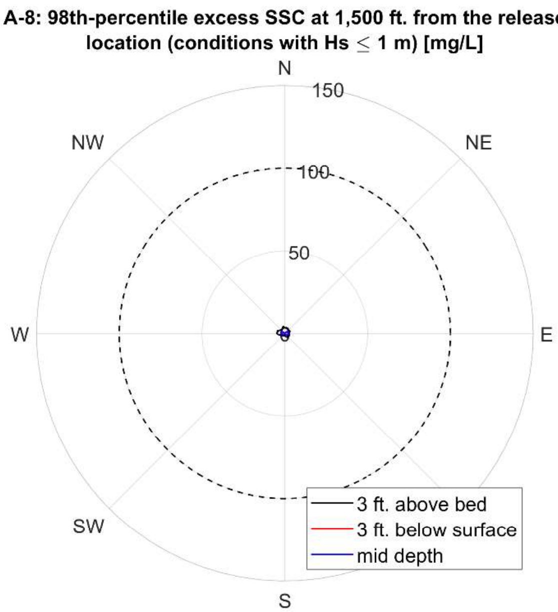
E.5.1 Sediment footprint with significant wave height ≤ 1 m



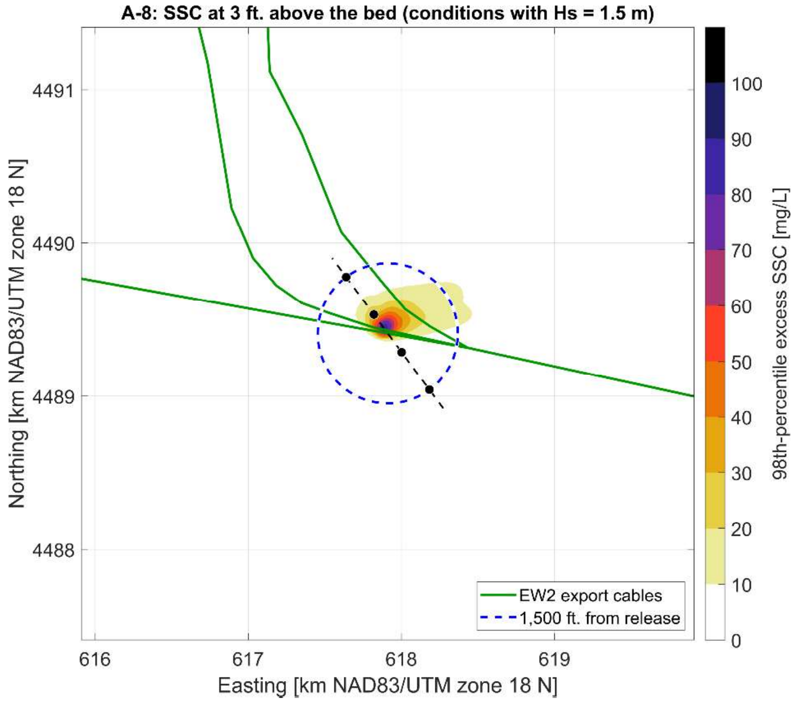

A-8: Mid depth SSC (conditions with Hs ≤ 1 m)
4491
4490
4489
4488
Northing [km NAD83/UTM zone 18 N]
616
617
618
619
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

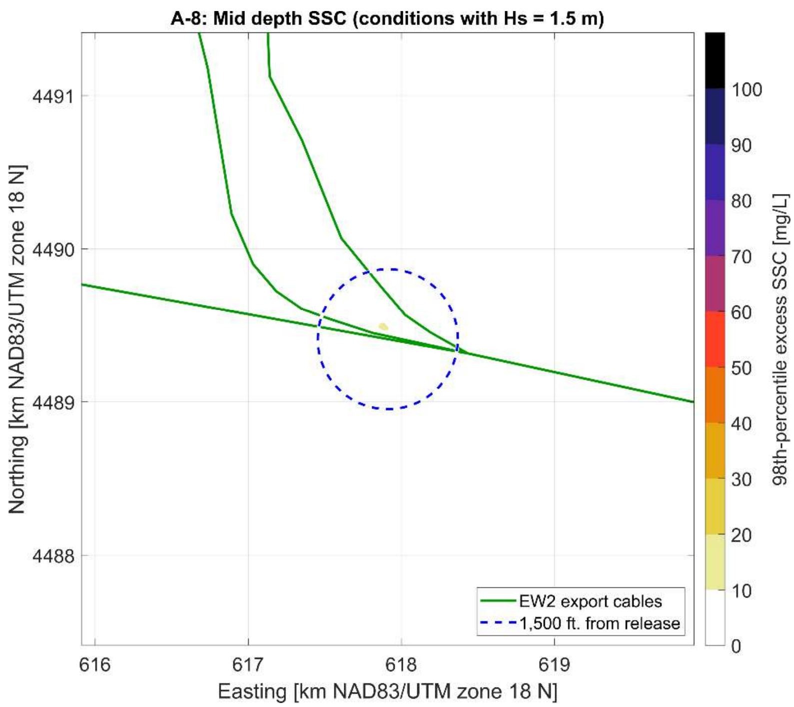

A-8: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
4491
4490
4489
4488
Northing [km NAD83/UTM zone 18 N]
616
617
618
619
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

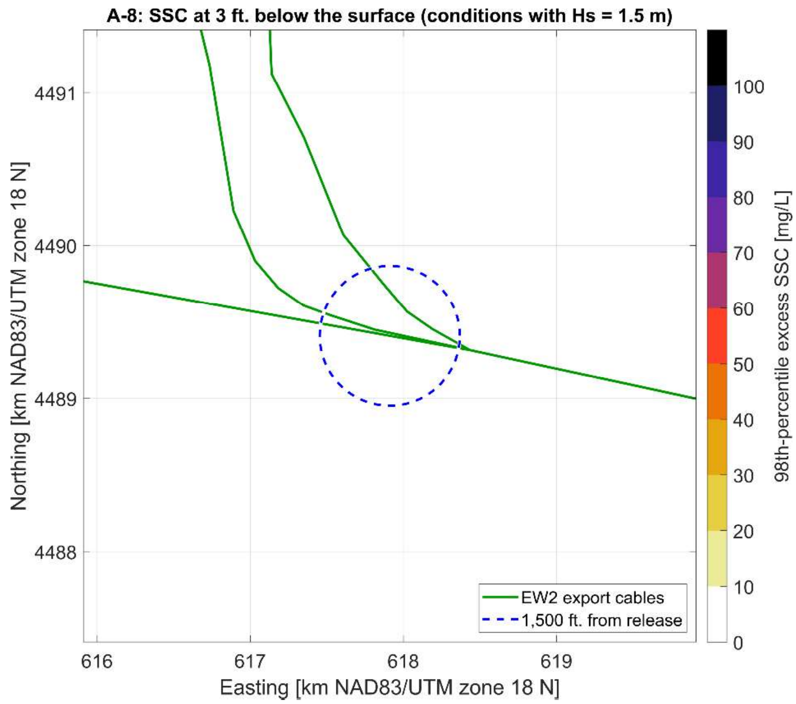

A-8: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
0
-5
-10
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 294°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

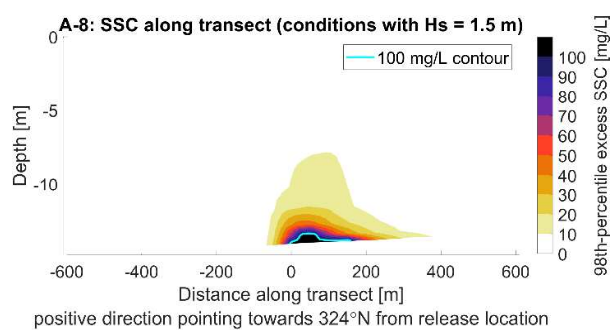

A-8: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

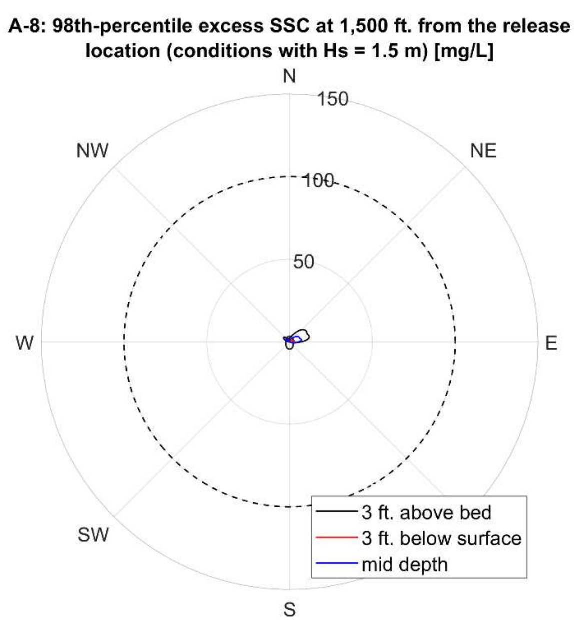
E.5.2 Sediment footprint with significant wave height ≈ 1.5 m



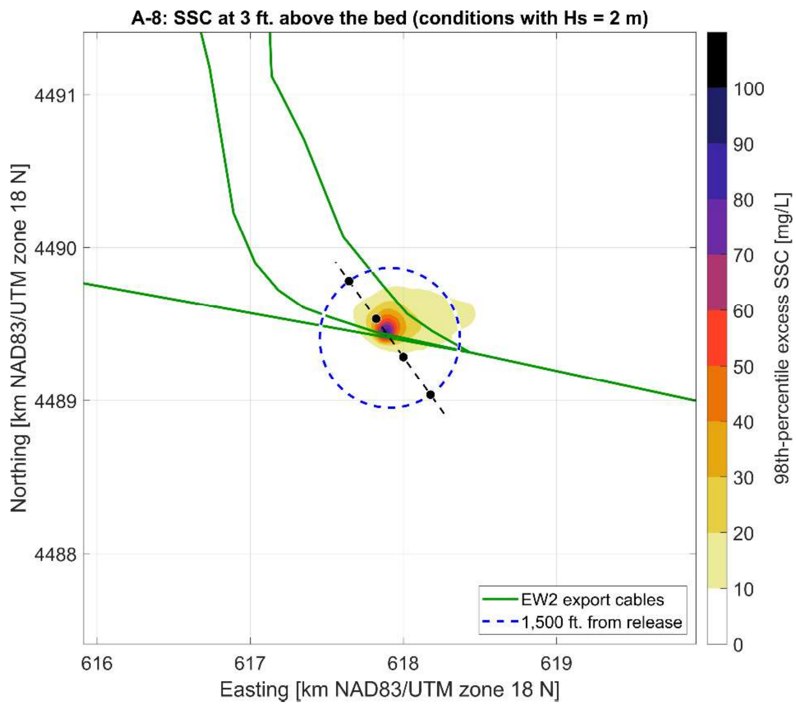


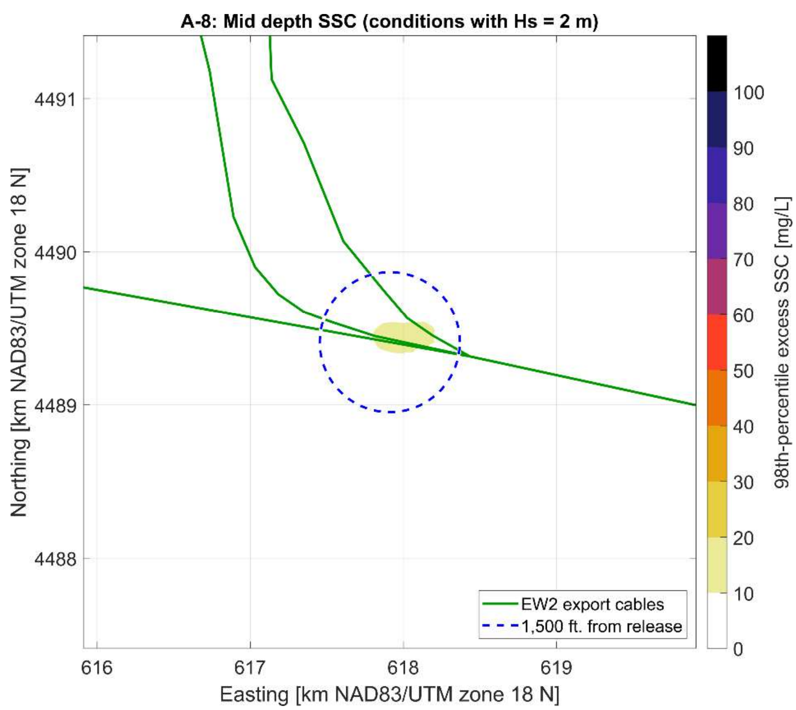

A-8: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
4491
4490
4489
4488
Northing [km NAD83/UTM zone 18 N]
616
617
618
619
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

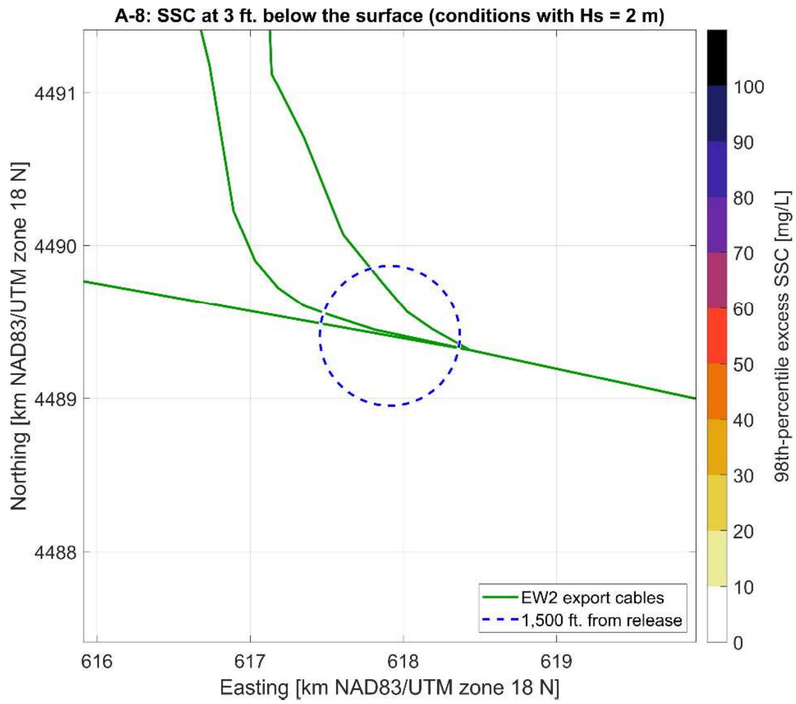

A-8: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
0
-5
-10
Depth [m]
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 324°N from release location
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

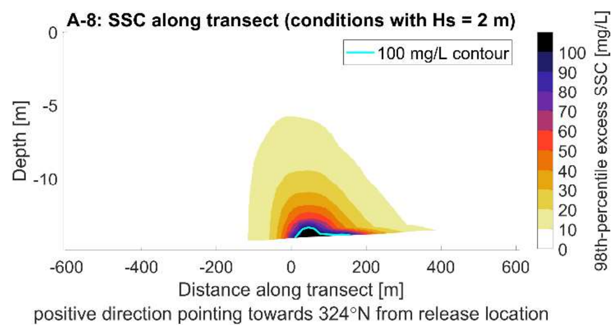

A-8: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

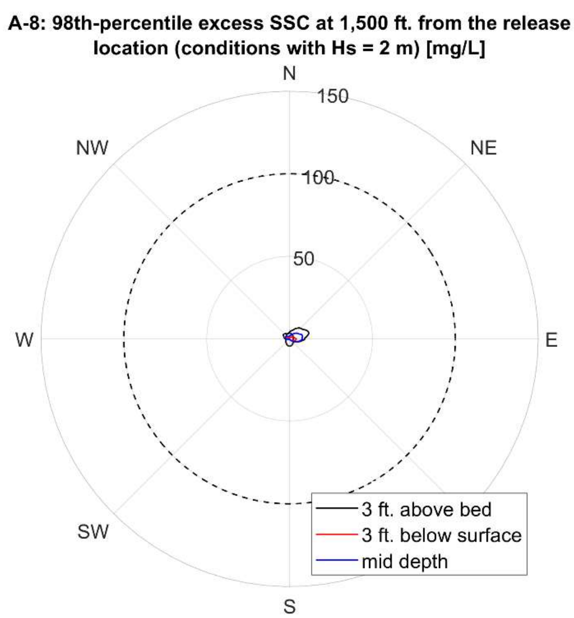
E.5.3 Sediment footprint with significant wave height ≈ 2 m



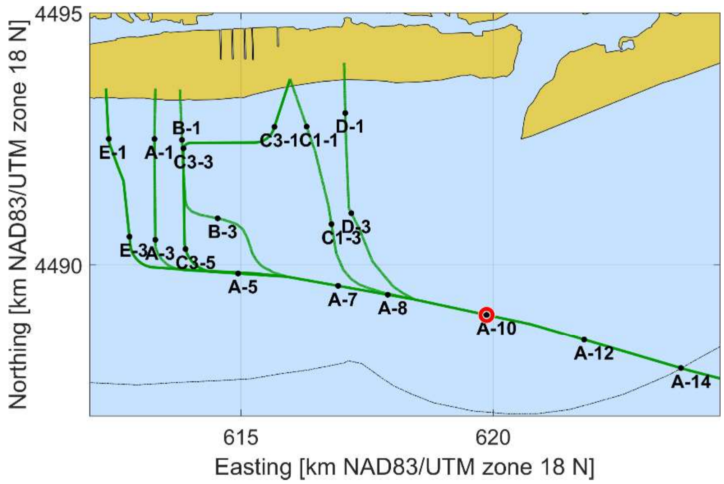



A-8: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release

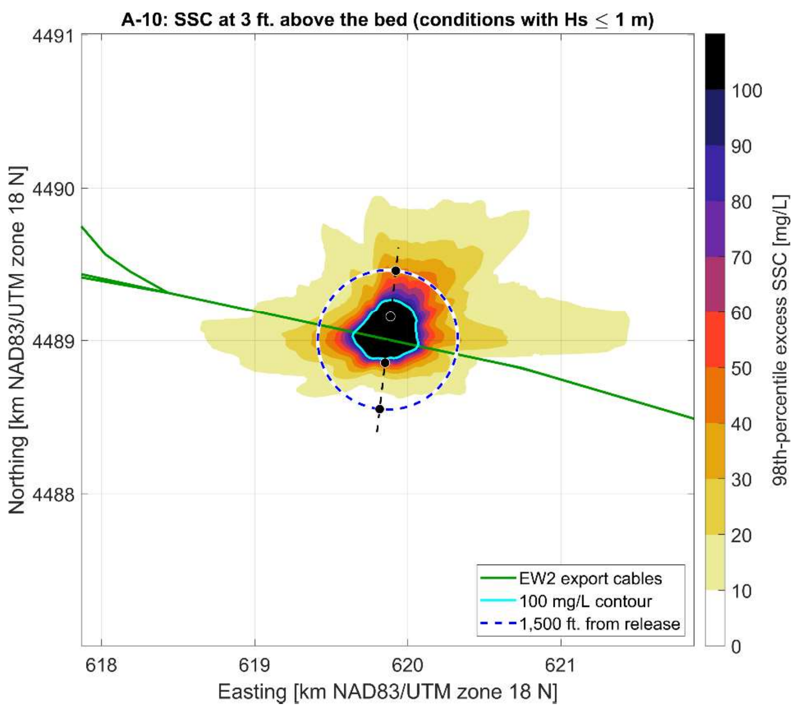

A-8: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 324°N from release location
98th-percentile excess SSC [mg/L]

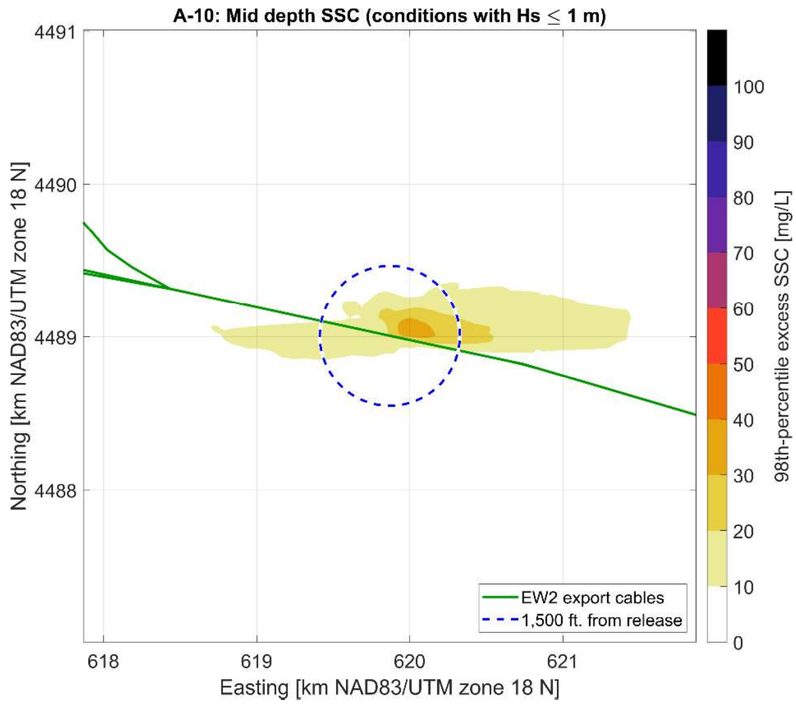

A-8: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

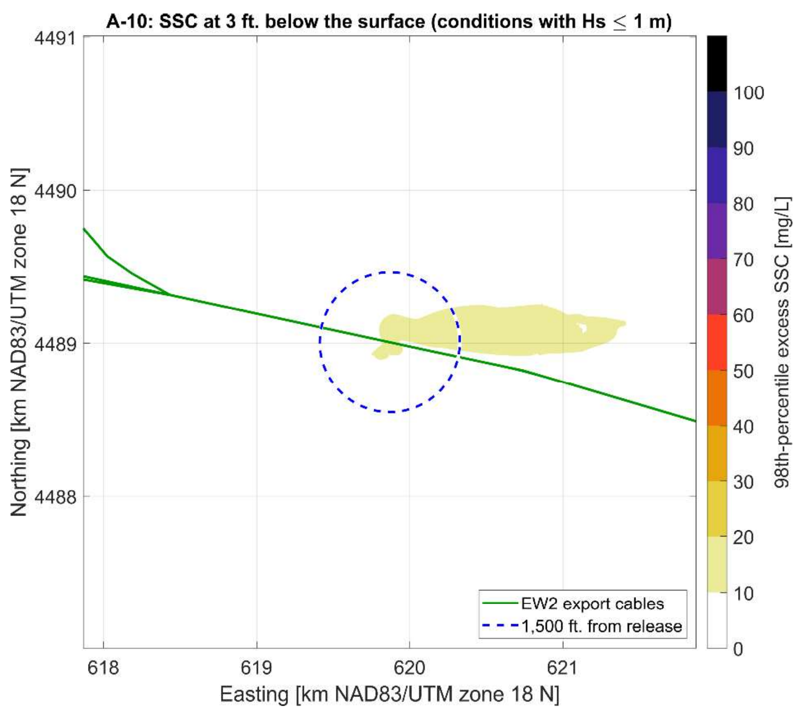
E.6 Release location A-10

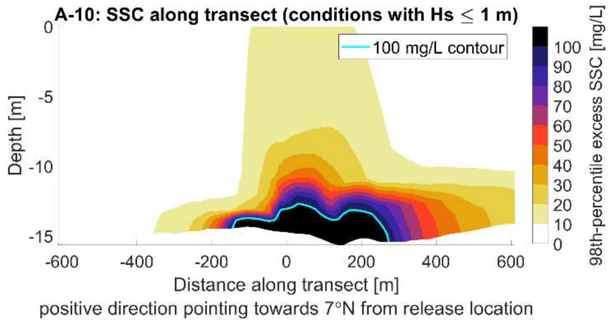


E.6.1 Sediment footprint with significant wave height ≤ 1 m

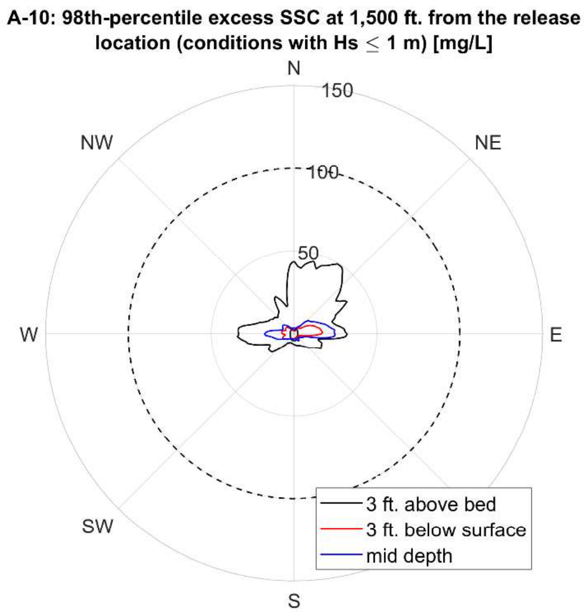



A-10: Mid depth SSC (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4491
4490
4489
4488
618
619
620
621
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100


A-10: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4491
4490
4489
4488
618
619
620
621
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100

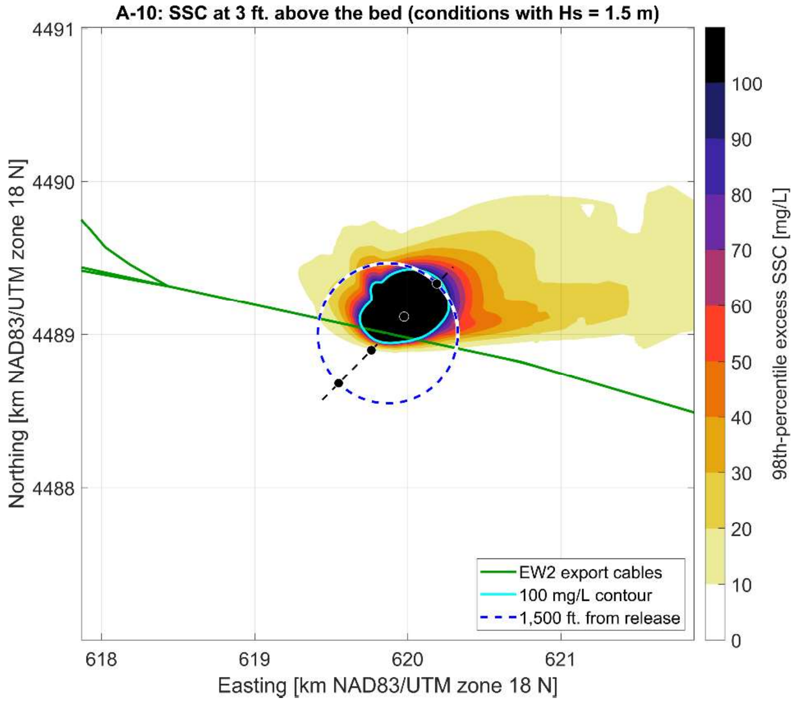


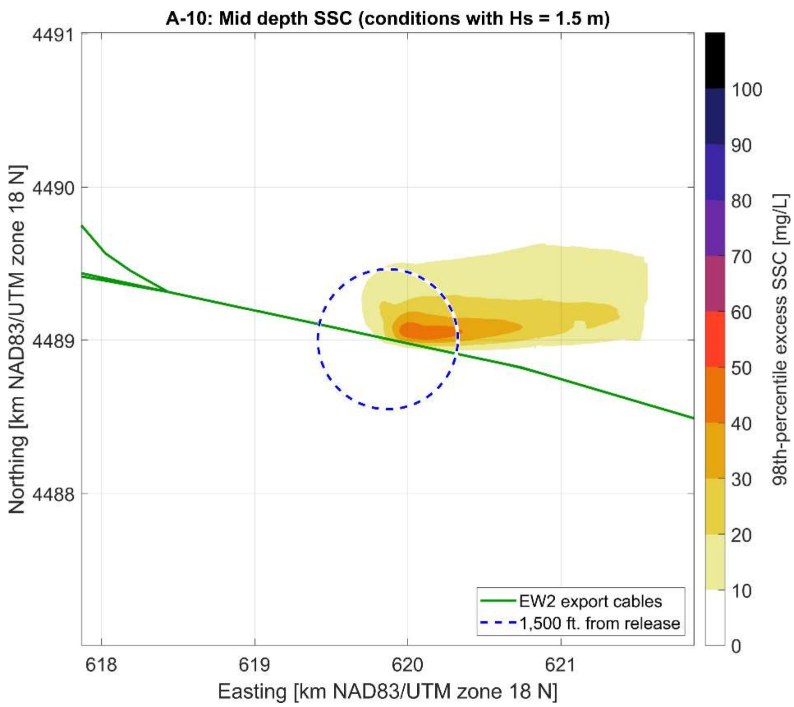
A-10: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
0
-5
-10
-15
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 7°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

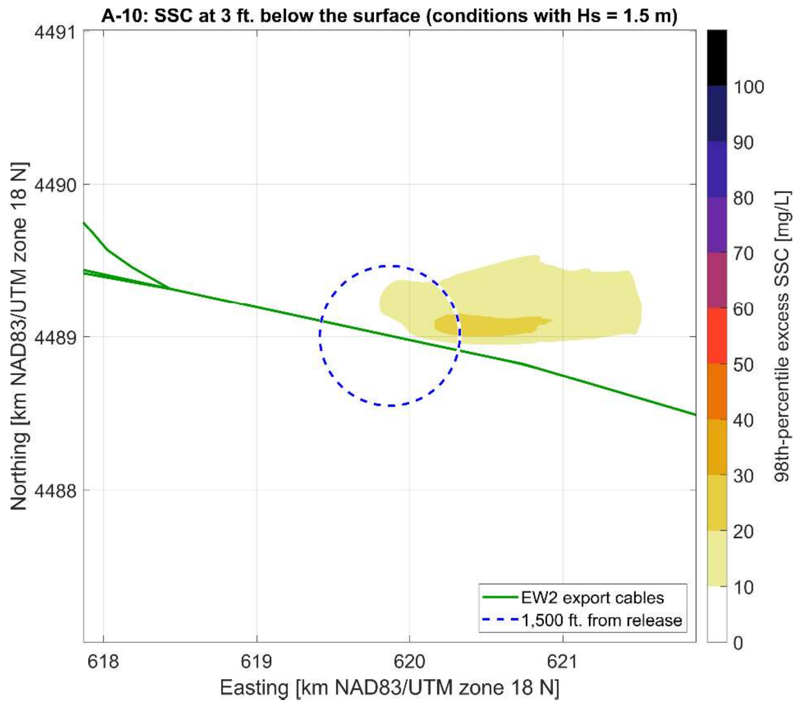


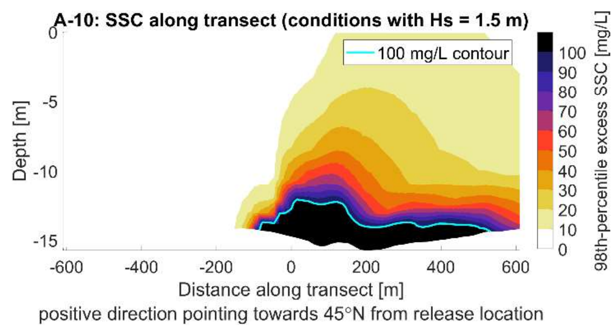
A-10: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

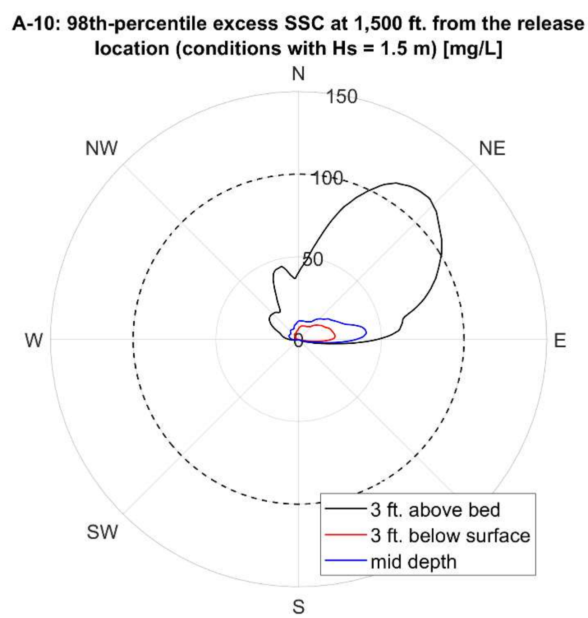
E.6.2 Sediment footprint with significant wave height ≈ 1.5 m



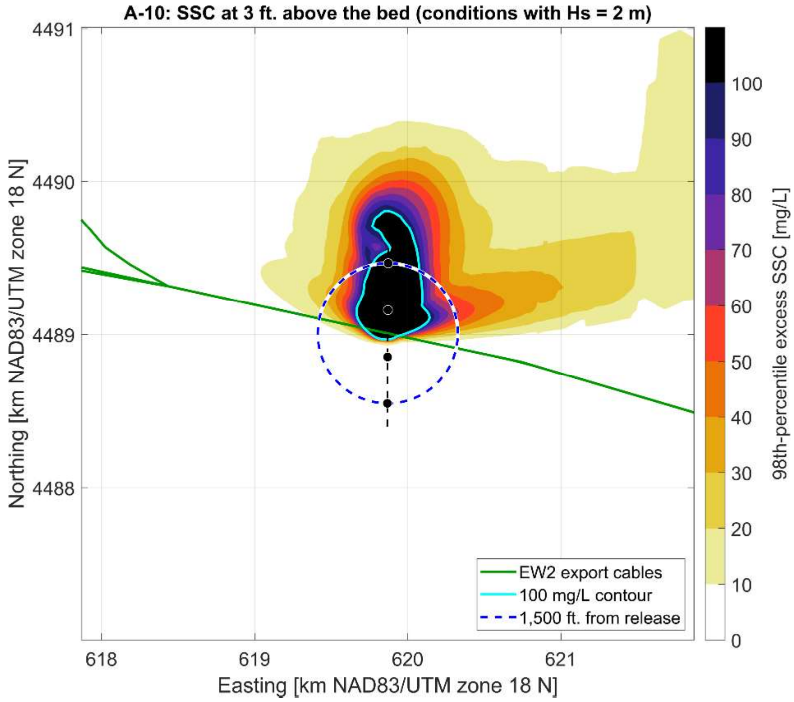


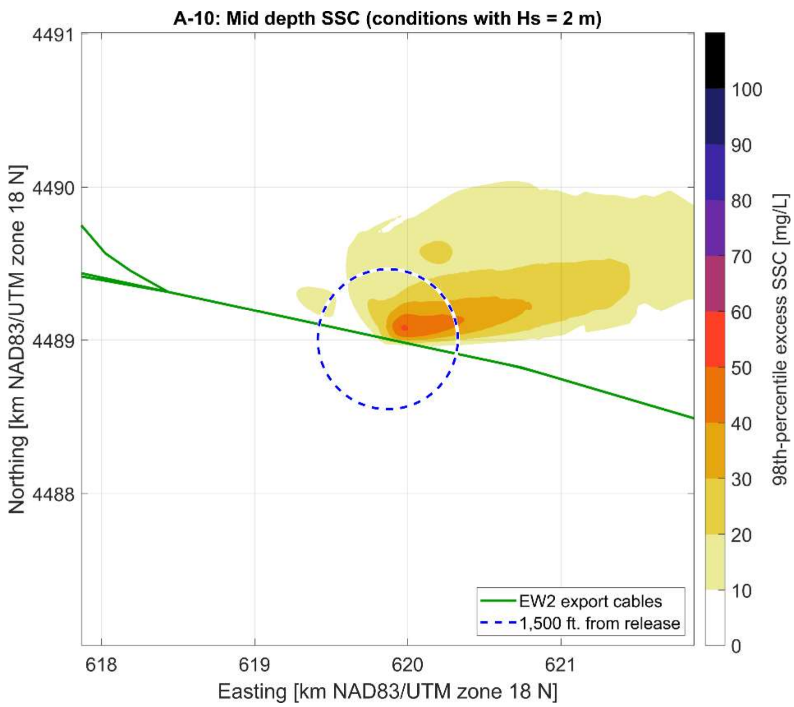

A-10: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release
4491
4490
4489
4488
618
619
620
621
0
10
20
30
40
50
60
70
80
90
100

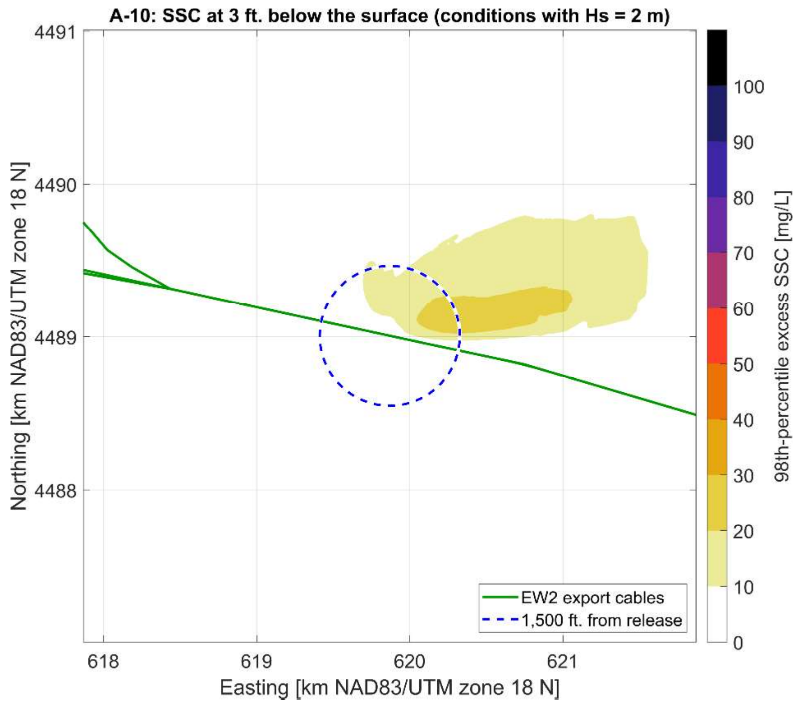

A-10: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 45°N from release location
98th-percentile excess SSC [mg/L]
0
-5
-10
-15
-600
-400
-200
0
200
400
600

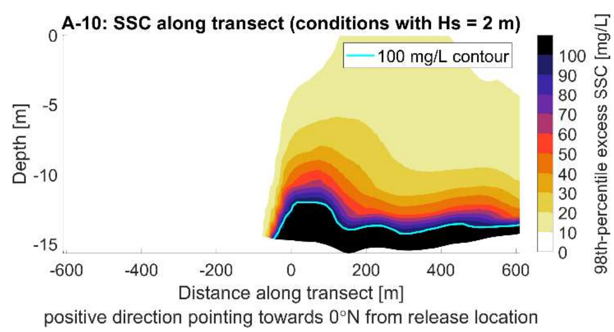

A-10: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

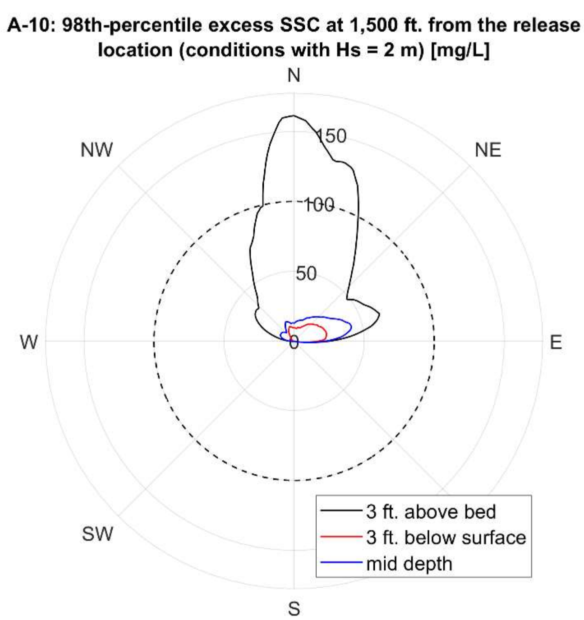
E.6.3 Sediment footprint with significant wave height ≈ 2 m



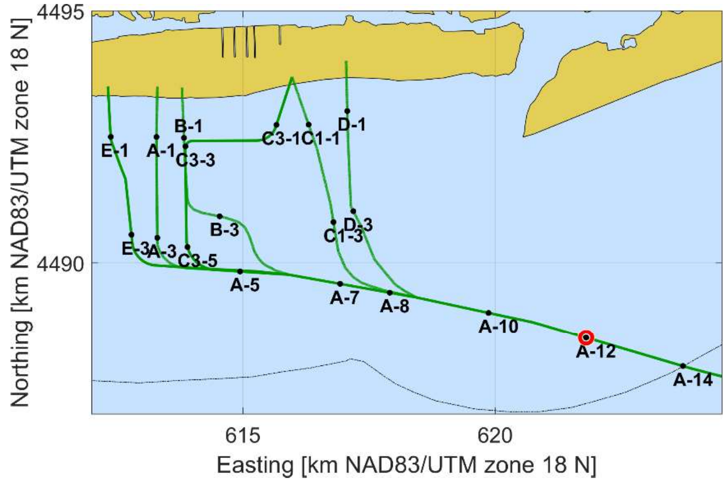



A-10: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4491
4490
4489
4488
618
619
620
621
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100

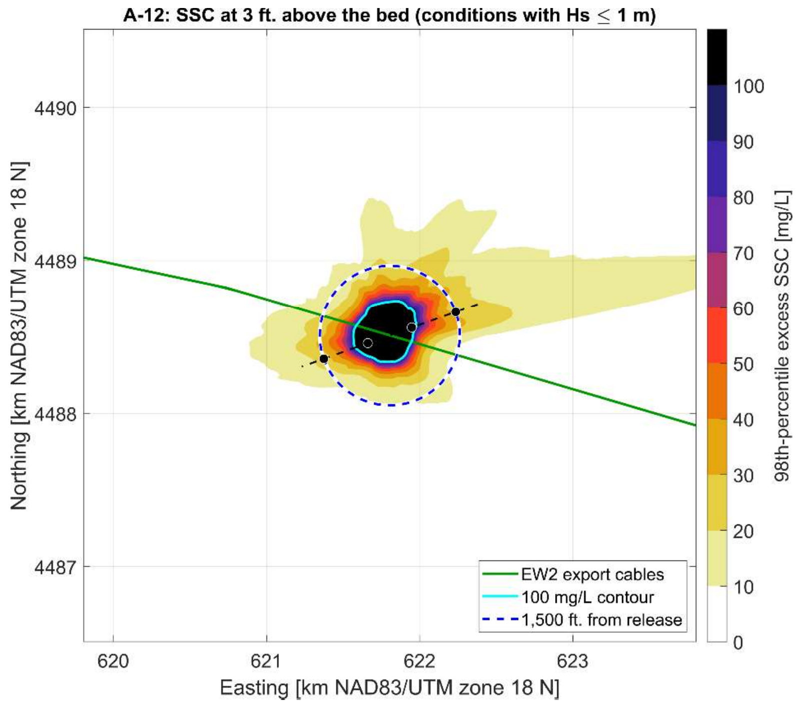

A-10: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
0
-5
-10
-15
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 0°N from release location
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100


A-10: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
S
SW
W
NW
0
50
100
150
3 ft. above bed
3 ft. below surface
mid depth

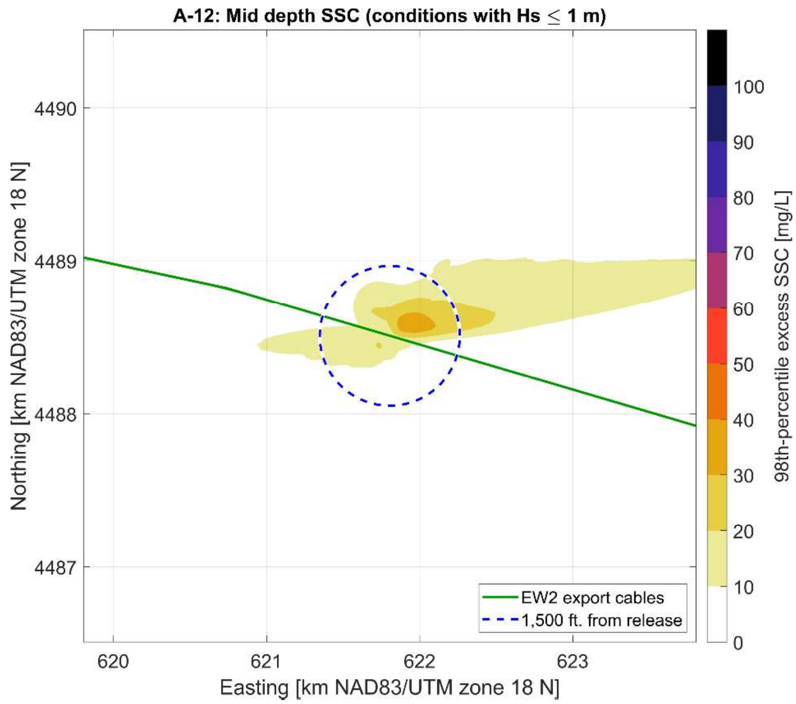
E.7 Release location A-12

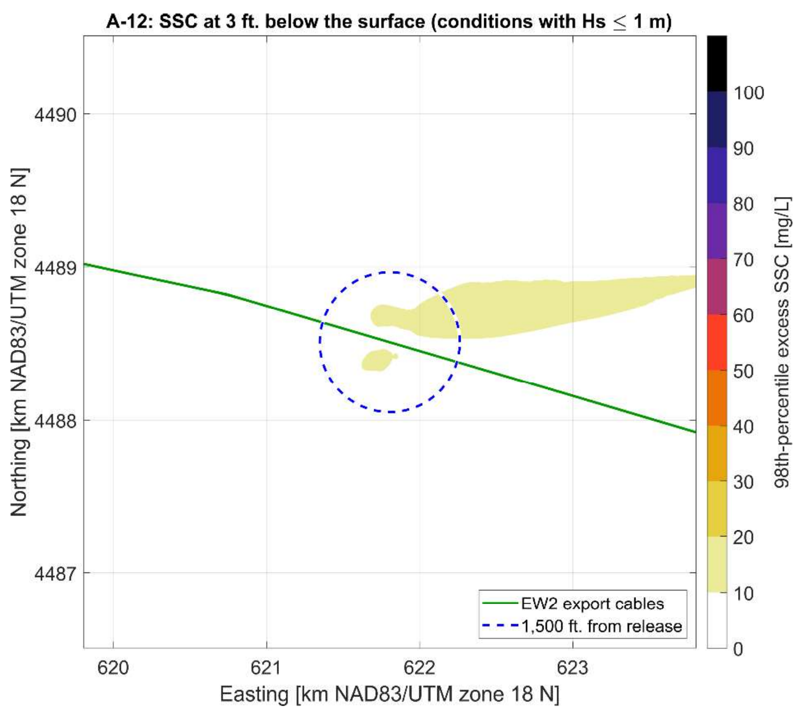


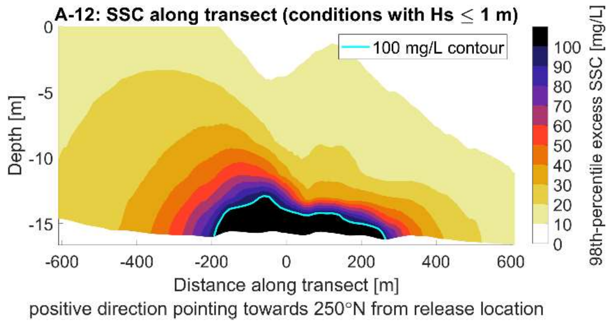
E.7.1 Sediment footprint with significant wave height ≤ 1 m

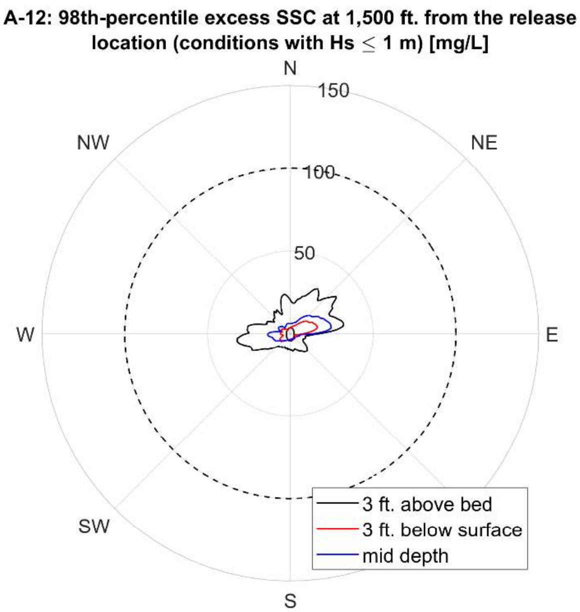


Deltares

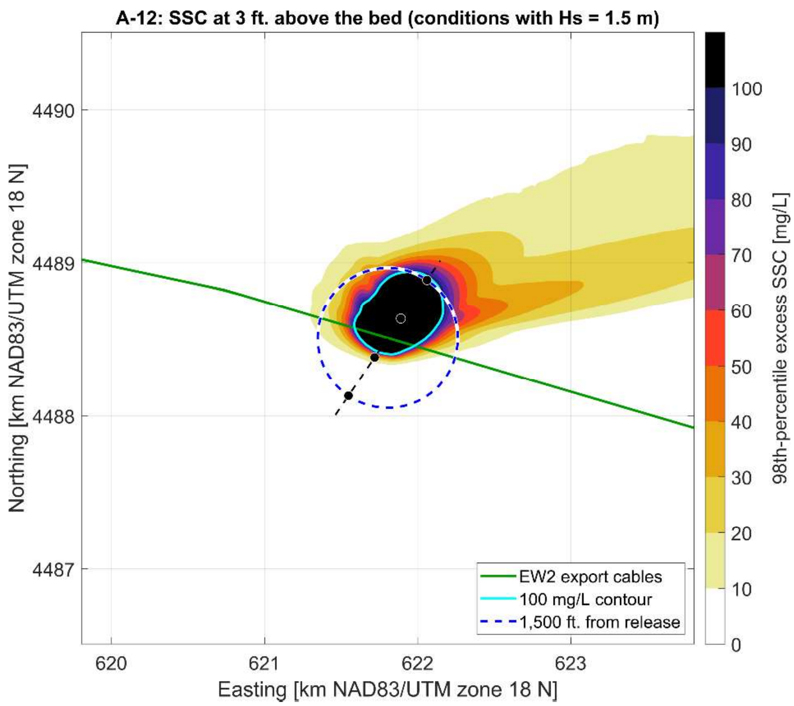

A-12: Mid depth SSC (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
4490
4489
4488
4487
Easting [km NAD83/UTM zone 18 N]
620
621
622
623
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

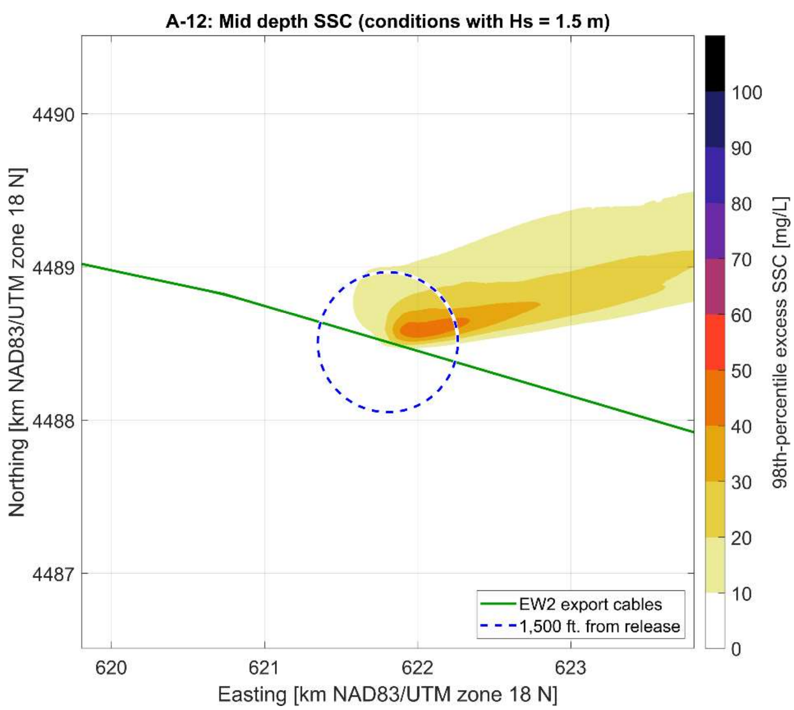

A-12: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
4490
4489
4488
4487
Easting [km NAD83/UTM zone 18 N]
620
621
622
623
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

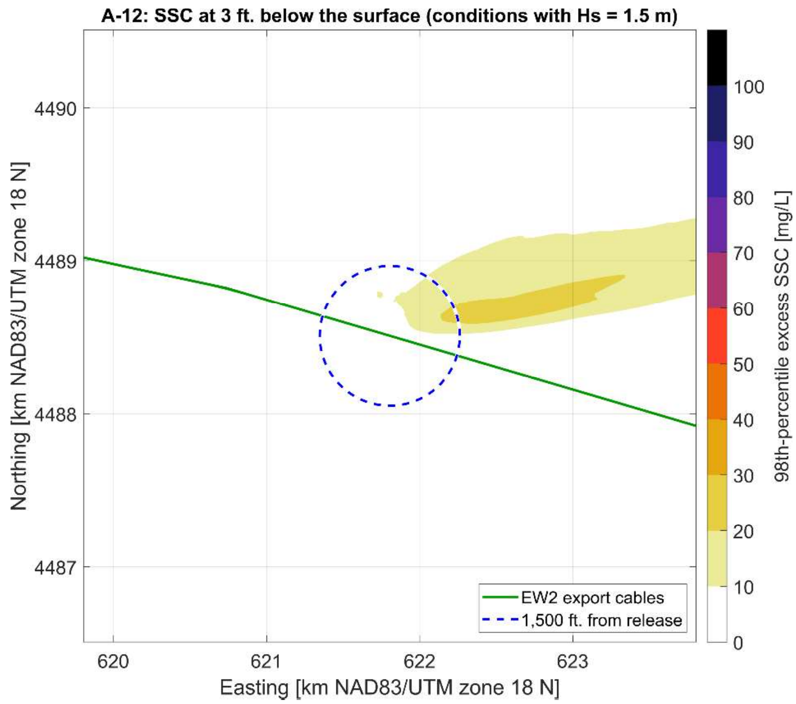

A-12: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
0
-5
-10
-15
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 250°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

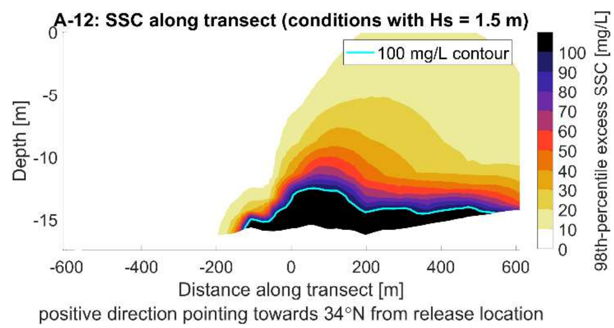

A-12: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
SW
S
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

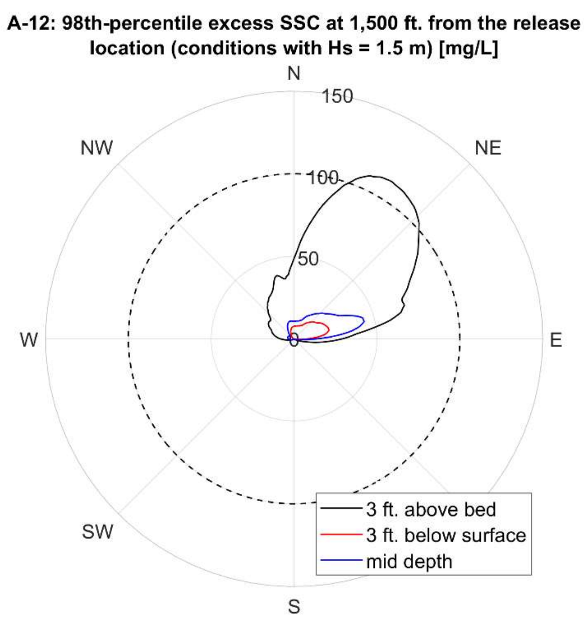
E.7.2 Sediment footprint with significant wave height ≈ 1.5 m



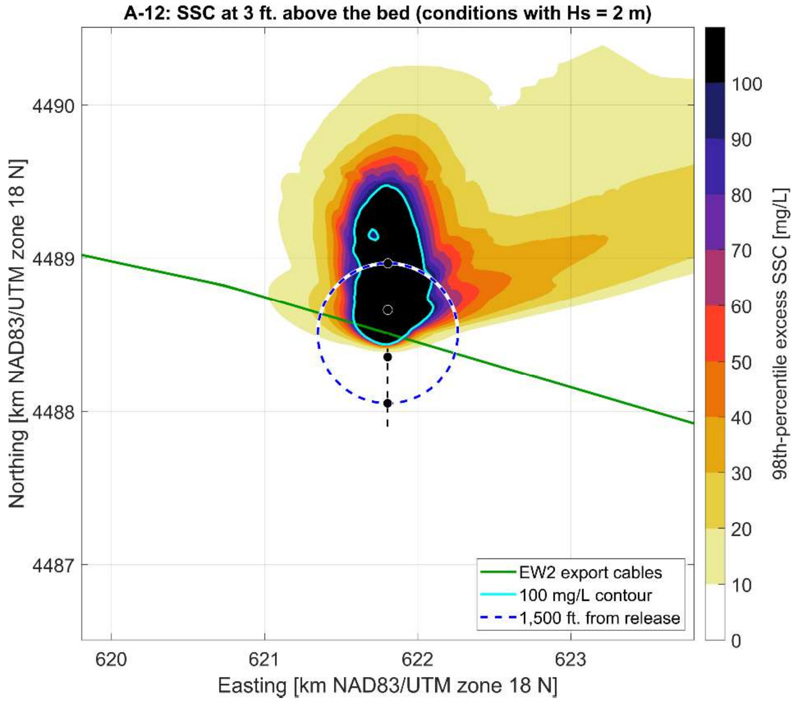


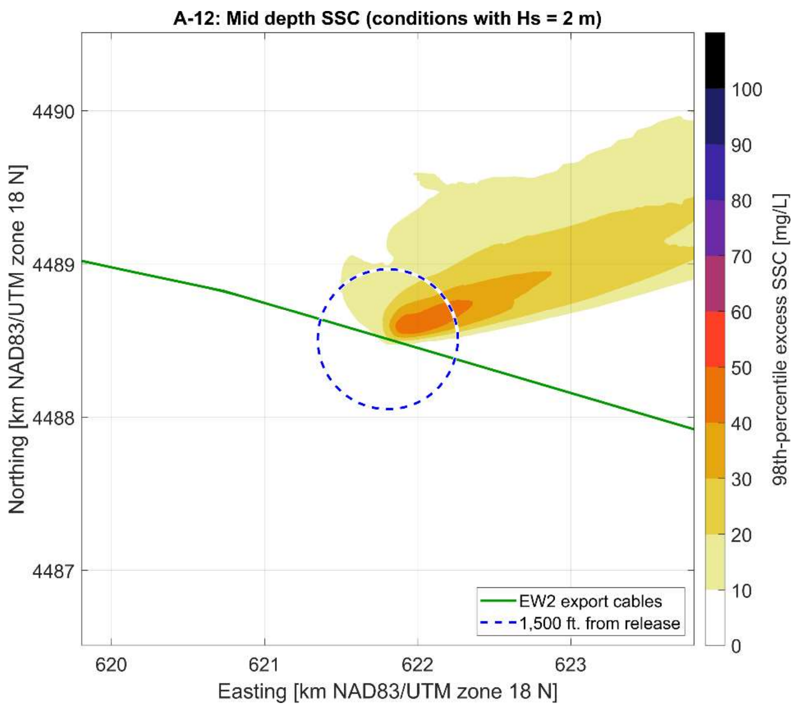

A-12: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release

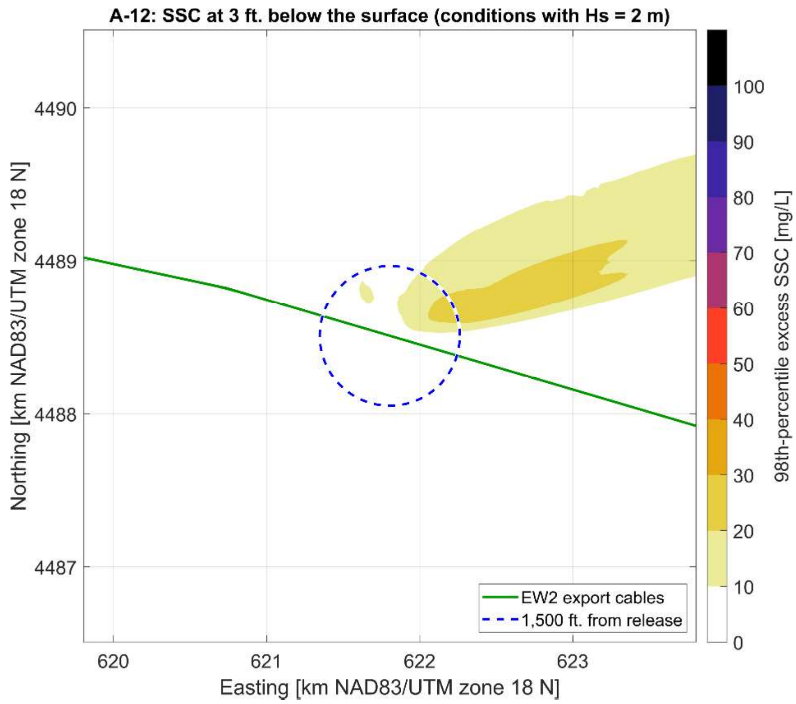

A-12: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 34°N from release location
98th-percentile excess SSC [mg/L]

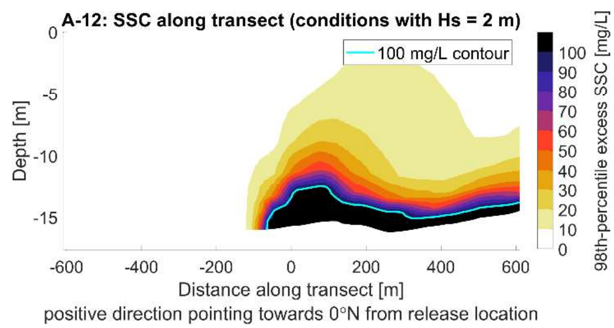

A-12: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

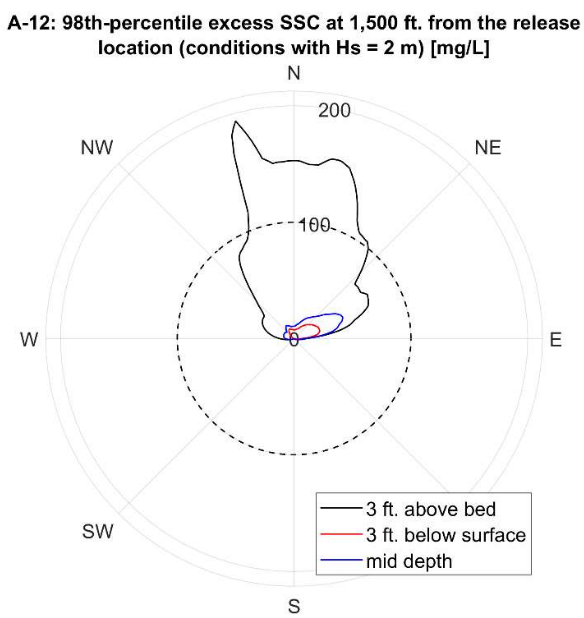
E.7.3 Sediment footprint with significant wave height ≈ 2 m



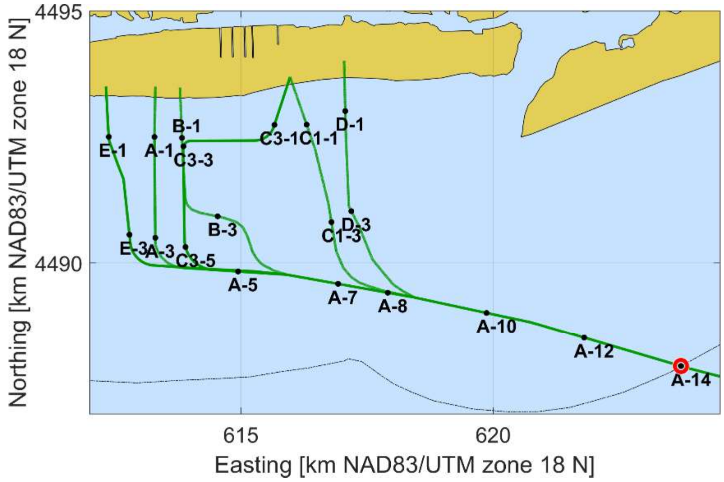



A-12: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release

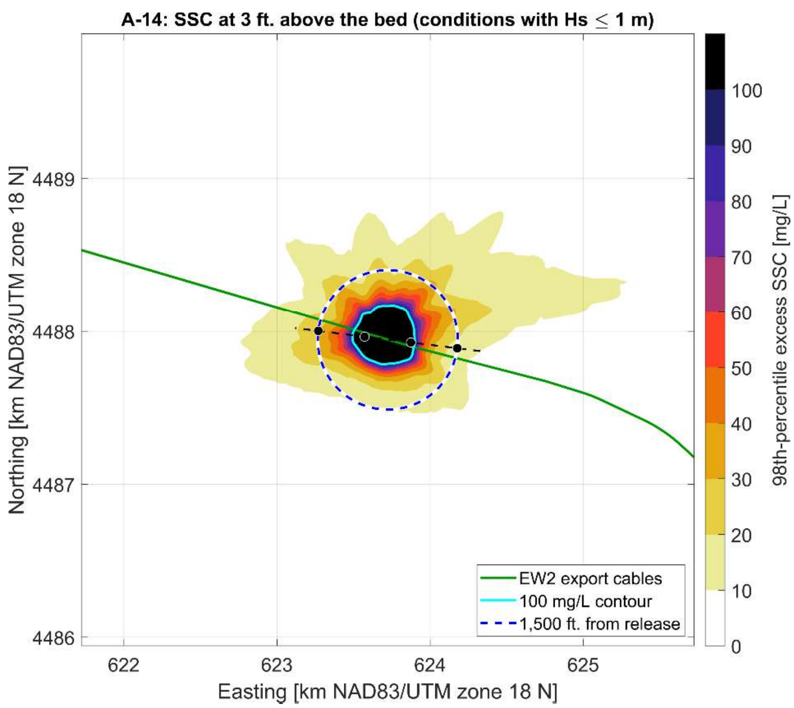

A-12: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 0°N from release location
98th-percentile excess SSC [mg/L]

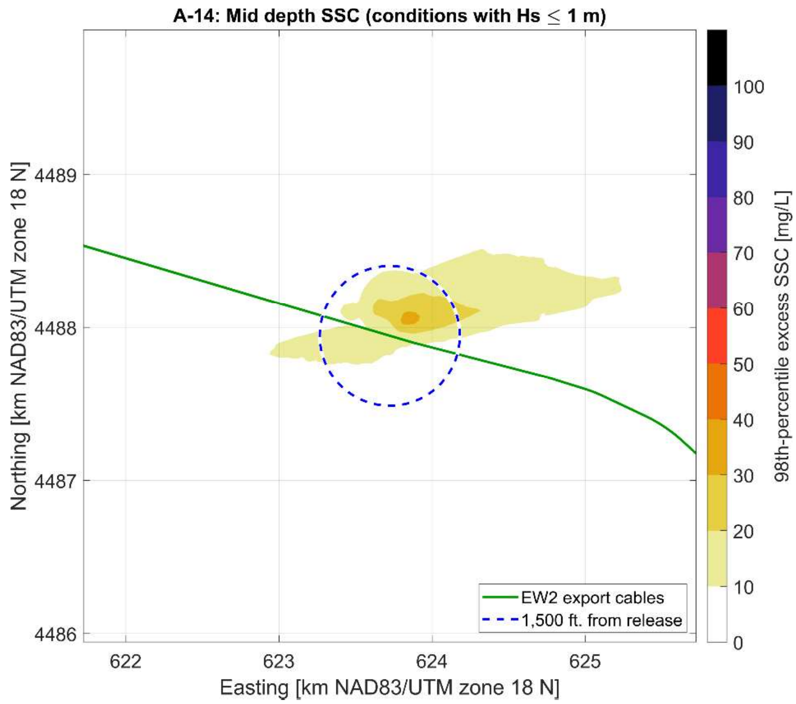

A-12: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
SW
S
W
NW
3 ft. above bed
3 ft. below surface
mid depth

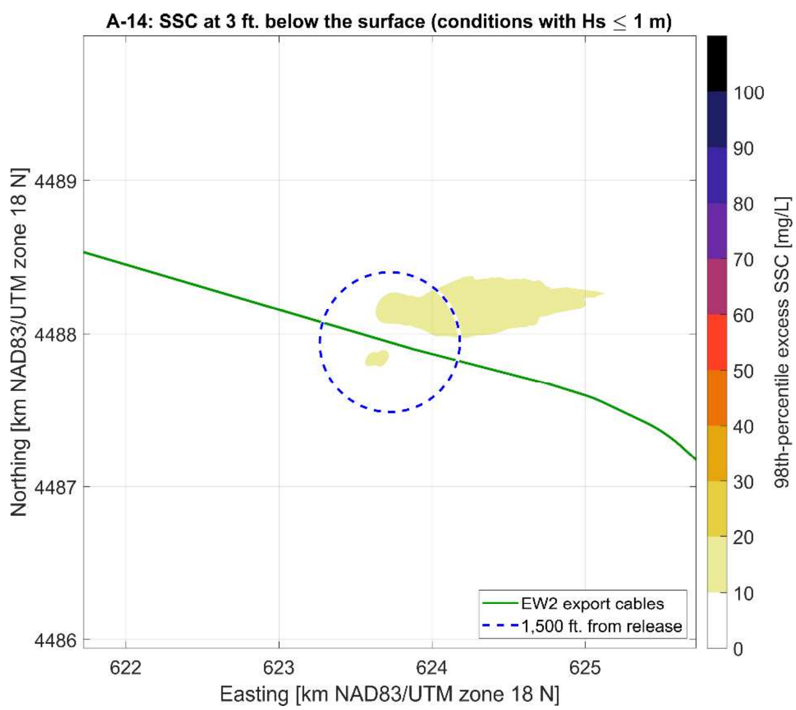
E.8 Release location A-14

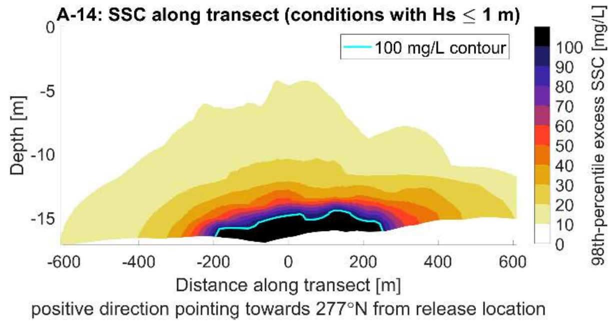


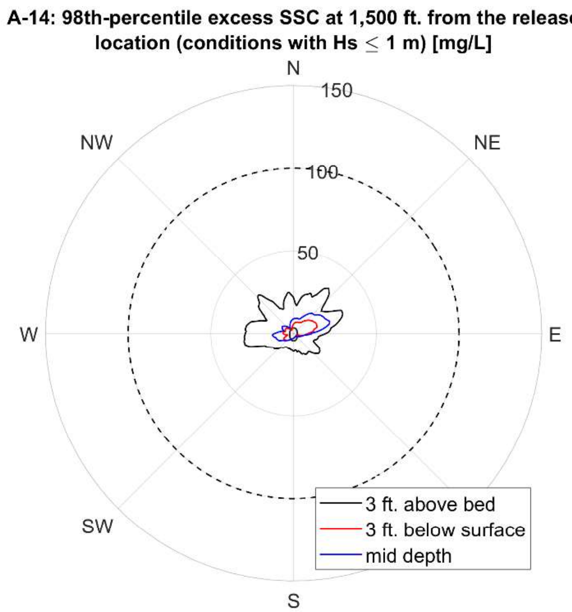
E.8.1 Sediment footprint with significant wave height ≤ 1 m



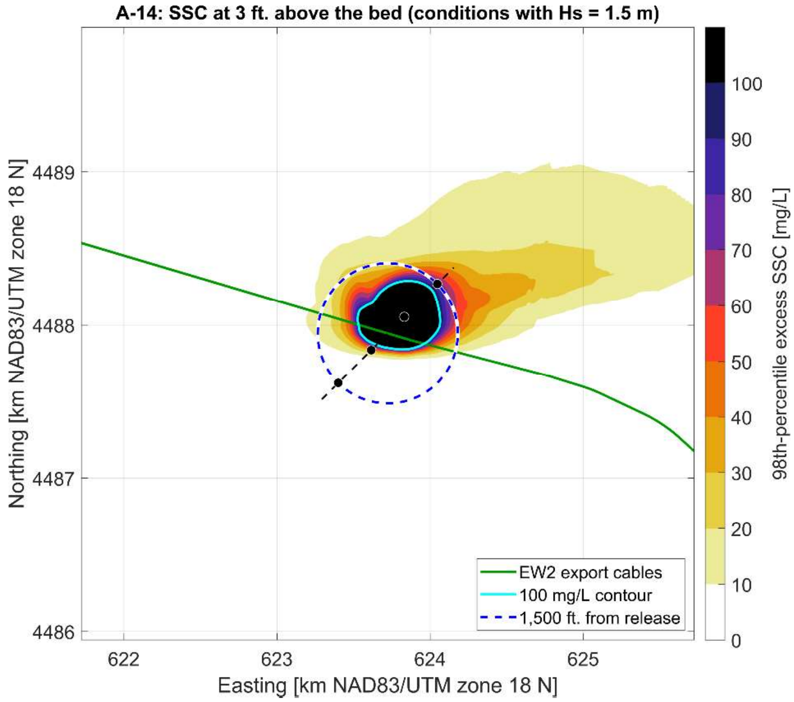

A-14: Mid depth SSC (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release
4486
4487
4488
4489
622
623
624
625
0
10
20
30
40
50
60
70
80
90
100

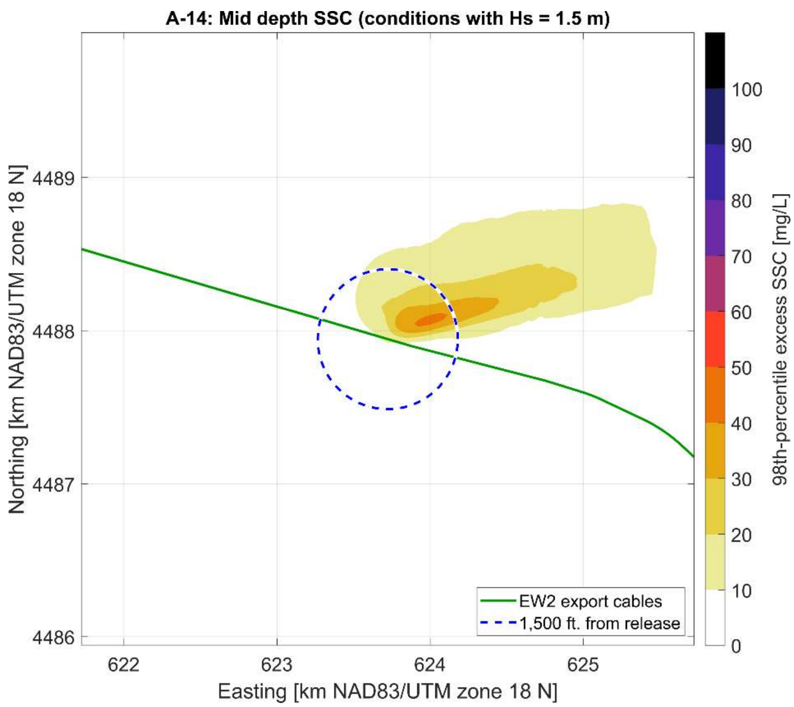

A-14: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release
4486
4487
4488
4489
622
623
624
625
0
10
20
30
40
50
60
70
80
90
100

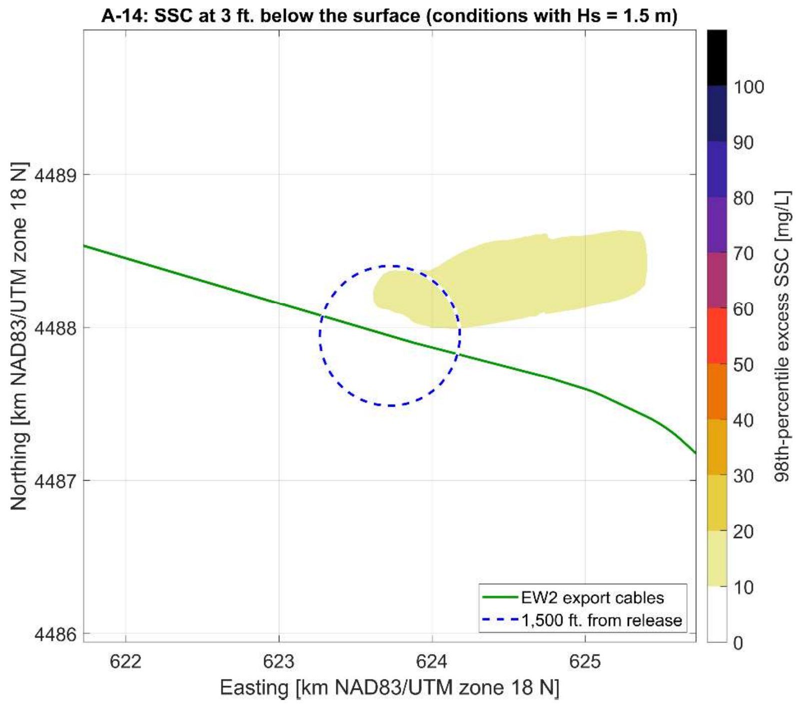

A-14: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
0
-5
-10
-15
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 277°N from release location
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]


A-14: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

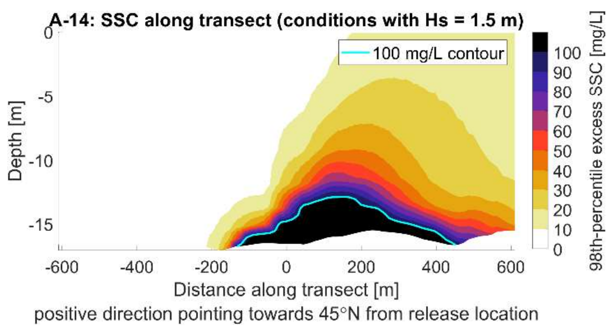
E.8.2 Sediment footprint with significant wave height ≈ 1.5 m



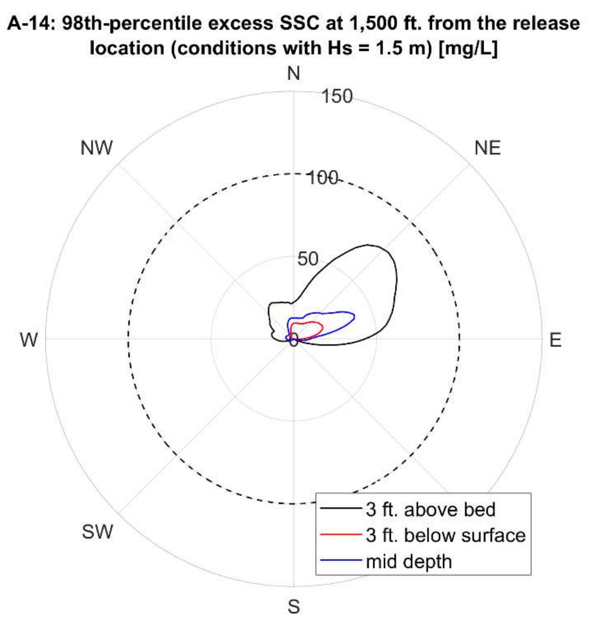




A-14: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release



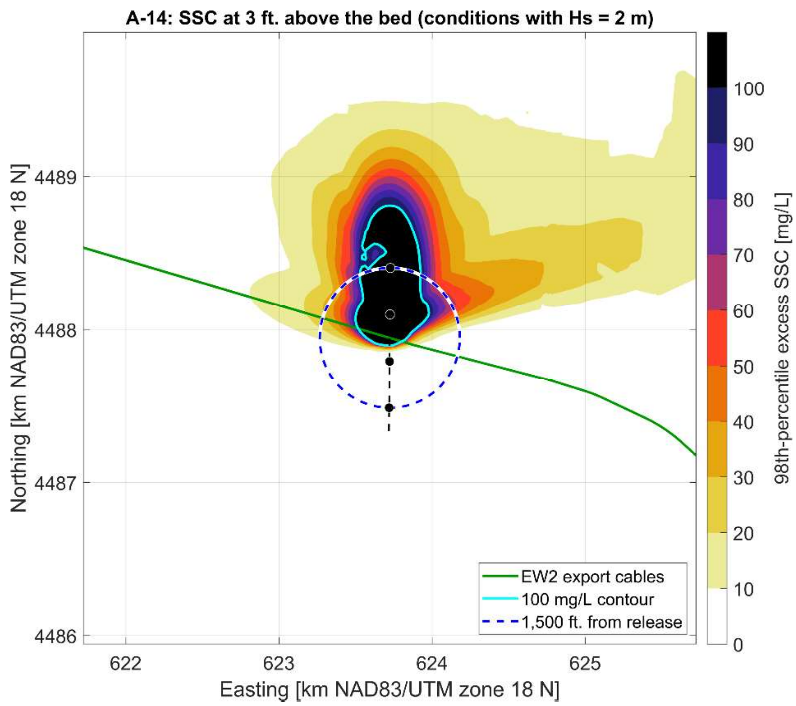
A-14: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 45°N from release location
98th-percentile excess SSC [mg/L]

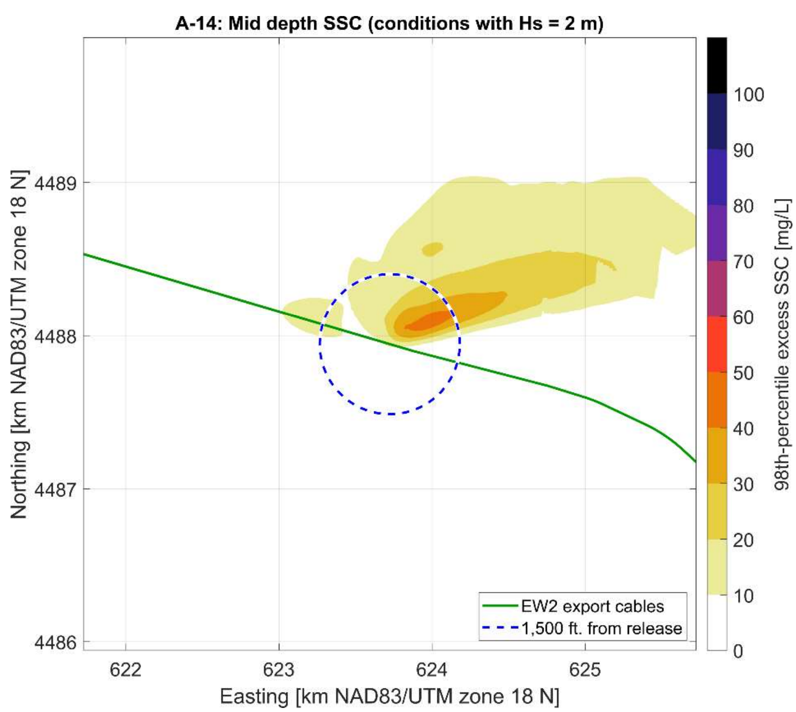


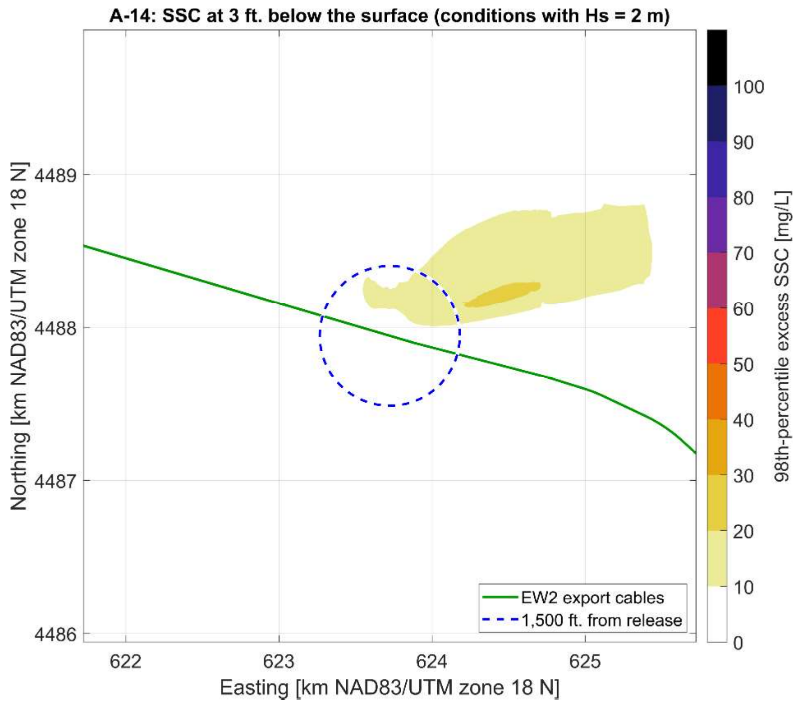
A-14: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
SW
S
NW
W
3 ft. above bed
3 ft. below surface
mid depth

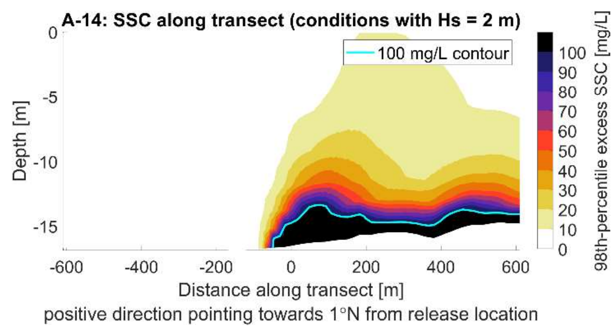
Deltares

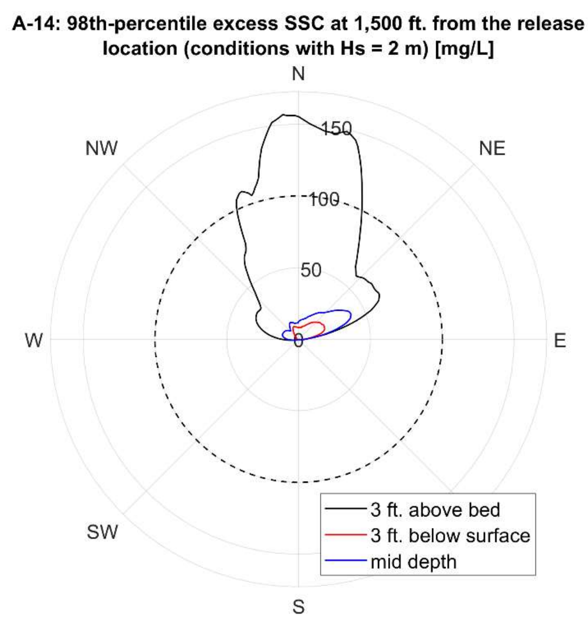
E.8.3 Sediment footprint with significant wave height ≈ 2 m



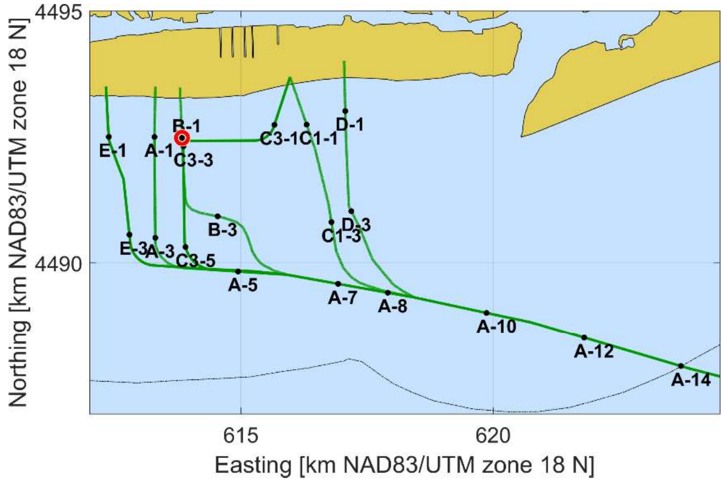



A-14: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release

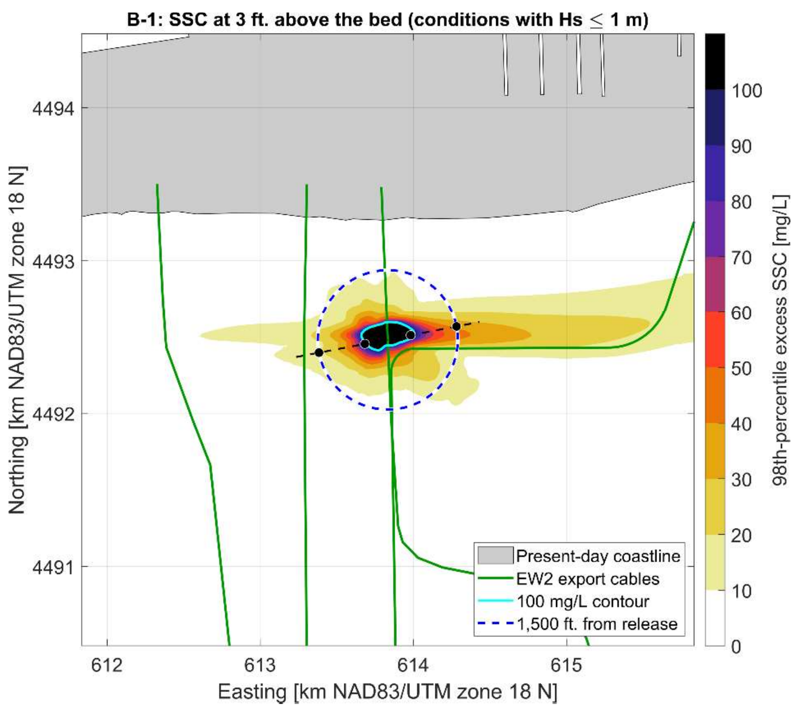

A-14: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 1°N from release location
98th-percentile excess SSC [mg/L]


A-14: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
SW
S
W
NW
3 ft. above bed
3 ft. below surface
mid depth

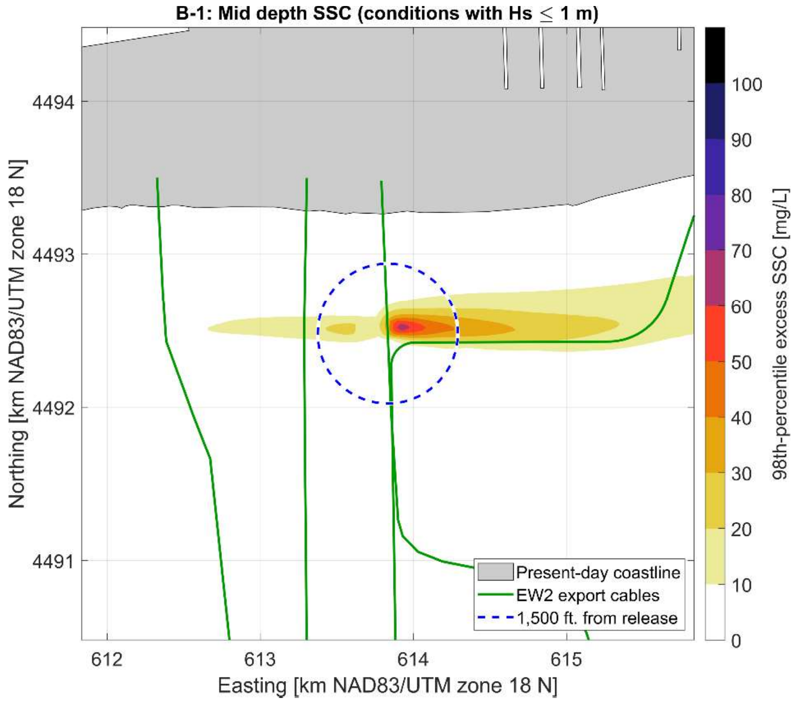
E.9 Release location B-1

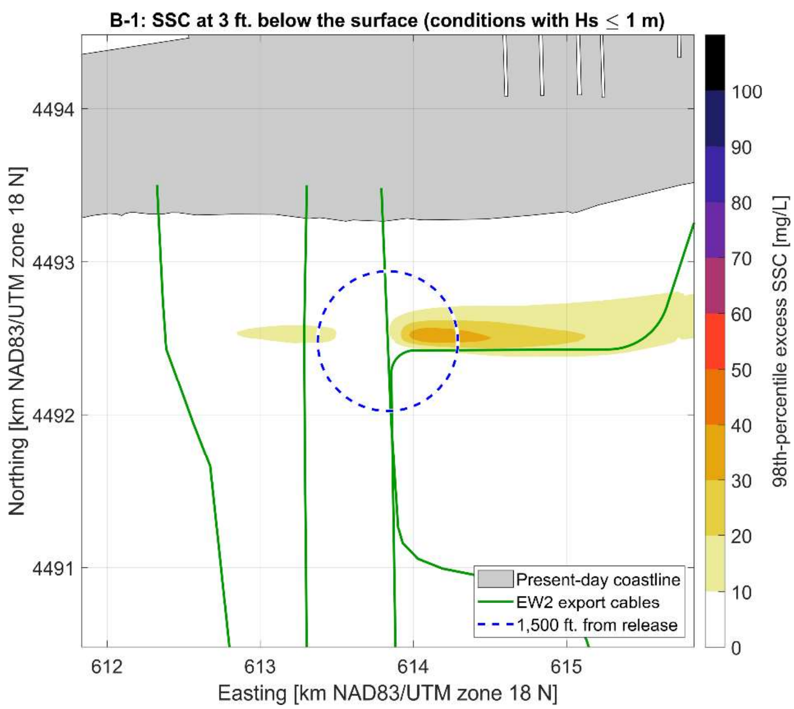


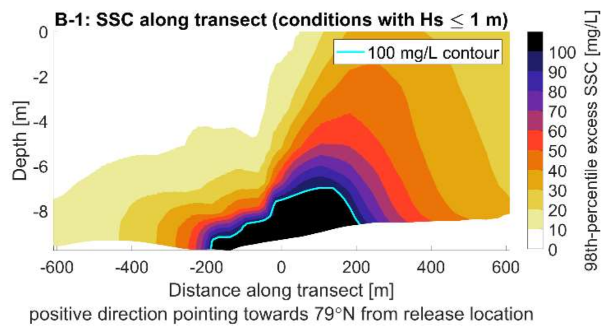
E.9.1 Sediment footprint with significant wave height ≤ 1 m

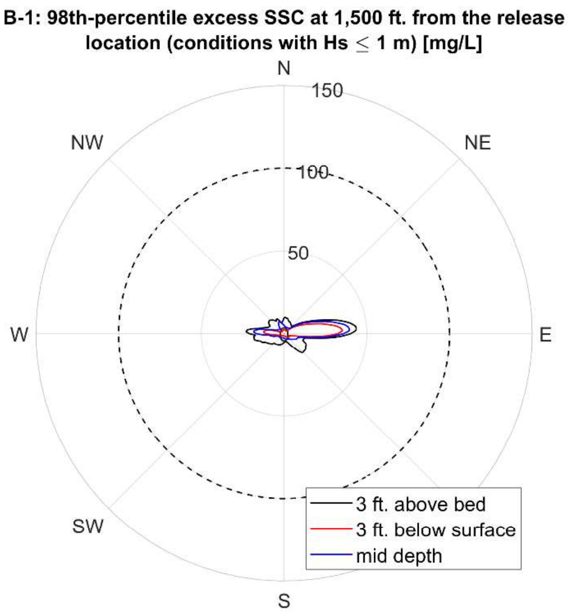


Deltares

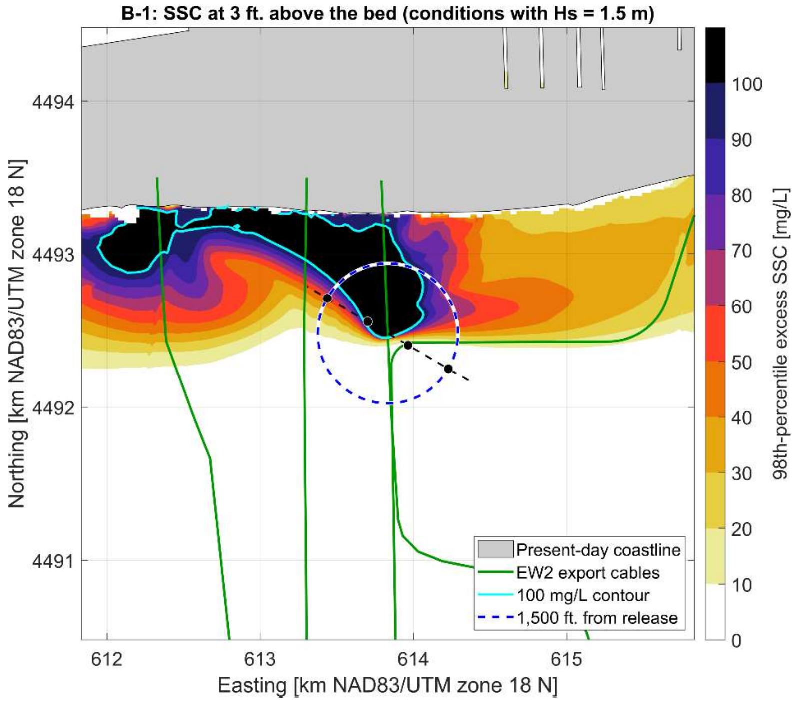

B-1: Mid depth SSC (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4494
4493
4492
4491
612
613
614
615
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100
Present-day coastline
EW2 export cables
1,500 ft. from release

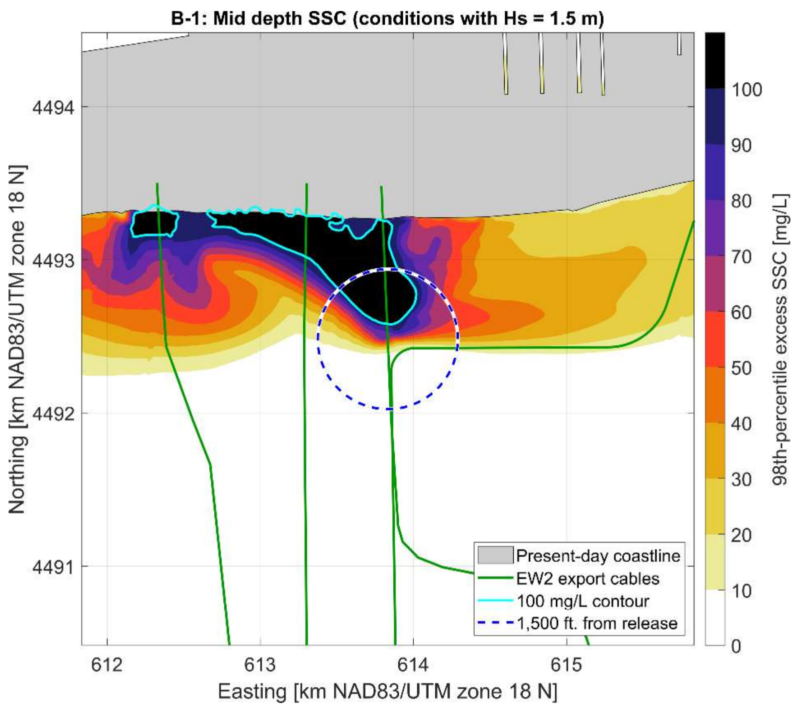

B-1: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4494
4493
4492
4491
612
613
614
615
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100
Present-day coastline
EW2 export cables
1,500 ft. from release

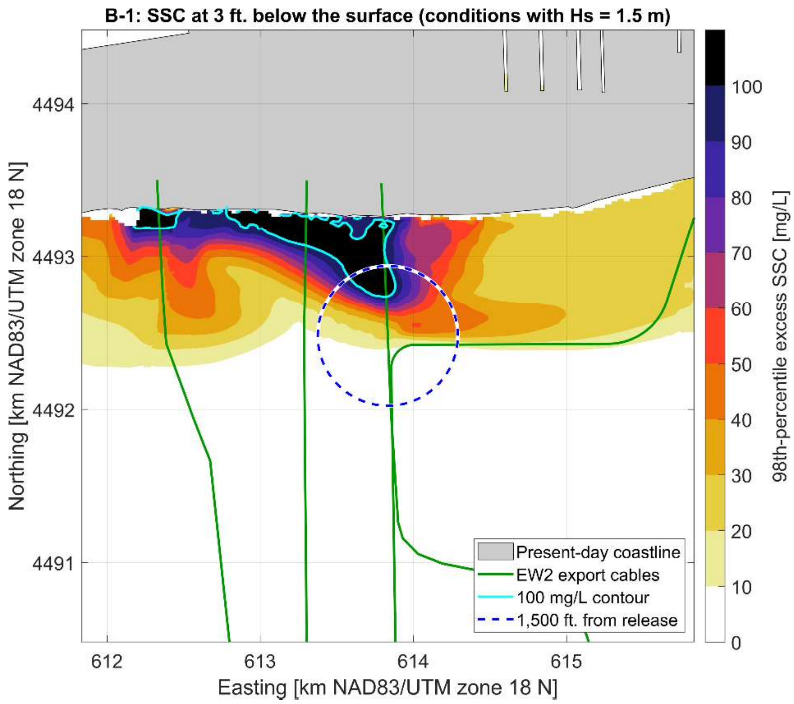

B-1: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 79°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0


B-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
SE
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

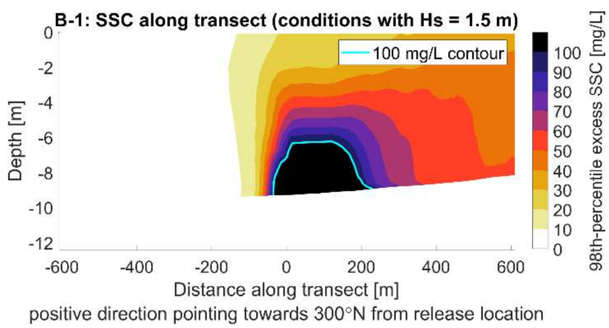
E.9.2 Sediment footprint with significant wave height ≈ 1.5 m



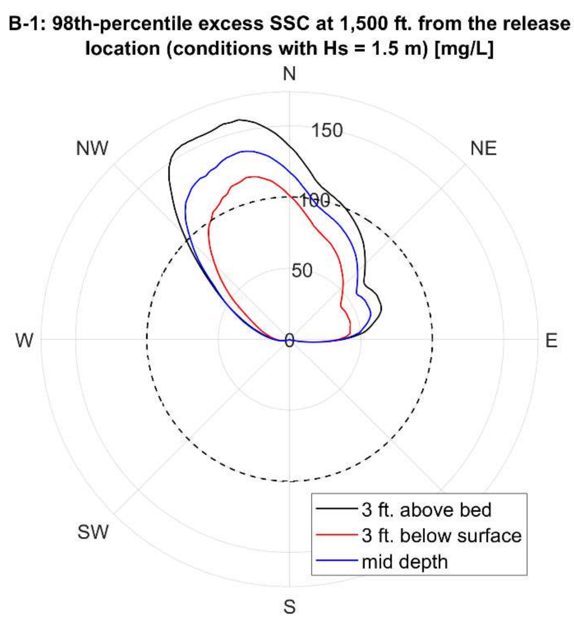




B-1: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
Present-day coastline
EW2 export cables
100 mg/L contour
1,500 ft. from release

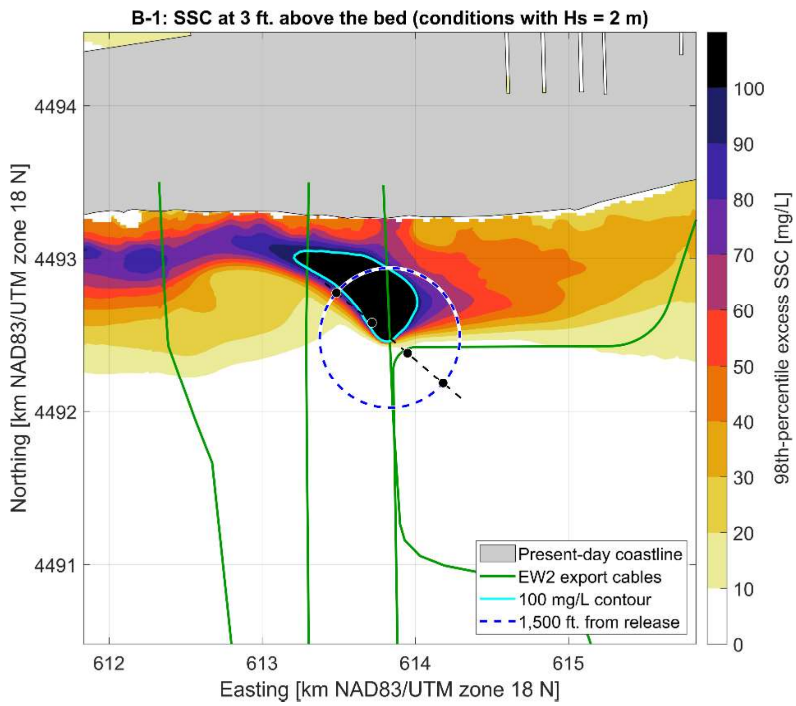


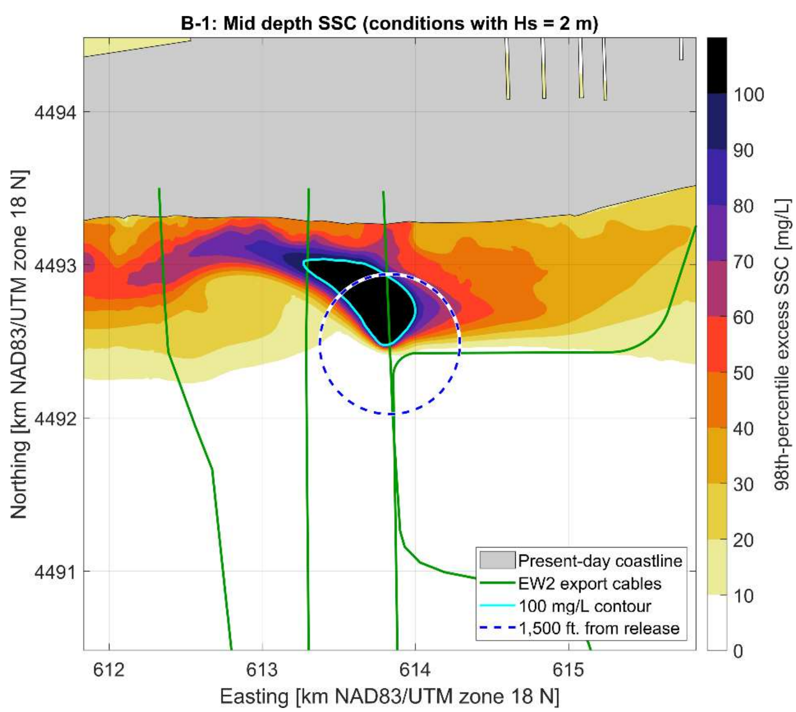
B-1: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 300°N from release location
98th-percentile excess SSC [mg/L]

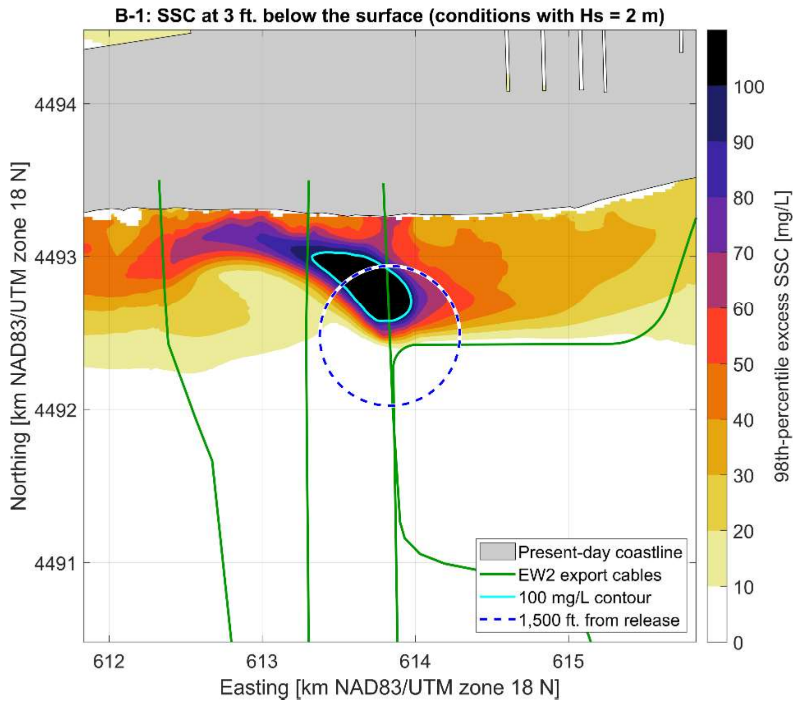


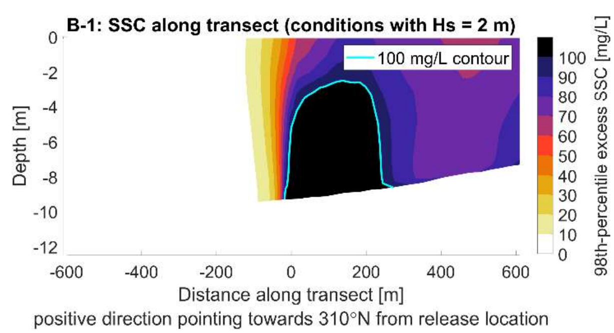
B-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

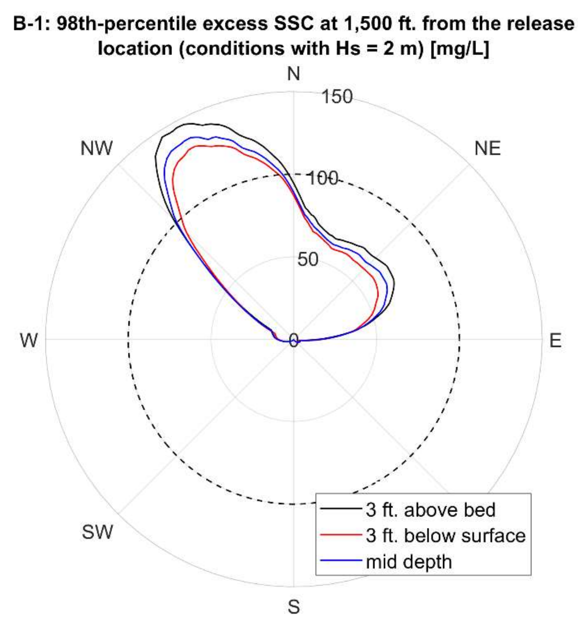
E.9.3 Sediment footprint with significant wave height ≈ 2 m



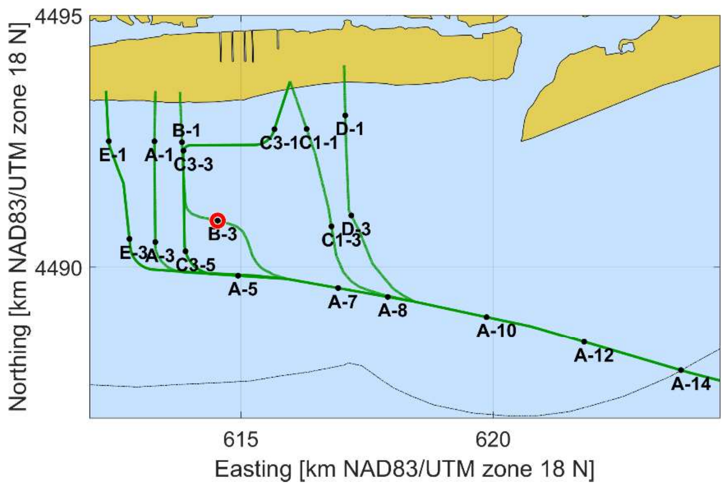



B-1: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4494
4493
4492
4491
612
613
614
615
Present-day coastline
EW2 export cables
100 mg/L contour
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

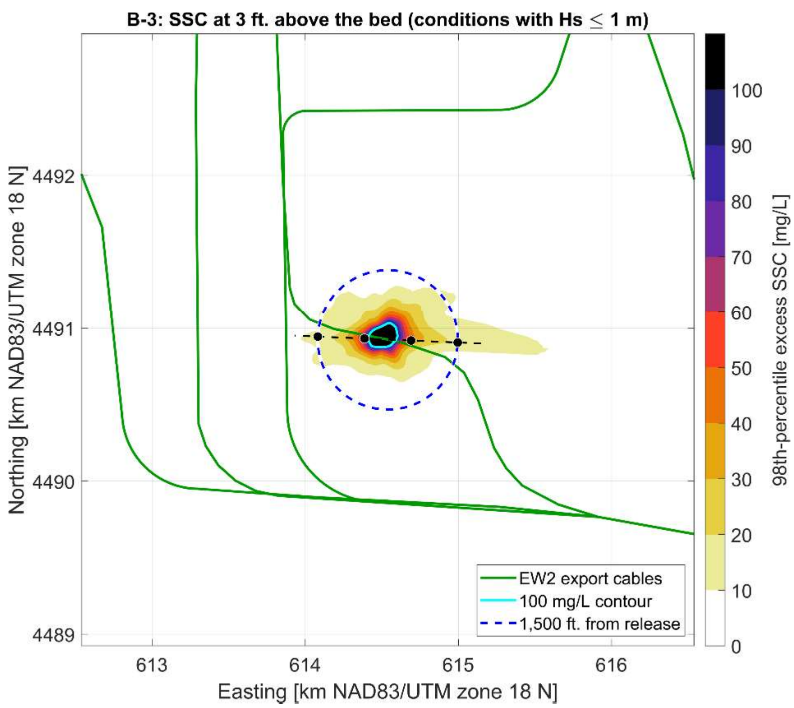

B-1: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 310°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0


B-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

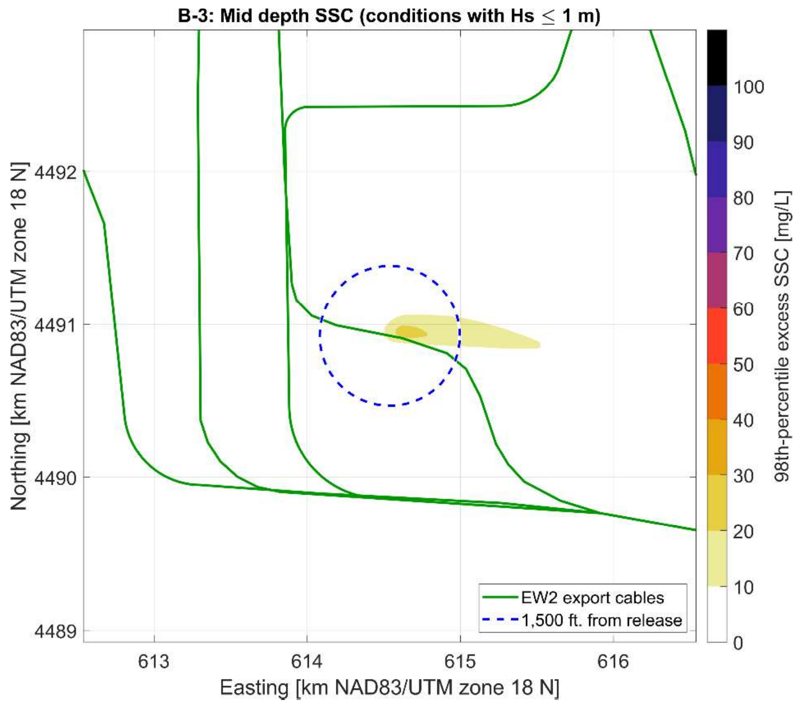
E.10 Release location B-3



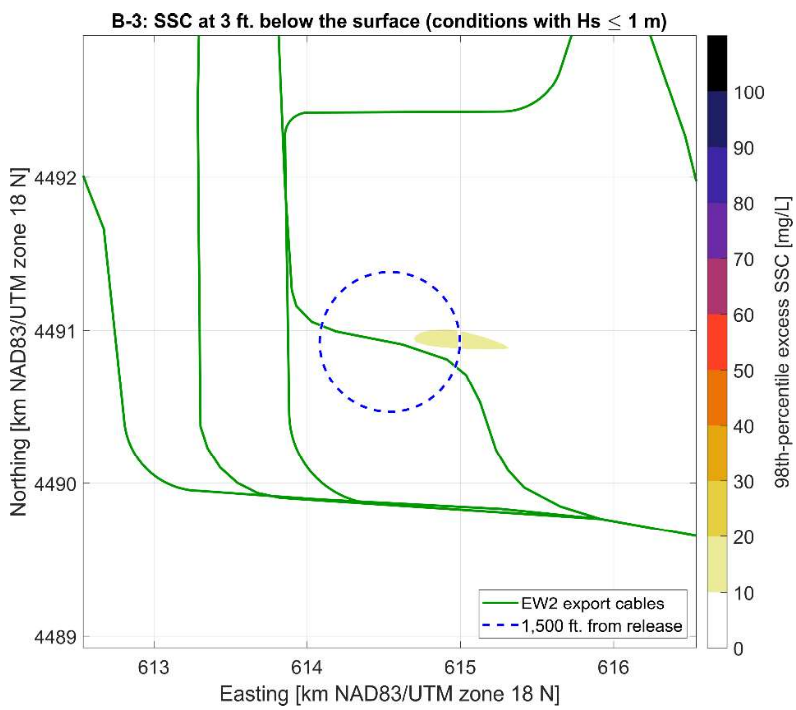
E.10.1 Sediment footprint with significant wave height ≤ 1 m



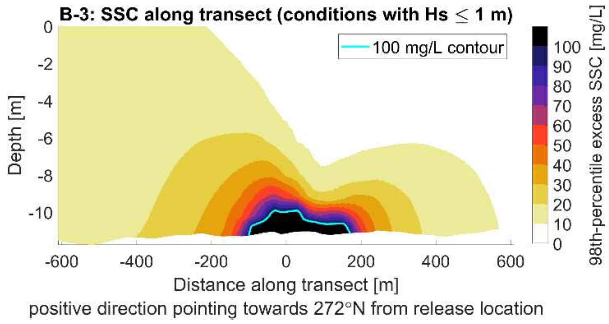
Deltares

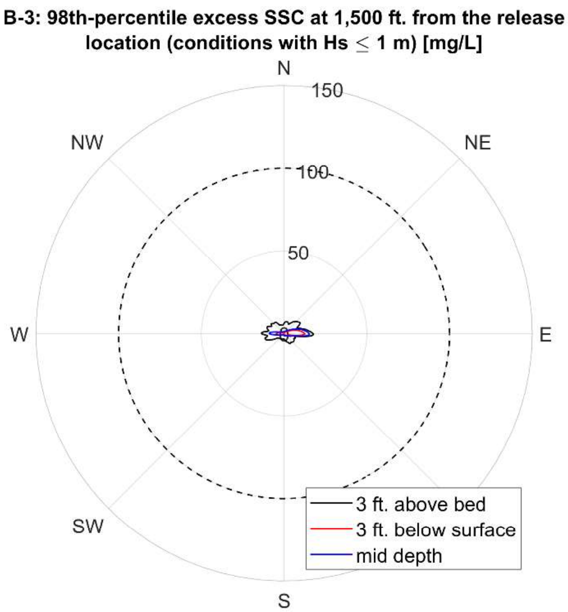


B-3: Mid depth SSC (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
613
614
615
616
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

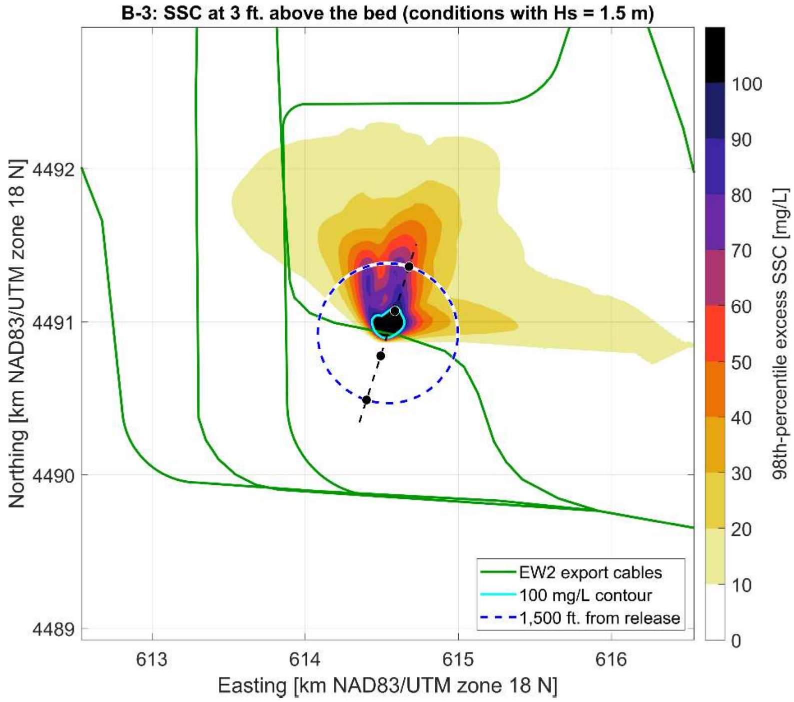


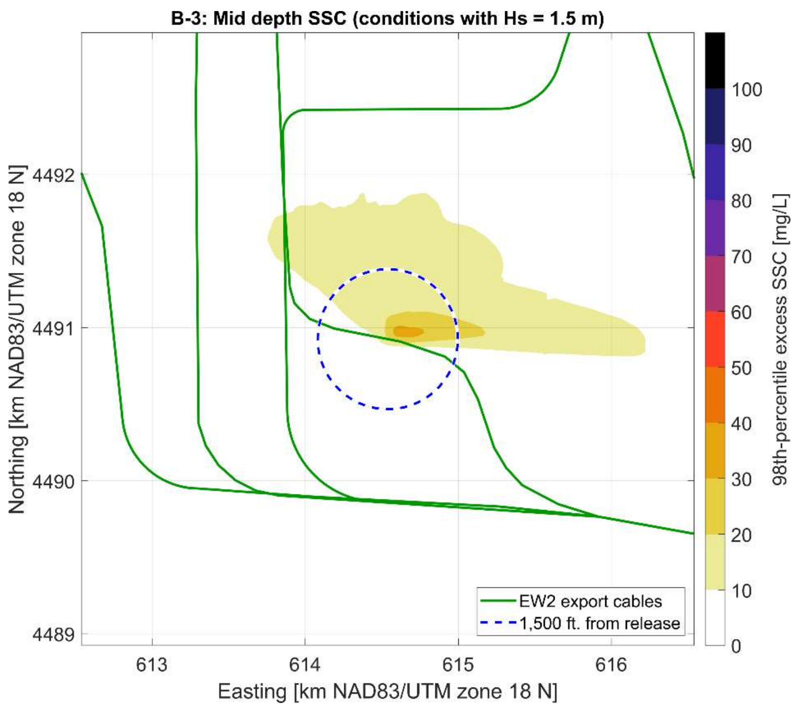
B-3: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
613
614
615
616
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

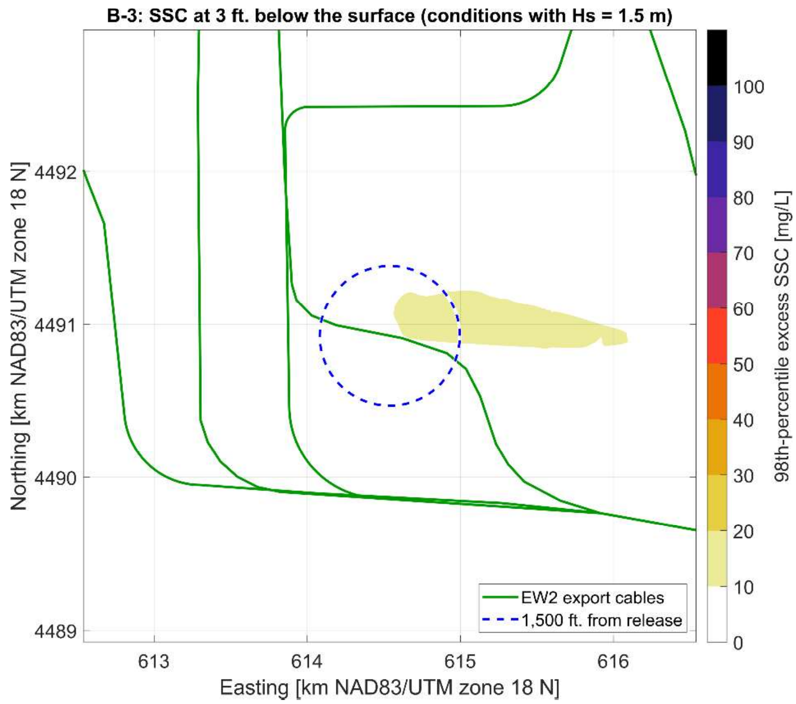

B-3: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-10
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 272°N from release location
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

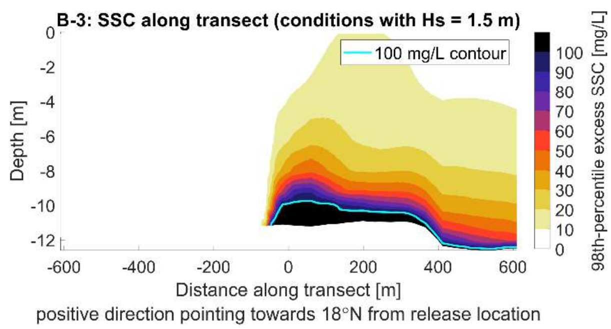

B-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
SW
S
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

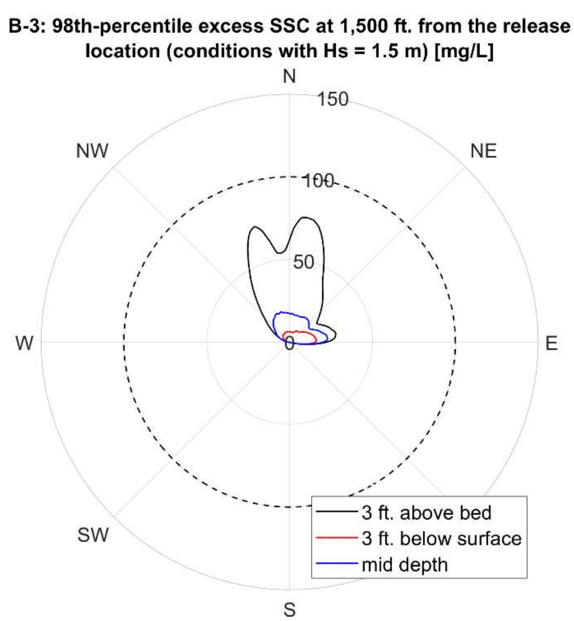
E.10.2 Sediment footprint with significant wave height ≈ 1.5 m



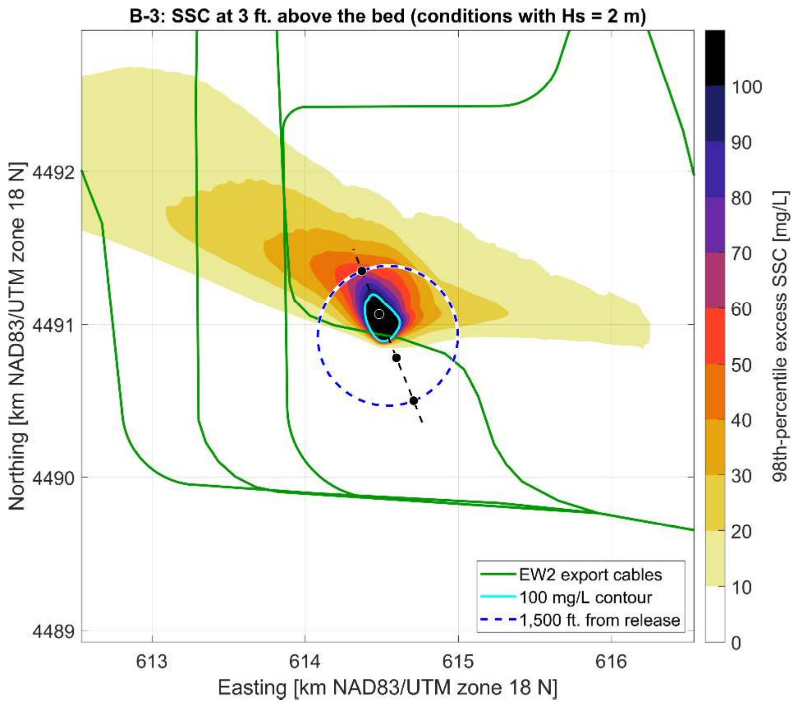


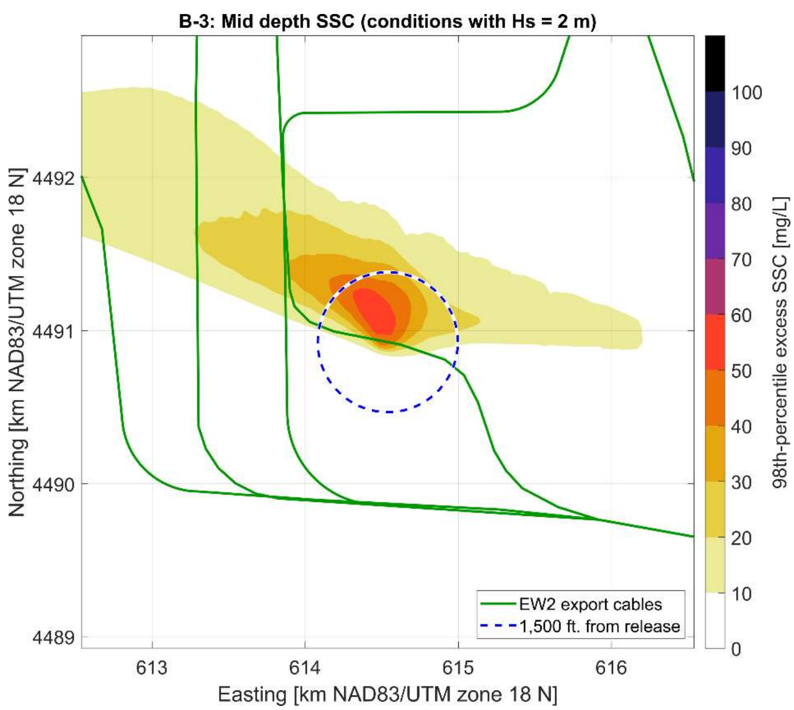

B-3: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
613
614
615
616
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100

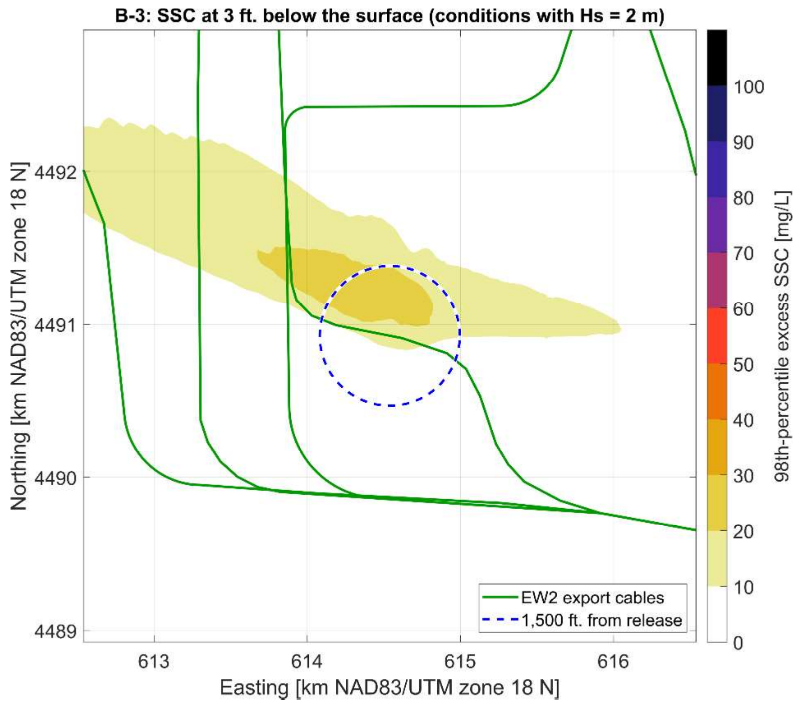

B-3: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 18°N from release location
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100

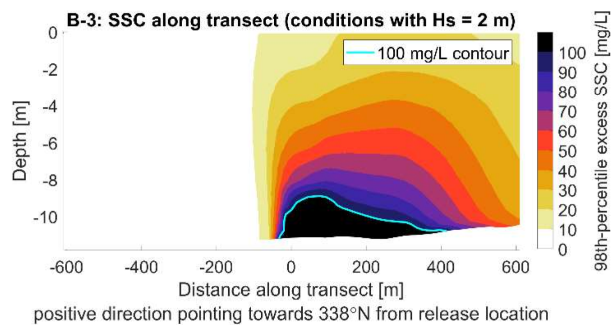

B-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

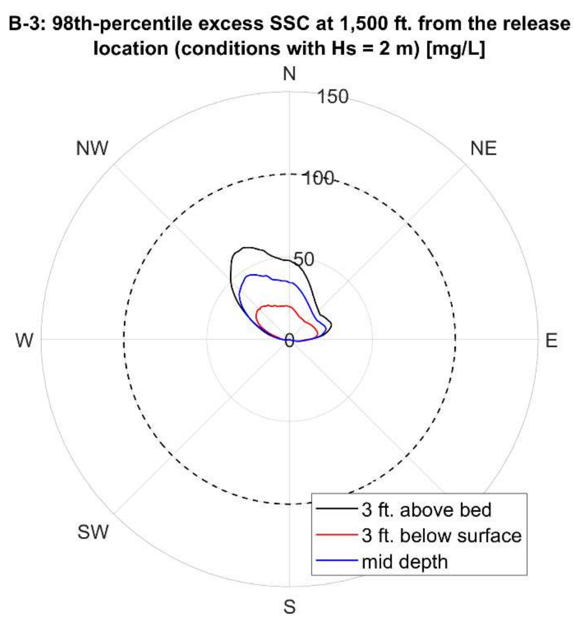
E.10.3 Sediment footprint with significant wave height ≈ 2 m



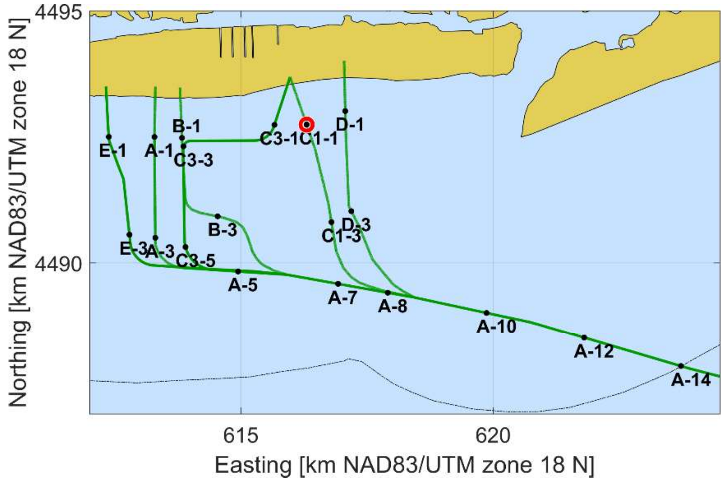



B-3: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release
4489
4490
4491
4492
613
614
615
616
0
10
20
30
40
50
60
70
80
90
100

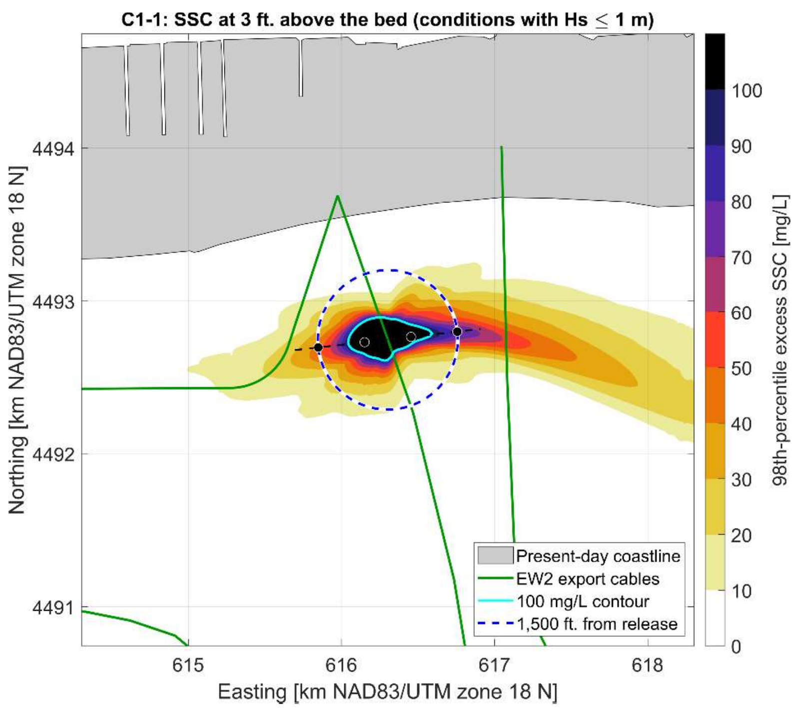

B-3: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 338°N from release location
98th-percentile excess SSC [mg/L]

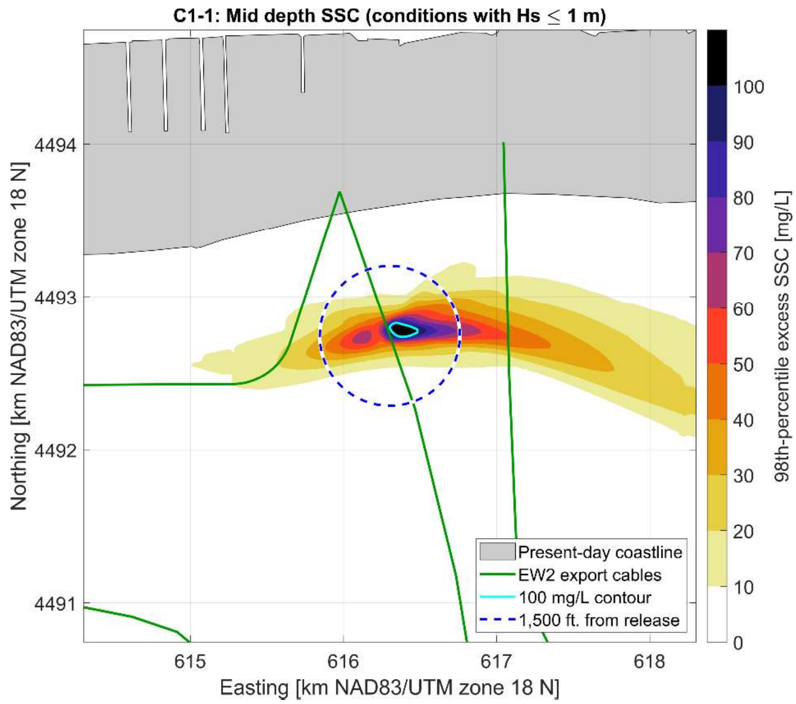

B-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

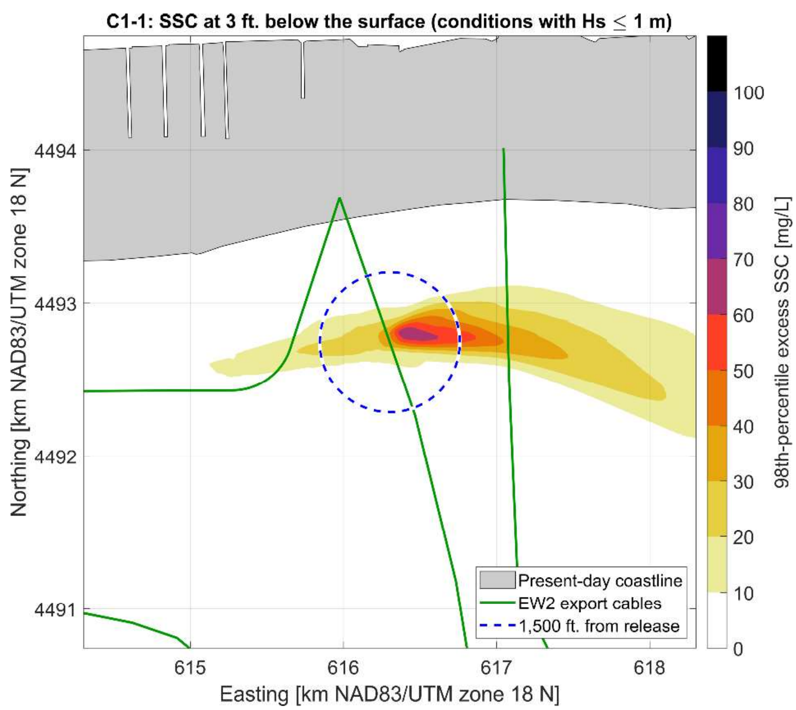
E.11 Release location C1-1

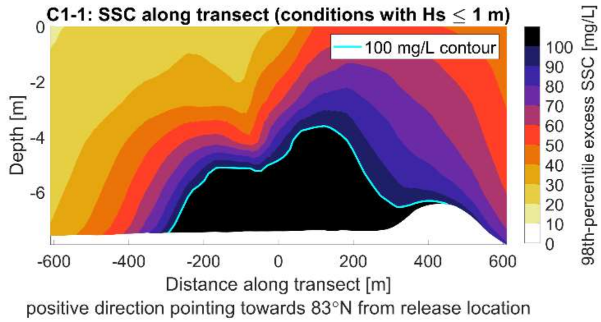


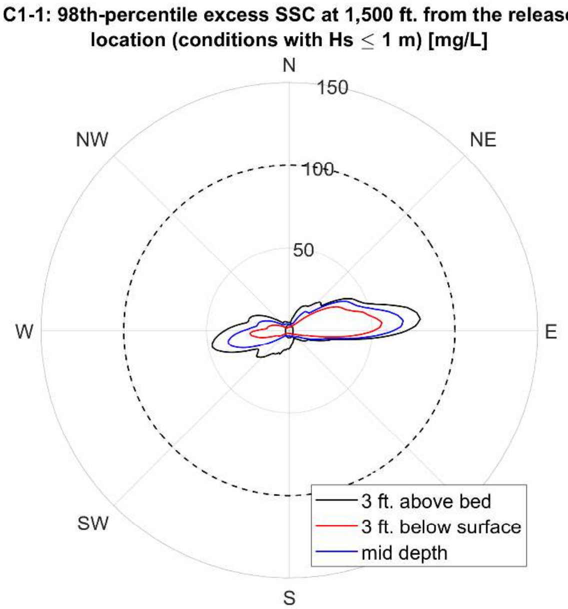
E.11.1 Sediment footprint with significant wave height ≤ 1 m



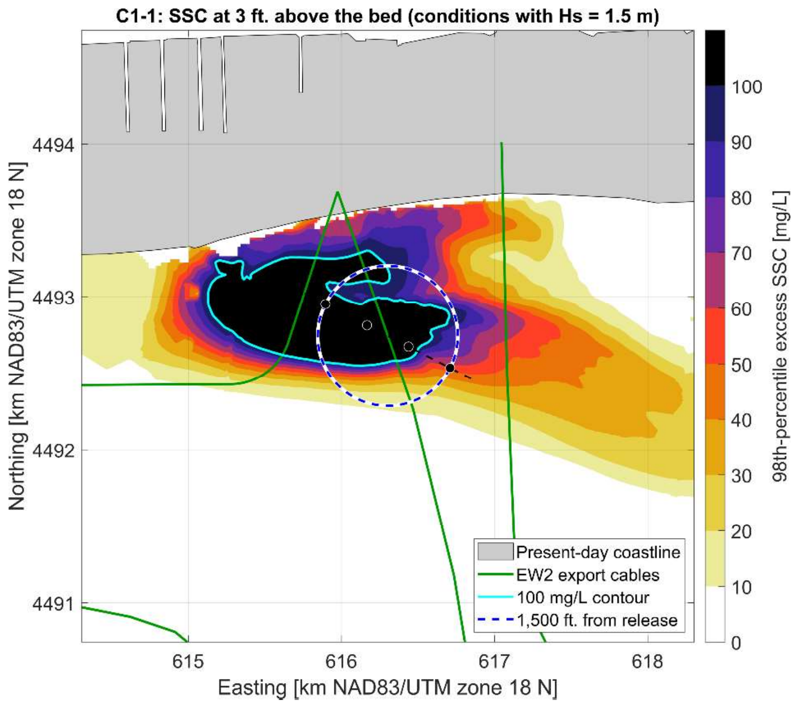

C1-1: Mid depth SSC (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
4494
4493
4492
4491
615
616
617
618
Easting [km NAD83/UTM zone 18 N]
Present-day coastline
EW2 export cables
100 mg/L contour
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

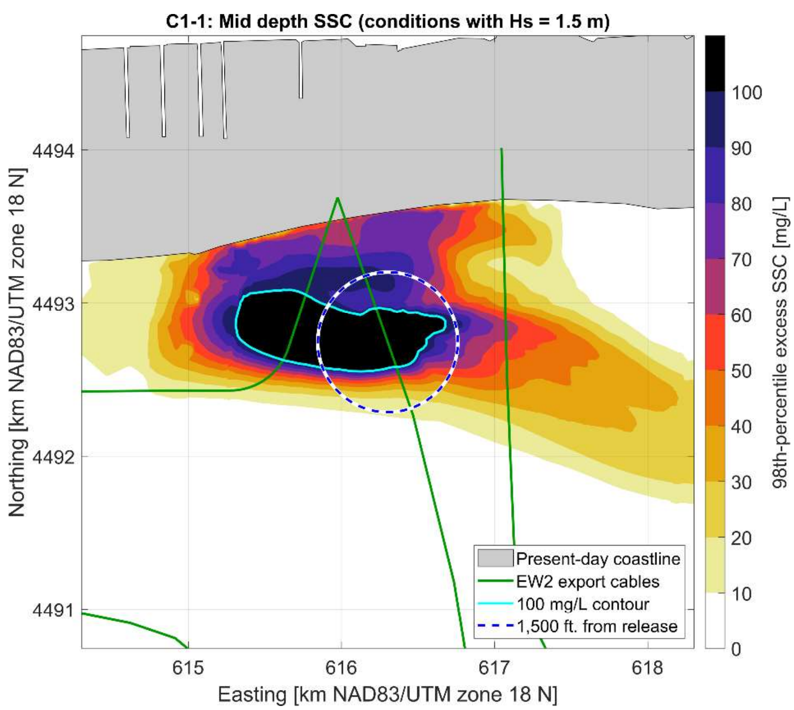

C1-1: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
4494
4493
4492
4491
615
616
617
618
Easting [km NAD83/UTM zone 18 N]
Present-day coastline
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

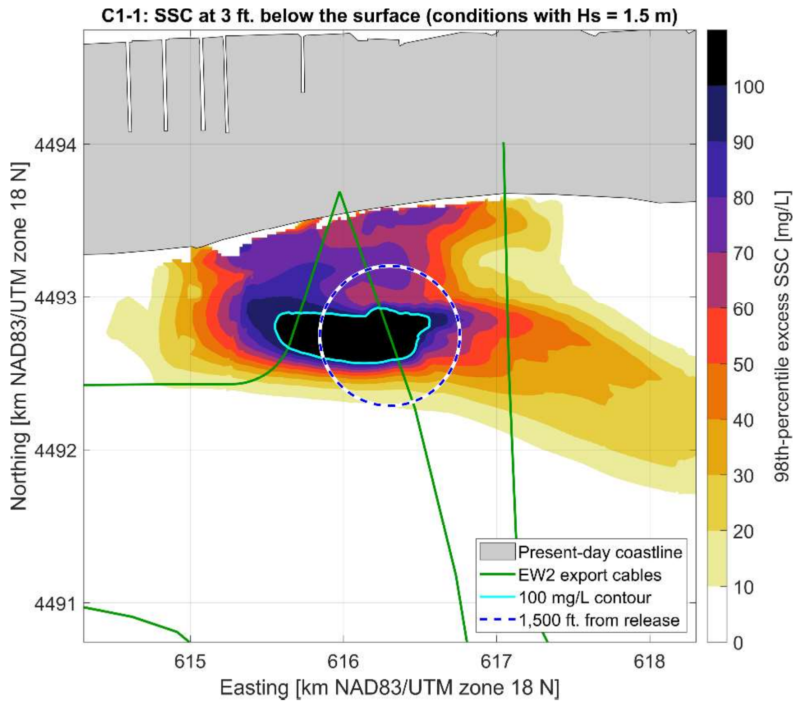

C1-1: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 83°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

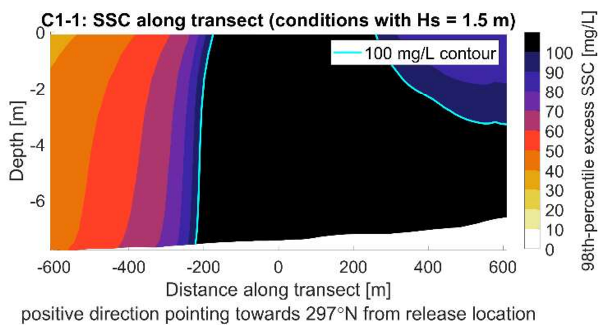

C1-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

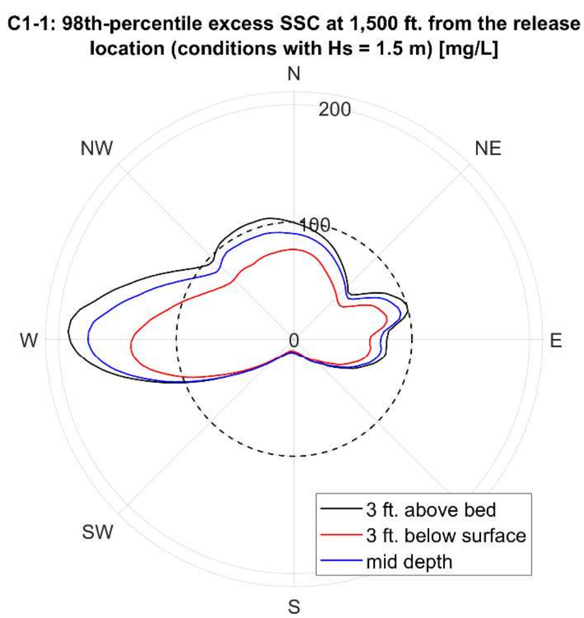
E.11.2 Sediment footprint with significant wave height ≈ 1.5 m



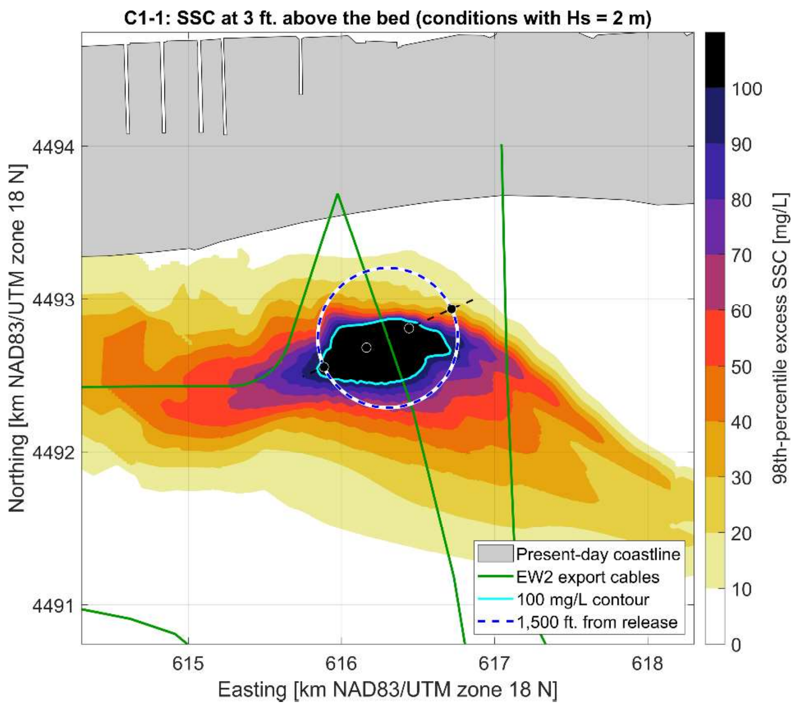


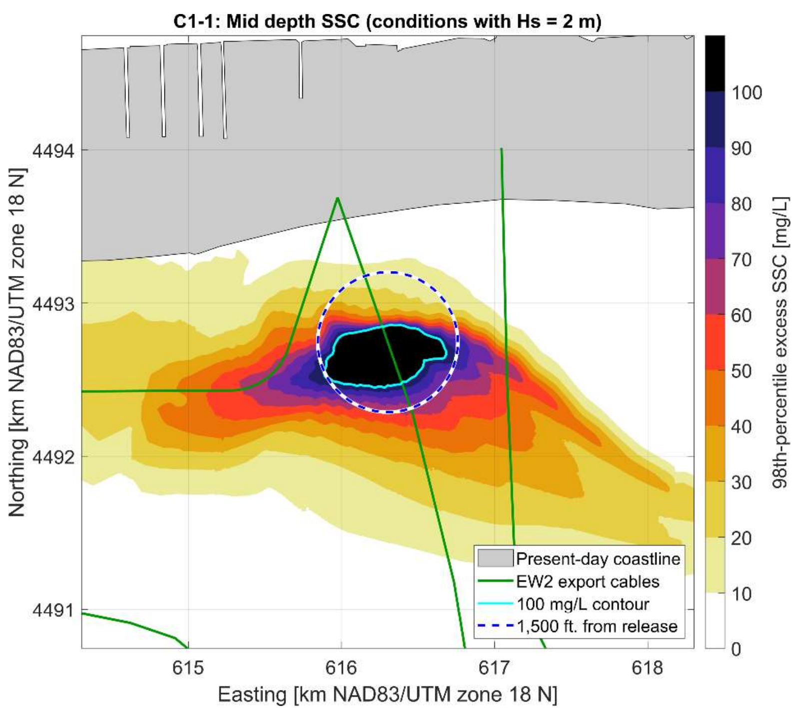

C1-1: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
Present-day coastline
EW2 export cables
100 mg/L contour
1,500 ft. from release

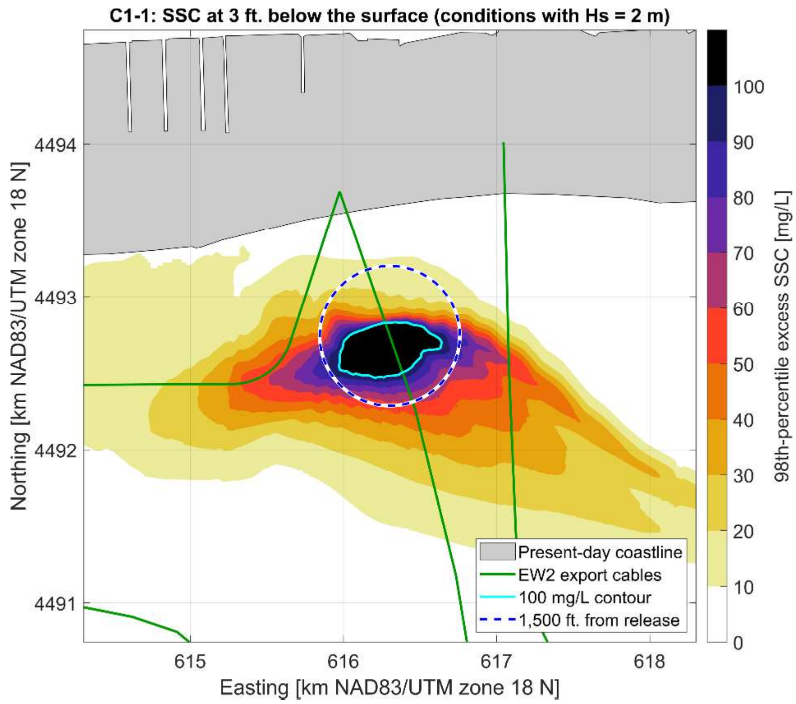

C1-1: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 297°N from release location
98th-percentile excess SSC [mg/L]

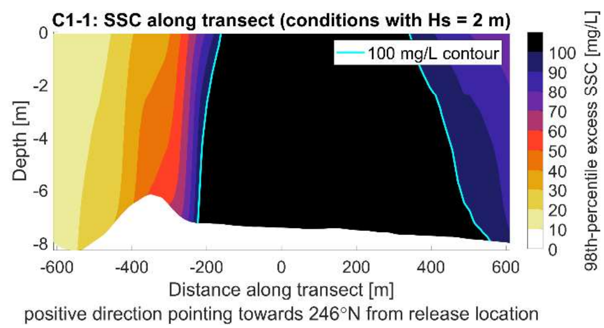

C1-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

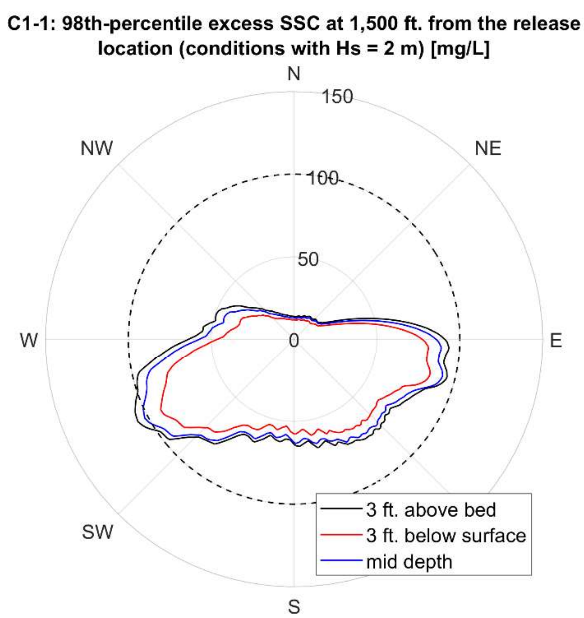
E.11.3 Sediment footprint with significant wave height ≈ 2 m





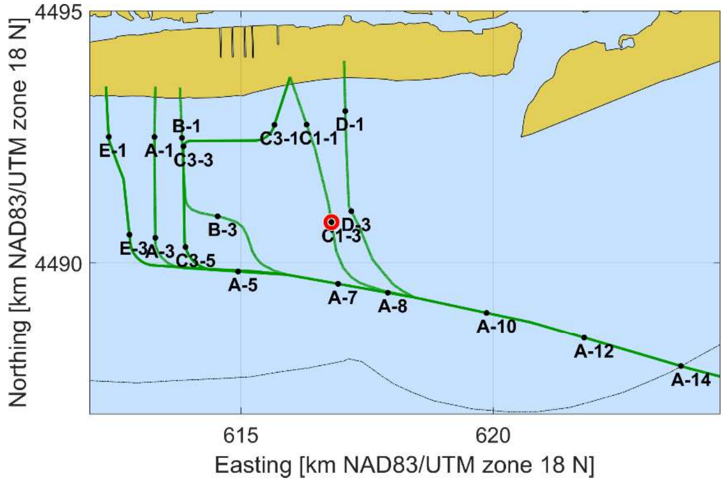

C1-1: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
Present-day coastline
EW2 export cables
100 mg/L contour
1,500 ft. from release


C1-1: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 246°N from release location
98th-percentile excess SSC [mg/L]

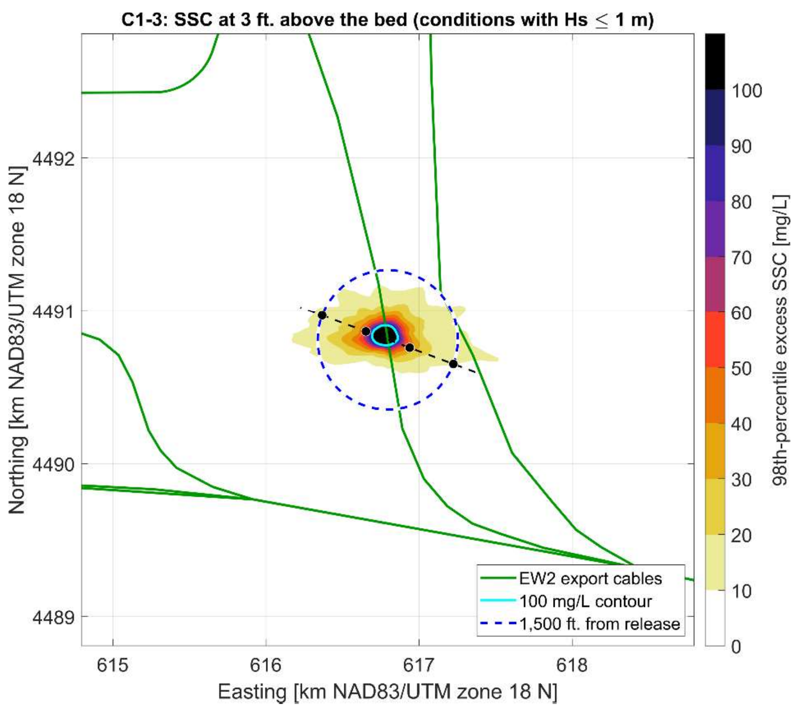

C1-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

Deltares

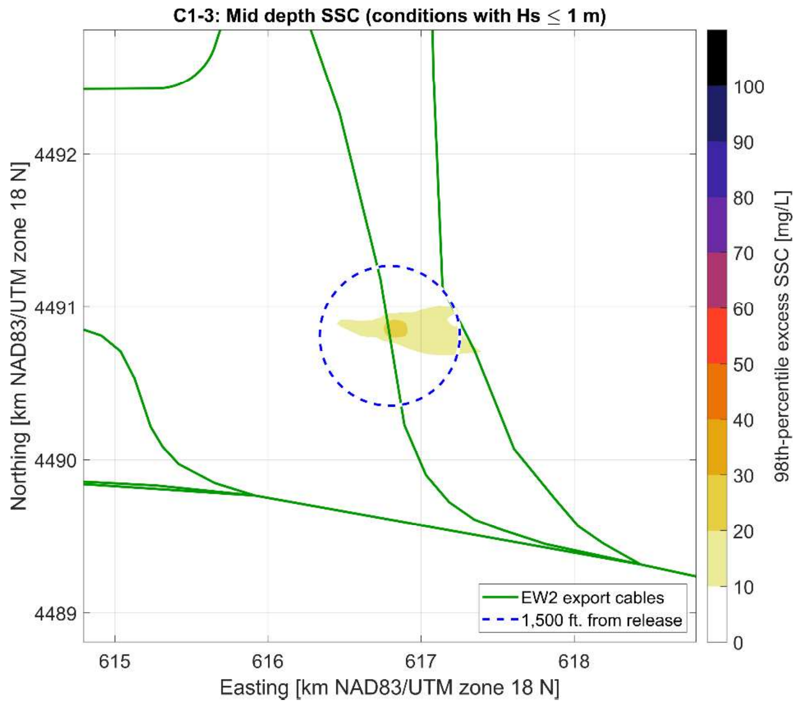
E.12 Release location C1-3

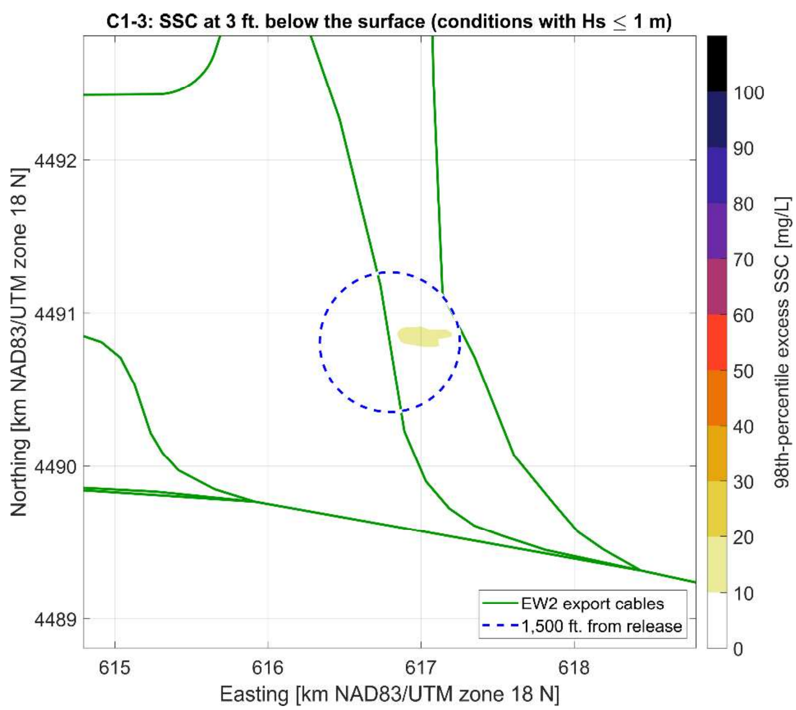


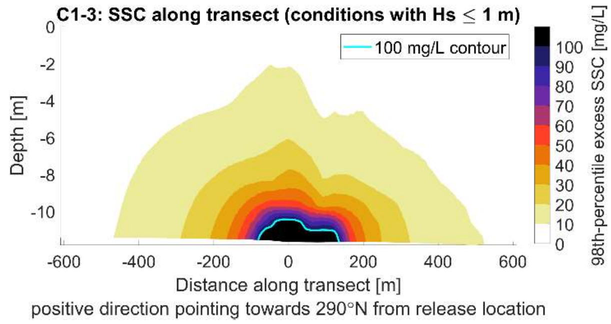
E.12.1 Sediment footprint with significant wave height ≤ 1 m

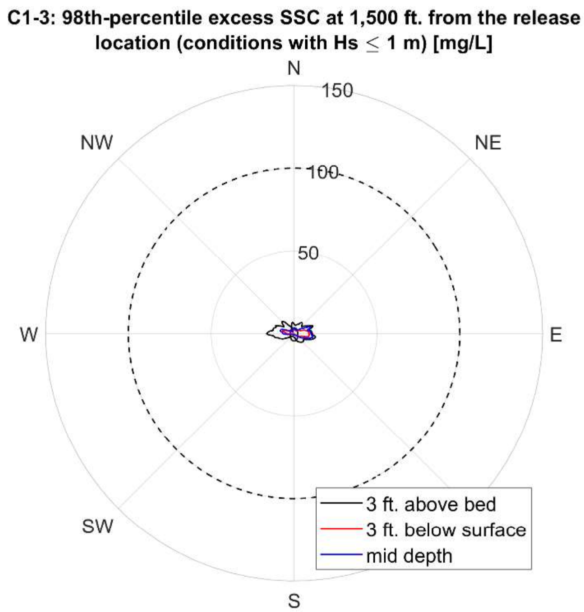


Deltares

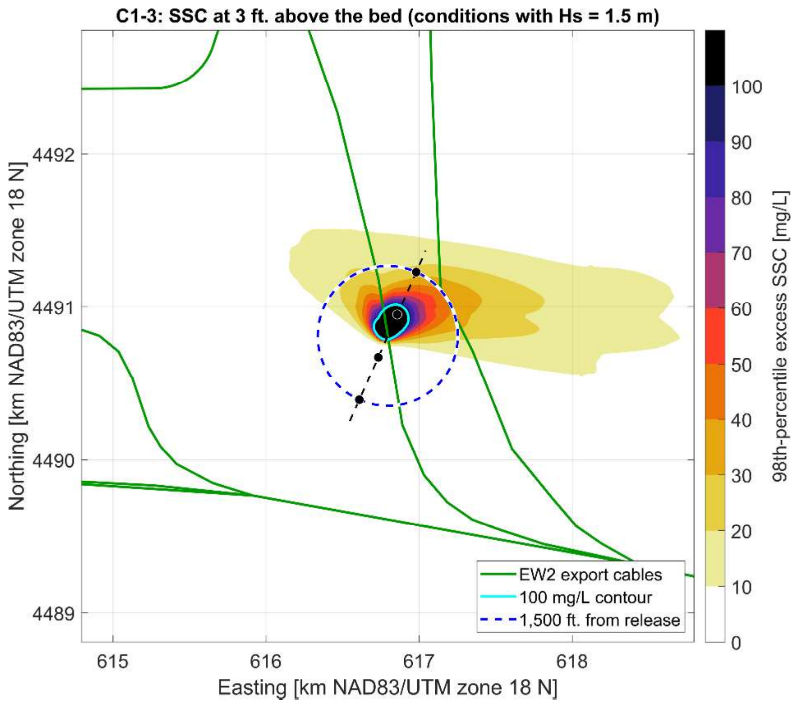

C1-3: Mid depth SSC (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4489
4490
4491
4492
615
616
617
618
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100

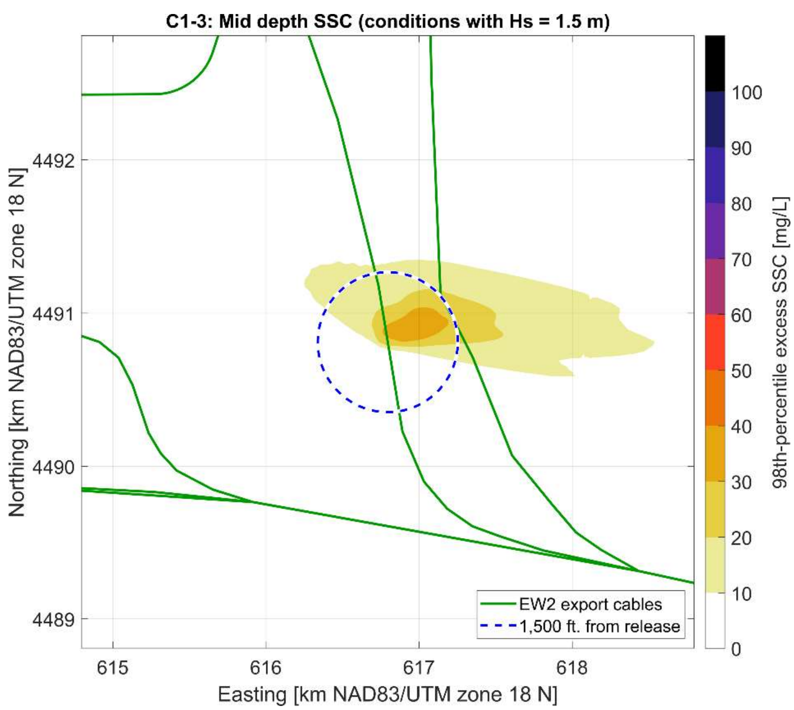

C1-3: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4489
4490
4491
4492
615
616
617
618
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100

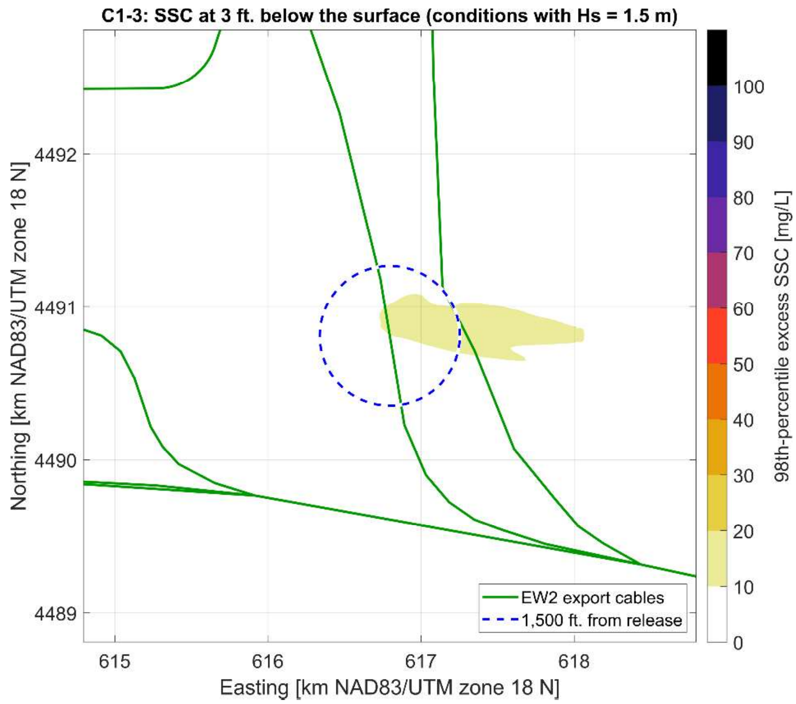

C1-3: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-10
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 290°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

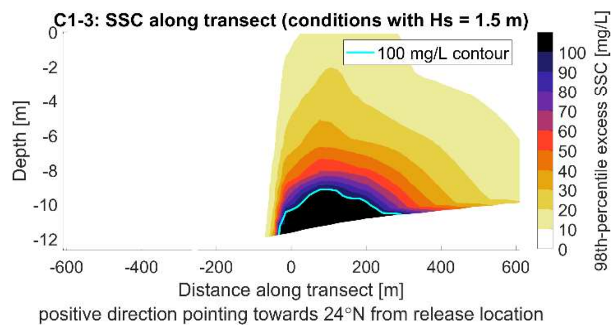

C1-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

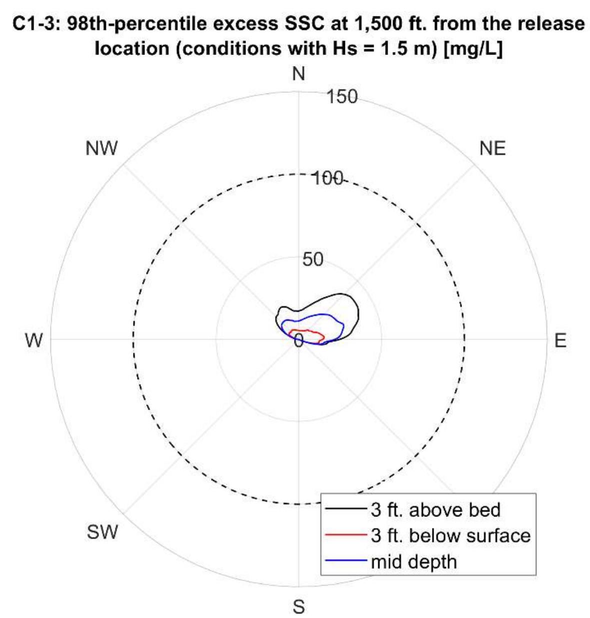
E.12.2 Sediment footprint with significant wave height ≈ 1.5 m



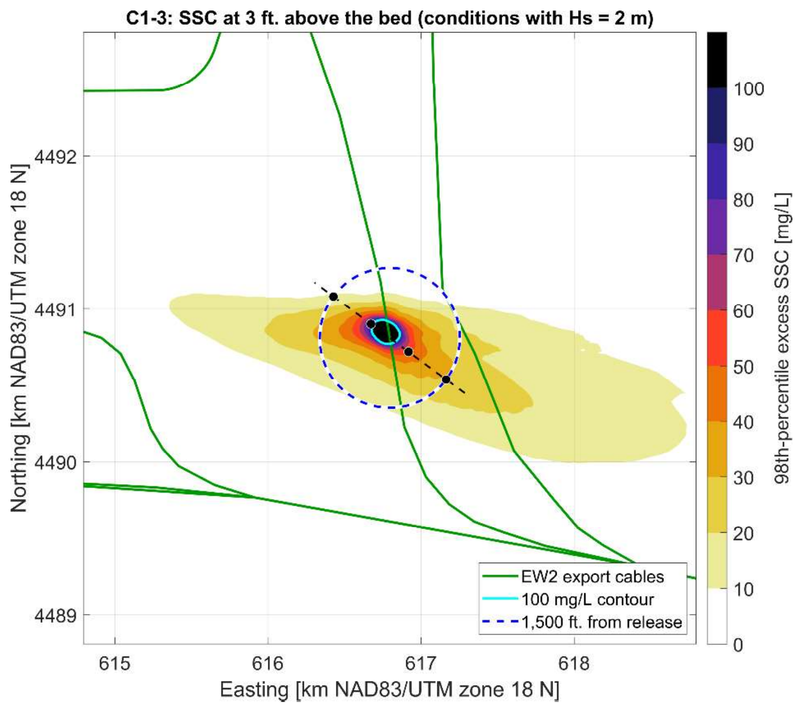


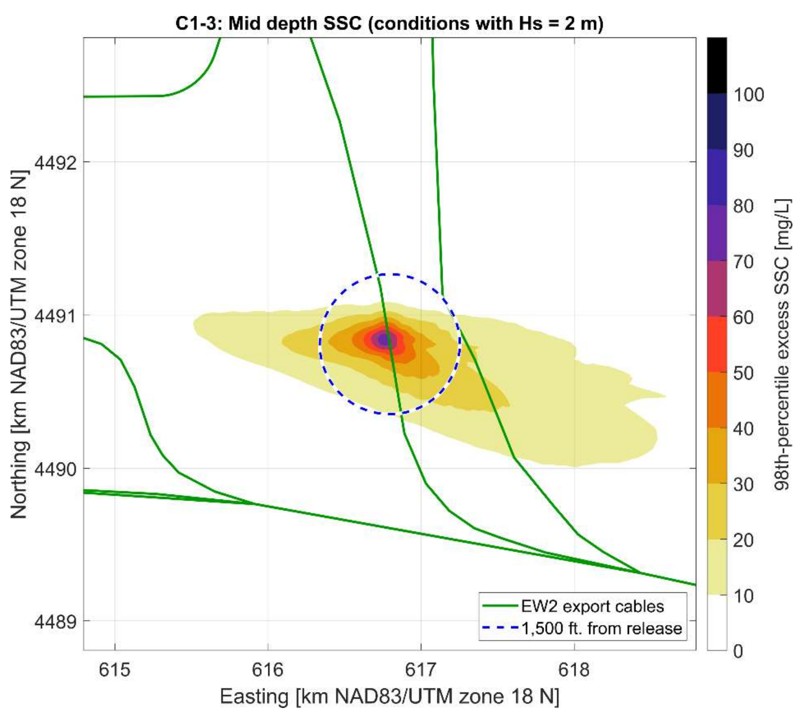

C1-3: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
Northing [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
615
616
617
618
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100

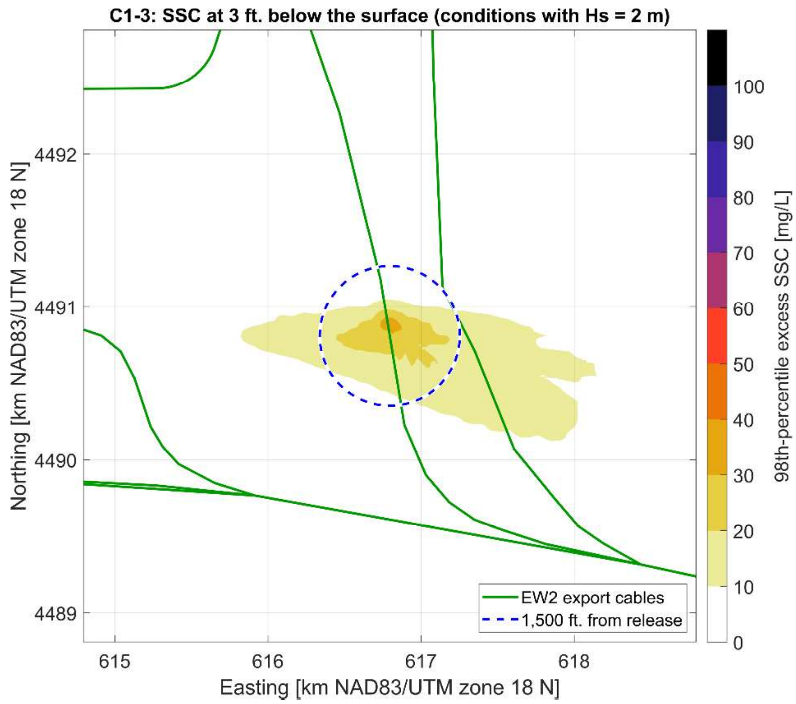

C1-3: SSC along transect (conditions with Hs = 1.5 m)
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 24°N from release location
100 mg/L contour
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100


C1-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
S
SW
W
NW
0
50
100
150
3 ft. above bed
3 ft. below surface
mid depth

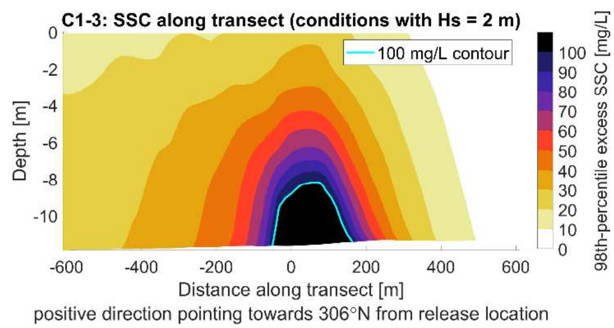
E.12.3 Sediment footprint with significant wave height ≈ 2 m



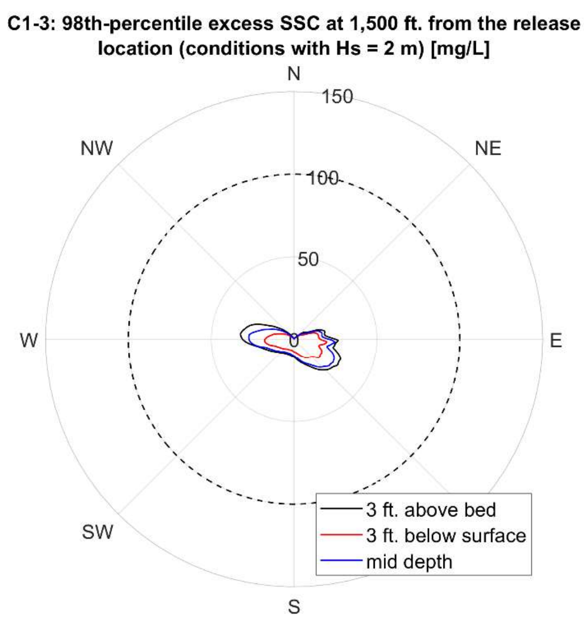




C1-3: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
Easting [km NAD83/UTM zone 18 N]
615
616
617
618
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

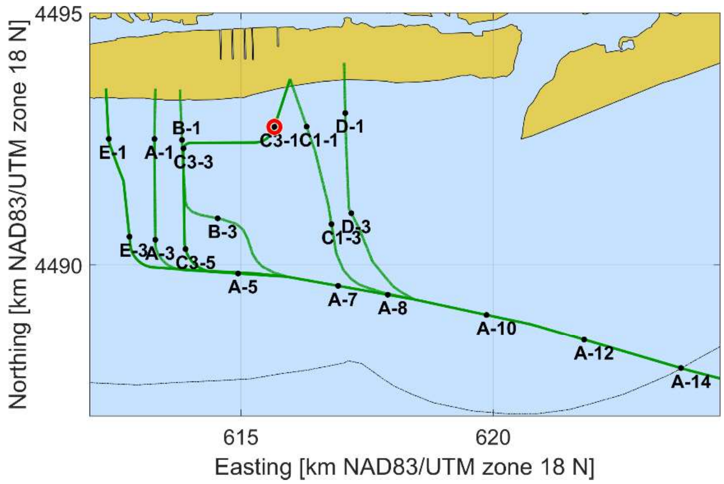


C1-3: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-10
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 306°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

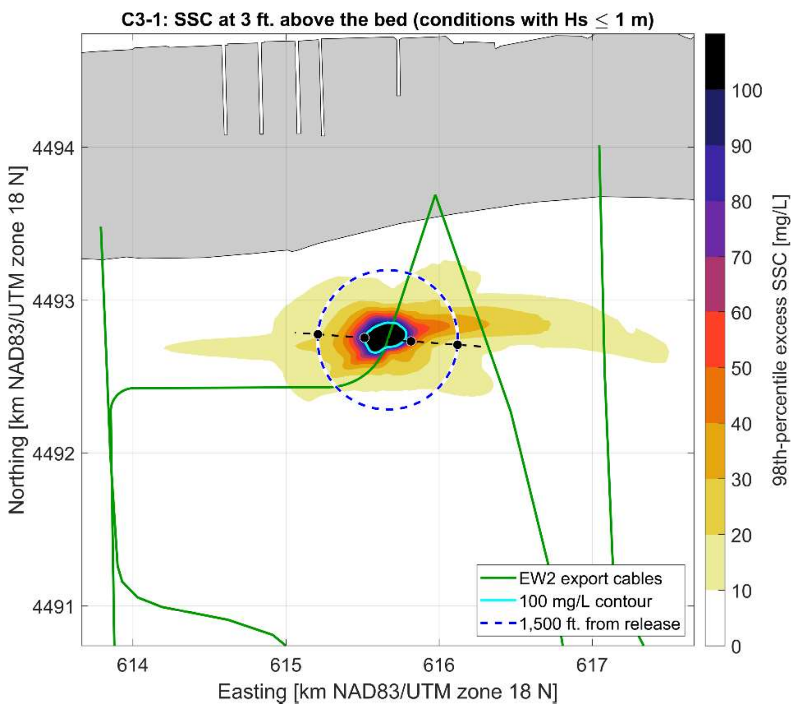


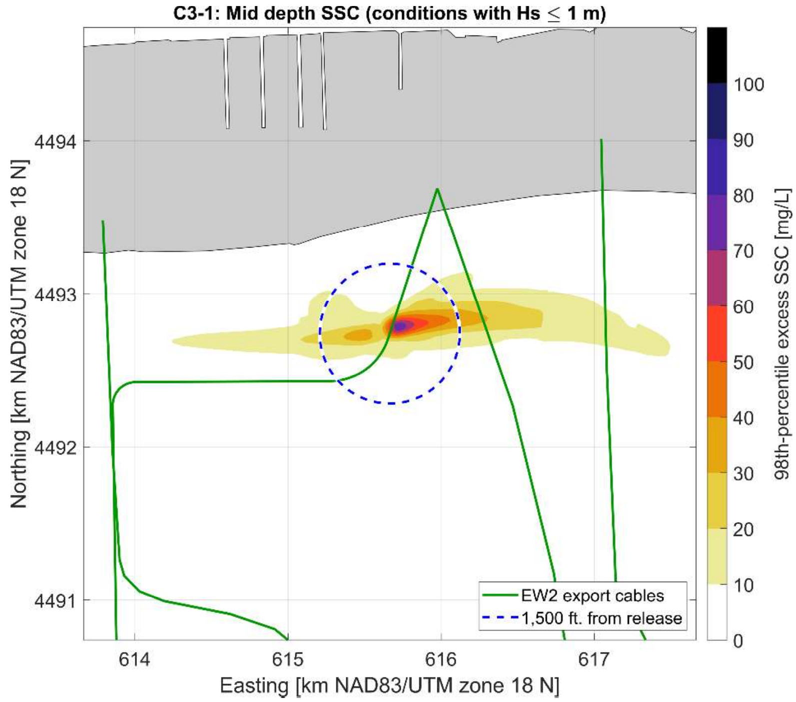
C1-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

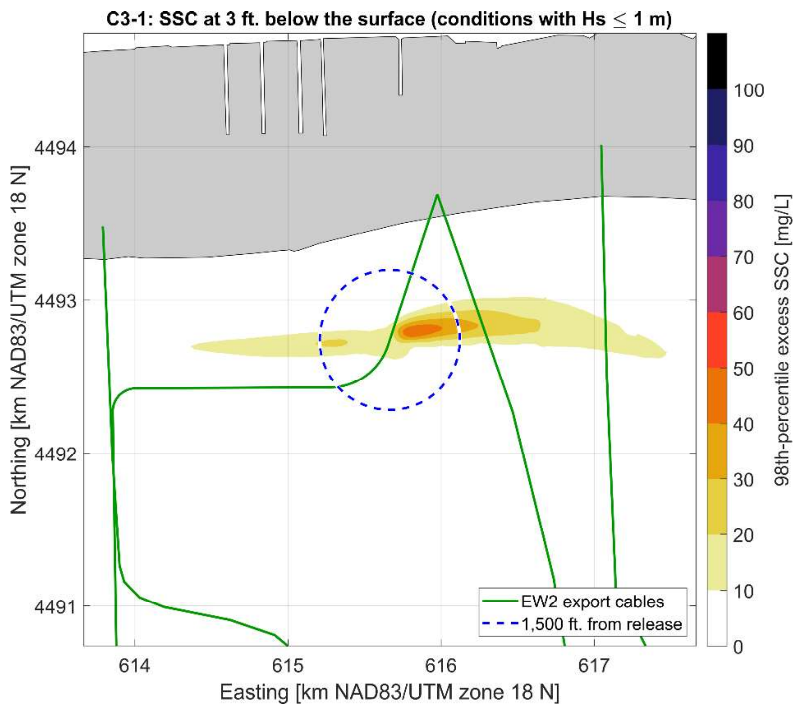
E.13 Release location C3-1

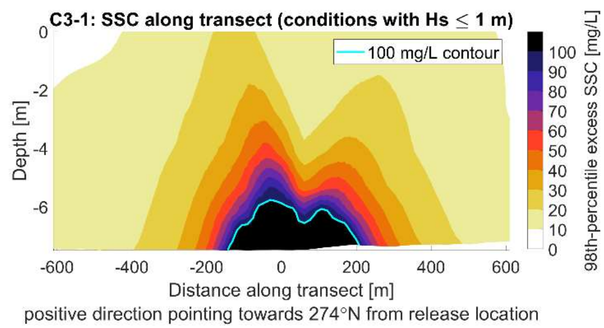


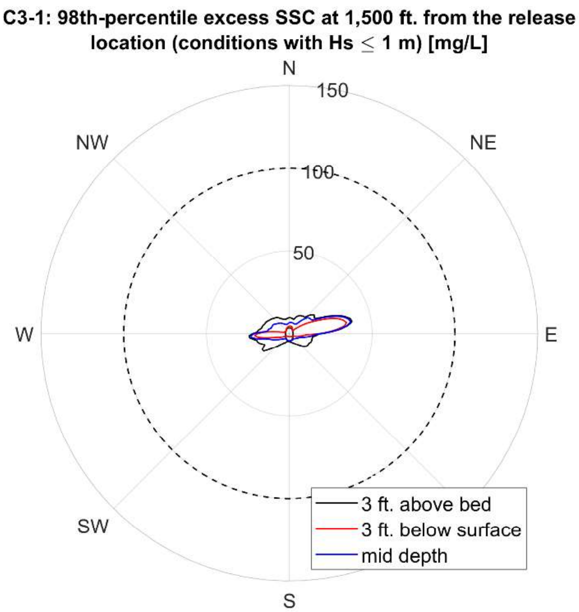
E.13.1 Sediment footprint with significant wave height ≤ 1 m



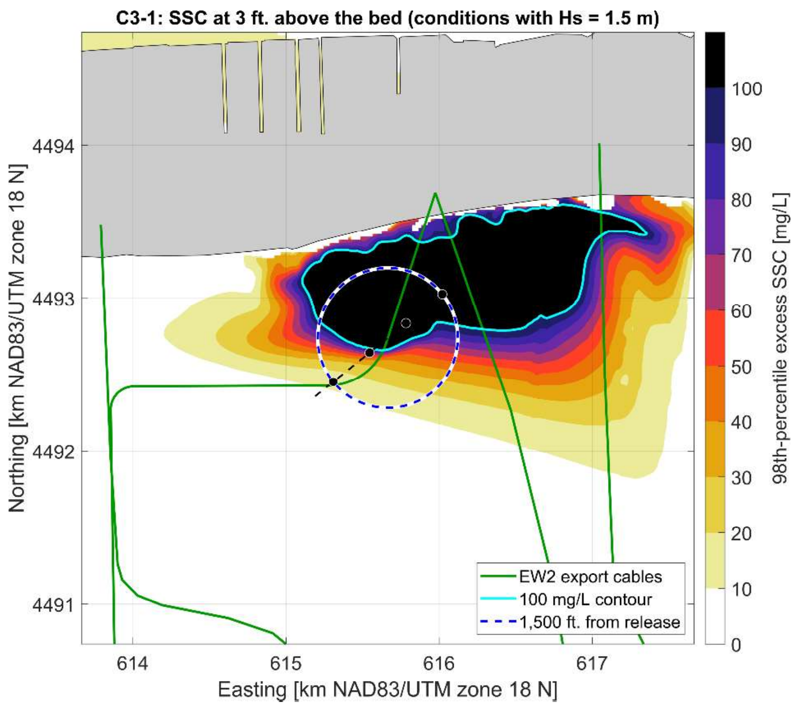

C3-1: Mid depth SSC (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release
4491
4492
4493
4494
614
615
616
617
0
10
20
30
40
50
60
70
80
90
100

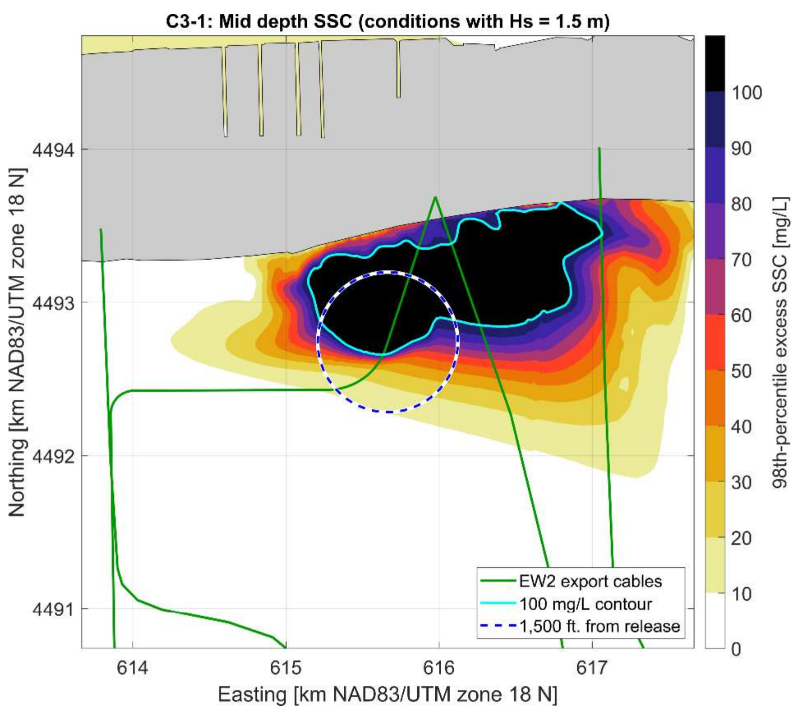

C3-1: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release
4491
4492
4493
4494
614
615
616
617
0
10
20
30
40
50
60
70
80
90
100

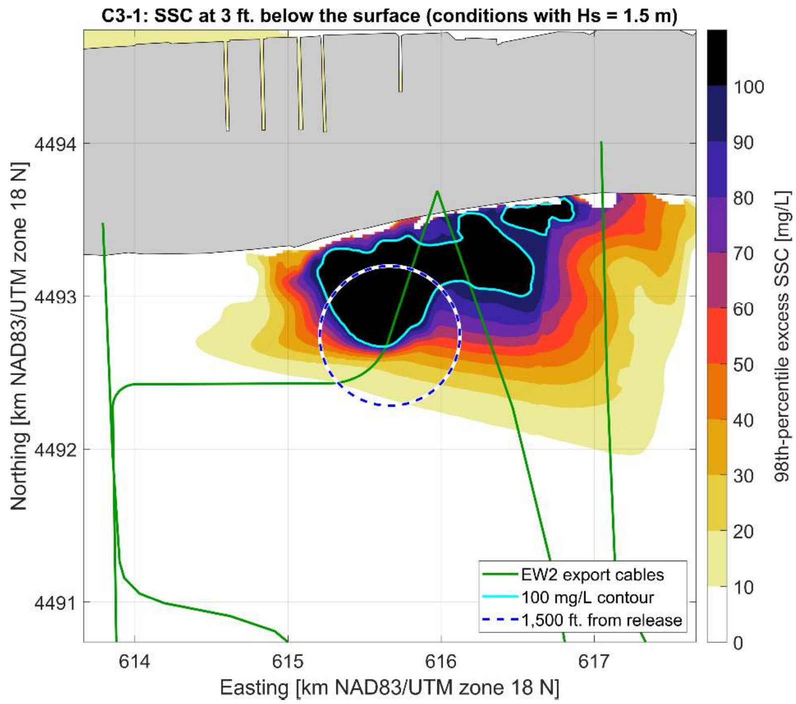

C3-1: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 274°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

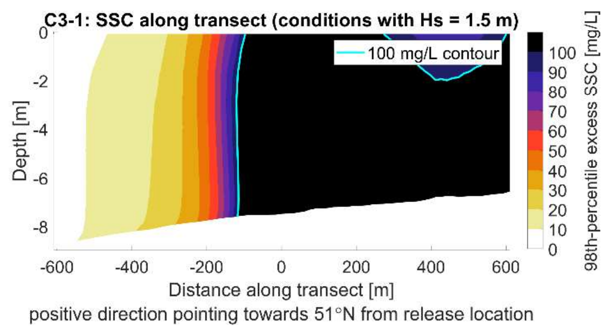

C3-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
SW
S
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

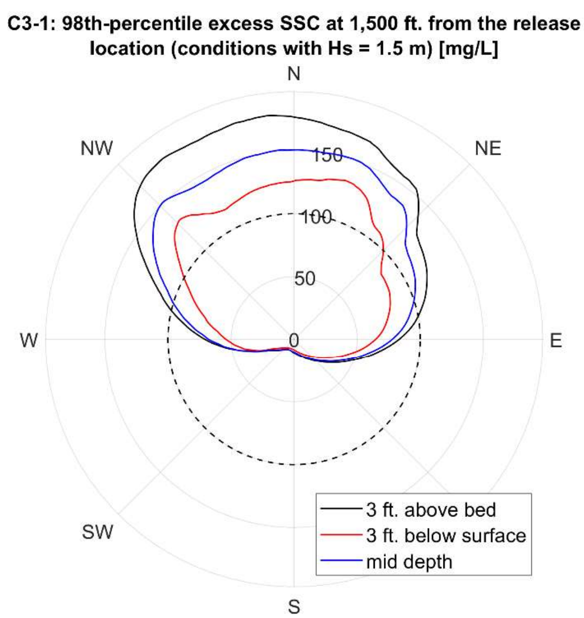
E.13.2 Sediment footprint with significant wave height ≈ 1.5 m



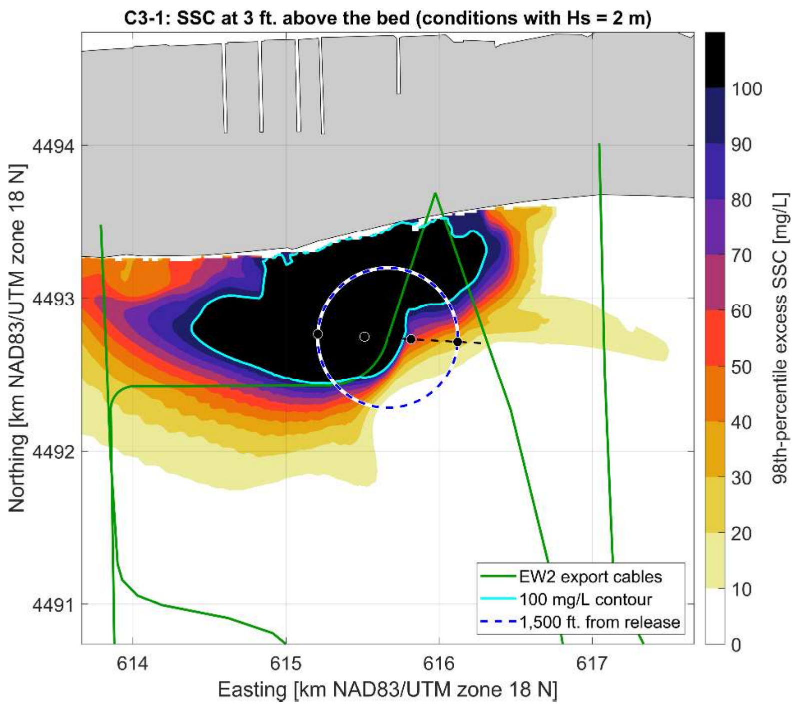


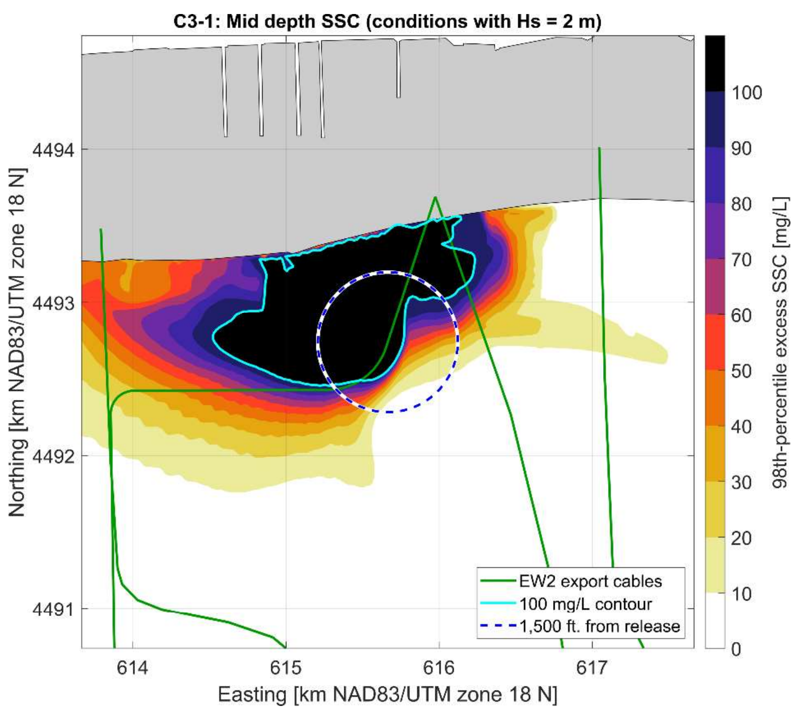

C3-1: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
100 mg/L contour
1,500 ft. from release

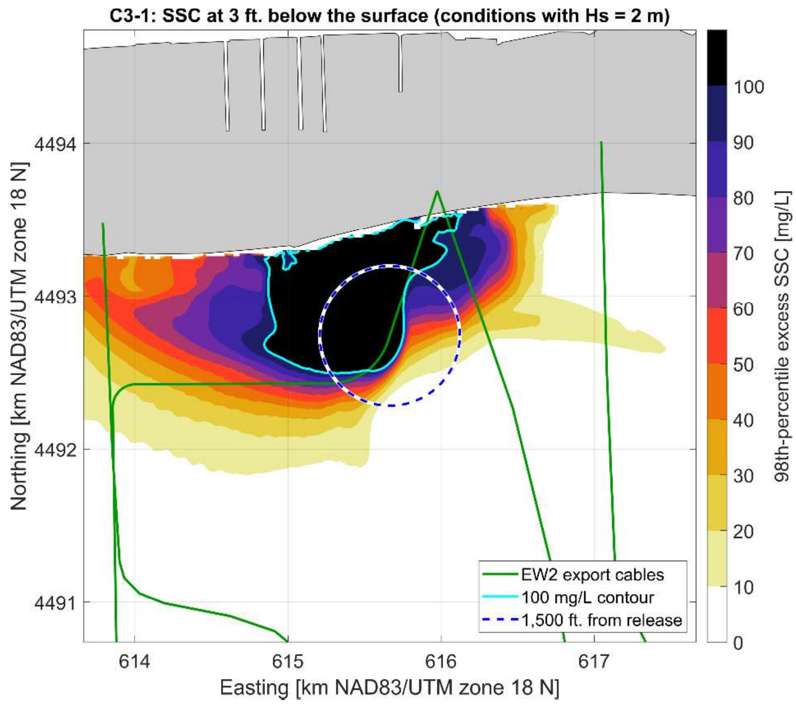

C3-1: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 51°N from release location
98th-percentile excess SSC [mg/L]

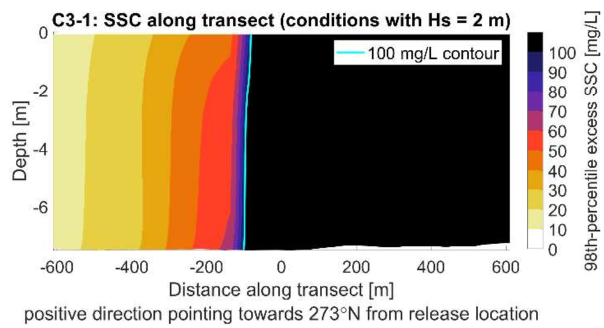

C3-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

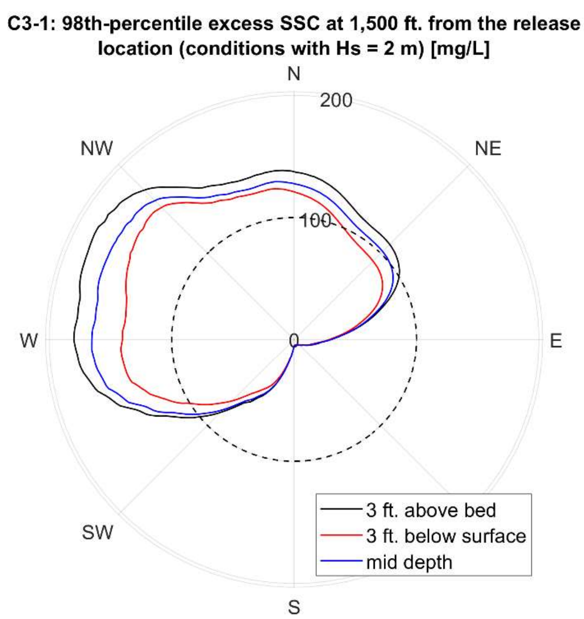
E.13.3 Sediment footprint with significant wave height ≈ 2 m



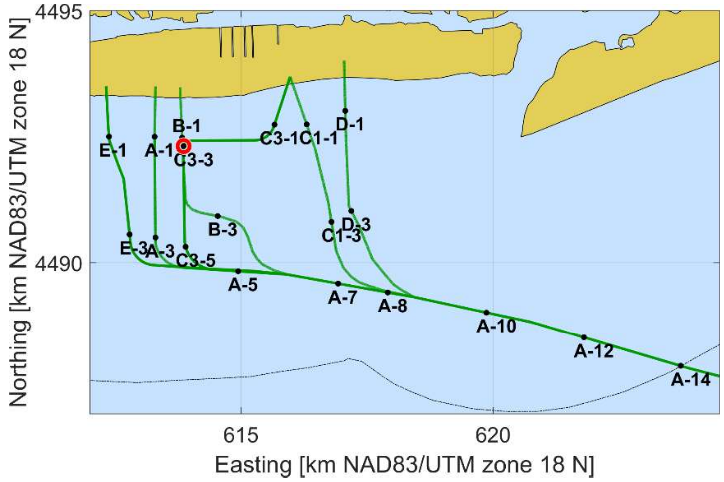



C3-1: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
100 mg/L contour
1,500 ft. from release

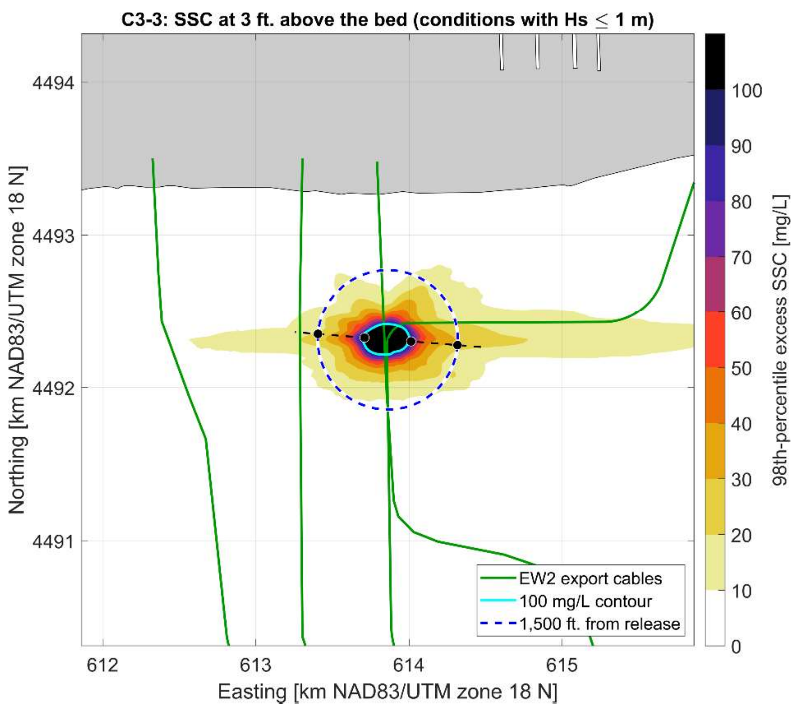

C3-1: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 273°N from release location
98th-percentile excess SSC [mg/L]

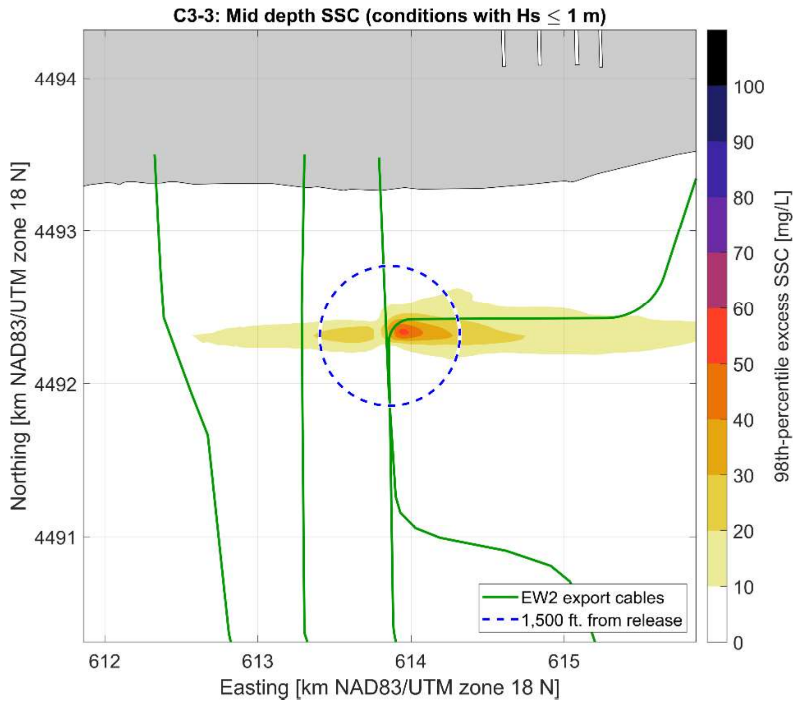

C3-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
S
SW
W
NW
200
100
0
3 ft. above bed
3 ft. below surface
mid depth

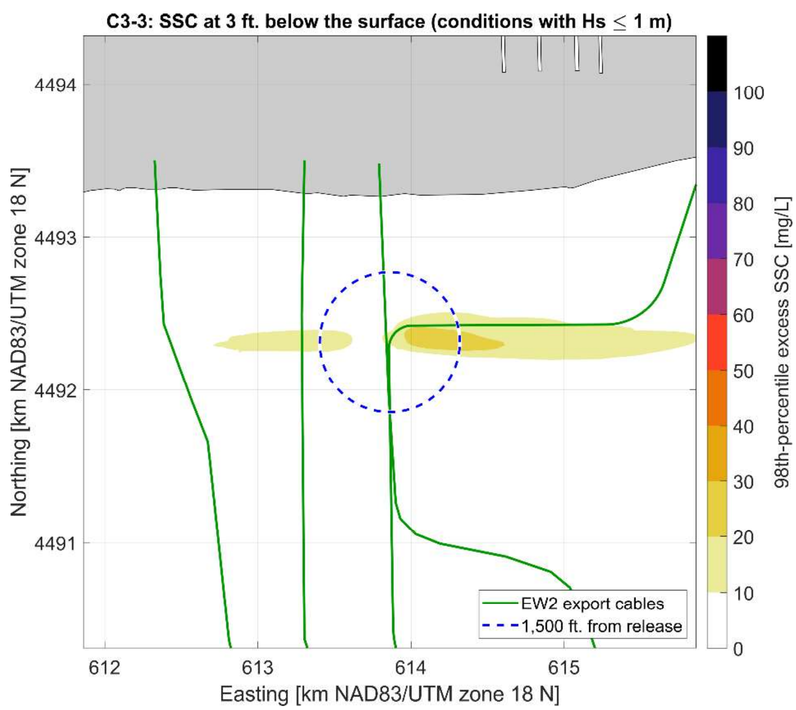
E.14 Release location C3-3

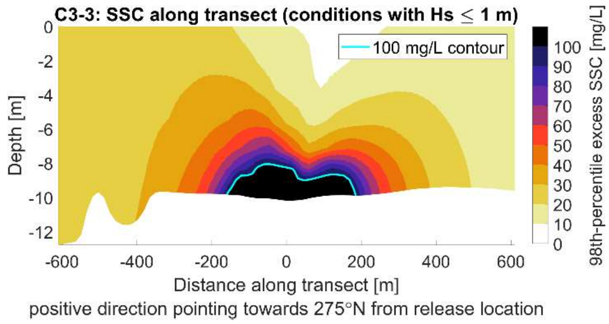


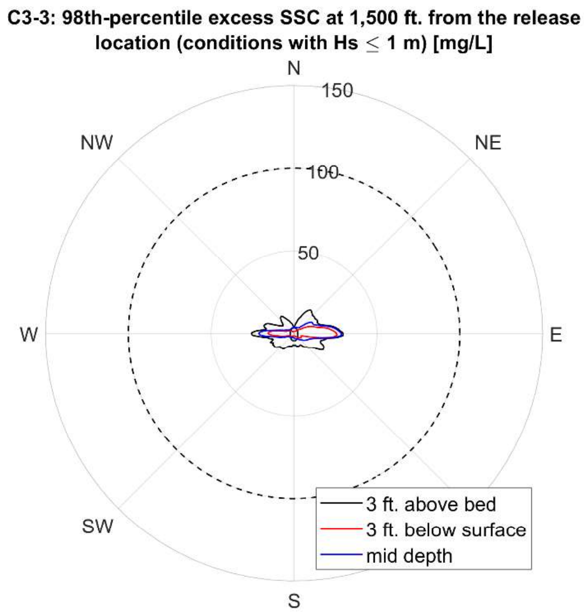
E.14.1 Sediment footprint with significant wave height ≤ 1 m



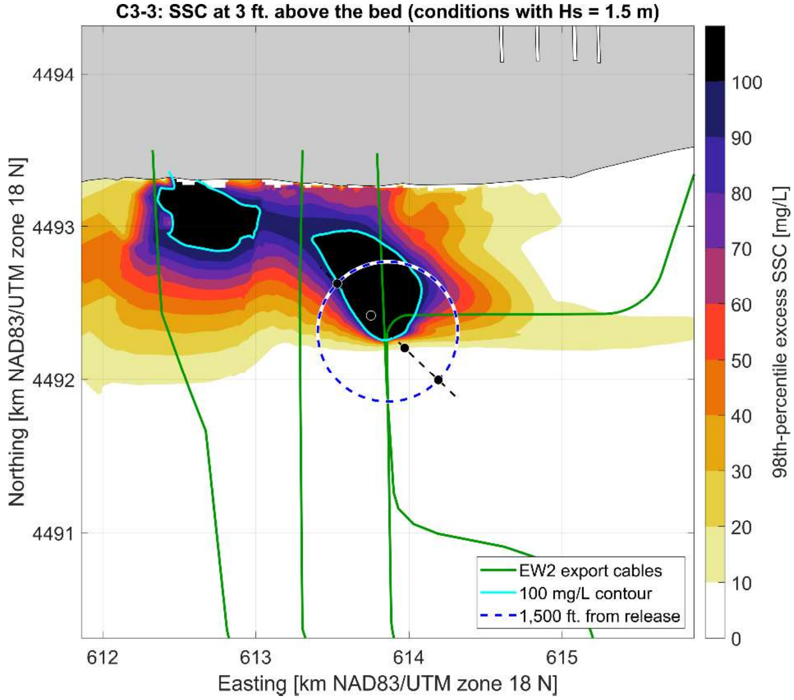

C3-3: Mid depth SSC (conditions with Hs ≤ 1 m)
4494
4493
4492
4491
Northing [km NAD83/UTM zone 18 N]
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

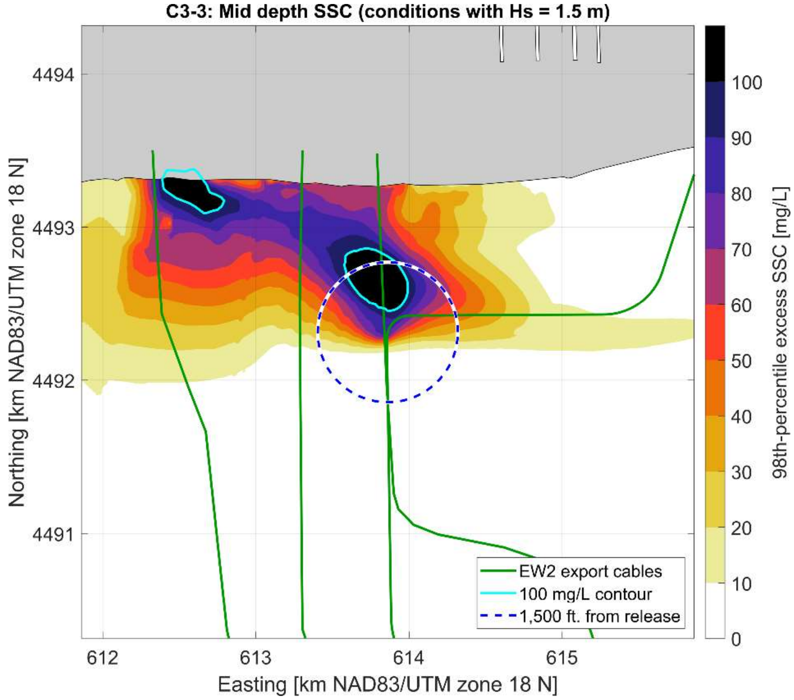

C3-3: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
4494
4493
4492
4491
Northing [km NAD83/UTM zone 18 N]
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

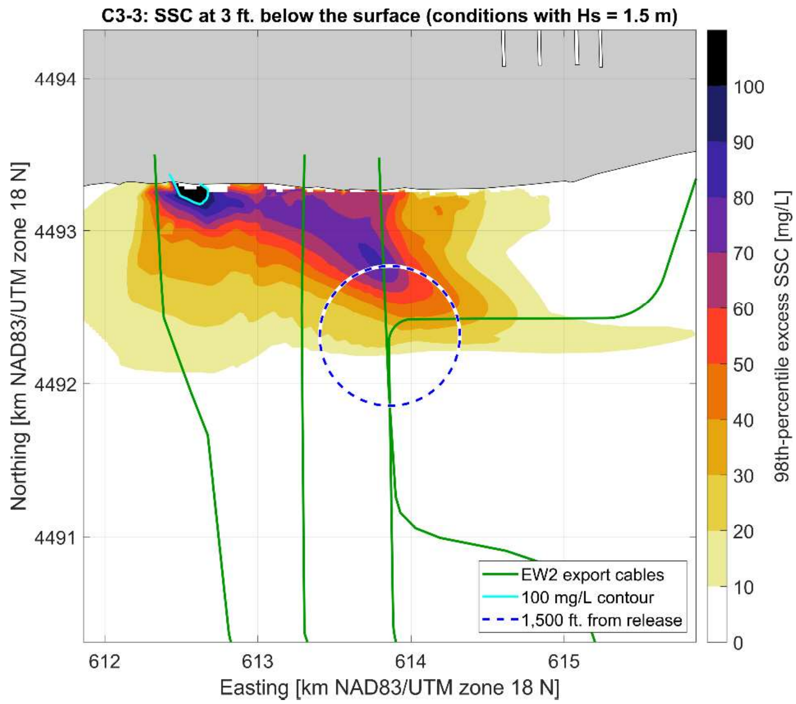

C3-3: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 275°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

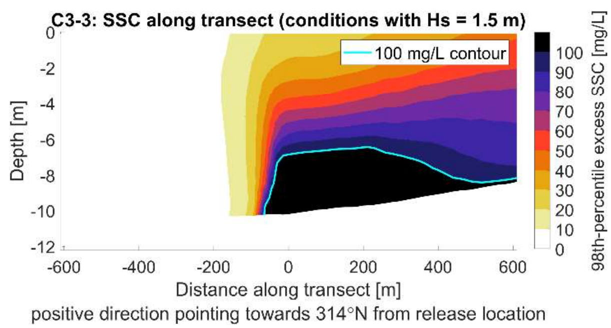

C3-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

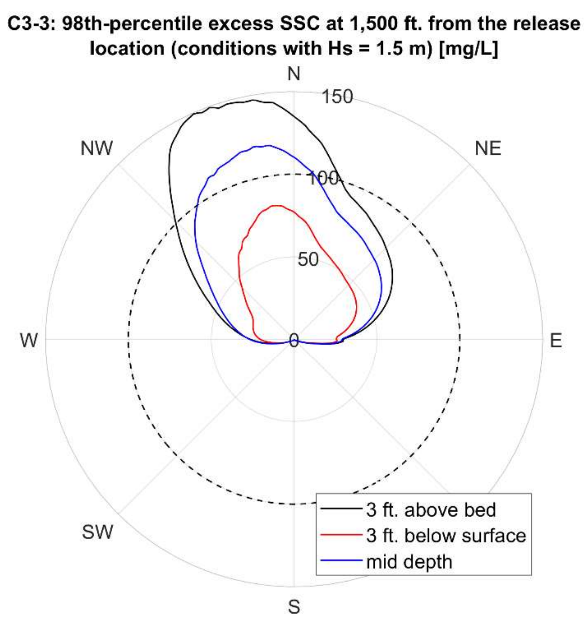
E.14.2 Sediment footprint with significant wave height ≈ 1.5 m



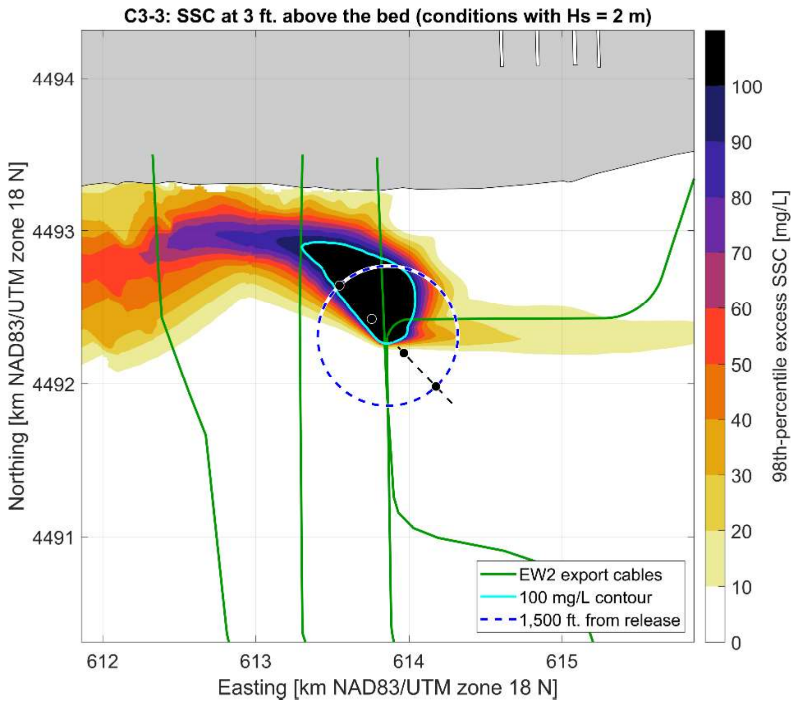


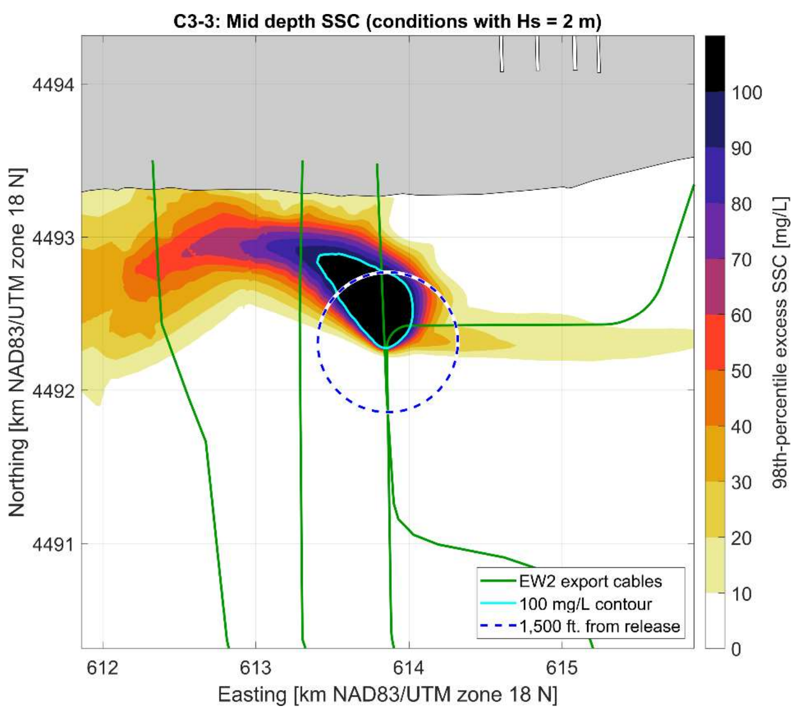

C3-3: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
4494
4493
4492
4491
Northing [km NAD83/UTM zone 18 N]
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
100 mg/L contour
1,500 ft. from release
0
10
20
30
40
50
60
70
80
90
100
98th-percentile excess SSC [mg/L]

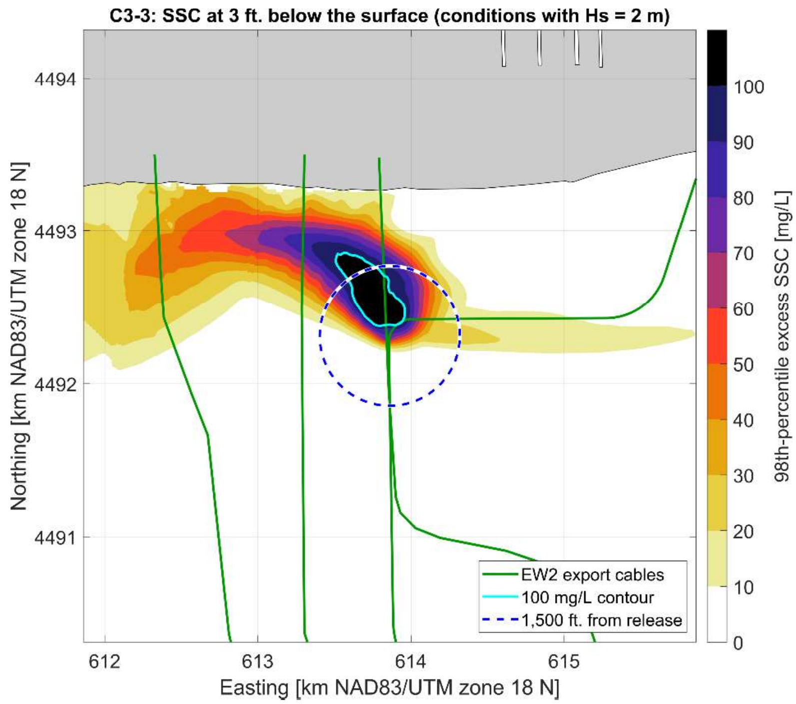

C3-3: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 314°N from release location
98th-percentile excess SSC [mg/L]

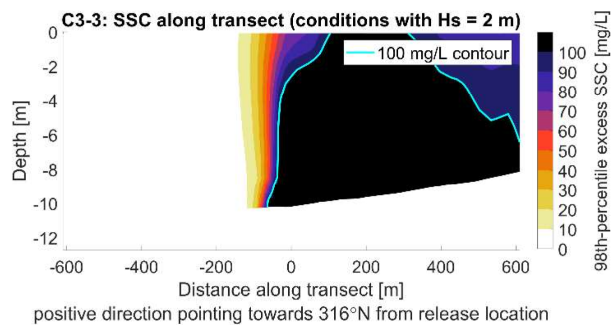

C3-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

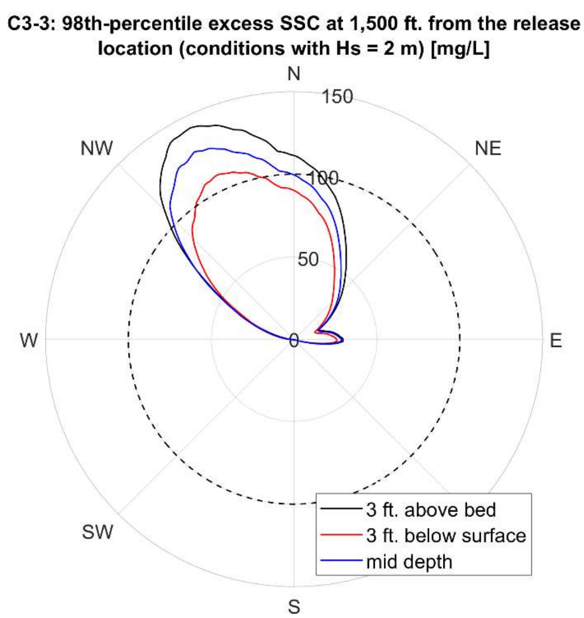
E.14.3 Sediment footprint with significant wave height ≈ 2 m



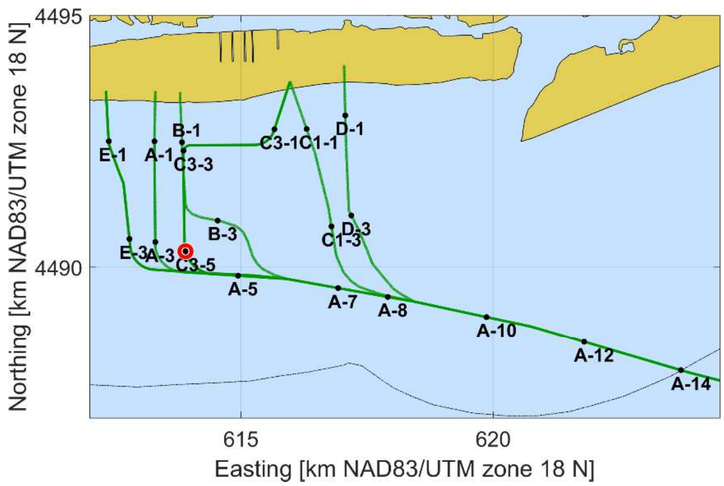



C3-3: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
100 mg/L contour
1,500 ft. from release

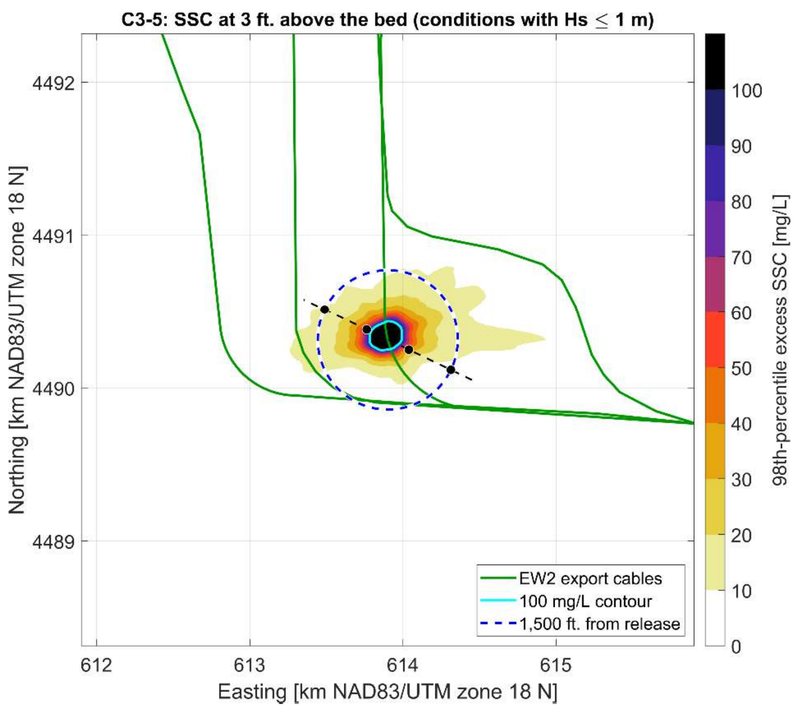

C3-3: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 316°N from release location
98th-percentile excess SSC [mg/L]

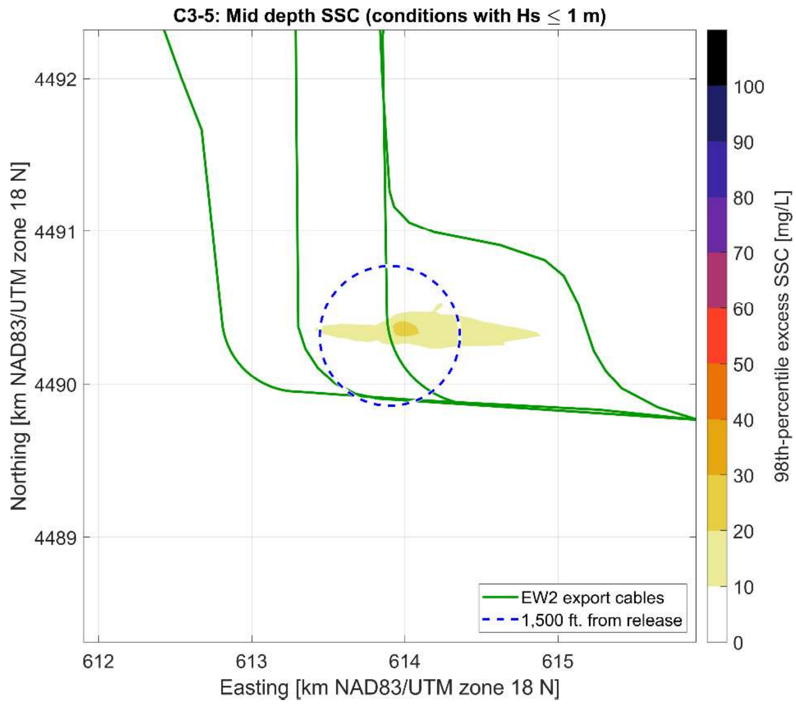

C3-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

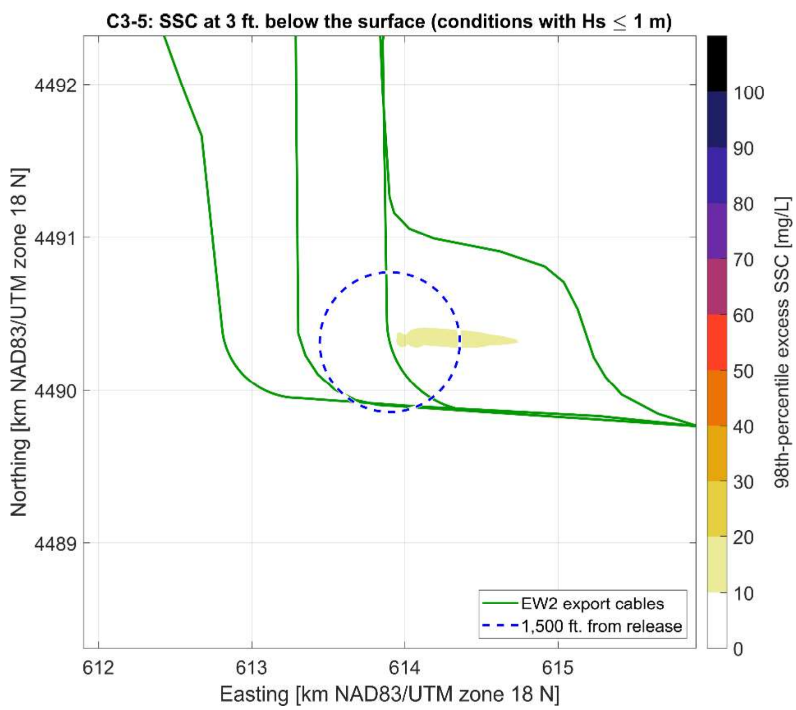
E.15 Release location C3-5

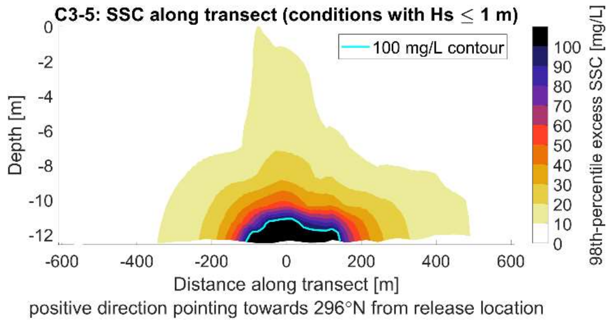


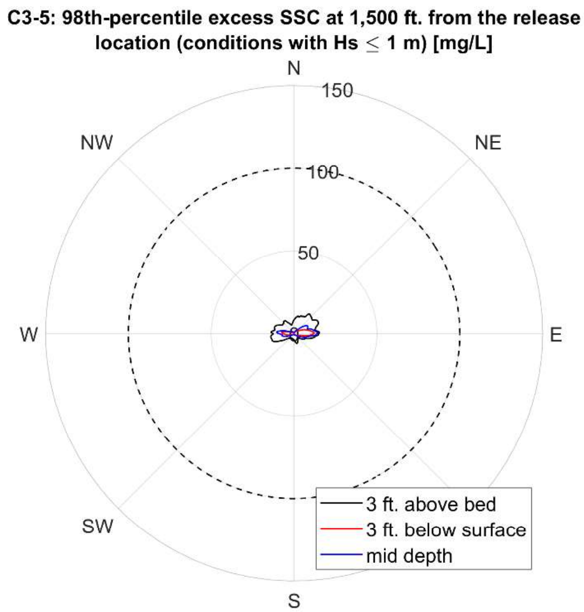
E.15.1 Sediment footprint with significant wave height ≤ 1 m



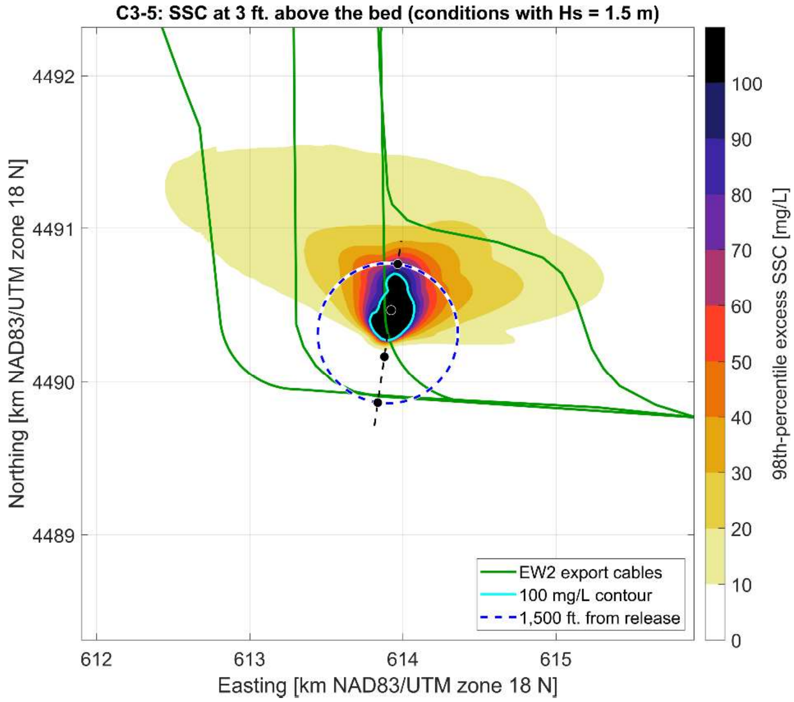

C3-5: Mid depth SSC (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release
4492
4491
4490
4489
612
613
614
615
0
10
20
30
40
50
60
70
80
90
100

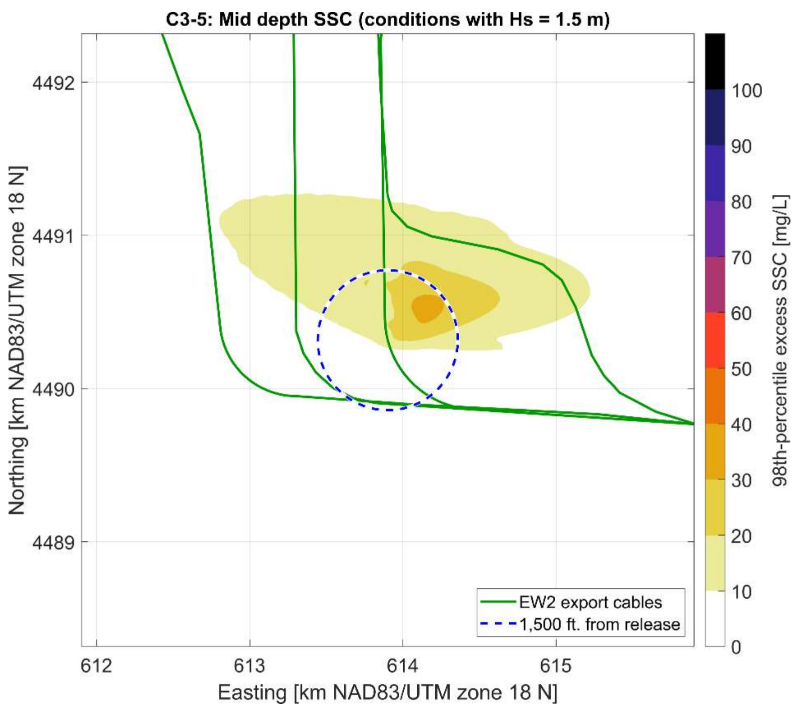

C3-5: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release
4492
4491
4490
4489
612
613
614
615
0
10
20
30
40
50
60
70
80
90
100

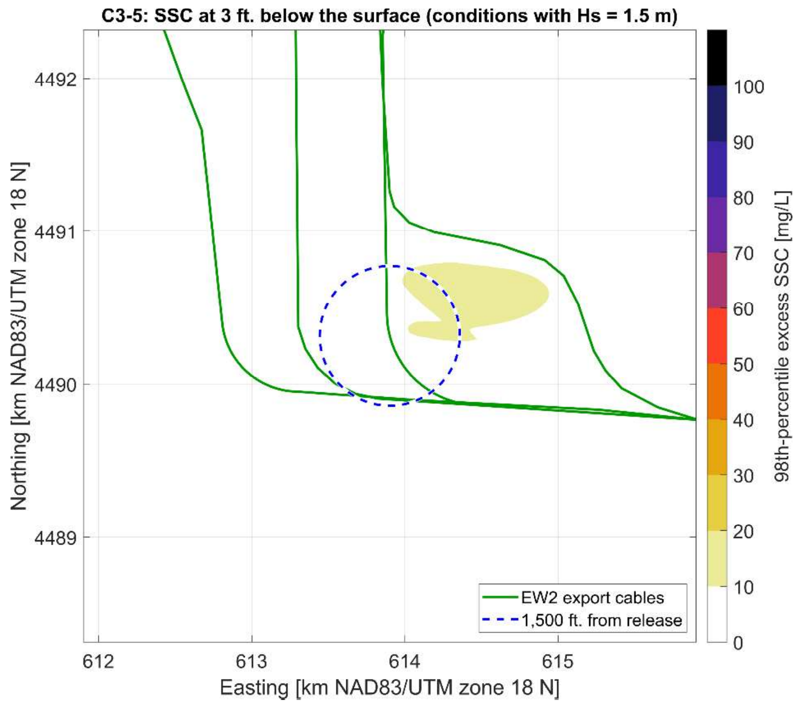

C3-5: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 296°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

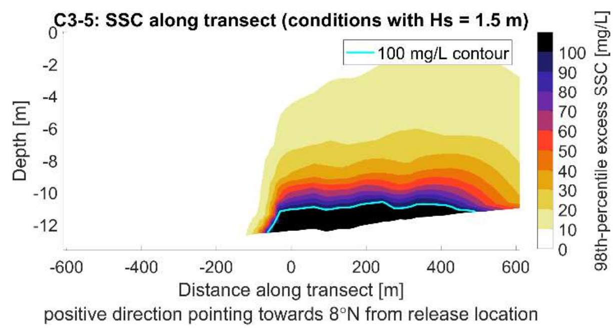

C3-5: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

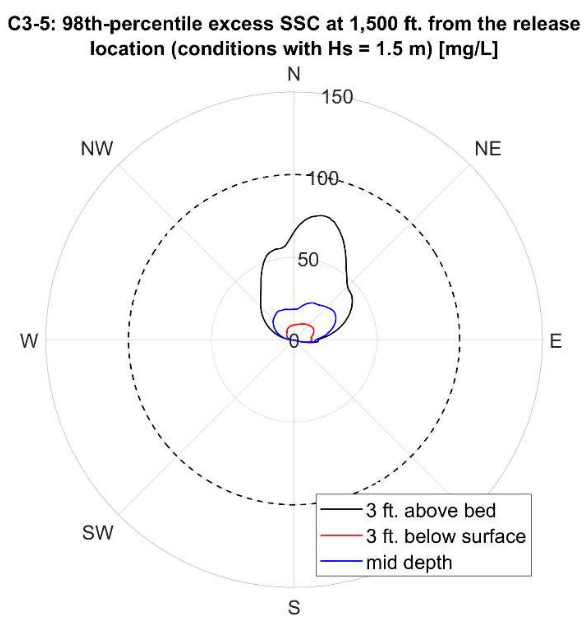
E.15.2 Sediment footprint with significant wave height ≈ 1.5 m



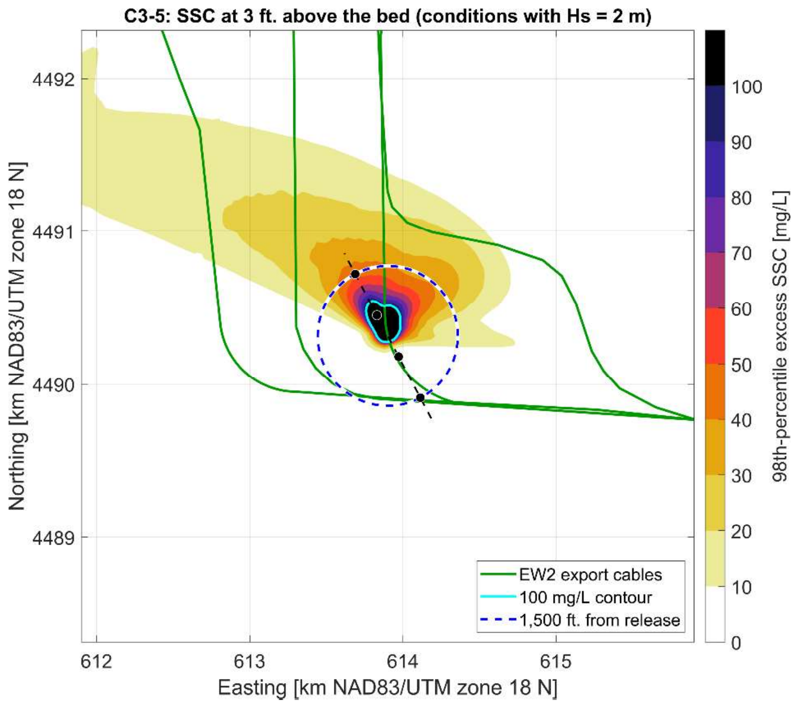


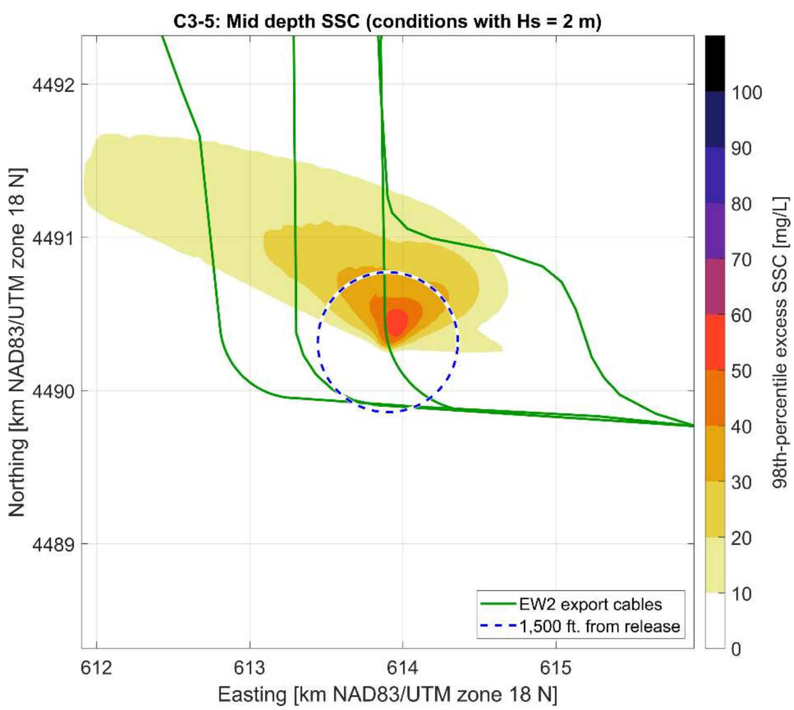

C3-5: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
612
613
614
615
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100

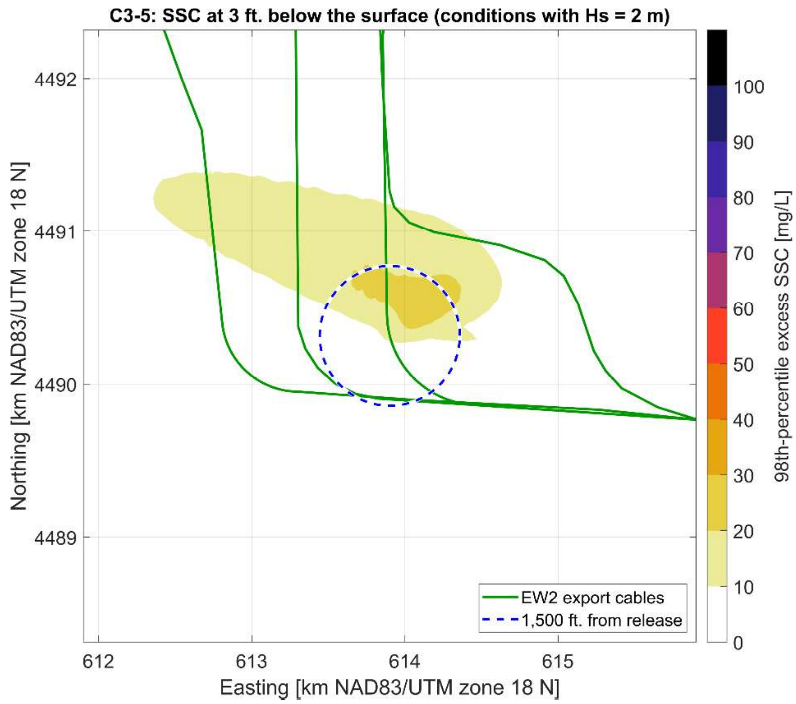

C3-5: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 8°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

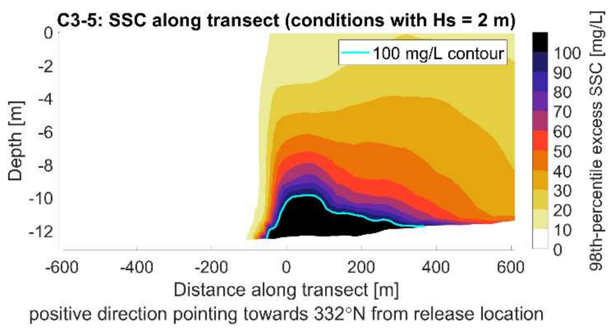

C3-5: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

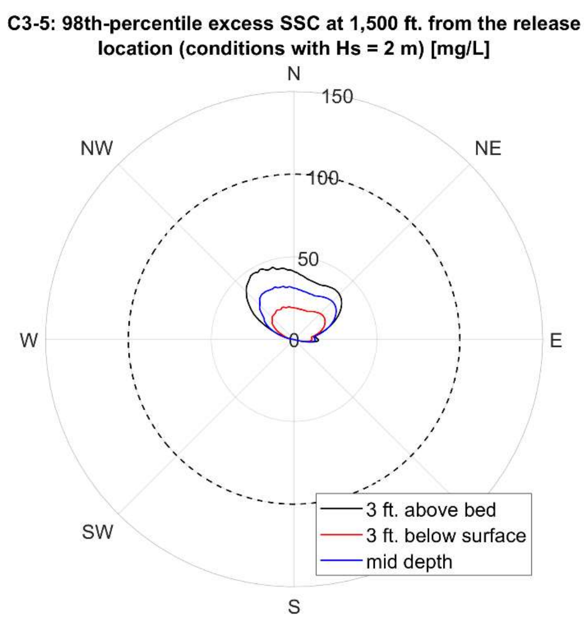
E.15.3 Sediment footprint with significant wave height ≈ 2 m



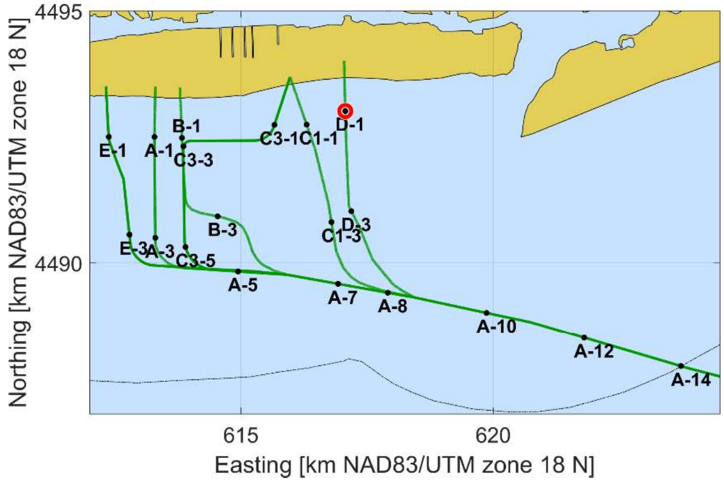



C3-5: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
Easting [km NAD83/UTM zone 18 N]
612
613
614
615
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

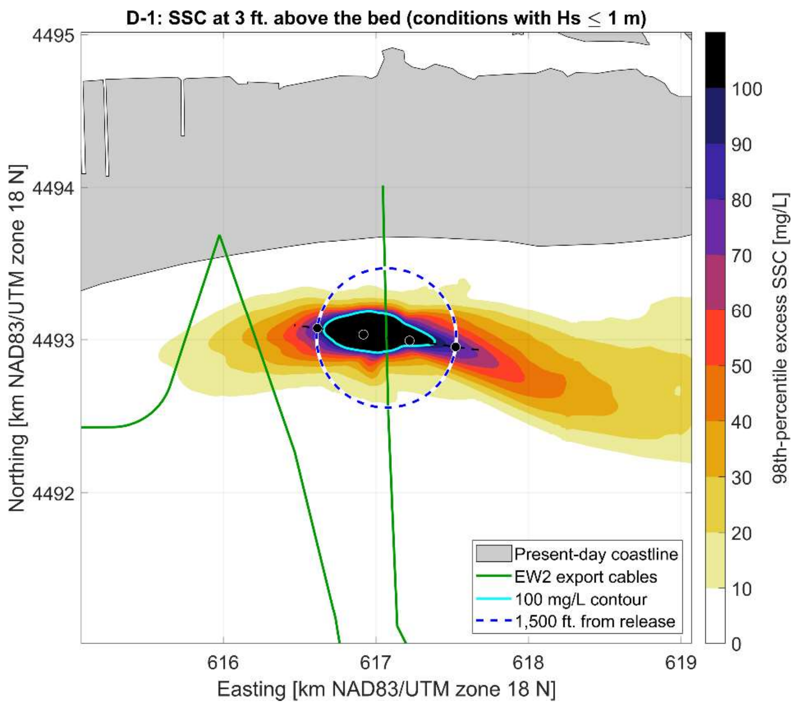

C3-5: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 332°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

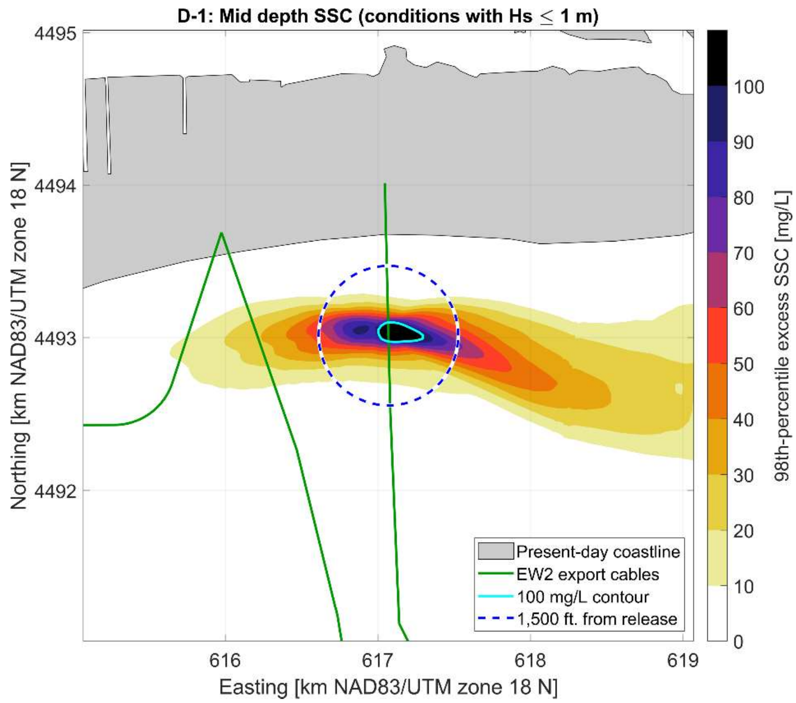

C3-5: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
SE
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

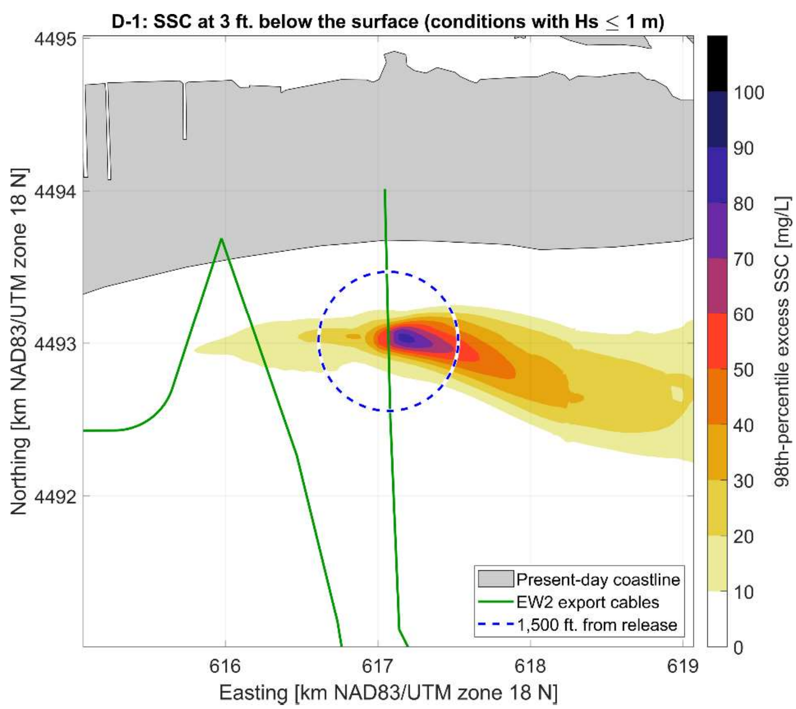
E.16 Release location D-1

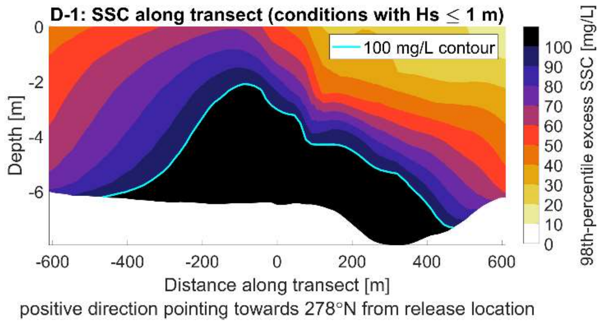


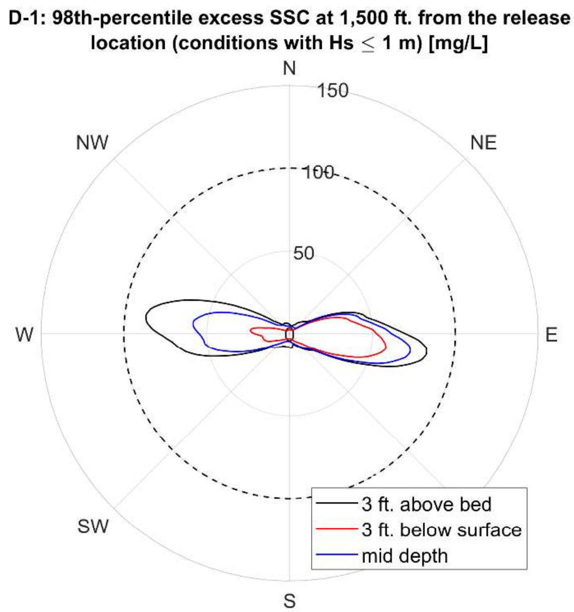
E.16.1 Sediment footprint with significant wave height ≤ 1 m



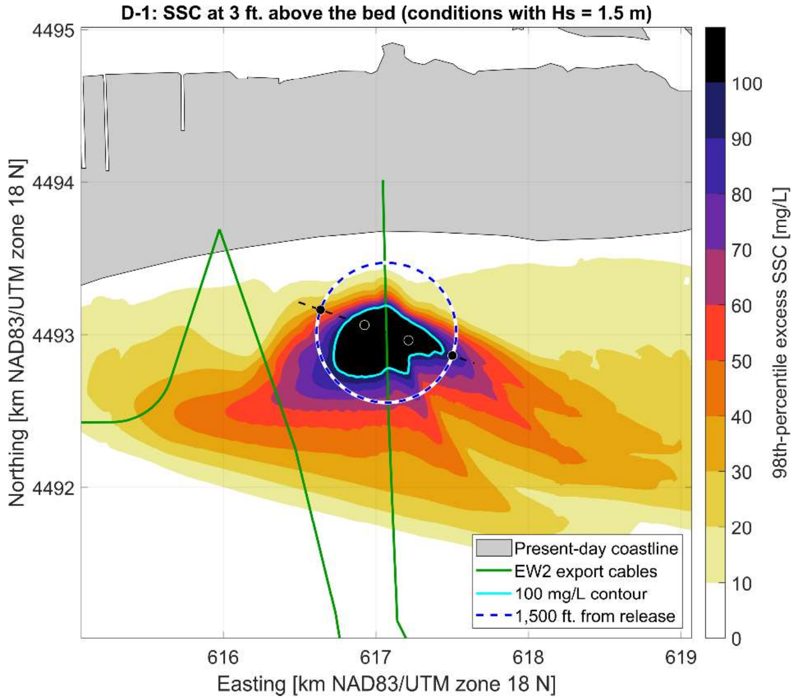

D-1: Mid depth SSC (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
4495
4494
4493
4492
616
617
618
619
0
10
20
30
40
50
60
70
80
90
100
Present-day coastline
EW2 export cables
100 mg/L contour
1,500 ft. from release

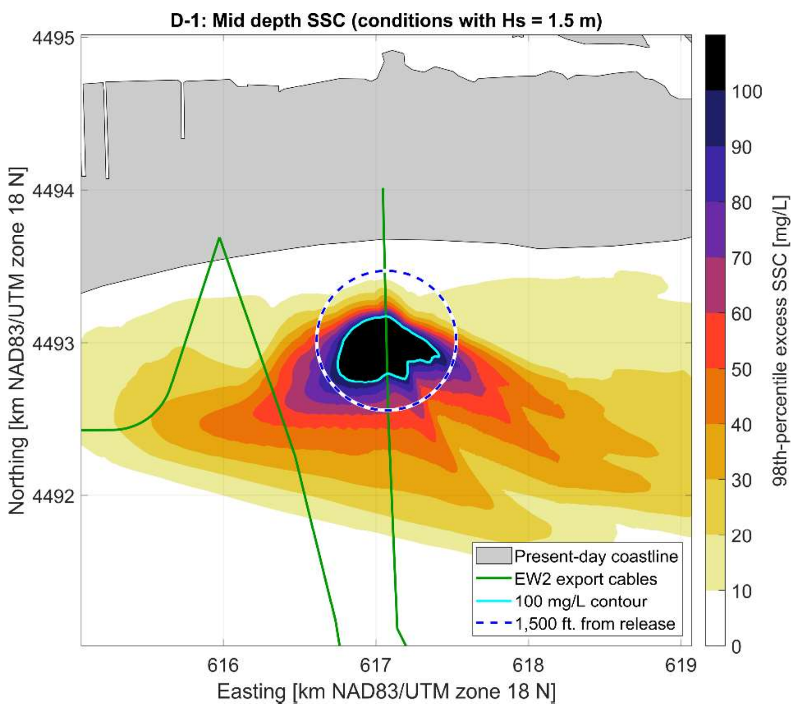

D-1: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
4495
4494
4493
4492
616
617
618
619
0
10
20
30
40
50
60
70
80
90
100
Present-day coastline
EW2 export cables
1,500 ft. from release

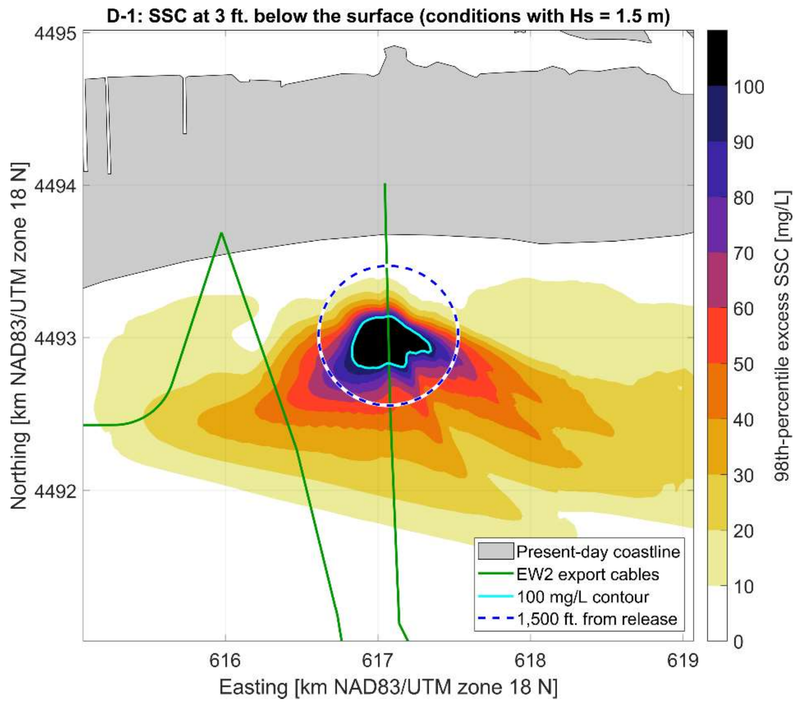

D-1: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 278°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

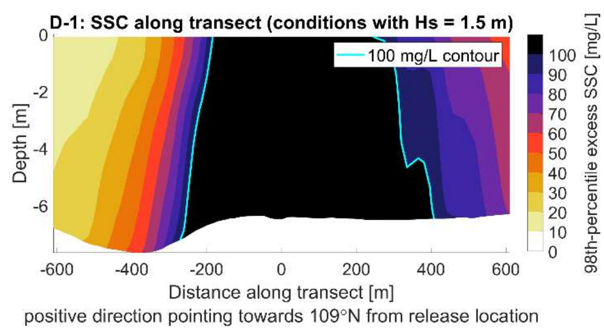

D-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

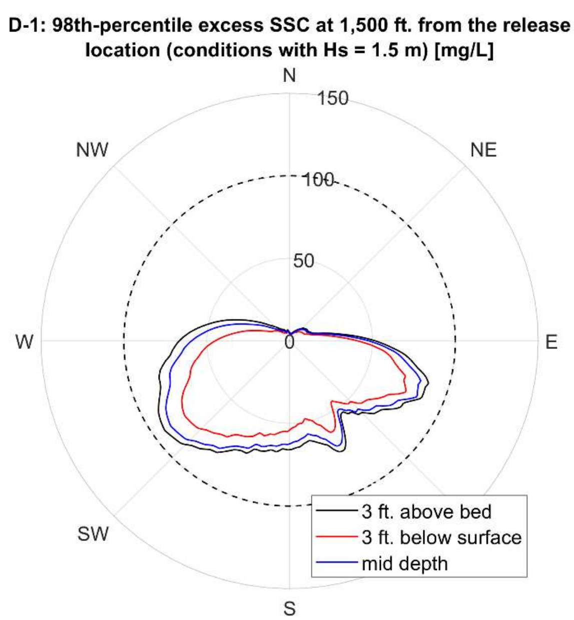
E.16.2 Sediment footprint with significant wave height ≈ 1.5 m



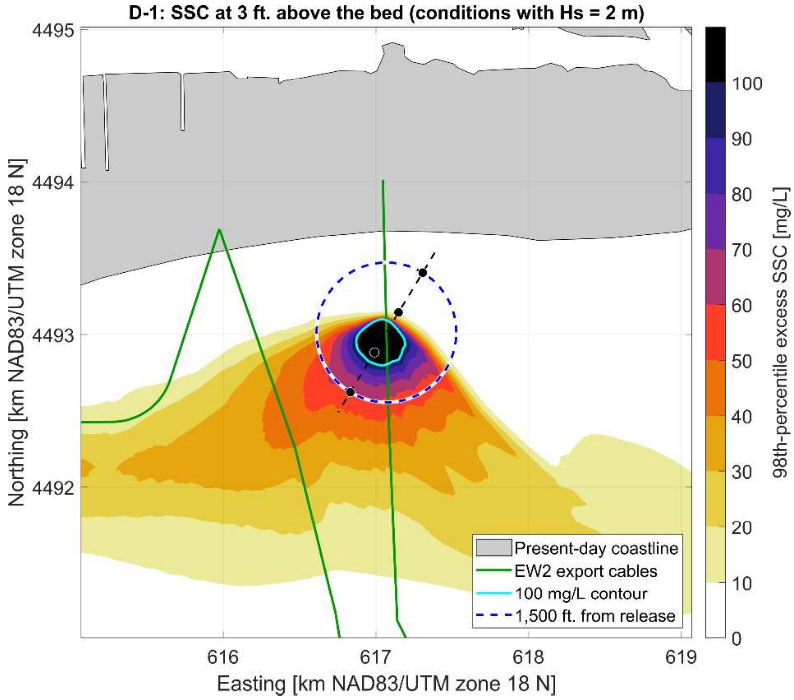


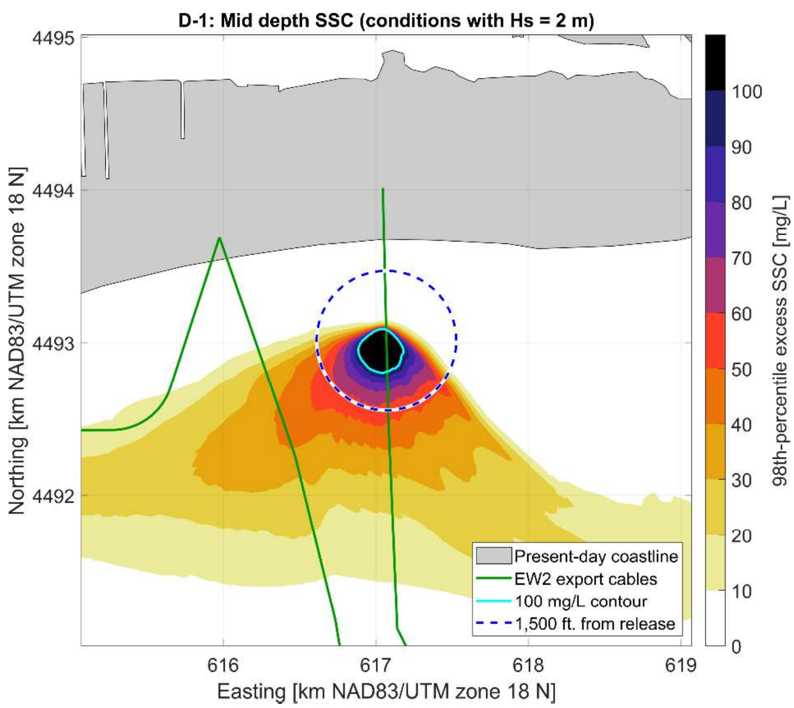

D-1: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
Present-day coastline
EW2 export cables
100 mg/L contour
1,500 ft. from release

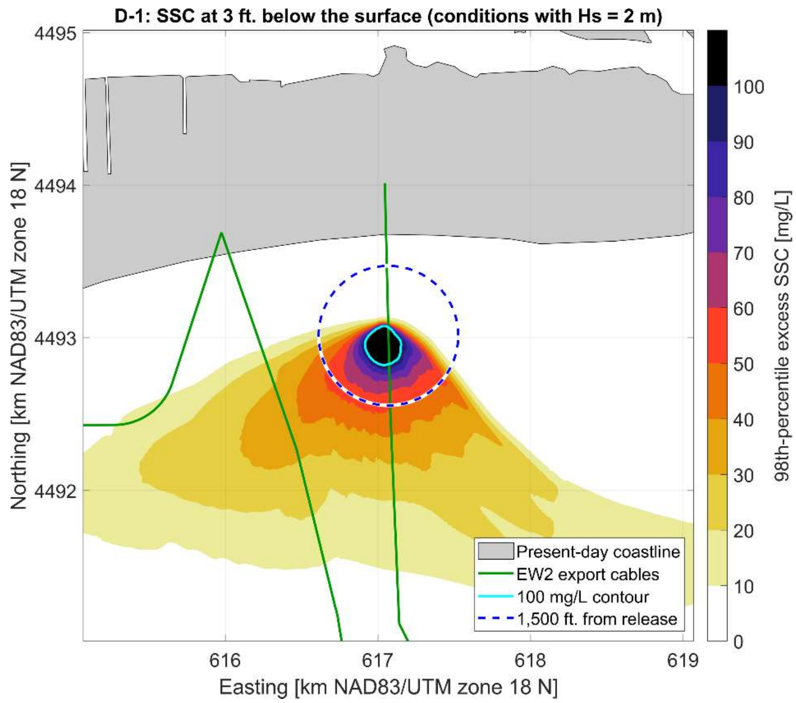

D-1: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 109°N from release location
98th-percentile excess SSC [mg/L]

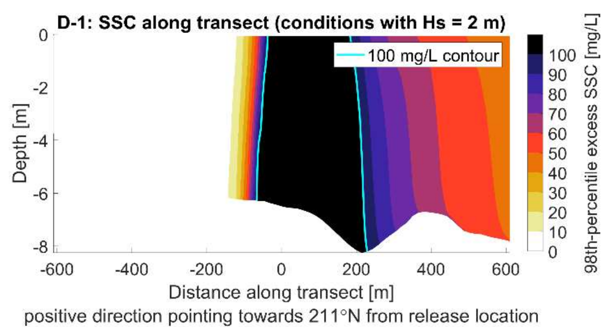

D-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
3 ft. above bed
3 ft. below surface
mid depth

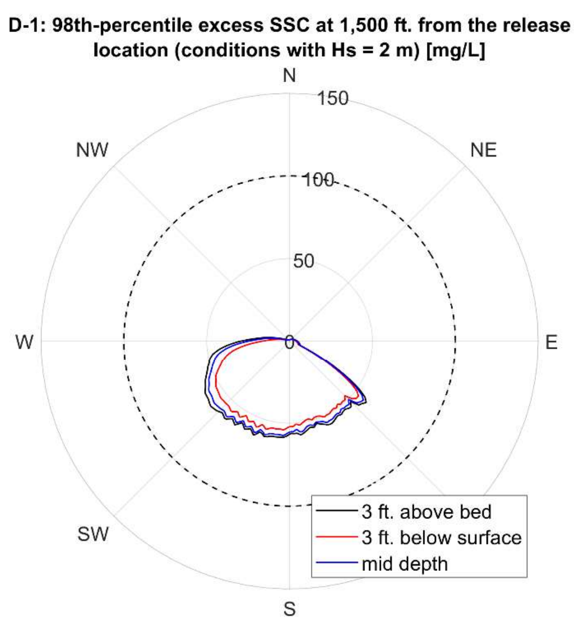
E.16.3 Sediment footprint with significant wave height ≈ 2 m



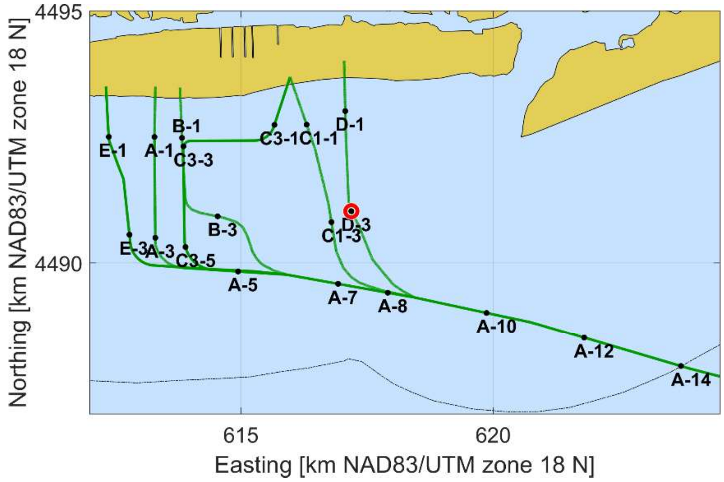



D-1: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4495
4494
4493
4492
616
617
618
619
Present-day coastline
EW2 export cables
100 mg/L contour
1,500 ft. from release
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100

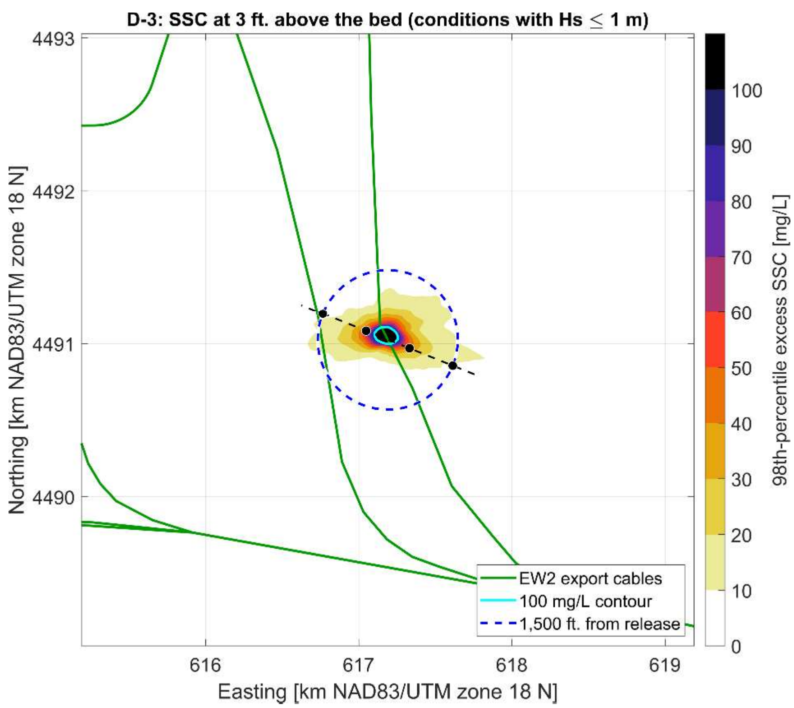

D-1: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 211°N from release location
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100

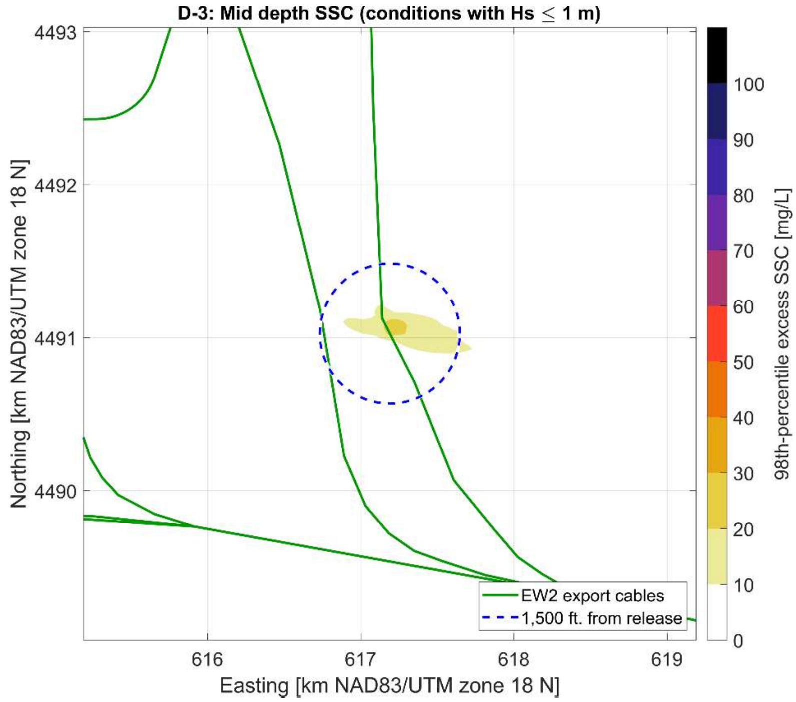

D-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
SW
S
NW
W
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

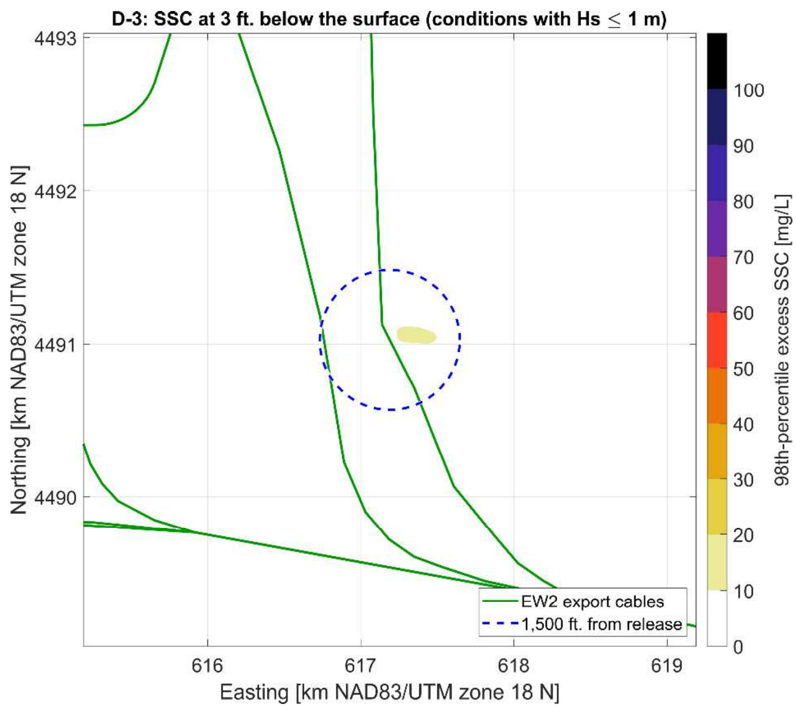
E.17 Release location D-3

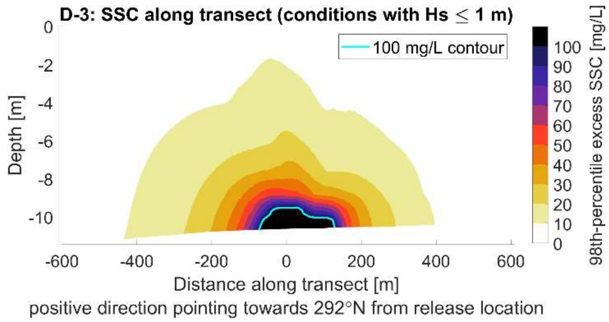


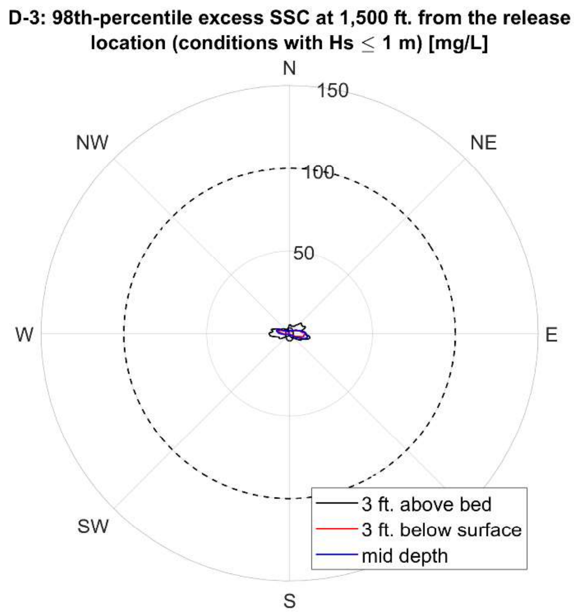
E.17.1 Sediment footprint with significant wave height ≤ 1 m



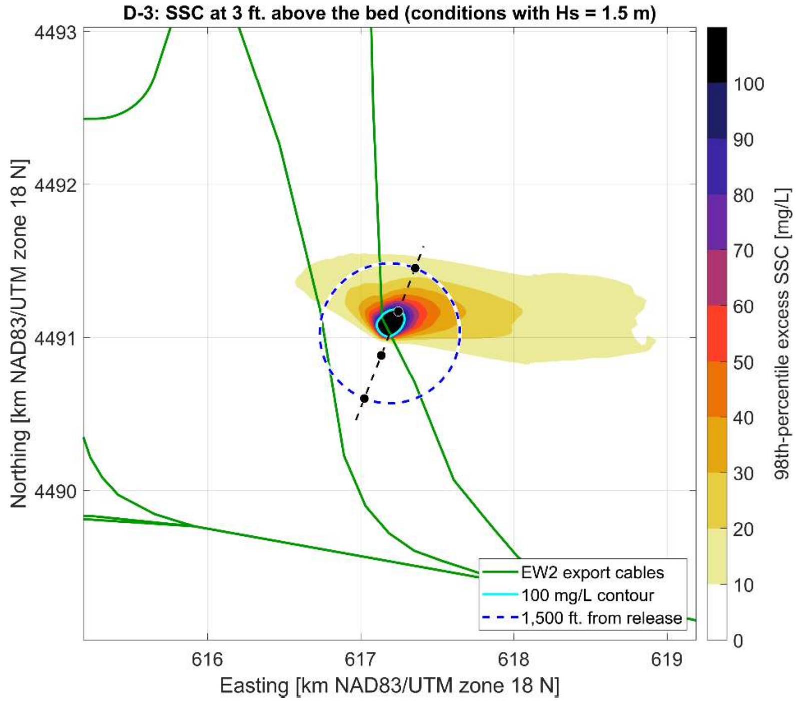

D-3: Mid depth SSC (conditions with Hs ≤ 1 m)
4493
4492
4491
4490
Northing [km NAD83/UTM zone 18 N]
616
617
618
619
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

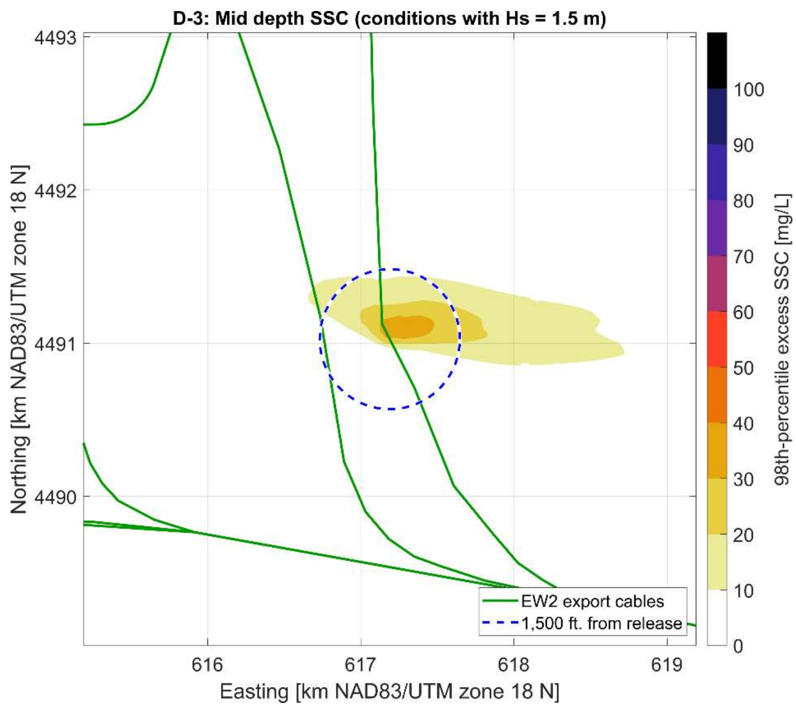

D-3: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
4493
4492
4491
4490
Northing [km NAD83/UTM zone 18 N]
616
617
618
619
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

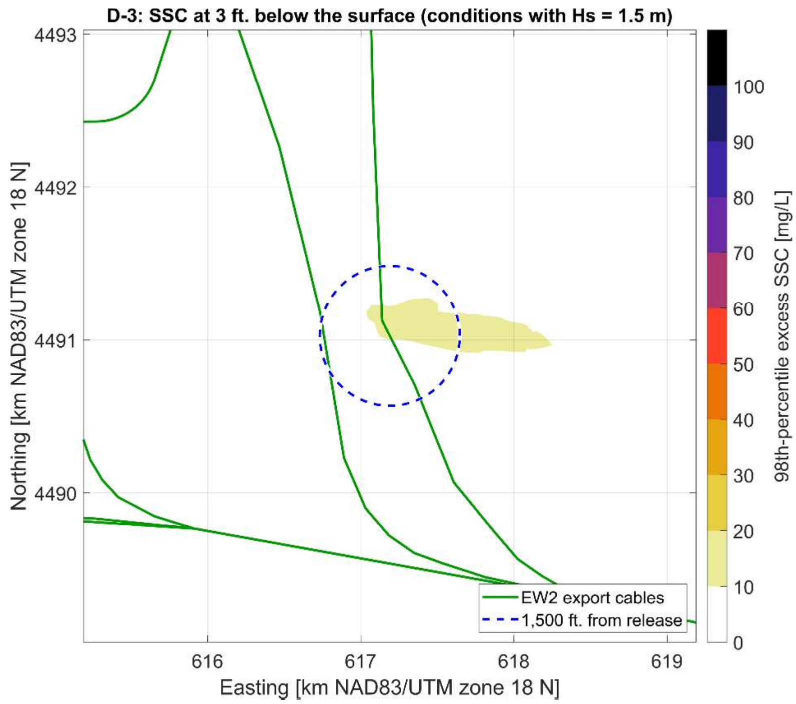

D-3: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-10
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 292°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

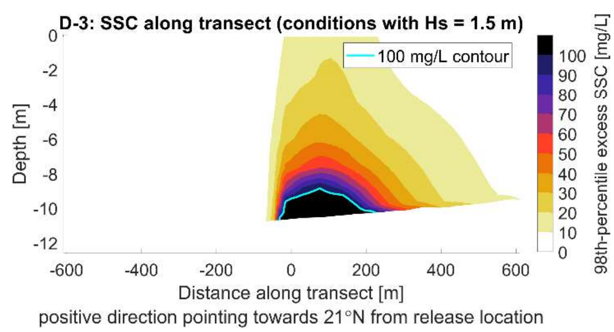

D-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

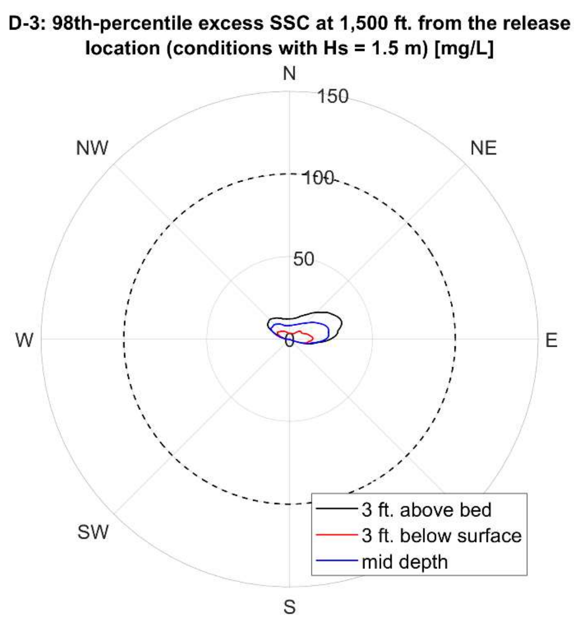
E.17.2 Sediment footprint with significant wave height ≈ 1.5 m



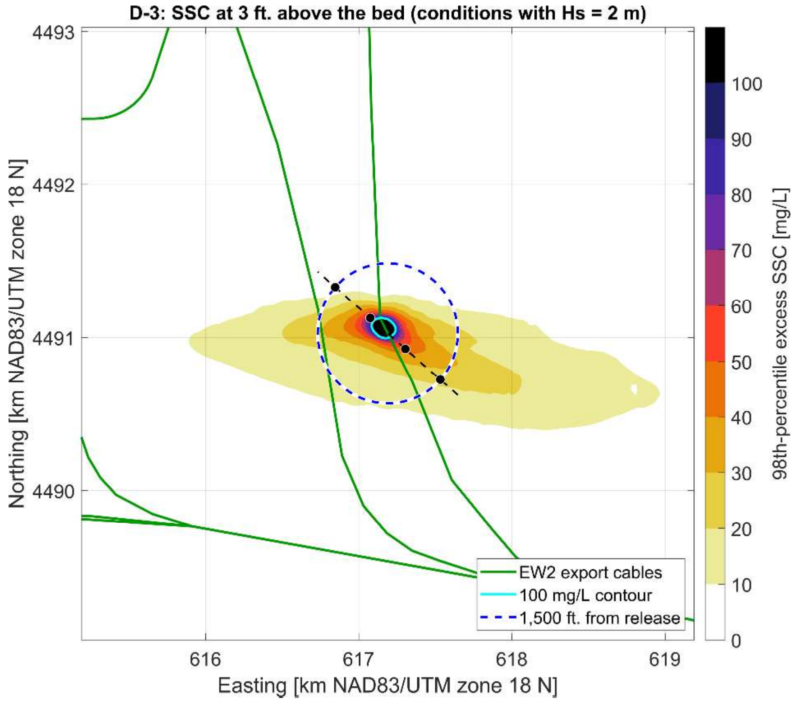


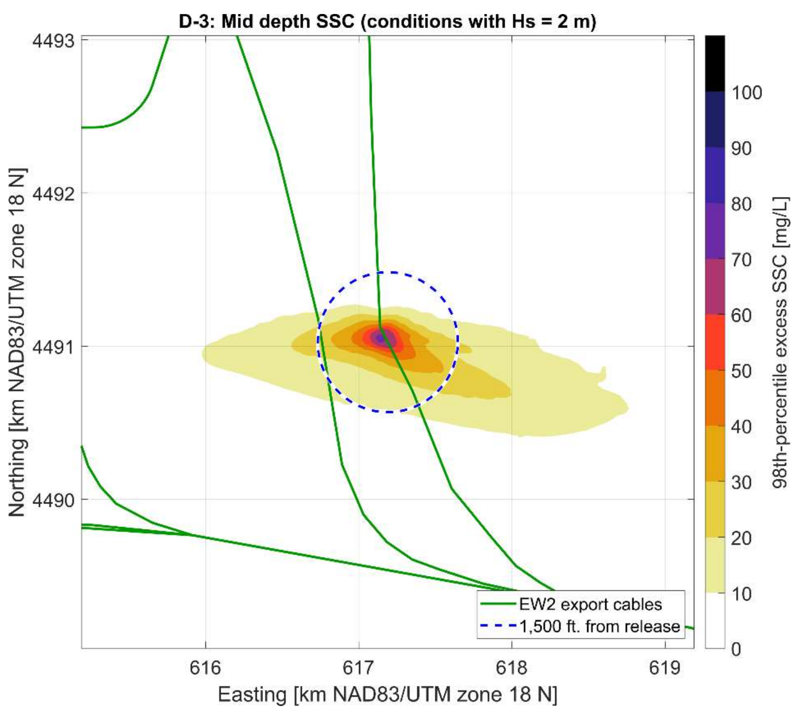

D-3: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
4493
4492
4491
4490
Northing [km NAD83/UTM zone 18 N]
616
617
618
619
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

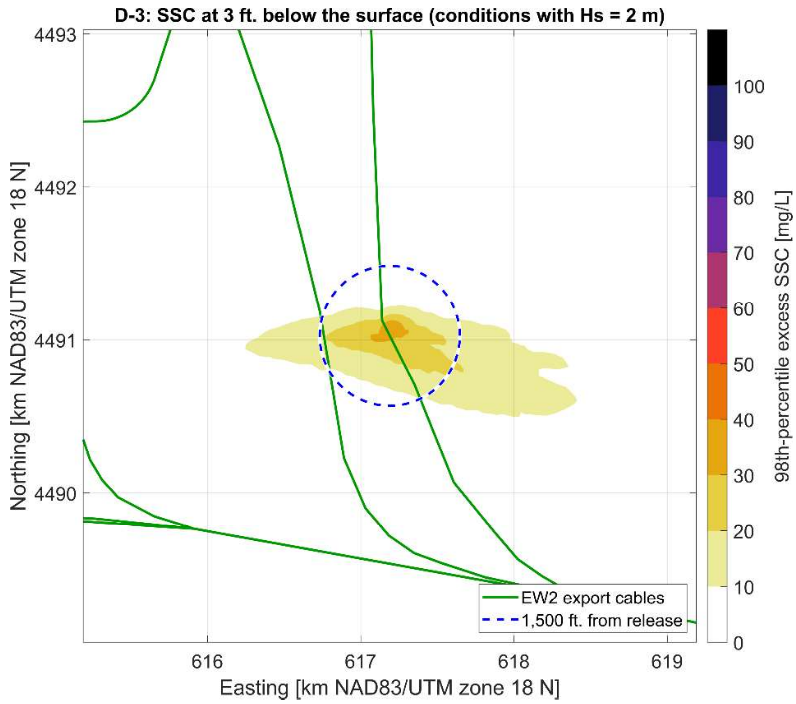

D-3: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
0
-2
-4
-6
-8
-10
-12
Depth [m]
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 21°N from release location
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

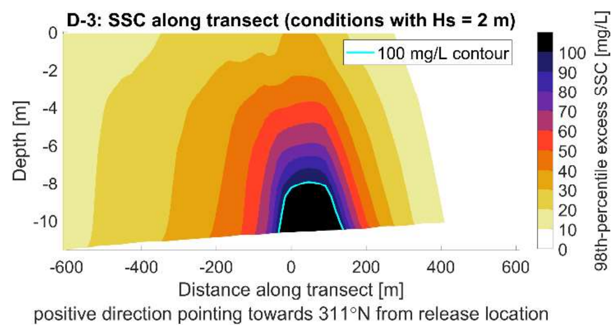

D-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

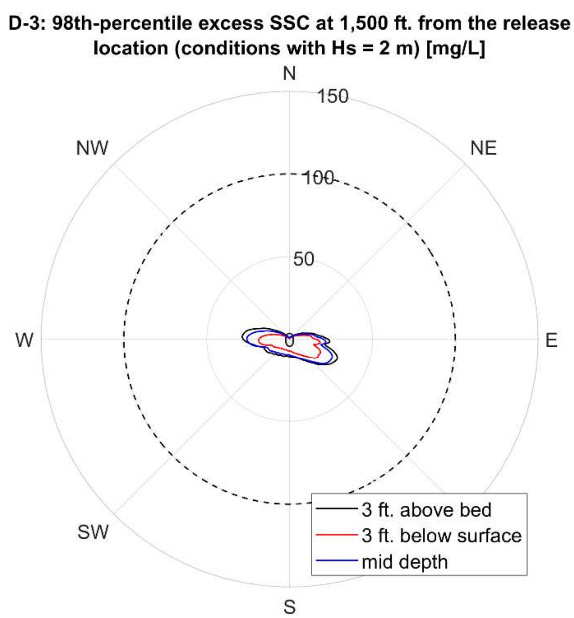
E.17.3 Sediment footprint with significant wave height ≈ 2 m



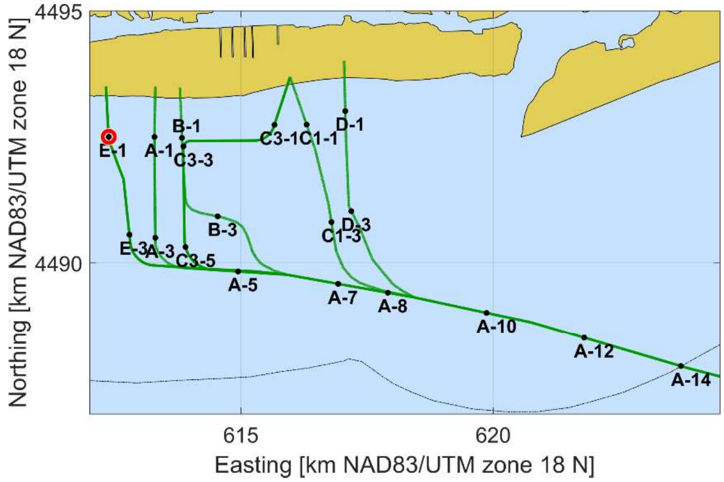



D-3: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release

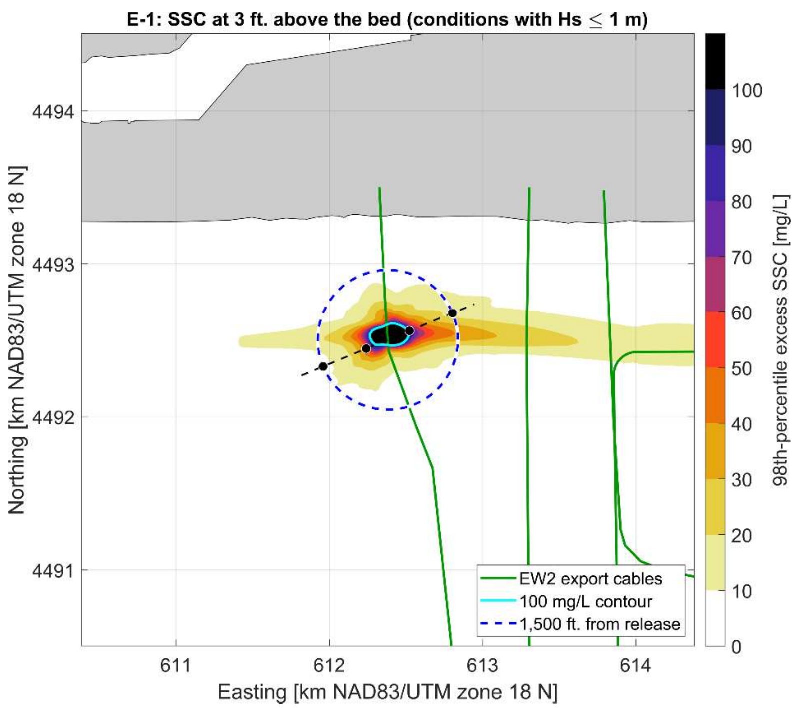

D-3: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 311°N from release location
98th-percentile excess SSC [mg/L]

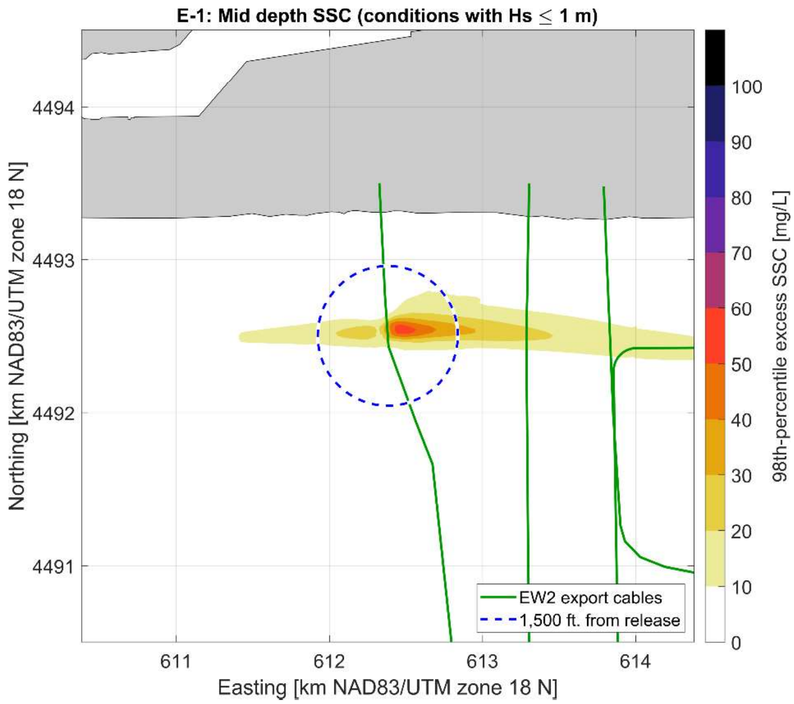

D-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
SW
S
NW
W
3 ft. above bed
3 ft. below surface
mid depth

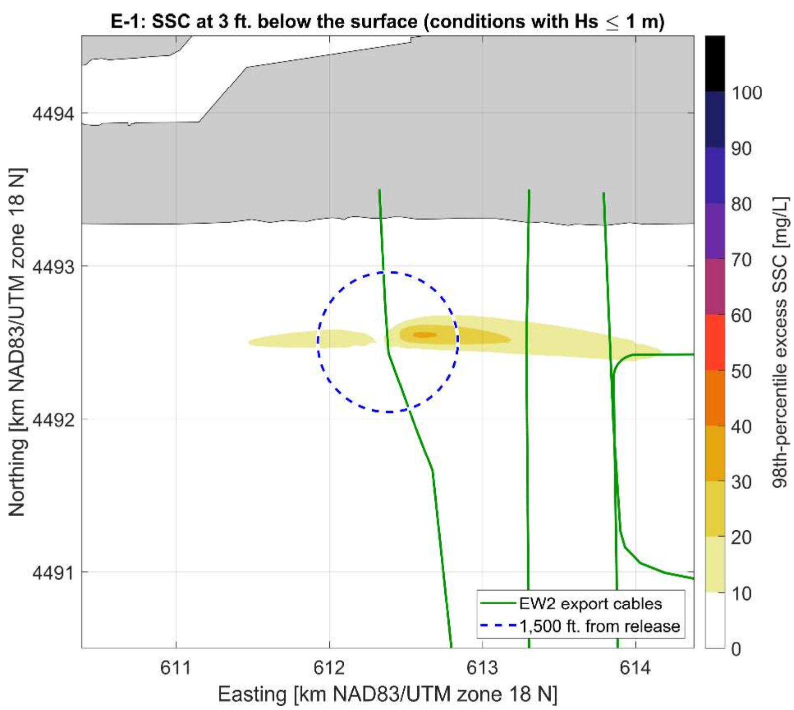
E.18 Release location E-1

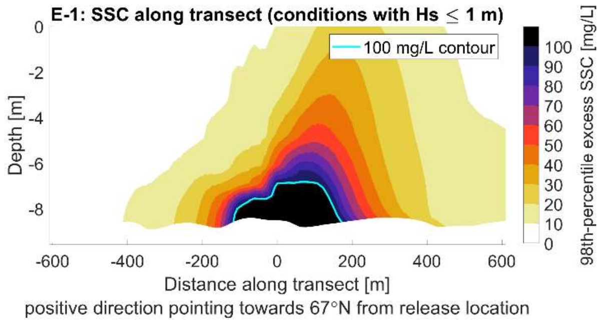


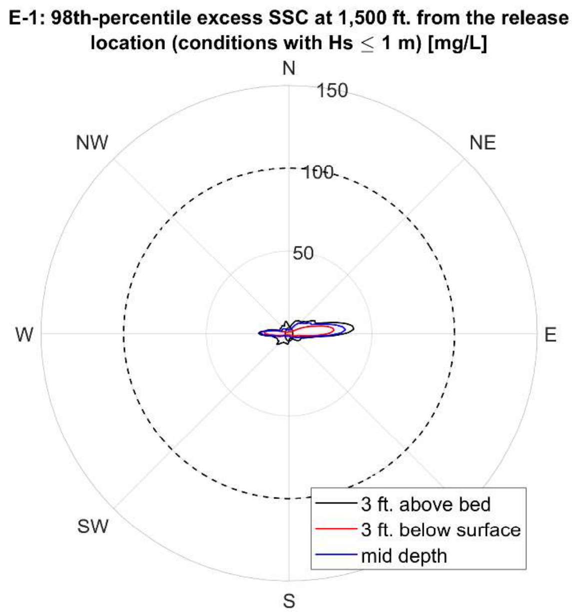
E.18.1 Sediment footprint with significant wave height ≤ 1 m



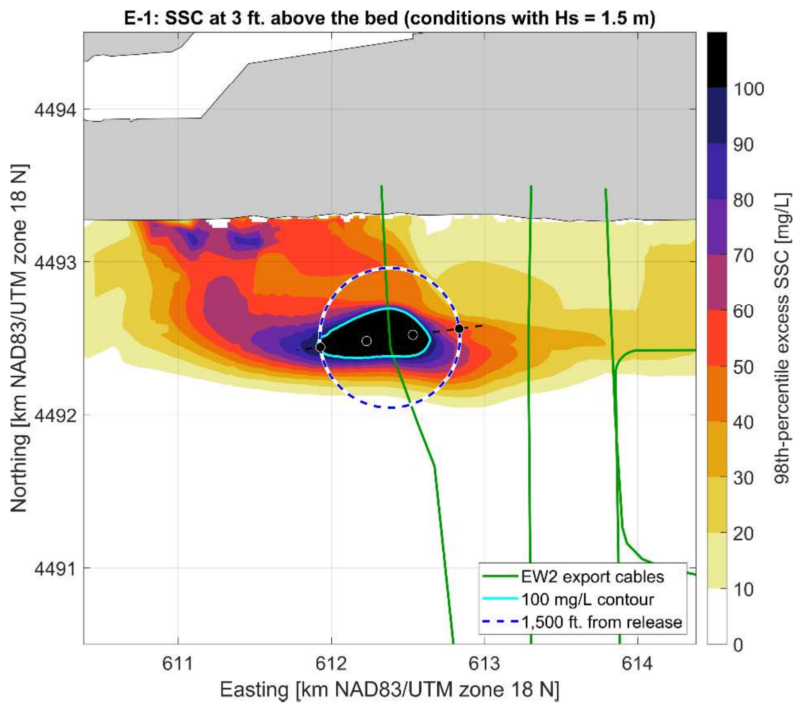

E-1: Mid depth SSC (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
4494
4493
4492
4491
Easting [km NAD83/UTM zone 18 N]
611
612
613
614
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

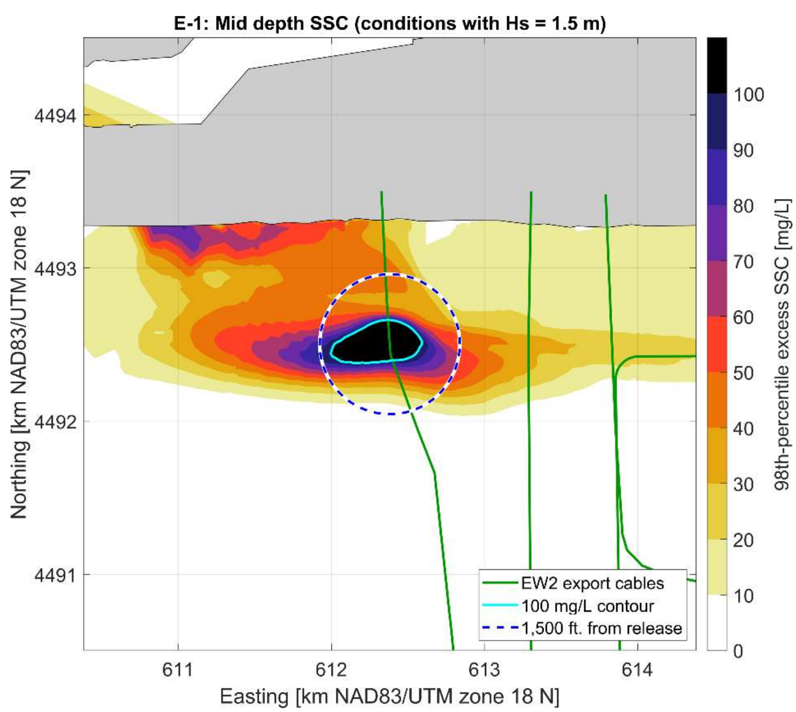

E-1: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
4494
4493
4492
4491
Easting [km NAD83/UTM zone 18 N]
611
612
613
614
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

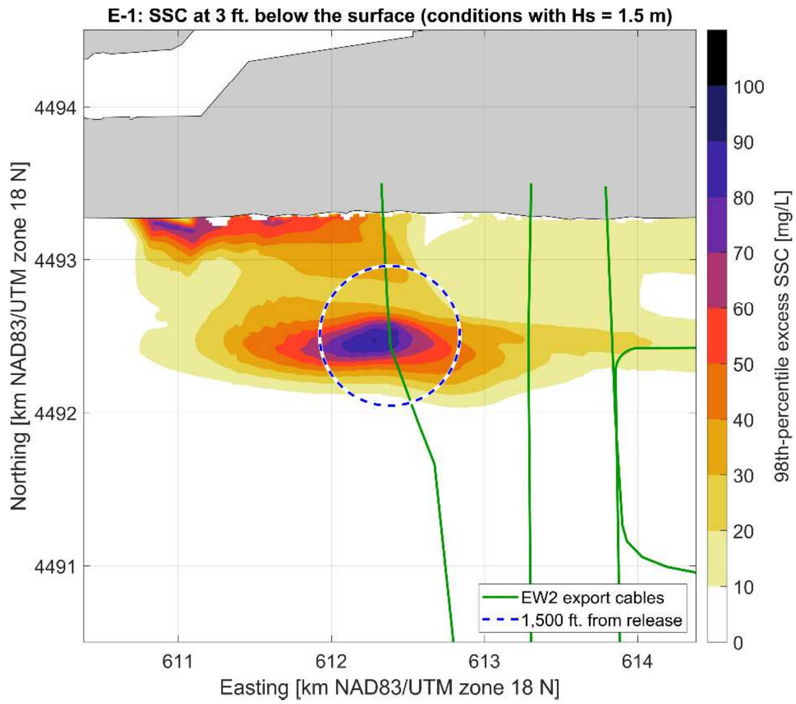

E-1: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 67°N from release location
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

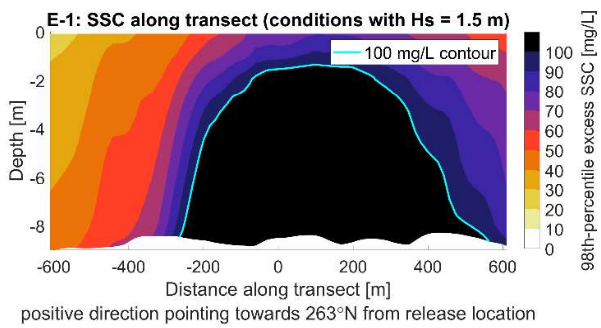

E-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
SW
S
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

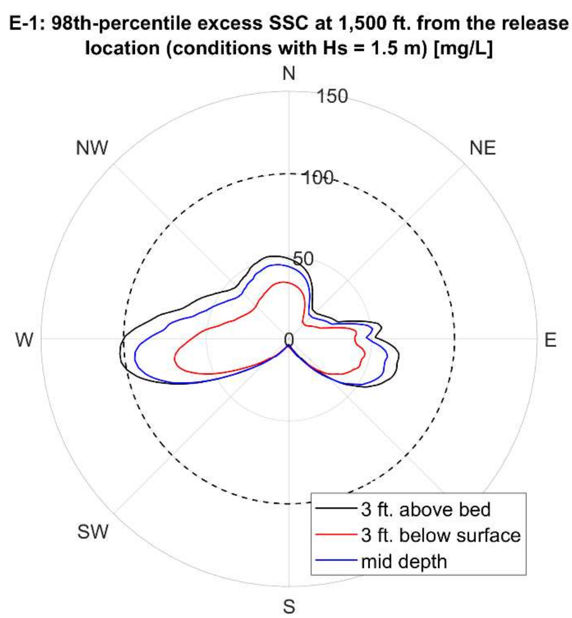
E.18.2 Sediment footprint with significant wave height ≈ 1.5 m



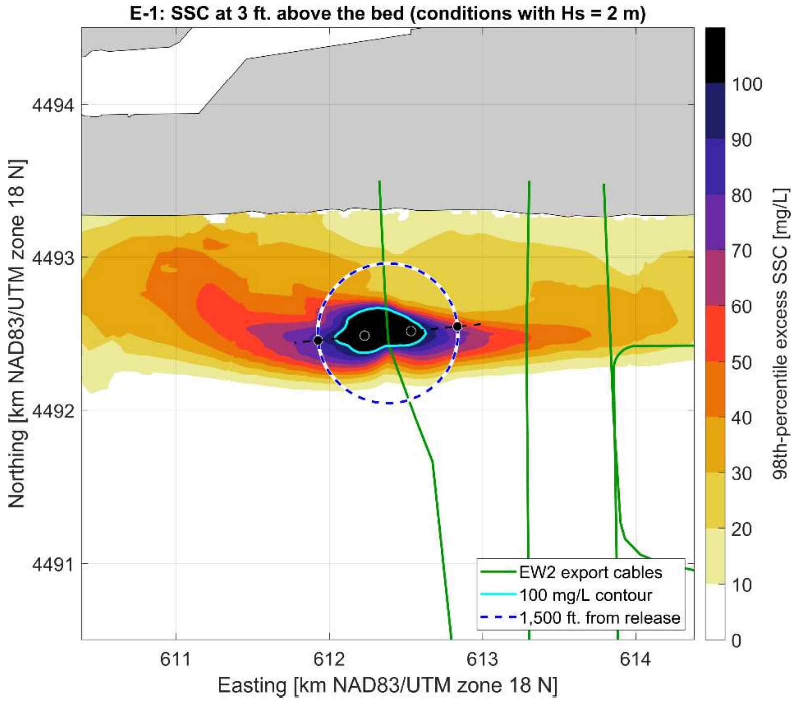


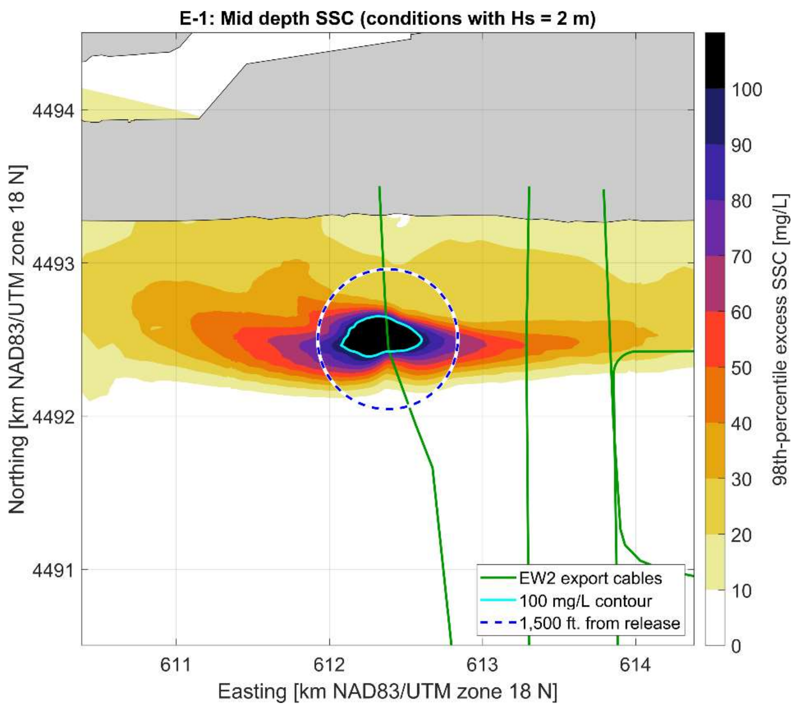

E-1: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release

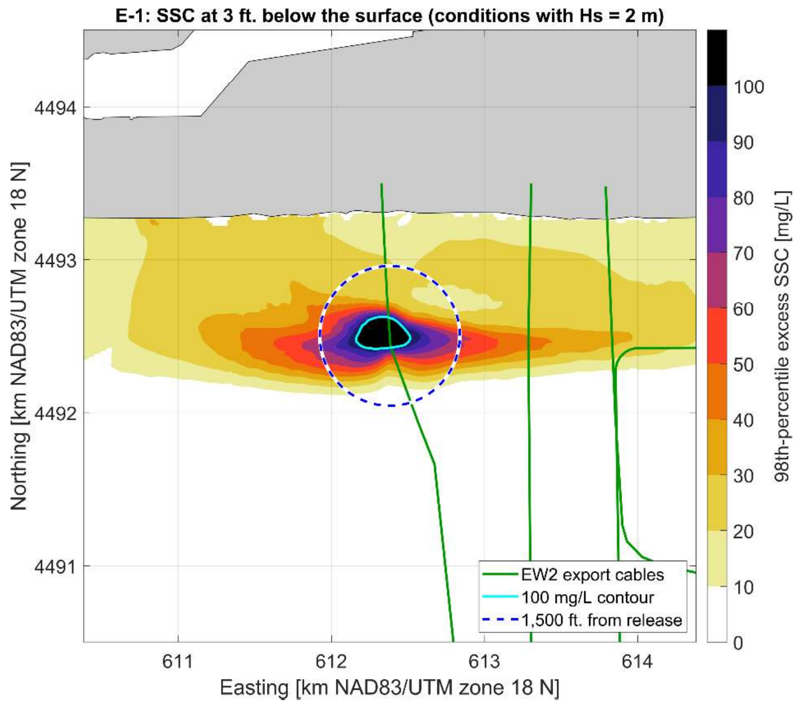

E-1: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 263°N from release location
98th-percentile excess SSC [mg/L]

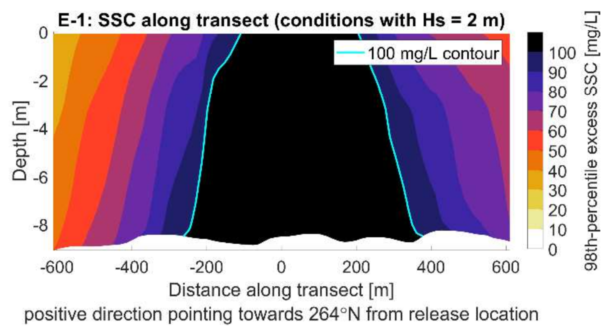

E-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

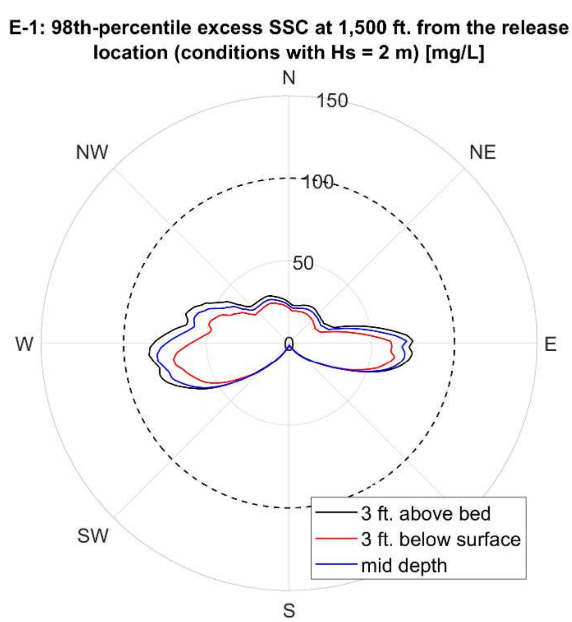
E.18.3 Sediment footprint with significant wave height ≈ 2 m



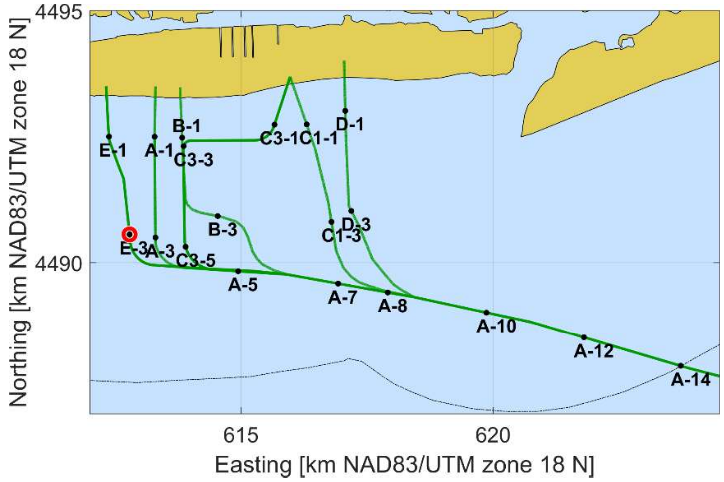



E-1: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
100 mg/L contour
1,500 ft. from release

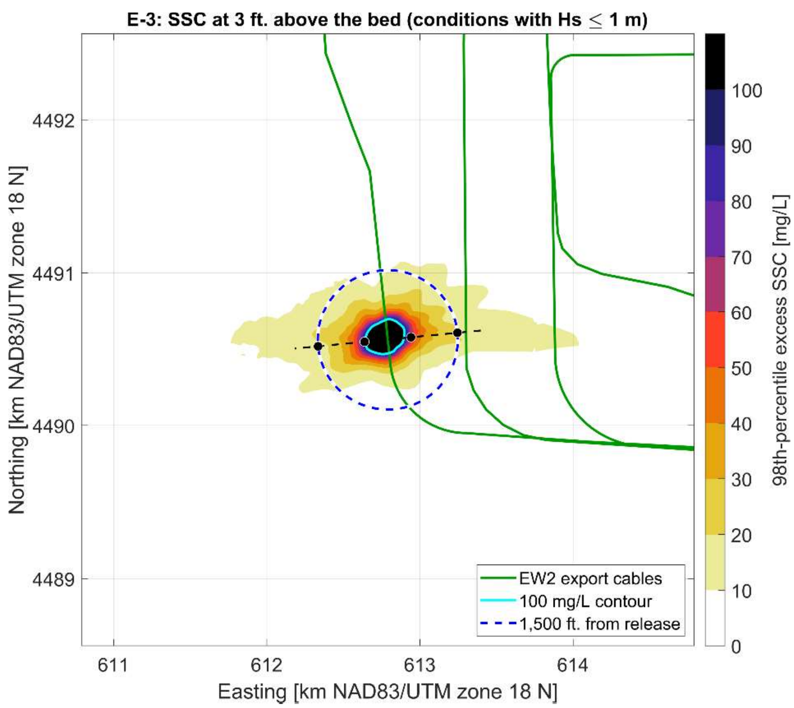

E-1: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 264°N from release location
98th-percentile excess SSC [mg/L]


E-1: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

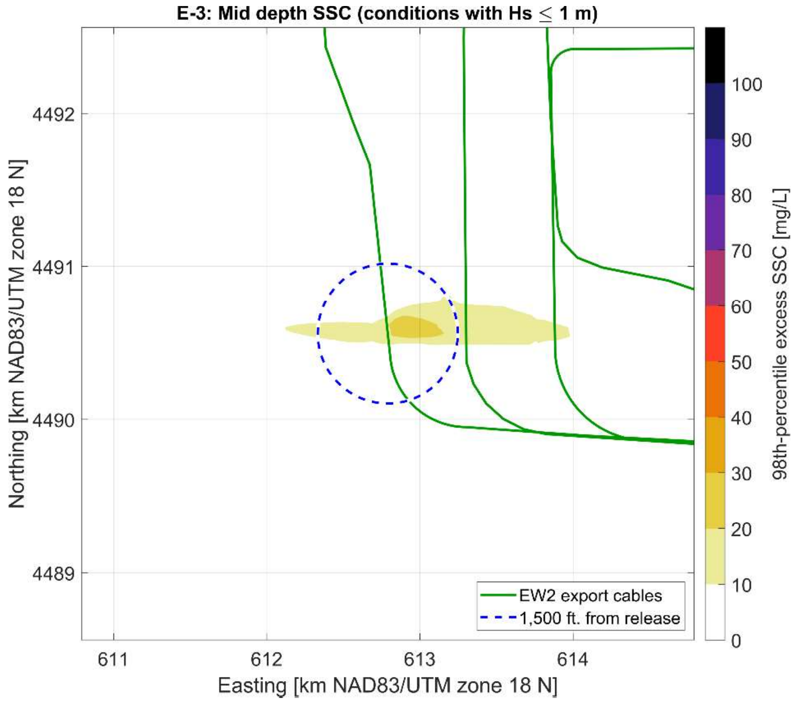
E.19 Release location E-3

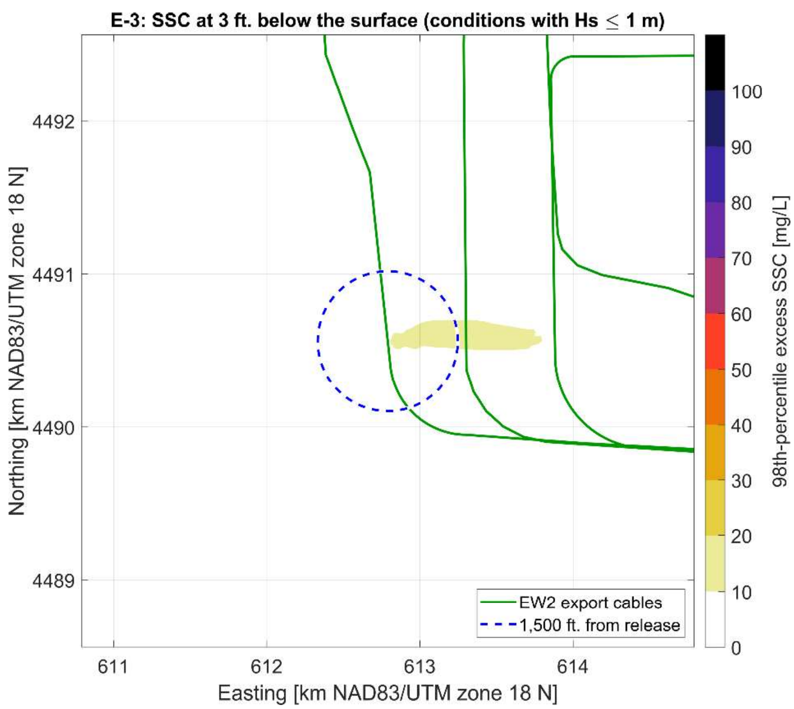


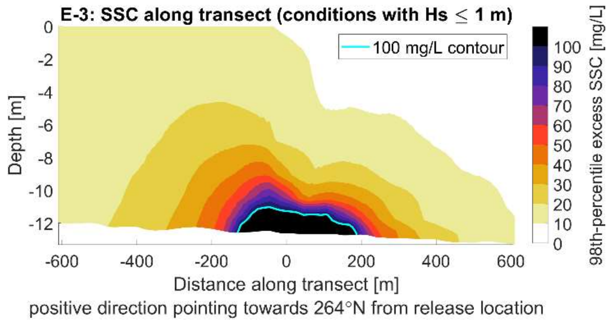
E.19.1 Sediment footprint with significant wave height ≤ 1 m

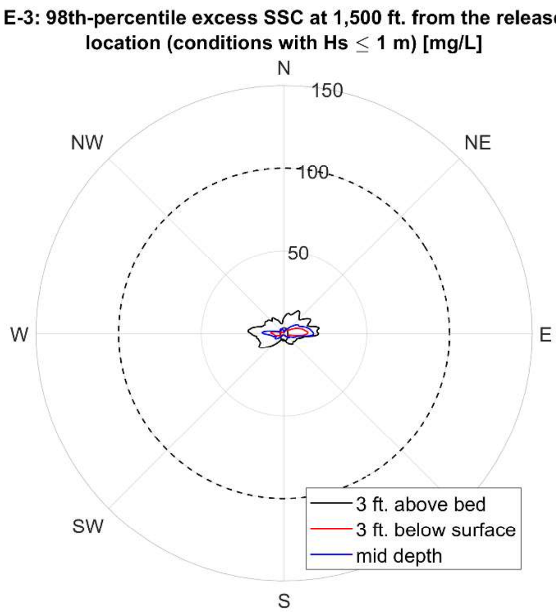


Deltares

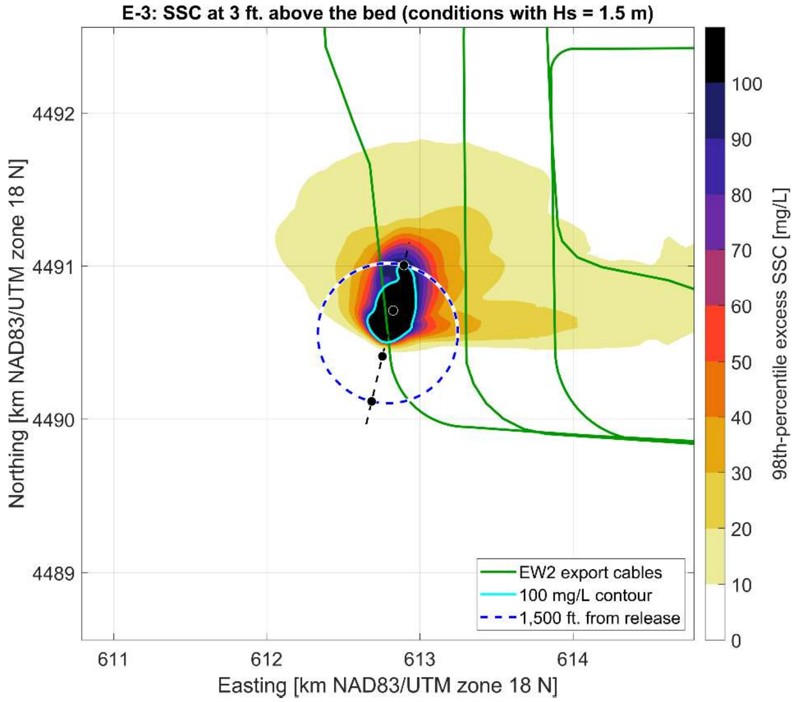

E-3: Mid depth SSC (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
611
612
613
614
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

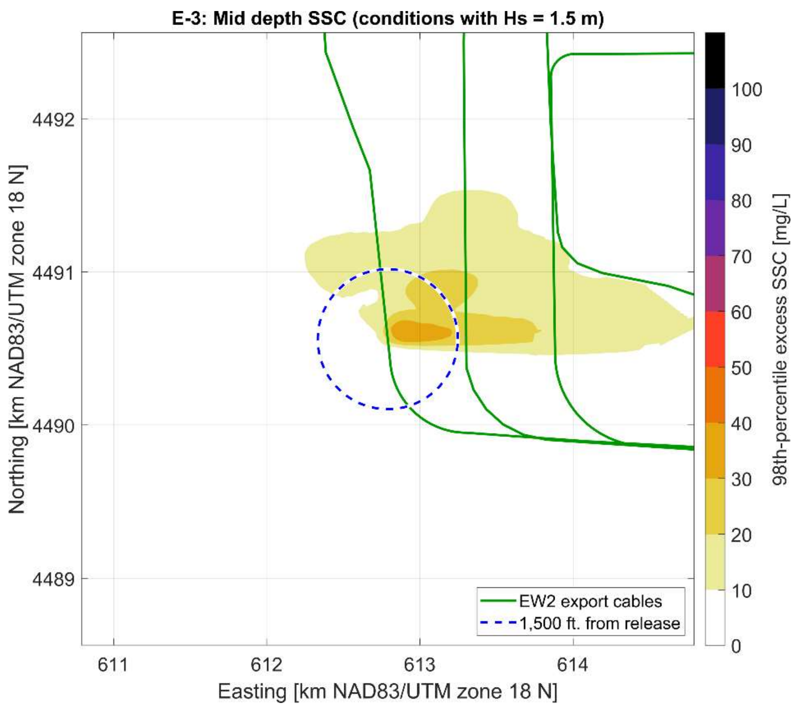

E-3: SSC at 3 ft. below the surface (conditions with Hs ≤ 1 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
611
612
613
614
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

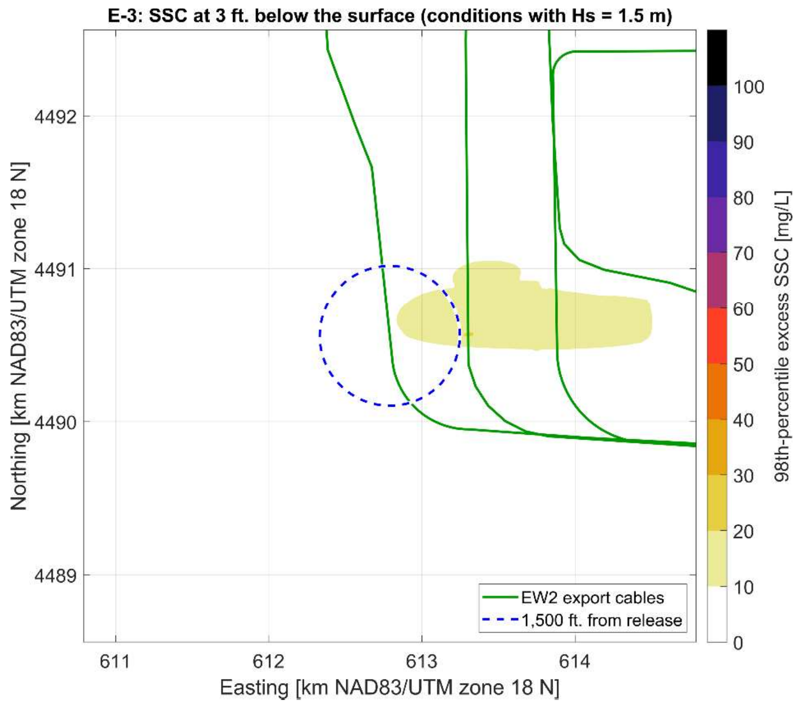

E-3: SSC along transect (conditions with Hs ≤ 1 m)
100 mg/L contour
Depth [m]
Distance along transect [m]
positive direction pointing towards 264°N from release location
98th-percentile excess SSC [mg/L]

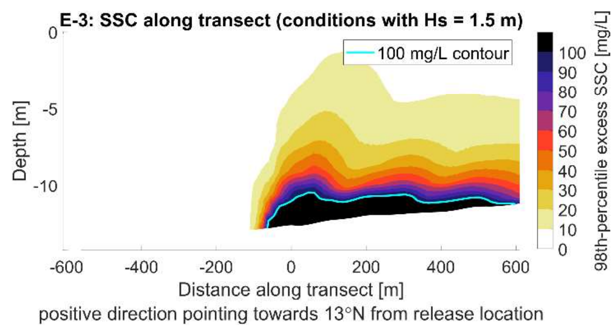

E-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs ≤ 1 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

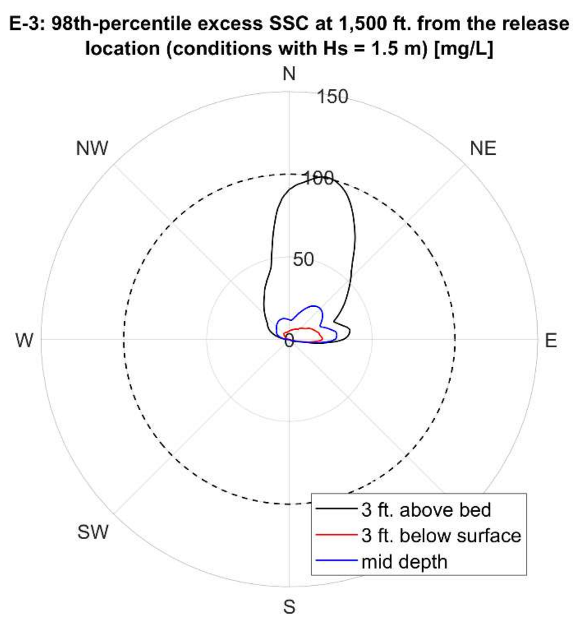
E.19.2 Sediment footprint with significant wave height ≈ 1.5 m



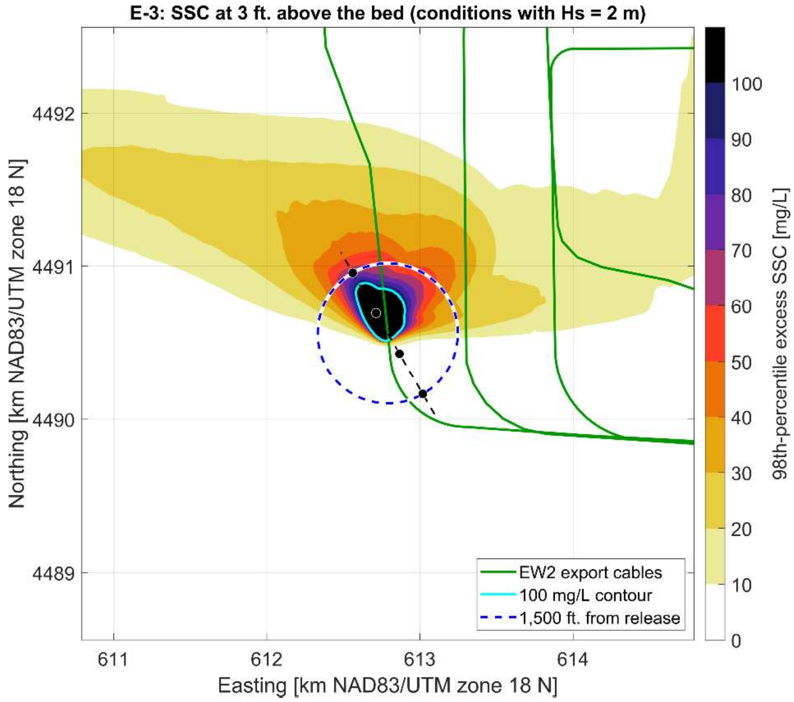


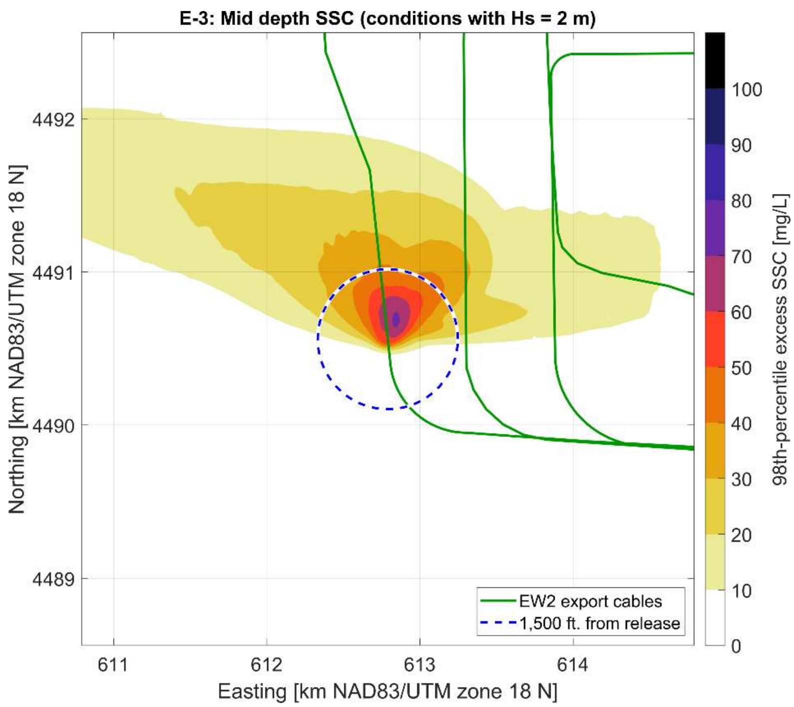

E-3: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
611
612
613
614
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

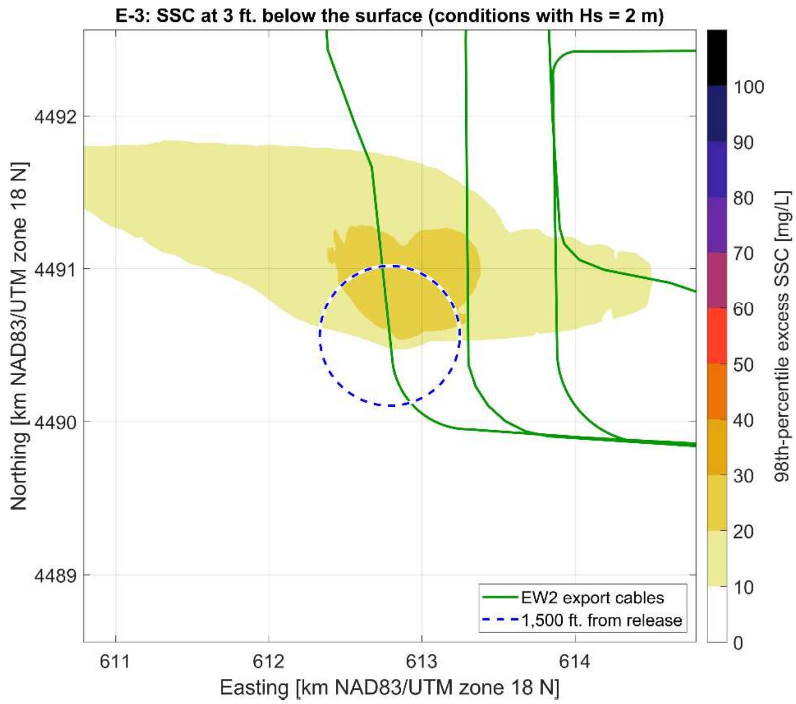

E-3: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
Depth [m]
0
-5
-10
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 13°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

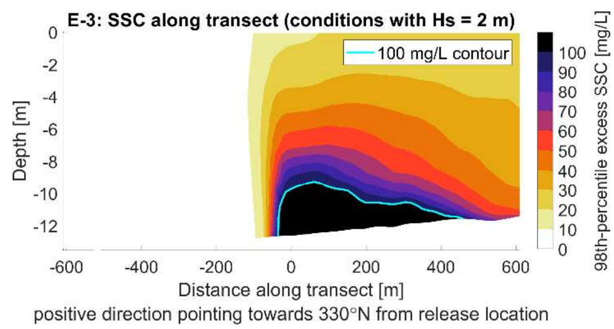

E-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

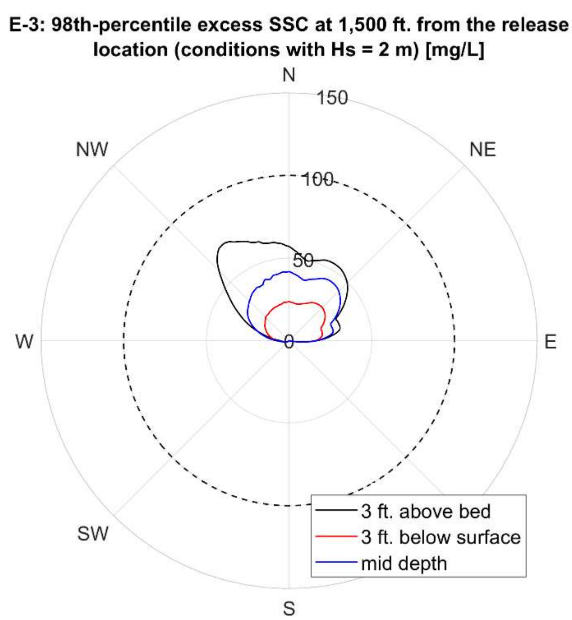
E.19.3 Sediment footprint with significant wave height ≈ 2 m





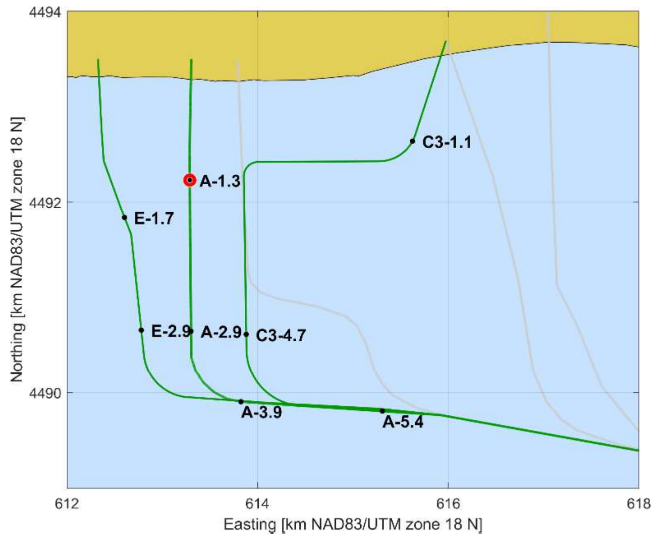

E-3: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
611
612
613
614
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0


E-3: SSC along transect (conditions with Hs = 2 m)
100 mg/L contour
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 330°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

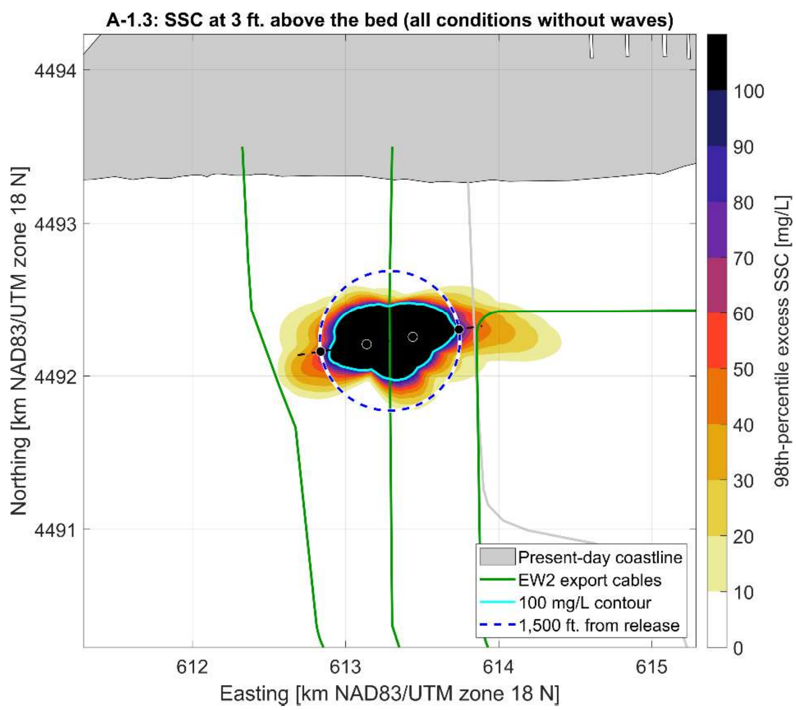

E-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

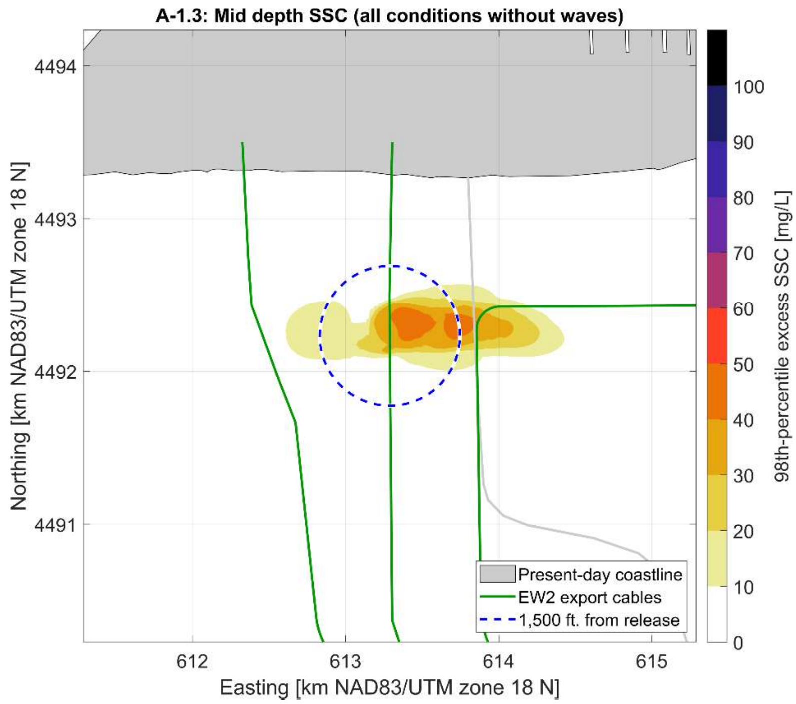
F Far-field modelling results (MFE)

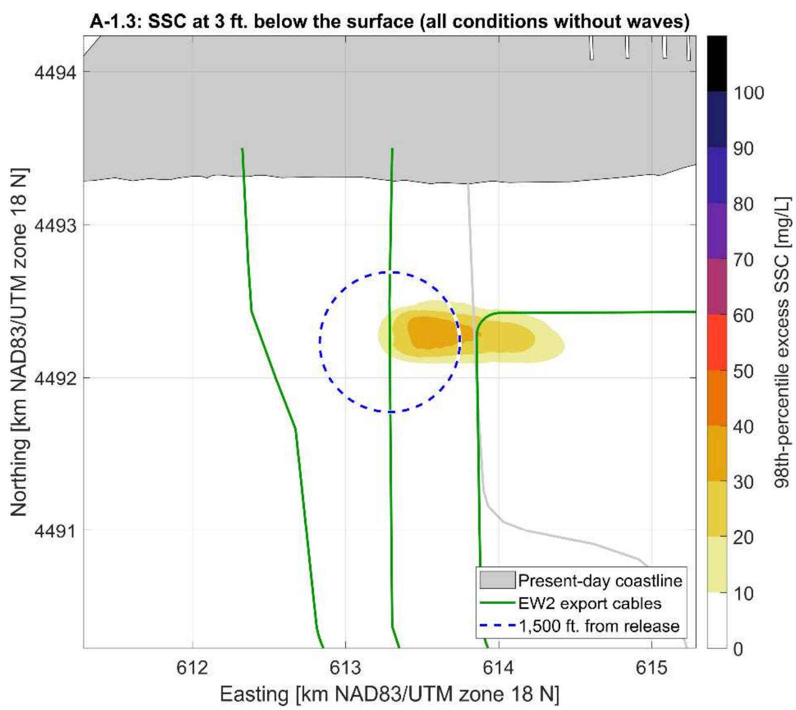
F.1 Release location A-1.3

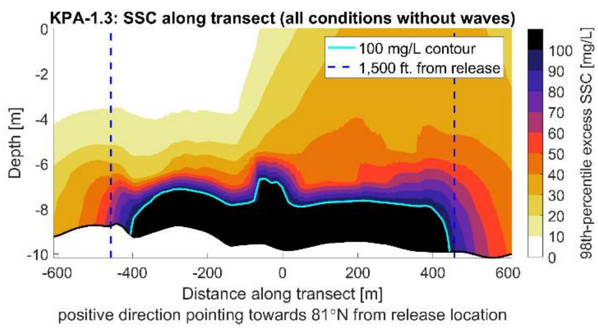


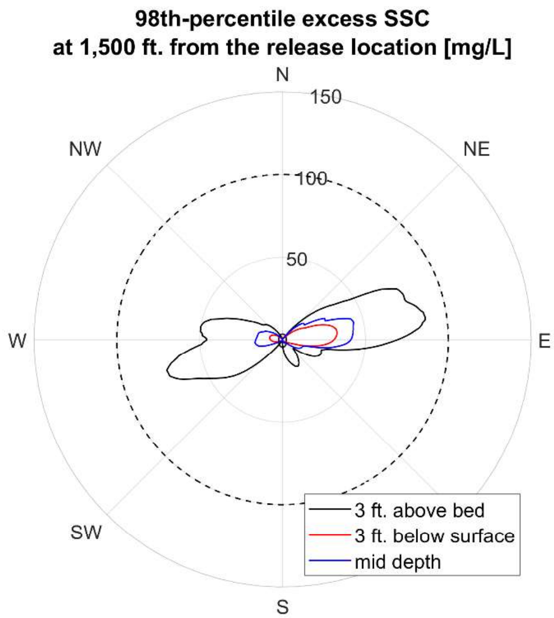
F.1.1 Sediment footprint without waves



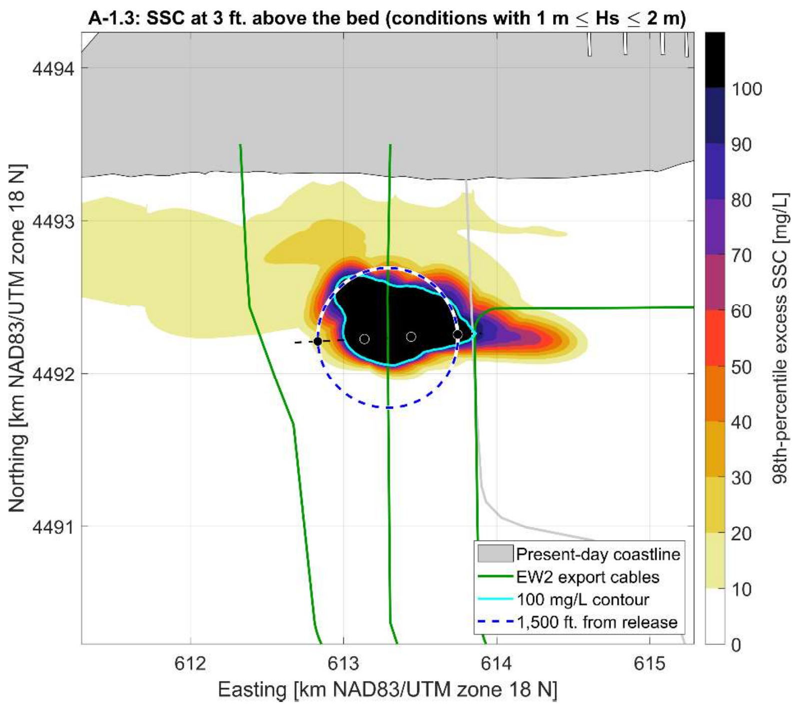

A-1.3: Mid depth SSC (all conditions without waves)
4494
4493
4492
4491
Northing [km NAD83/UTM zone 18 N]
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
Present-day coastline
EW2 export cables
1,500 ft. from release
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

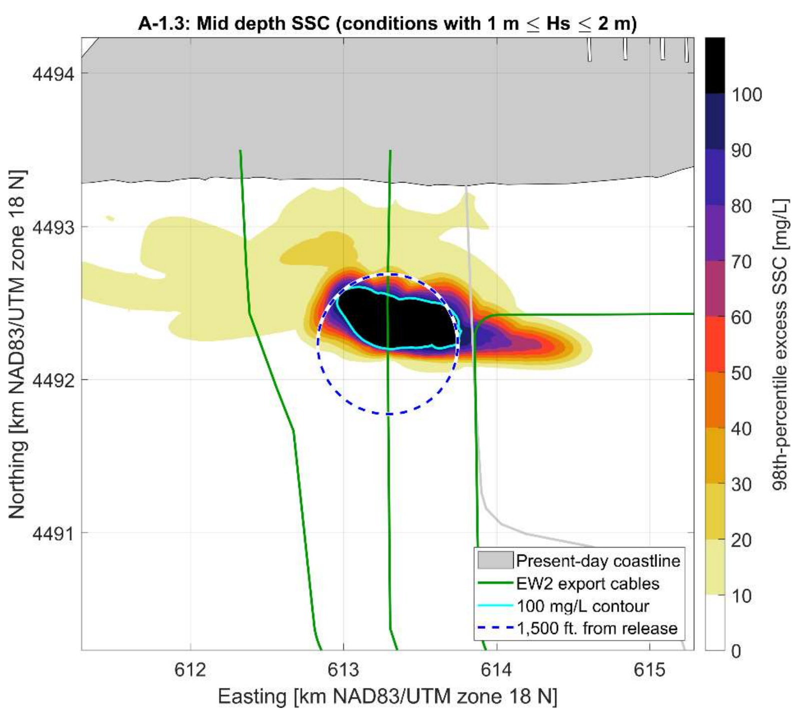

A-1.3: SSC at 3 ft. below the surface (all conditions without waves)
4494
4493
4492
4491
Northing [km NAD83/UTM zone 18 N]
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
Present-day coastline
EW2 export cables
1,500 ft. from release
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

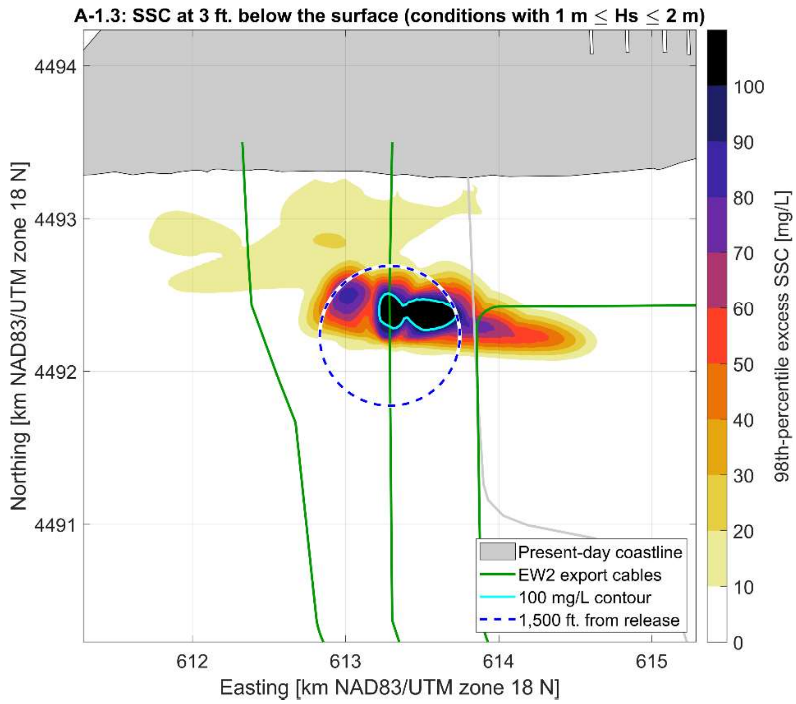

KPA-1.3: SSC along transect (all conditions without waves)
100 mg/L contour
1,500 ft. from release
Depth [m]
0
-2
-4
-6
-8
-10
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 81°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

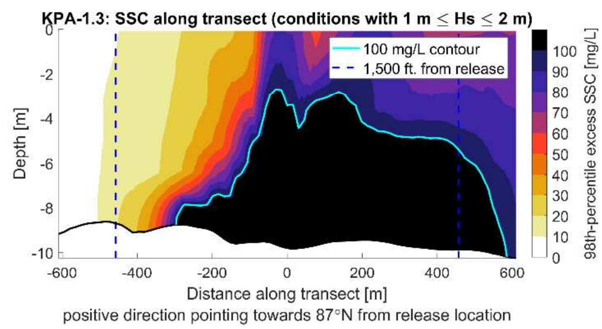

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

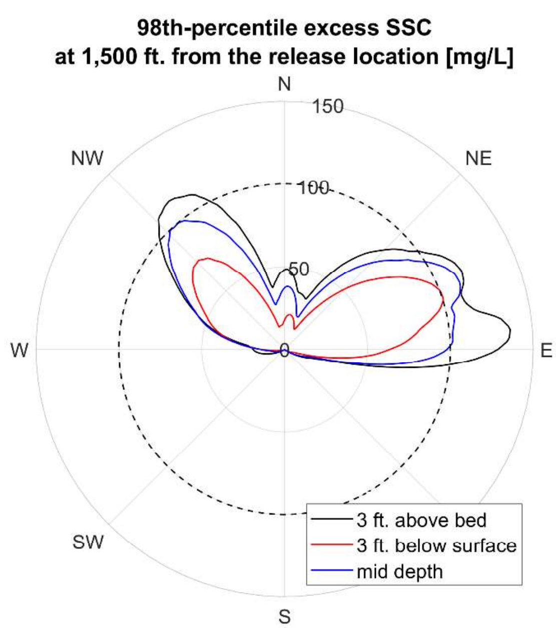
F.1.2 Sediment footprint with waves



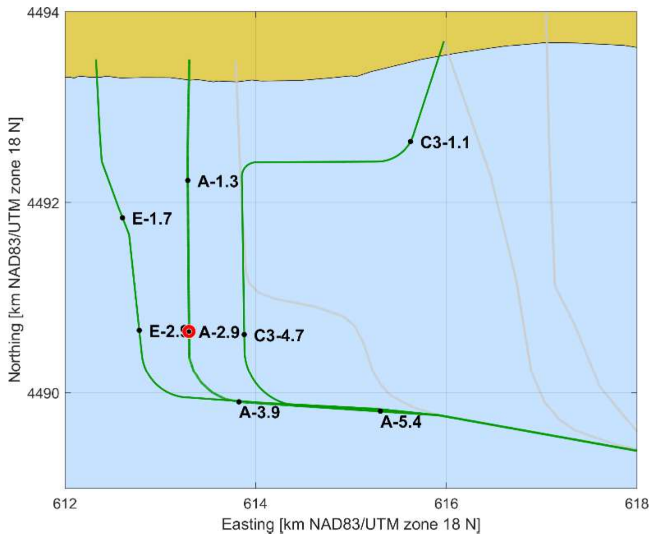



A-1.3: SSC at 3 ft. below the surface (conditions with 1 m ≤ Hs ≤ 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
Present-day coastline
EW2 export cables
100 mg/L contour
1,500 ft. from release

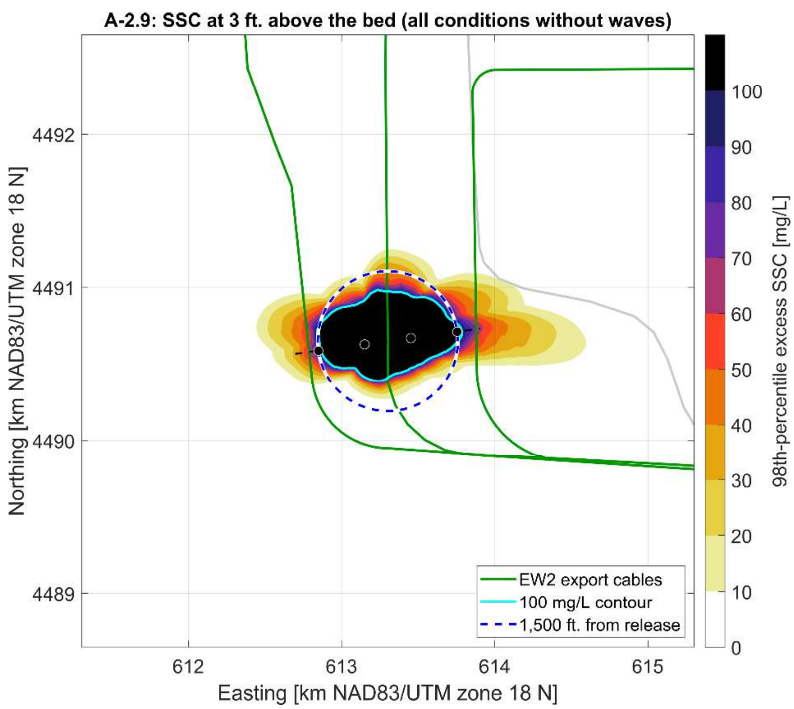

KPA-1.3: SSC along transect (conditions with 1 m ≤ Hs ≤ 2 m)
100 mg/L contour
1,500 ft. from release
Depth [m]
Distance along transect [m]
positive direction pointing towards 87°N from release location
98th-percentile excess SSC [mg/L]


98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

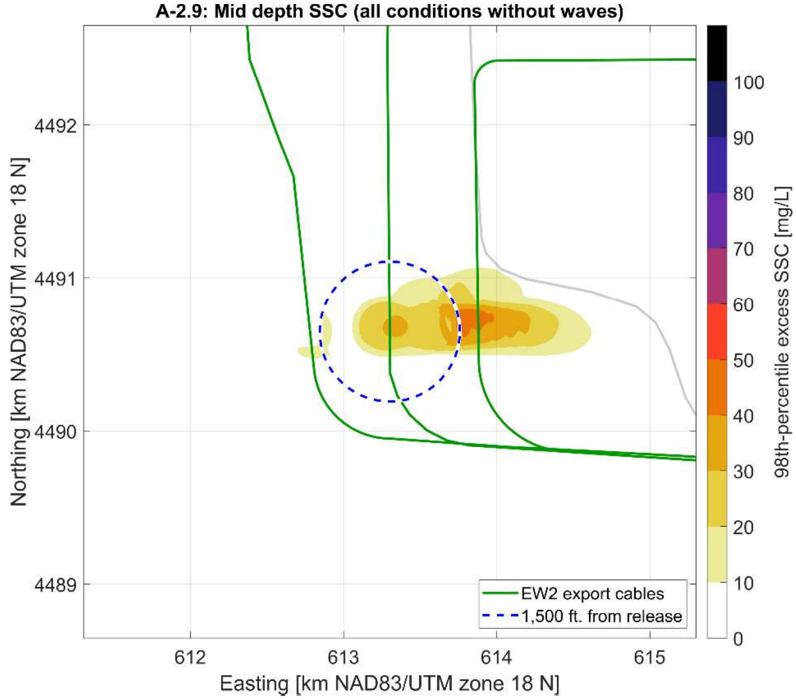
F.2 Release location A-2.9



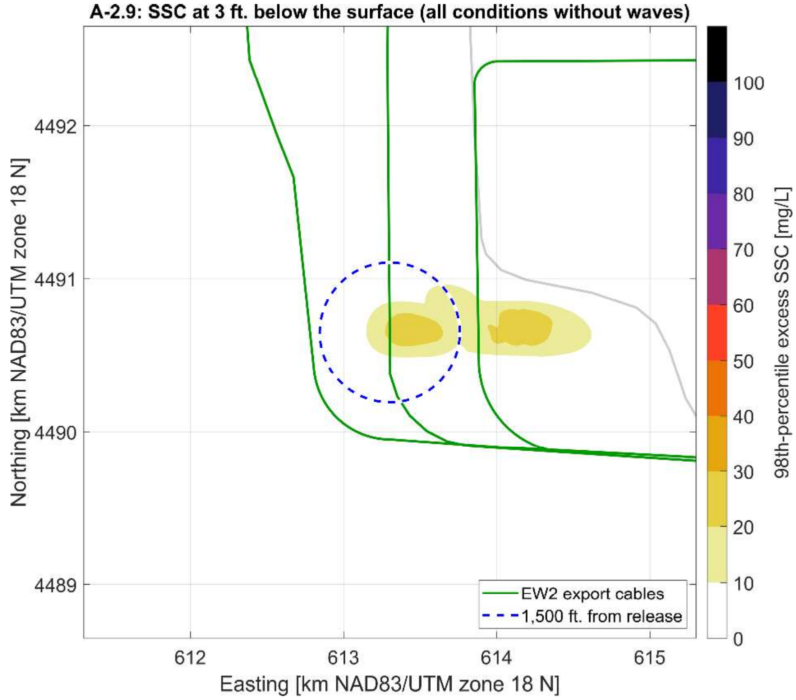
F.2.1 Sediment footprint without waves

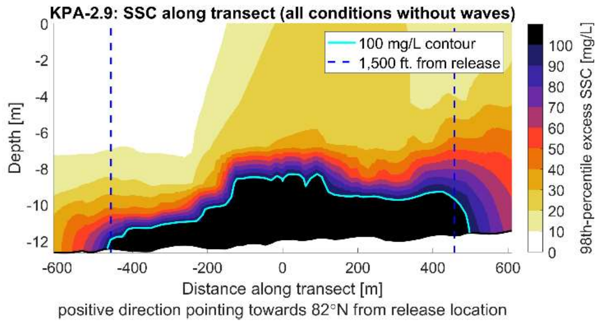


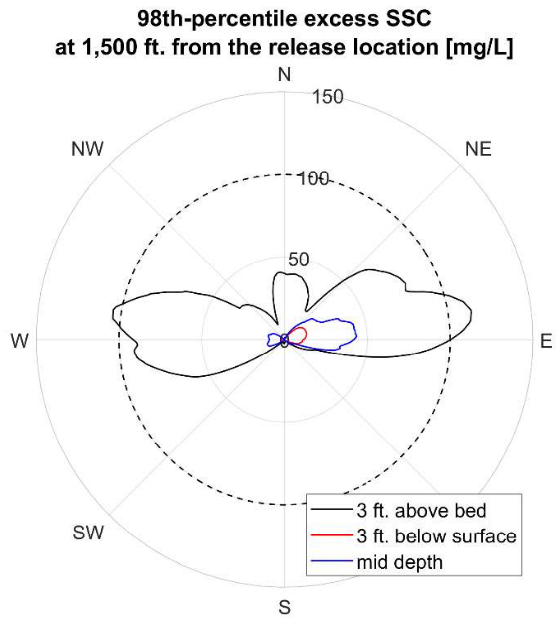
A-2.9: Mid depth SSC (all conditions without waves)



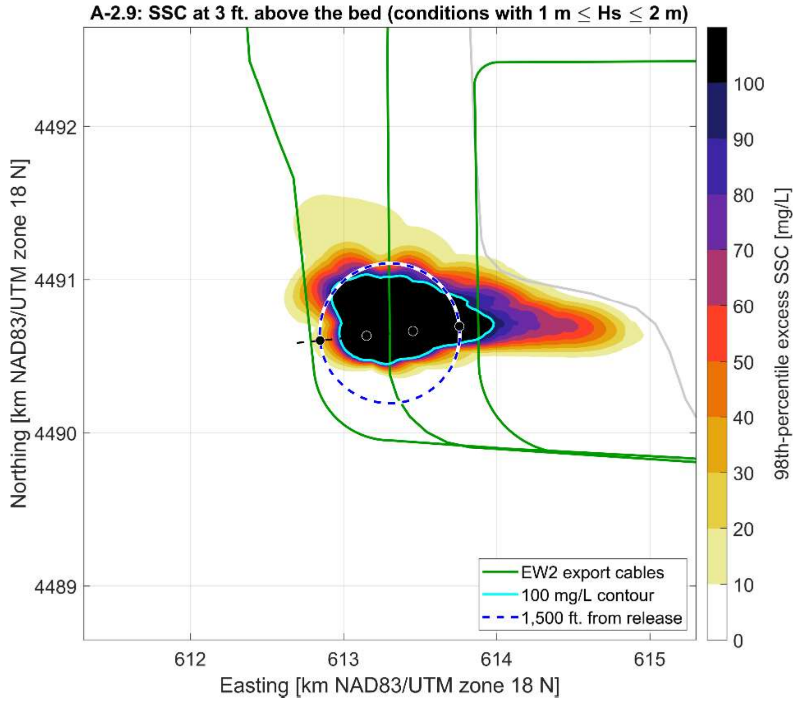
A-2.9: SSC at 3 ft. below the surface (all conditions without waves)

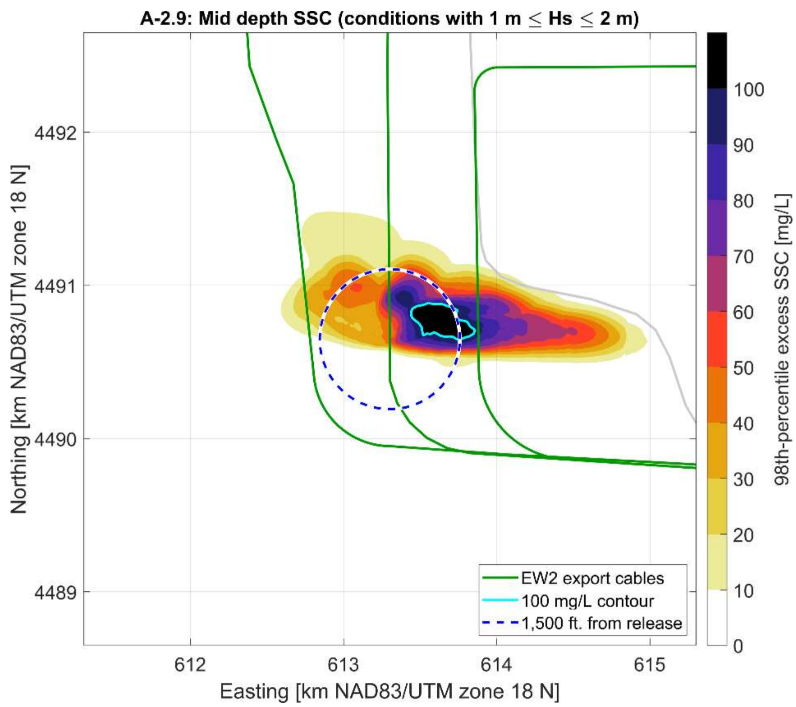


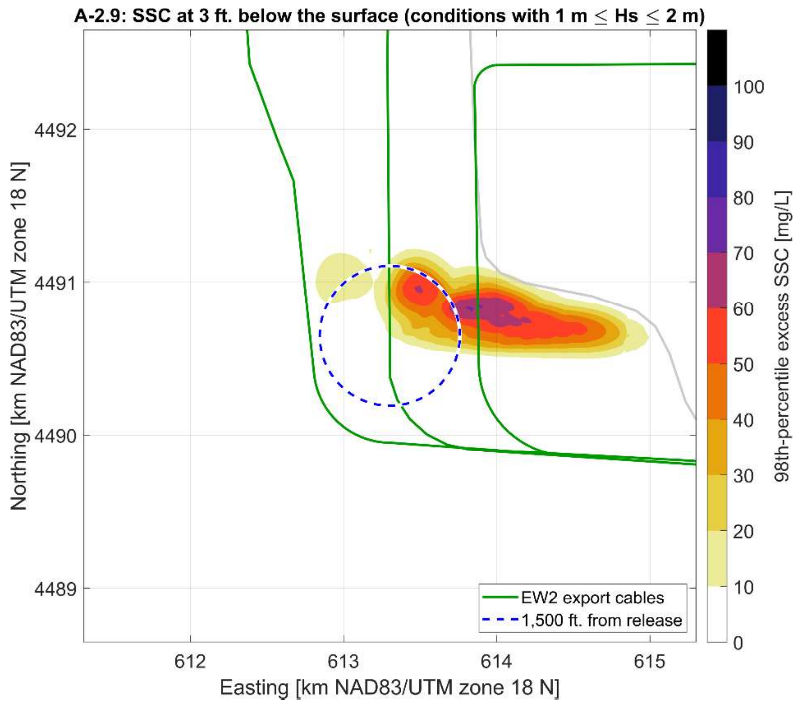

KPA-2.9: SSC along transect (all conditions without waves)
100 mg/L contour
1,500 ft. from release
Depth [m]
Distance along transect [m]
positive direction pointing towards 82°N from release location
98th-percentile excess SSC [mg/L]

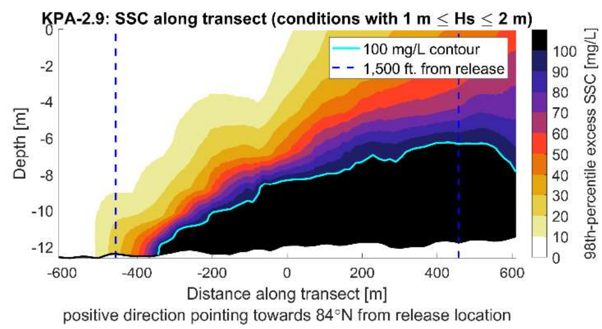

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
SW
S
W
NW
3 ft. above bed
3 ft. below surface
mid depth

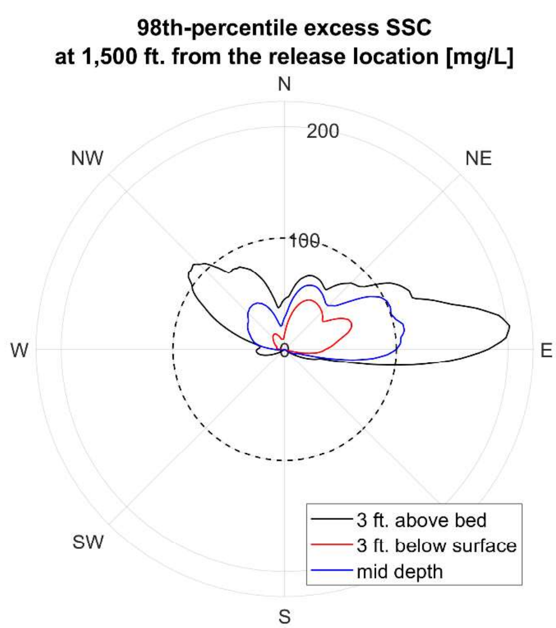
F.2.2 Sediment footprint with waves



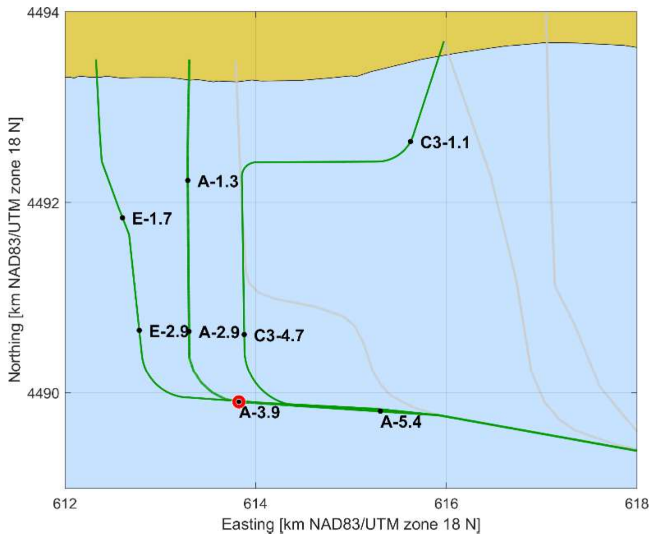



A-2.9: SSC at 3 ft. below the surface (conditions with 1 m ≤ Hs ≤ 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release

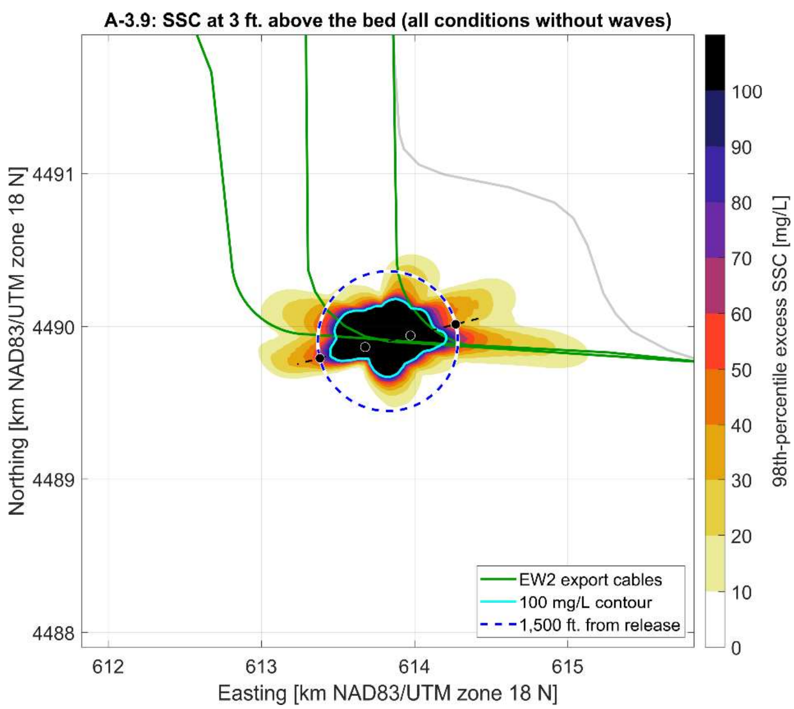

KPA-2.9: SSC along transect (conditions with 1 m ≤ Hs ≤ 2 m)
100 mg/L contour
1,500 ft. from release
Depth [m]
98th-percentile excess SSC [mg/L]
Distance along transect [m]
positive direction pointing towards 84°N from release location

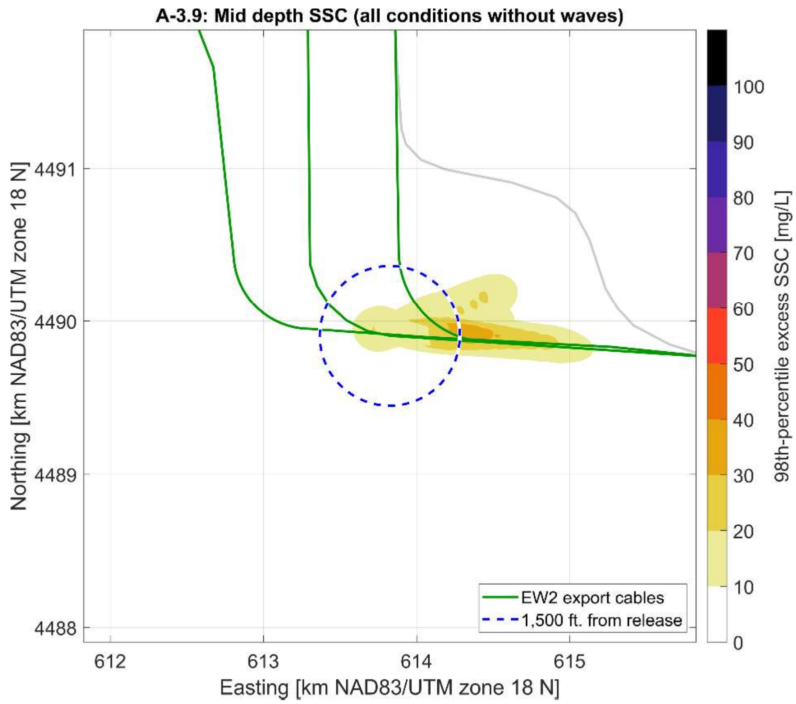

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
SE
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

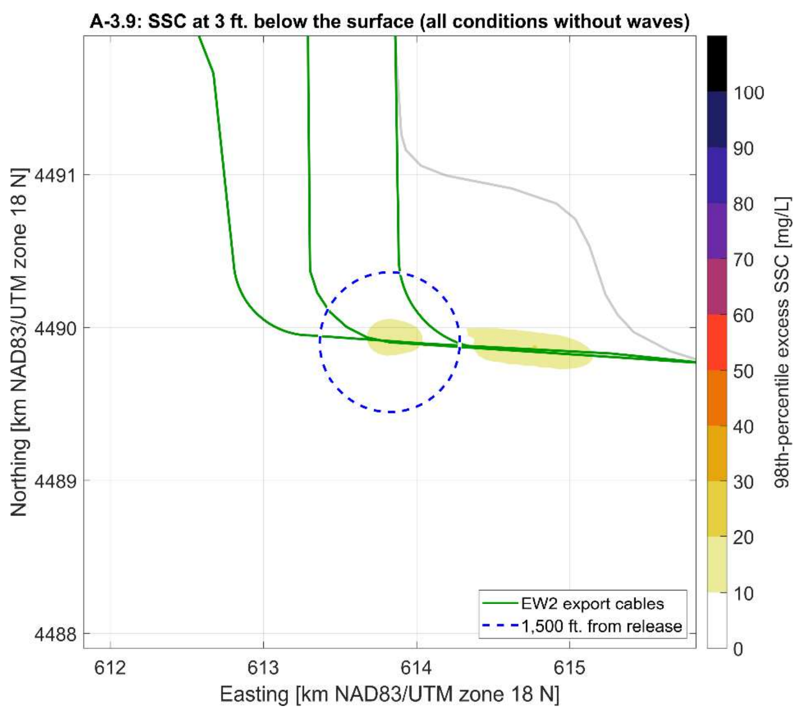
F.3 Release location A-3.9

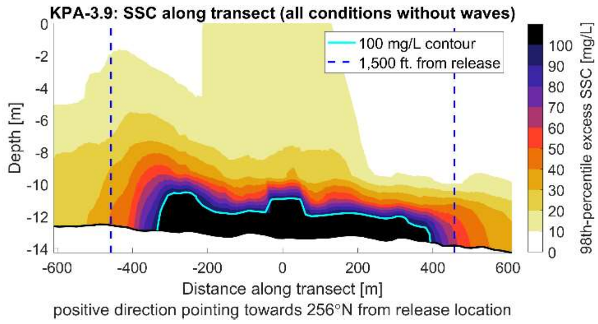


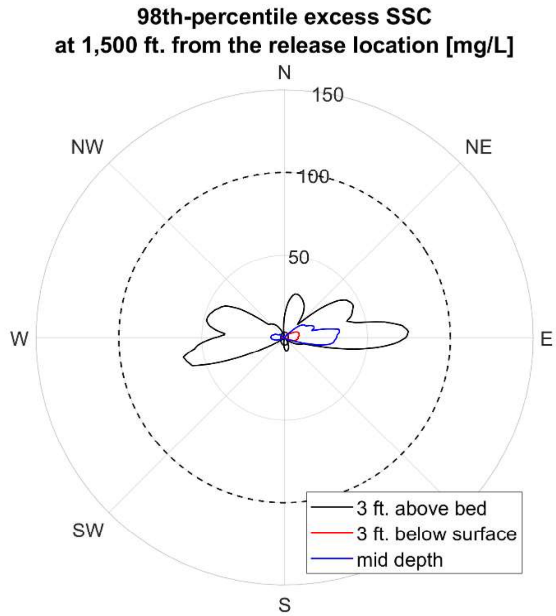
F.3.1 Sediment footprint without waves



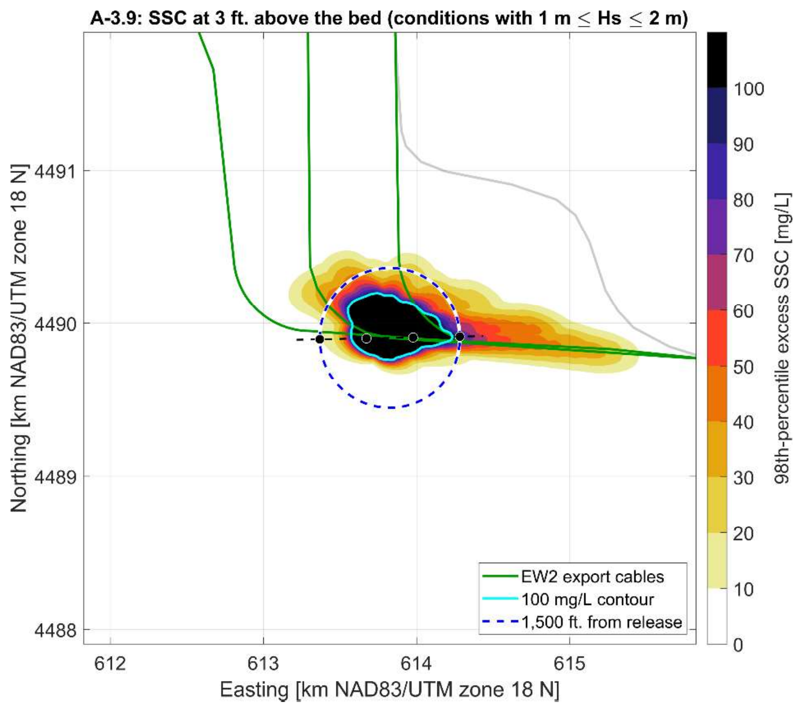

A-3.9: Mid depth SSC (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release
4491
4490
4489
4488
612
613
614
615
0
10
20
30
40
50
60
70
80
90
100

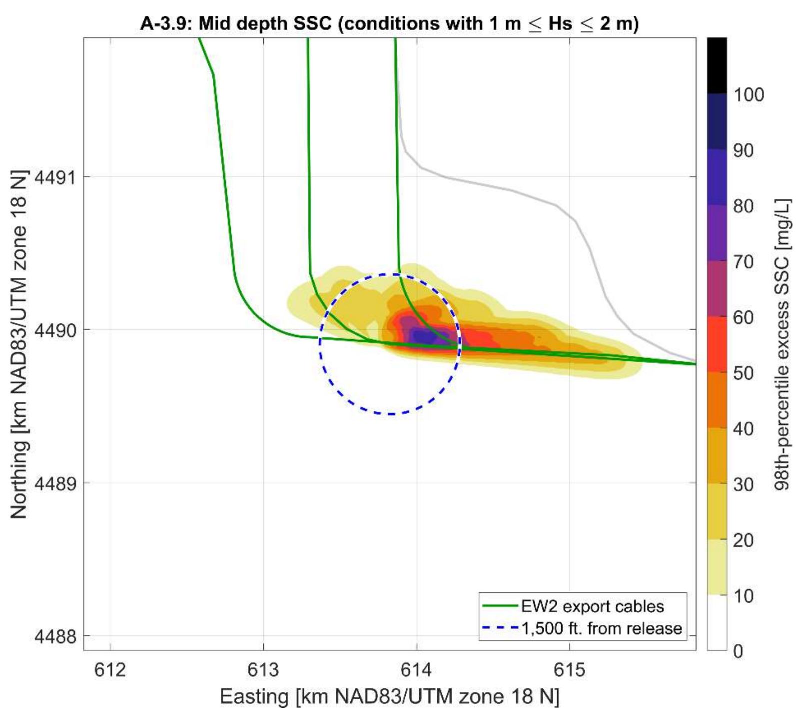

A-3.9: SSC at 3 ft. below the surface (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release
4491
4490
4489
4488
612
613
614
615
0
10
20
30
40
50
60
70
80
90
100

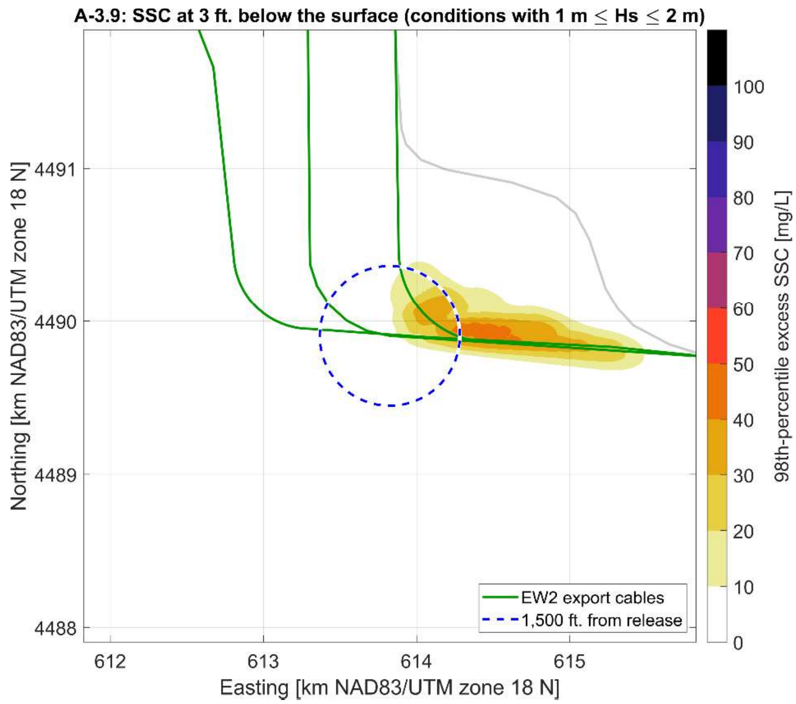

KPA-3.9: SSC along transect (all conditions without waves)
100 mg/L contour
1,500 ft. from release
Depth [m]
Distance along transect [m]
positive direction pointing towards 256°N from release location
98th-percentile excess SSC [mg/L]

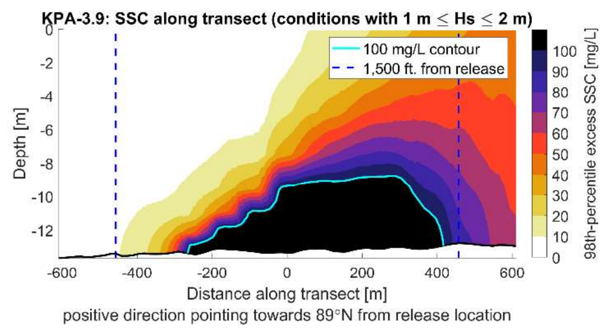

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
SW
S
W
NW
3 ft. above bed
3 ft. below surface
mid depth

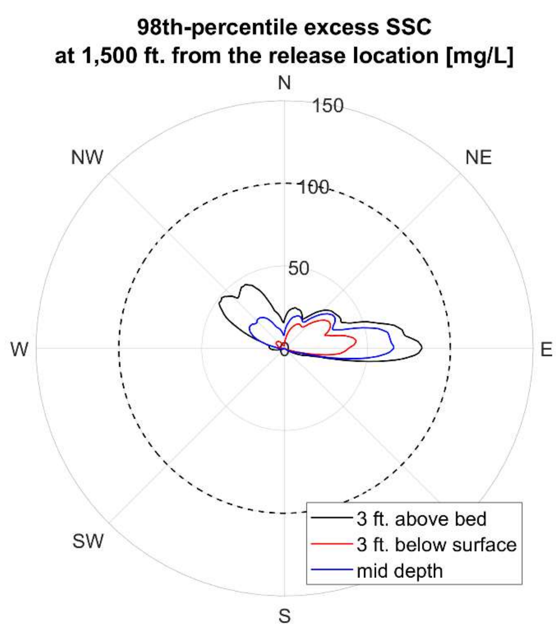
F.3.2 Sediment footprint with waves



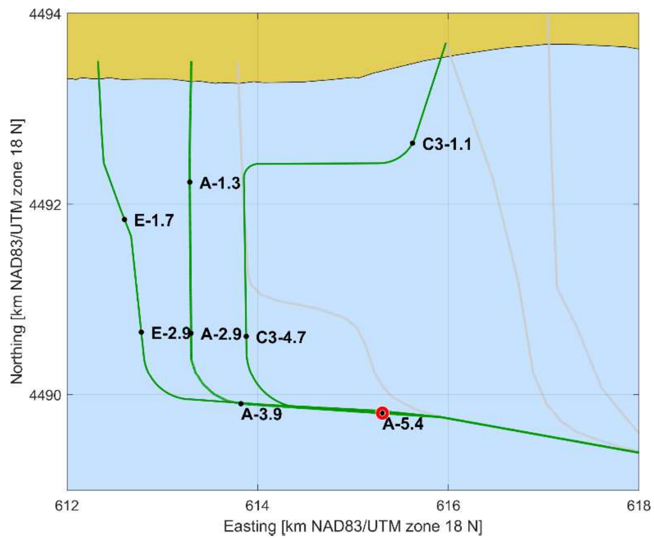



A-3.9: SSC at 3 ft. below the surface (conditions with 1 m ≤ Hs ≤ 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4491
4490
4489
4488
612
613
614
615
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

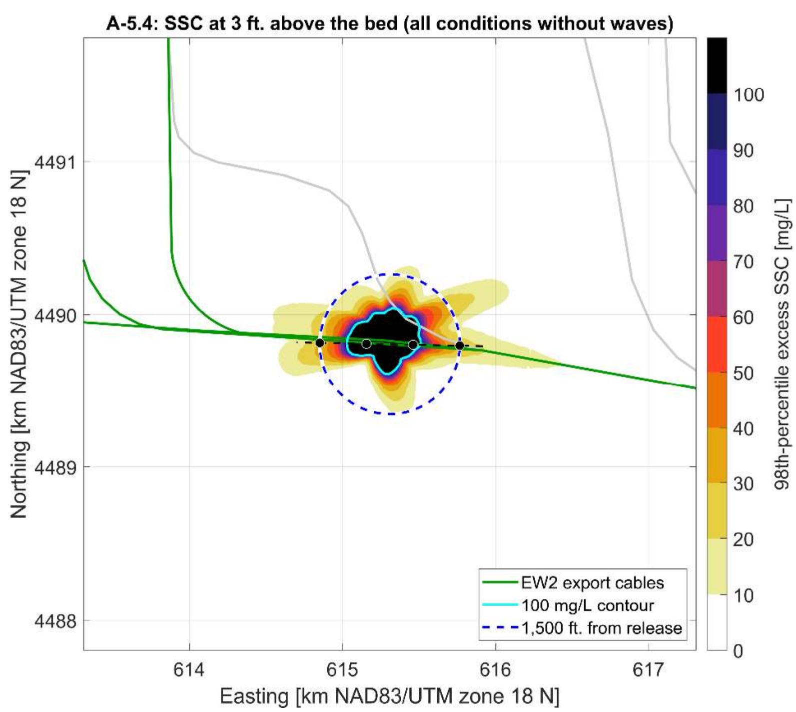

KPA-3.9: SSC along transect (conditions with 1 m ≤ Hs ≤ 2 m)
Depth [m]
0
-2
-4
-6
-8
-10
-12
100 mg/L contour
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 89°N from release location

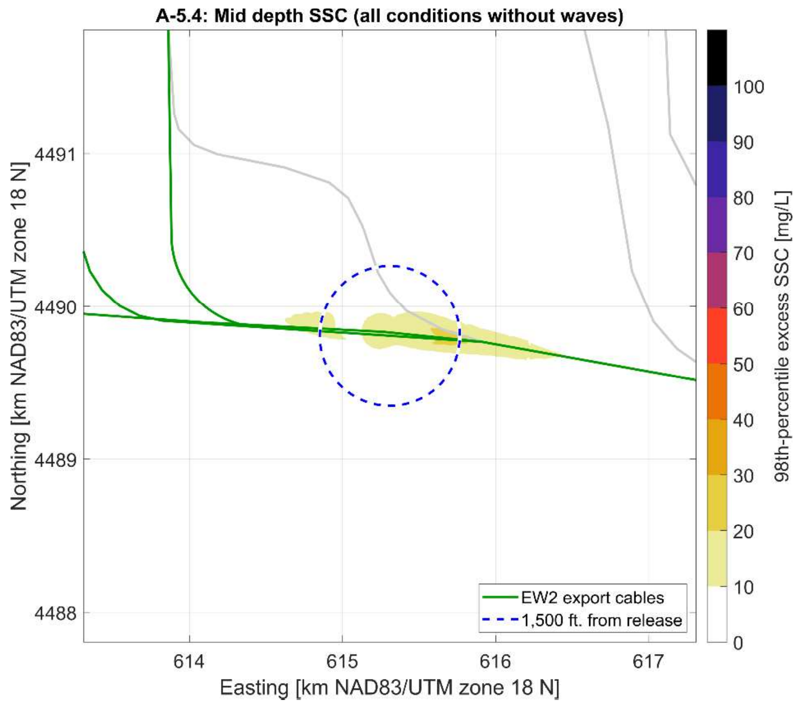

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

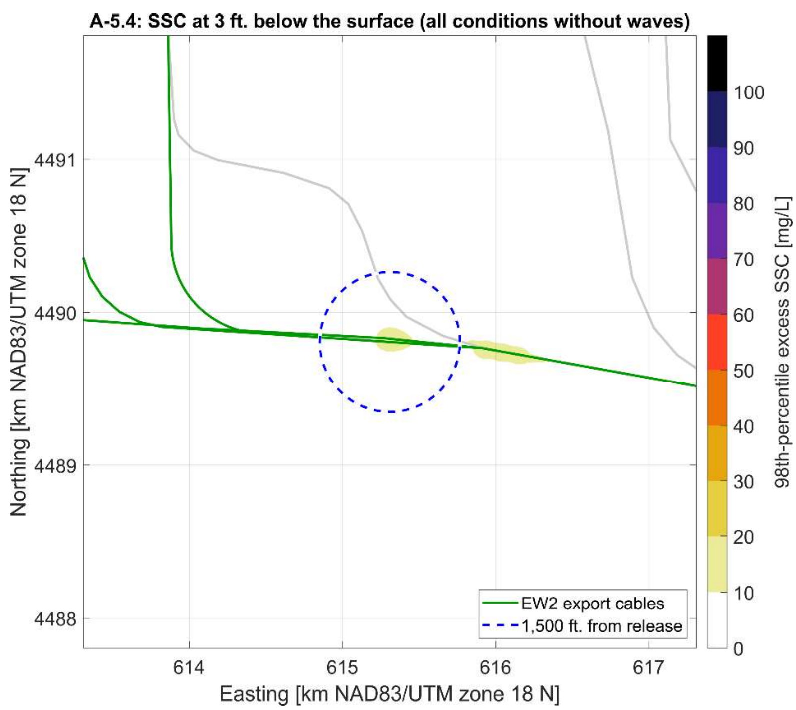
F.4 Release location A-5.4

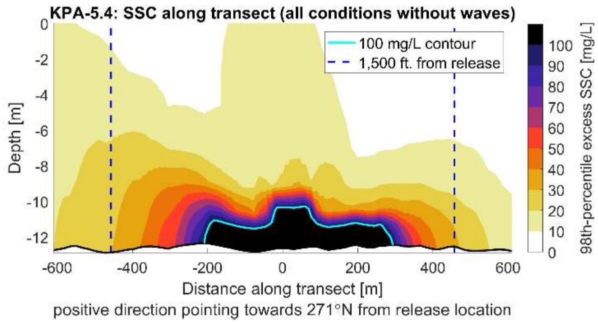


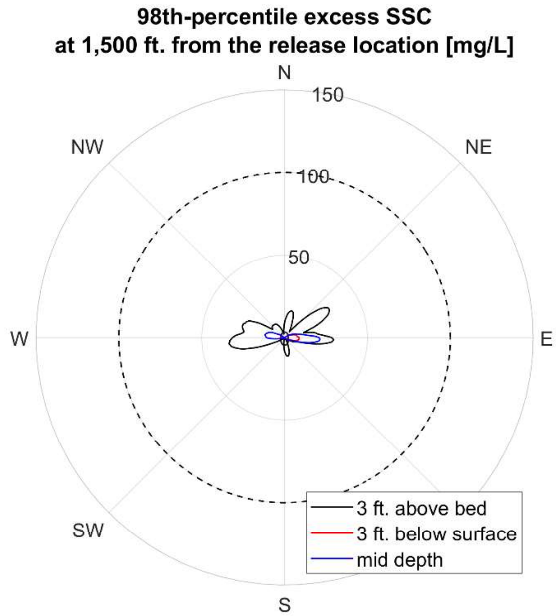
F.4.1 Sediment footprint without waves



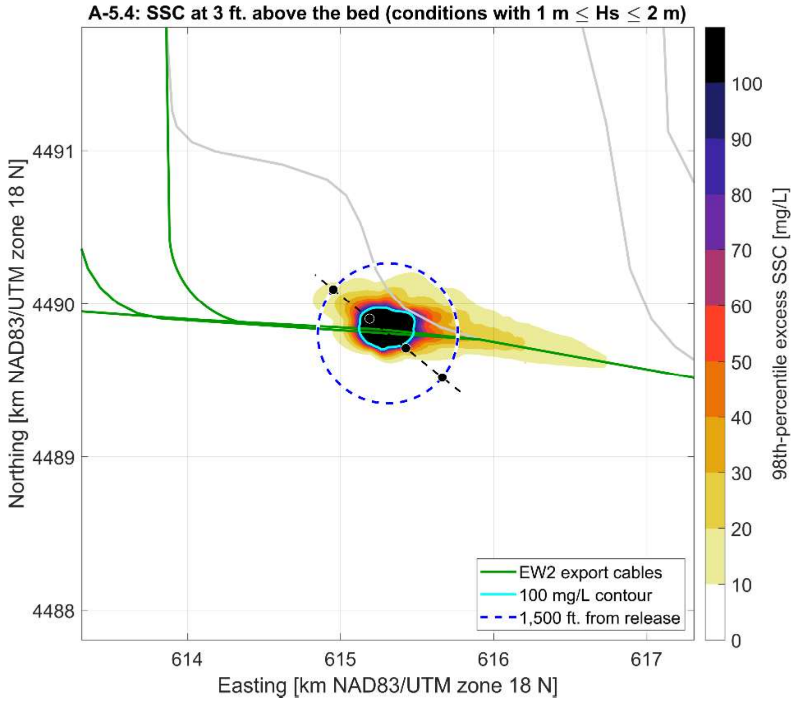

A-5.4: Mid depth SSC (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
4491
4490
4489
4488
614
615
616
617
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

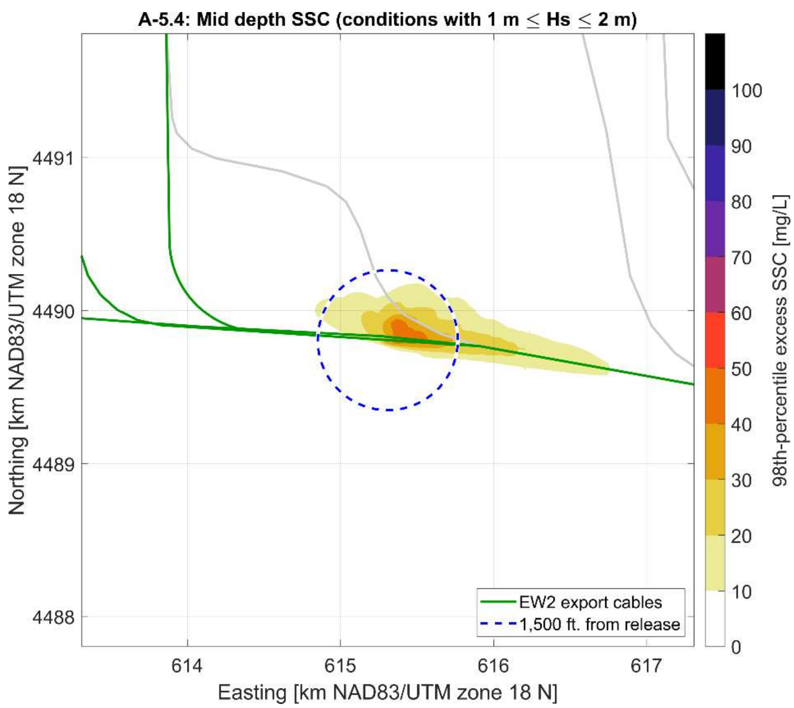

A-5.4: SSC at 3 ft. below the surface (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
4491
4490
4489
4488
614
615
616
617
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

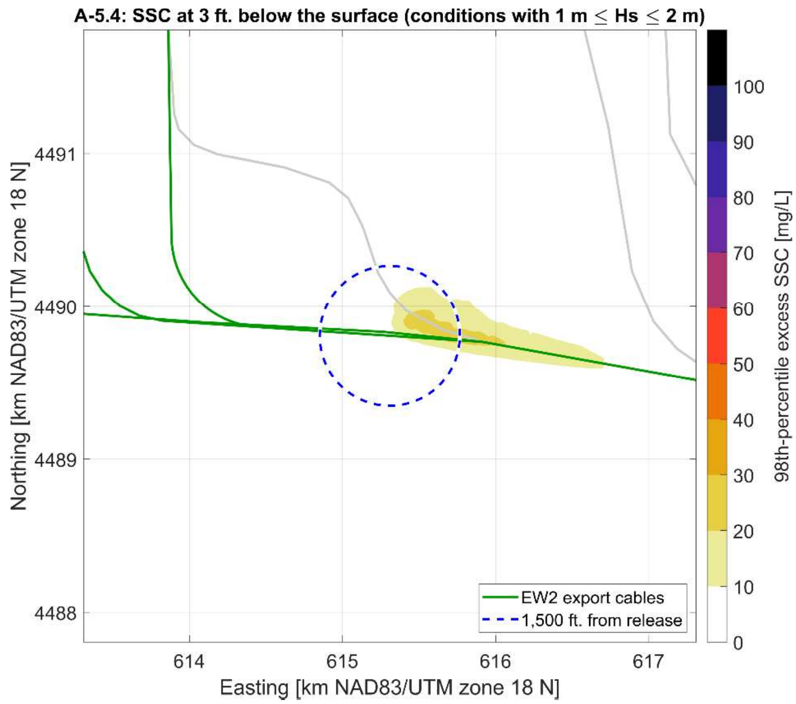

KPA-5.4: SSC along transect (all conditions without waves)
100 mg/L contour
1,500 ft. from release
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 271°N from release location
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

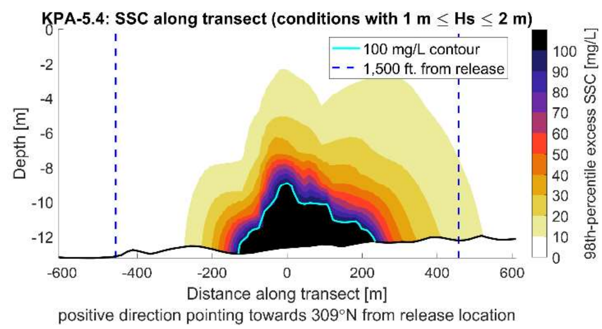

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
SW
S
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

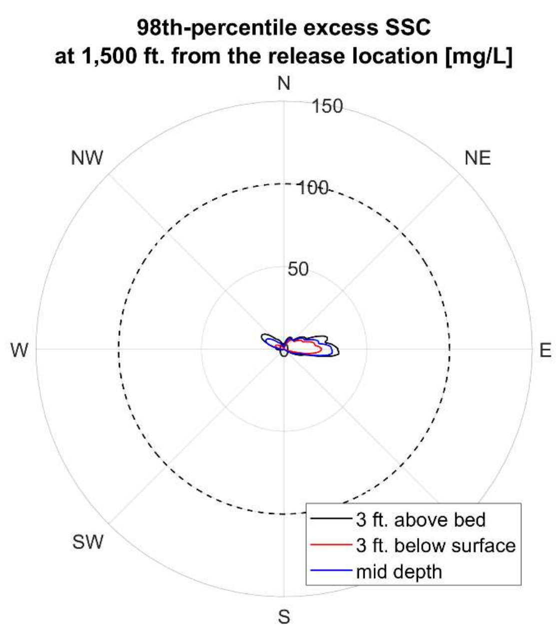
F.4.2 Sediment footprint with waves



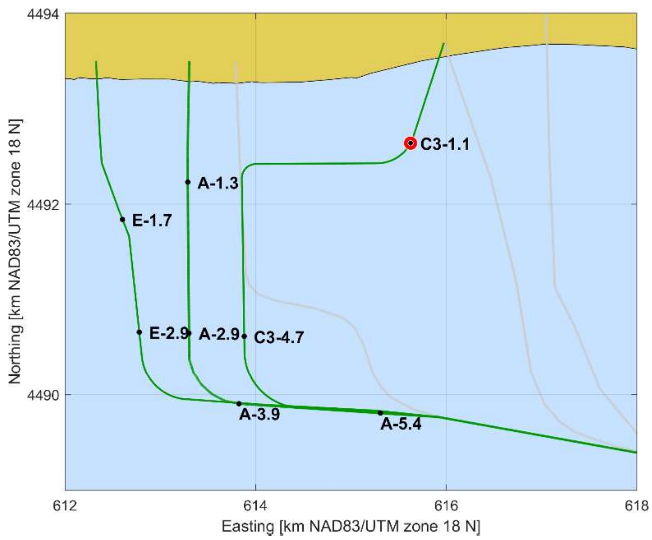



A-5.4: SSC at 3 ft. below the surface (conditions with 1 m ≤ Hs ≤ 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release

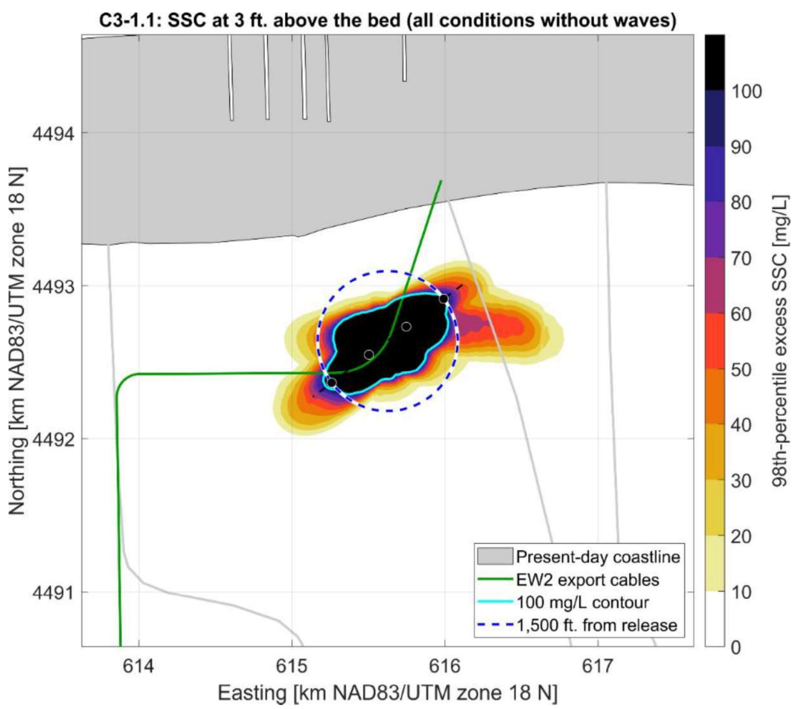

KPA-5.4: SSC along transect (conditions with 1 m ≤ Hs ≤ 2 m)
100 mg/L contour
1,500 ft. from release
Depth [m]
Distance along transect [m]
positive direction pointing towards 309°N from release location
98th-percentile excess SSC [mg/L]

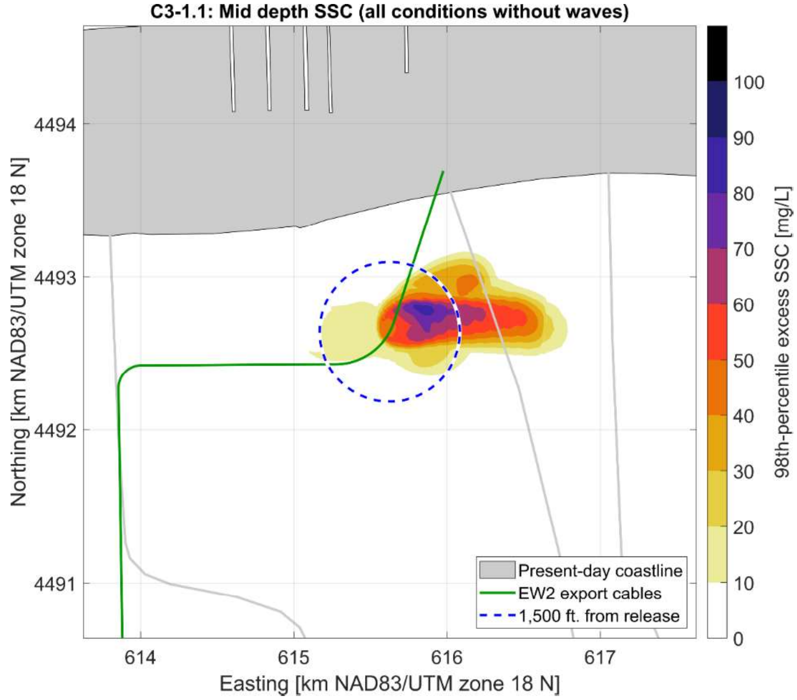

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

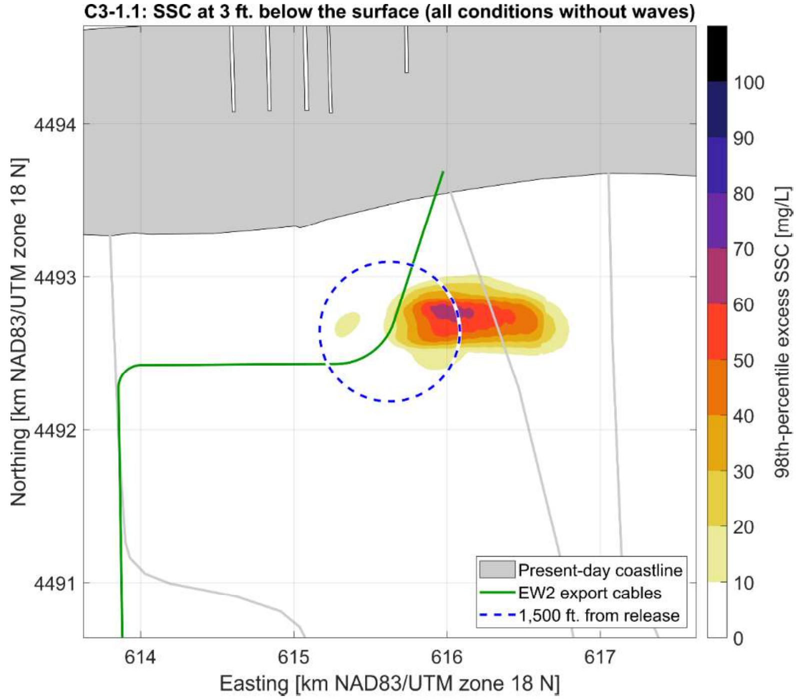
F.5 Release location C3-1.1

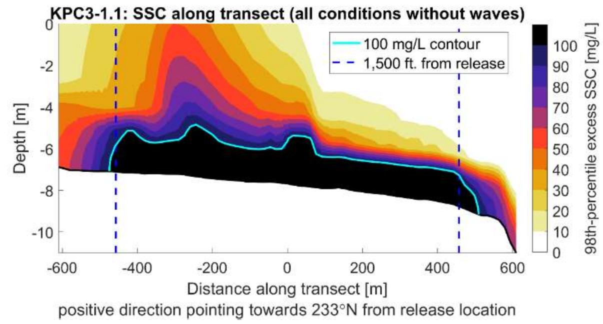


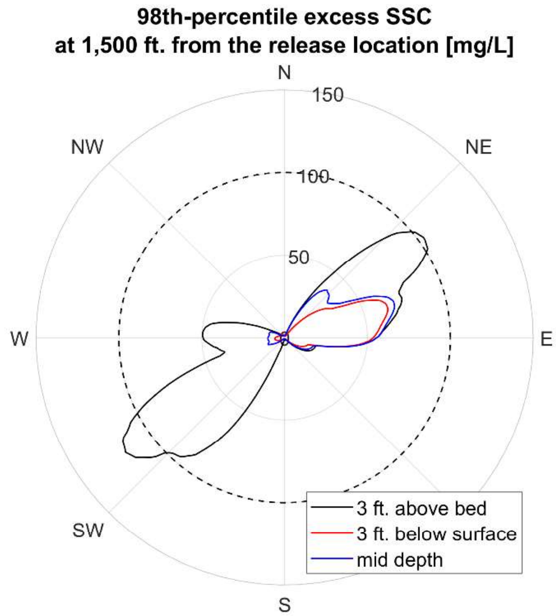
F.5.1 Sediment footprint without waves




C3-1.1: Mid depth SSC (all conditions without waves)
4494
4493
4492
4491
Northing [km NAD83/UTM zone 18 N]
614
615
616
617
Easting [km NAD83/UTM zone 18 N]
Present-day coastline
EW2 export cables
1,500 ft. from release
0
10
20
30
40
50
60
70
80
90
100
98th-percentile excess SSC [mg/L]

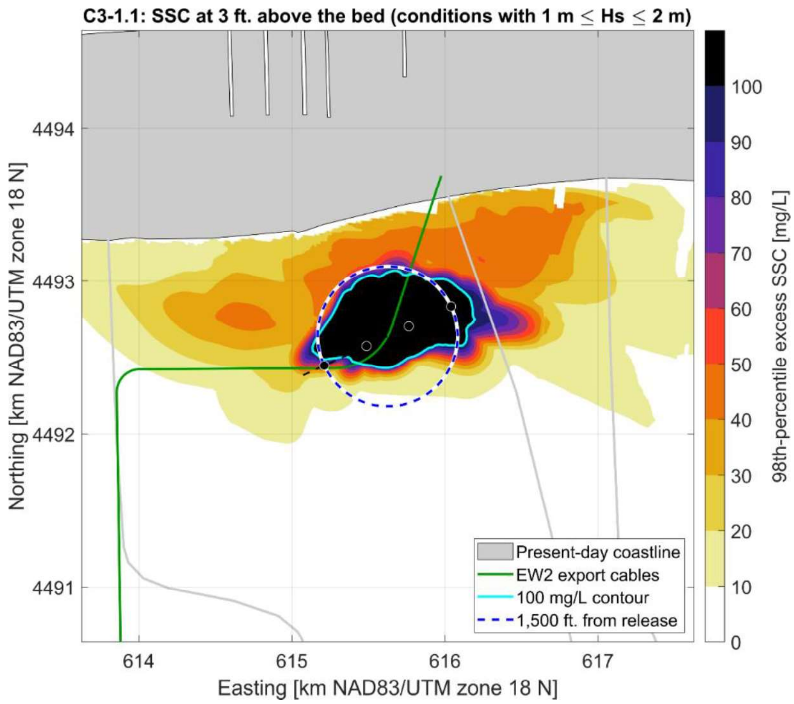

C3-1.1: SSC at 3 ft. below the surface (all conditions without waves)
4494
4493
4492
4491
Northing [km NAD83/UTM zone 18 N]
614
615
616
617
Easting [km NAD83/UTM zone 18 N]
Present-day coastline
EW2 export cables
1,500 ft. from release
0
10
20
30
40
50
60
70
80
90
100
98th-percentile excess SSC [mg/L]

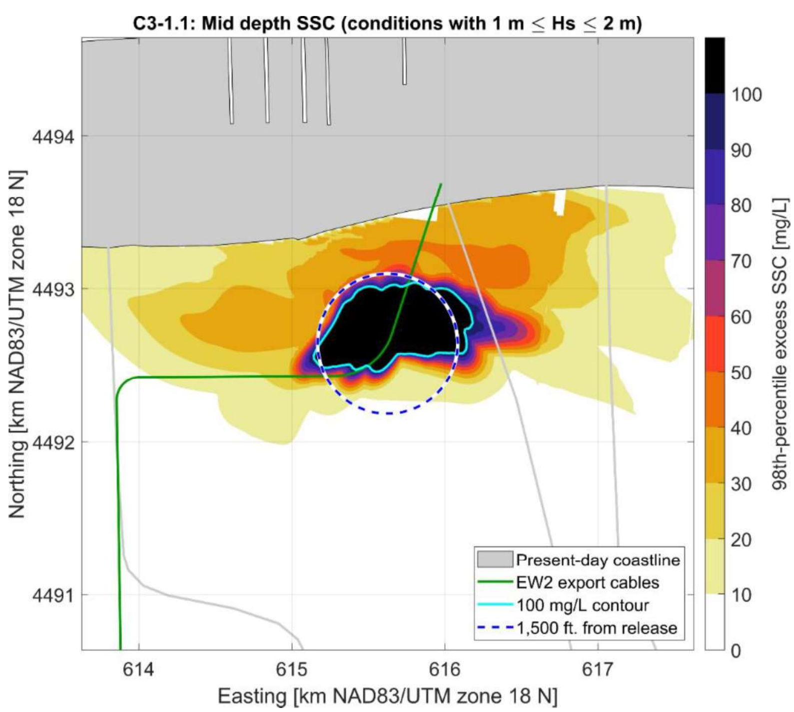

KPC3-1.1: SSC along transect (all conditions without waves)
100 mg/L contour
1,500 ft. from release
Depth [m]
0
-2
-4
-6
-8
-10
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 233°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

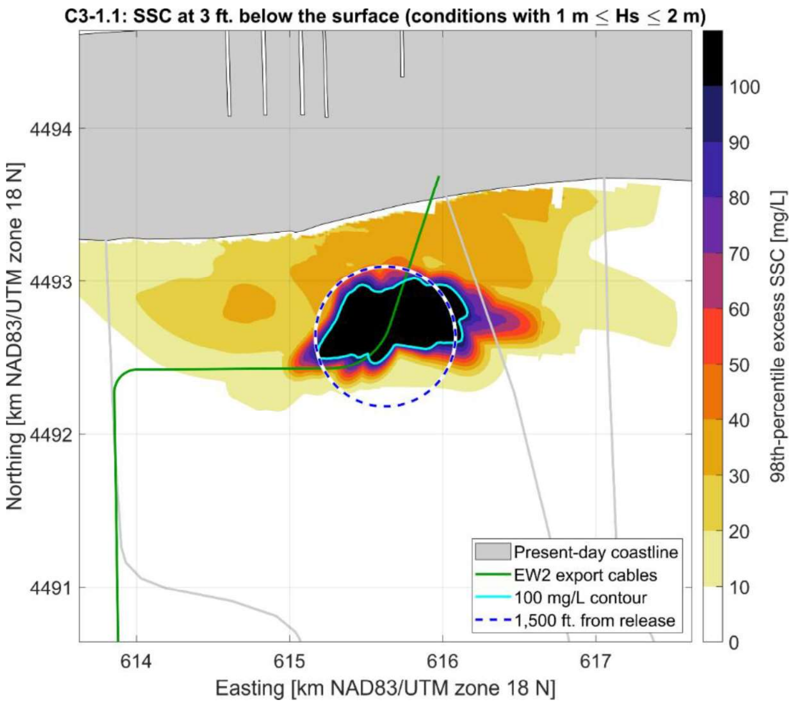

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
SW
S
NW
W
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

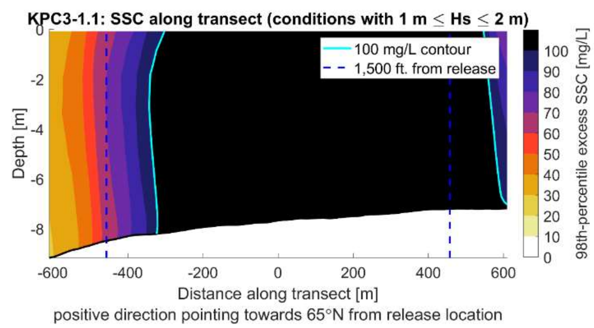
Deltares

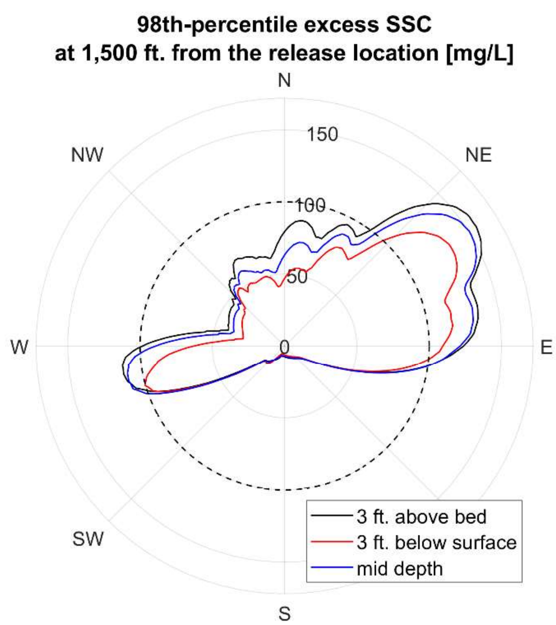
F.5.2 Sediment footprint with waves



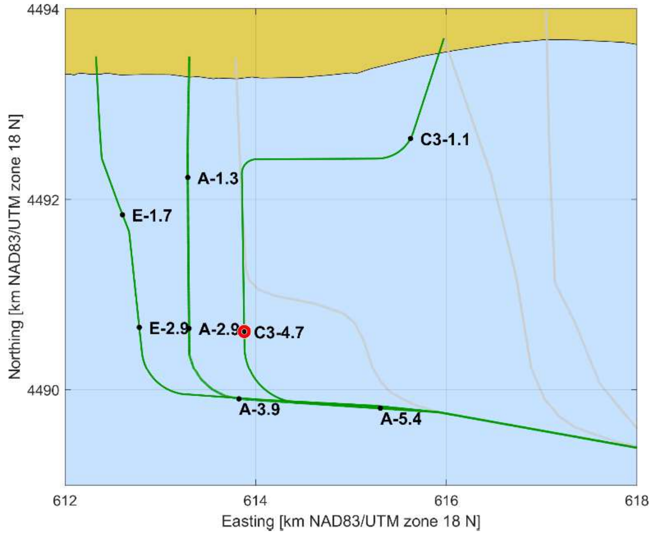



C3-1.1: SSC at 3 ft. below the surface (conditions with 1 m ≤ Hs ≤ 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
Present-day coastline
EW2 export cables
100 mg/L contour
1,500 ft. from release

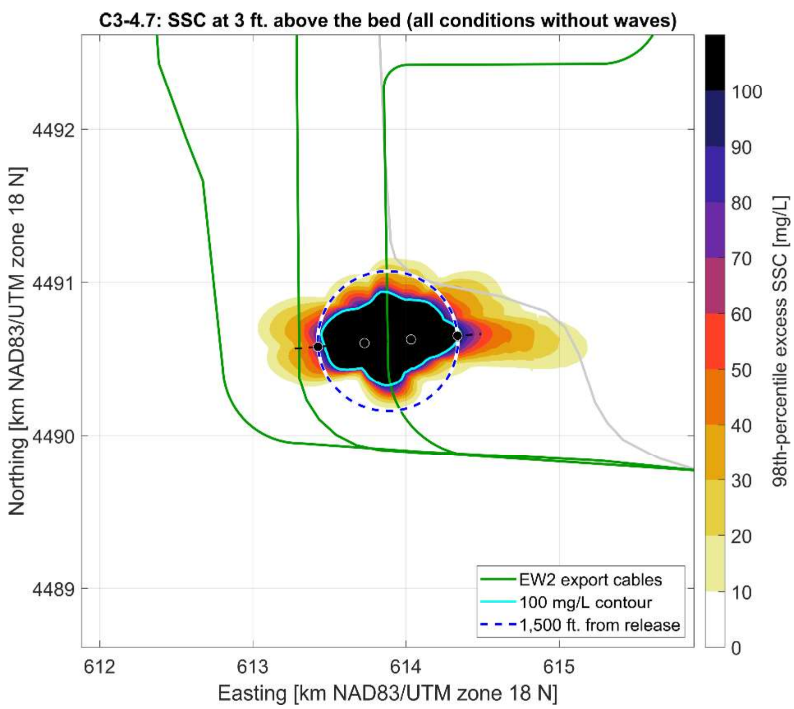

KPC3-1.1: SSC along transect (conditions with 1 m ≤ Hs ≤ 2 m)
Depth [m]
100 mg/L contour
1,500 ft. from release
98th-percentile excess SSC [mg/L]
Distance along transect [m]
positive direction pointing towards 65°N from release location

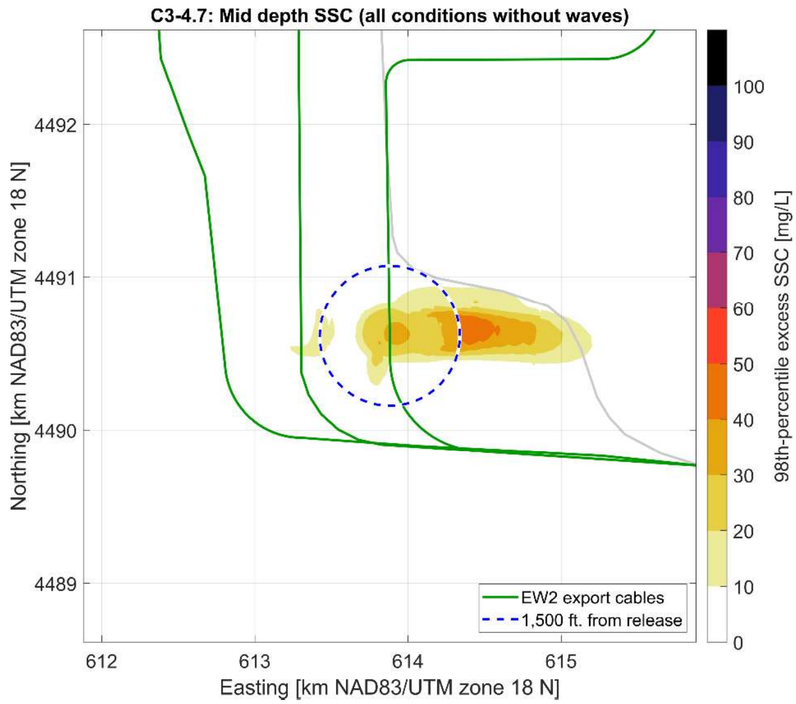

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

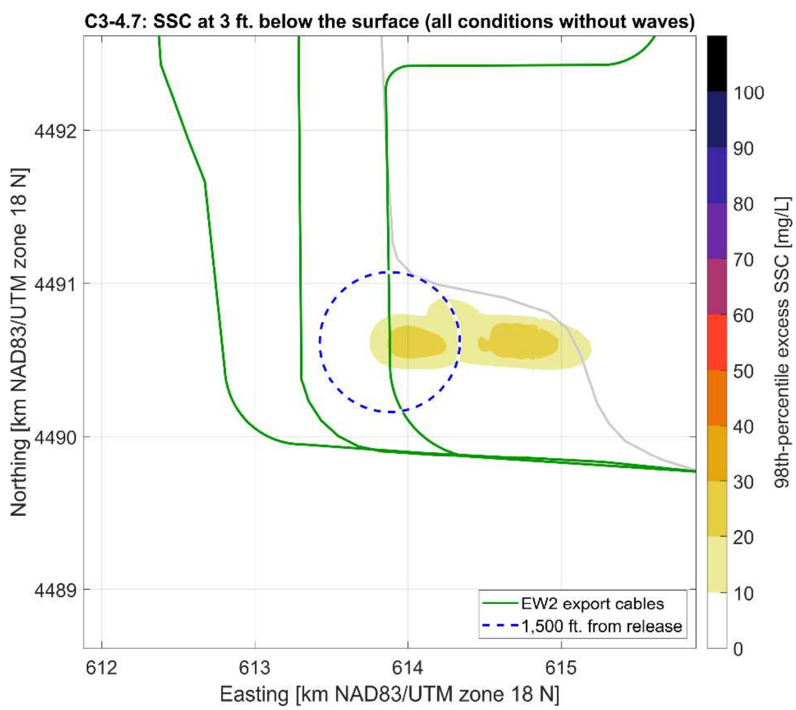
F.6 Release location C3-4.7

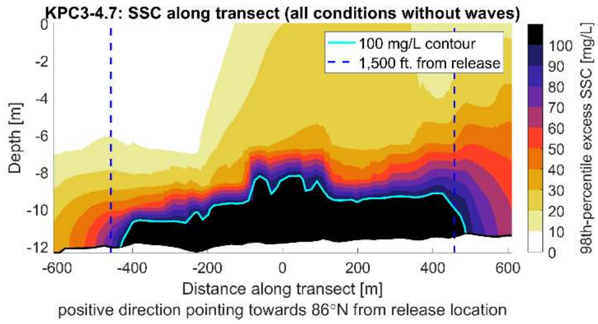


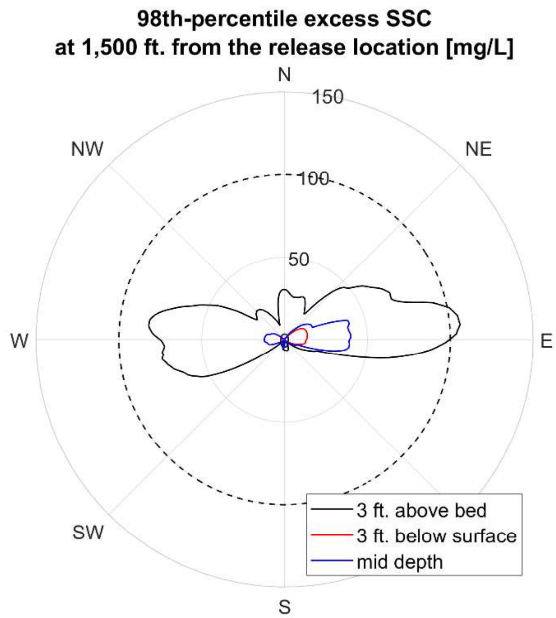
F.6.1 Sediment footprint without waves



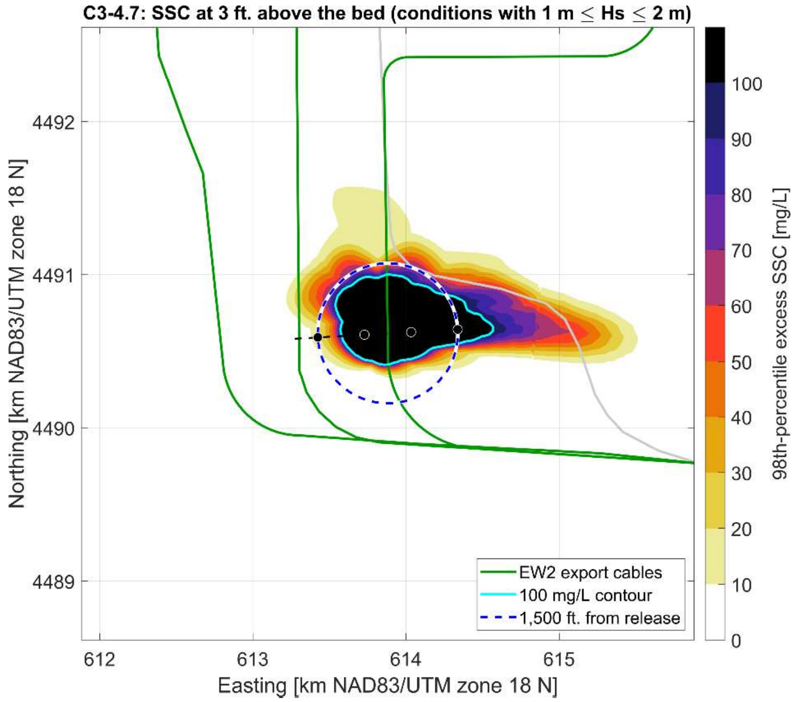

C3-4.7: Mid depth SSC (all conditions without waves)
4492
4491
4490
4489
Northing [km NAD83/UTM zone 18 N]
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

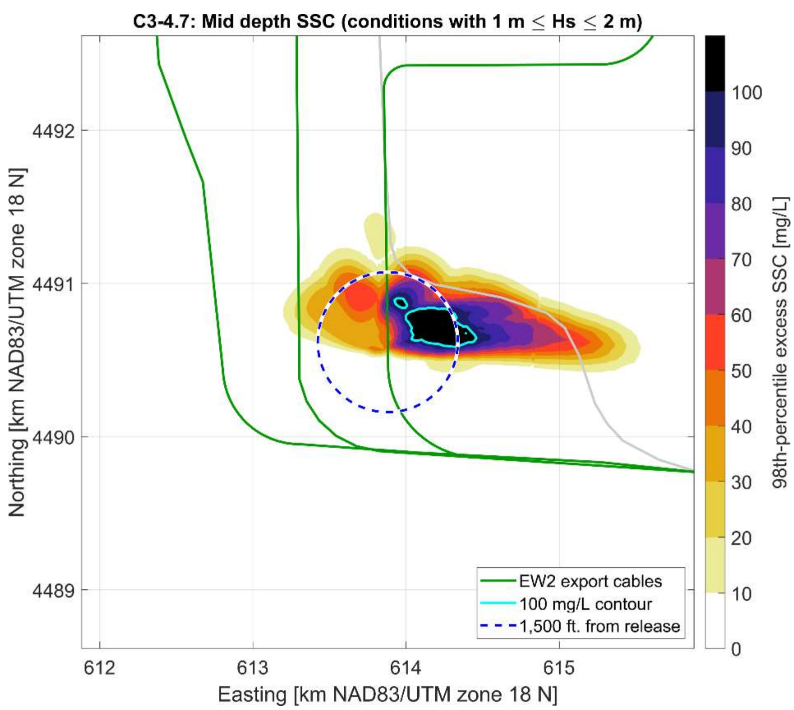

C3-4.7: SSC at 3 ft. below the surface (all conditions without waves)
4492
4491
4490
4489
Northing [km NAD83/UTM zone 18 N]
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

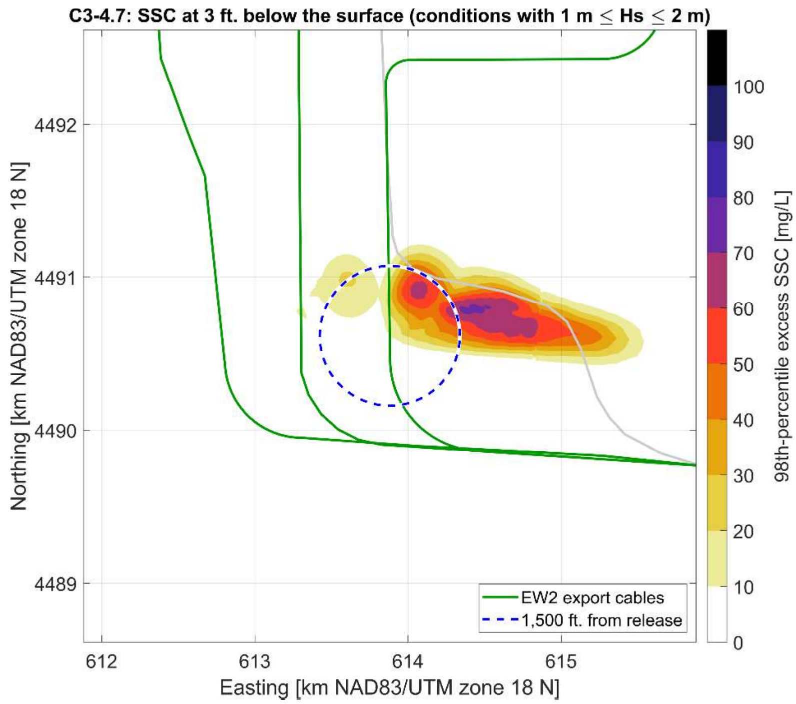

KPC3-4.7: SSC along transect (all conditions without waves)
100 mg/L contour
1,500 ft. from release
Depth [m]
Distance along transect [m]
positive direction pointing towards 86°N from release location
98th-percentile excess SSC [mg/L]

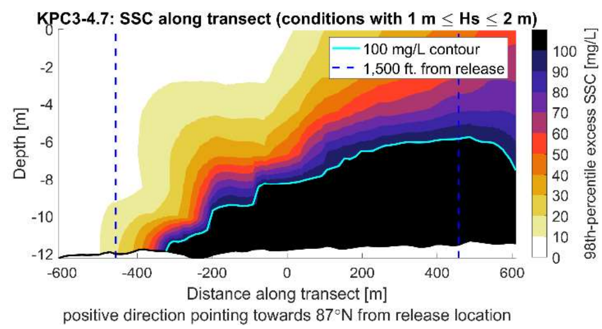

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
SW
S
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

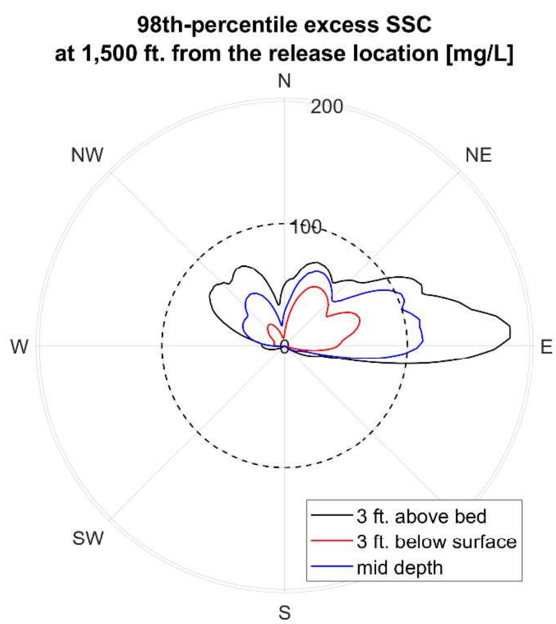
F.6.2 Sediment footprint with waves



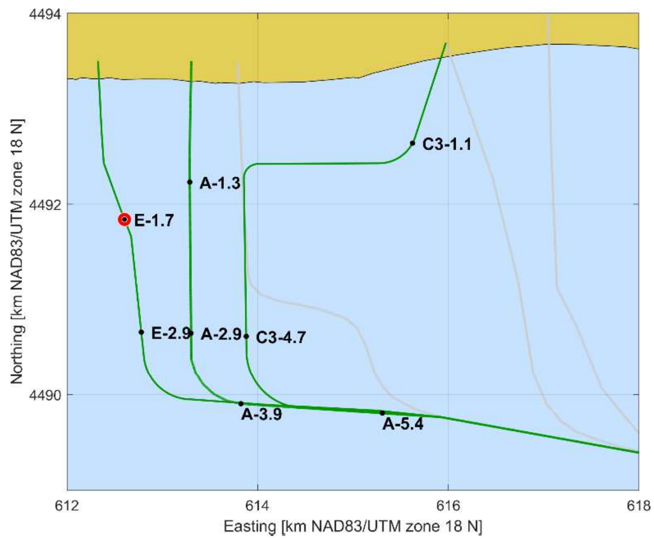



C3-4.7: SSC at 3 ft. below the surface (conditions with 1 m ≤ Hs ≤ 2 m)
4492
4491
4490
4489
Northing [km NAD83/UTM zone 18 N]
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]

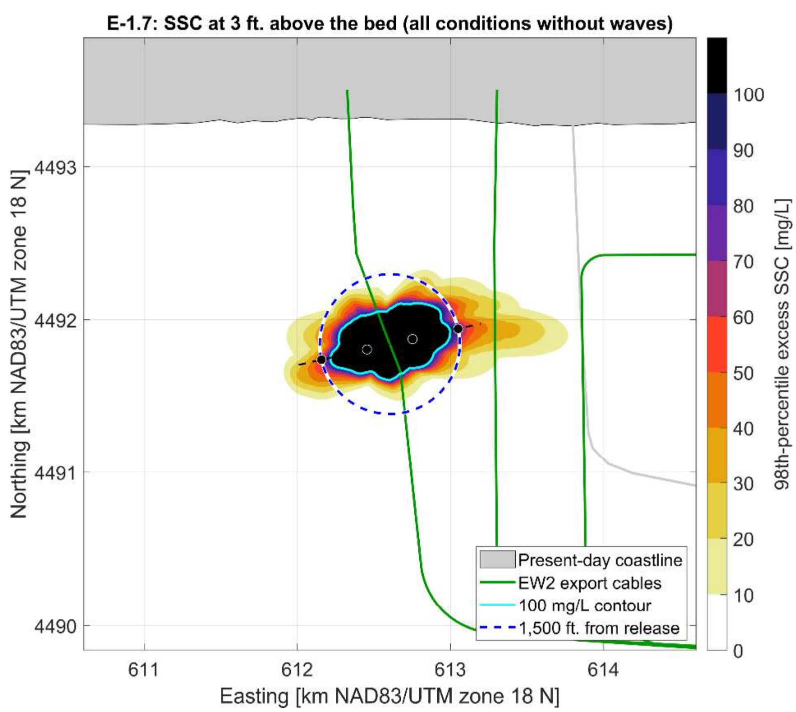

KPC3-4.7: SSC along transect (conditions with 1 m ≤ Hs ≤ 2 m)
100 mg/L contour
1,500 ft. from release
0
-2
-4
-6
-8
-10
-12
Depth [m]
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 87°N from release location
100
90
80
70
60
50
40
30
20
10
0
98th-percentile excess SSC [mg/L]


98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
200
100
0
3 ft. above bed
3 ft. below surface
mid depth

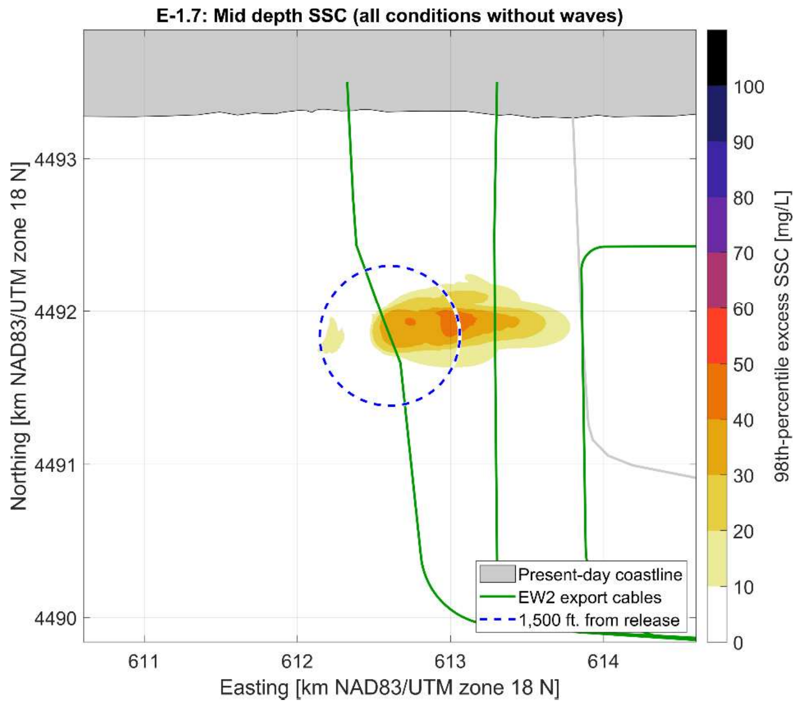
F.7 Release location E-1.7

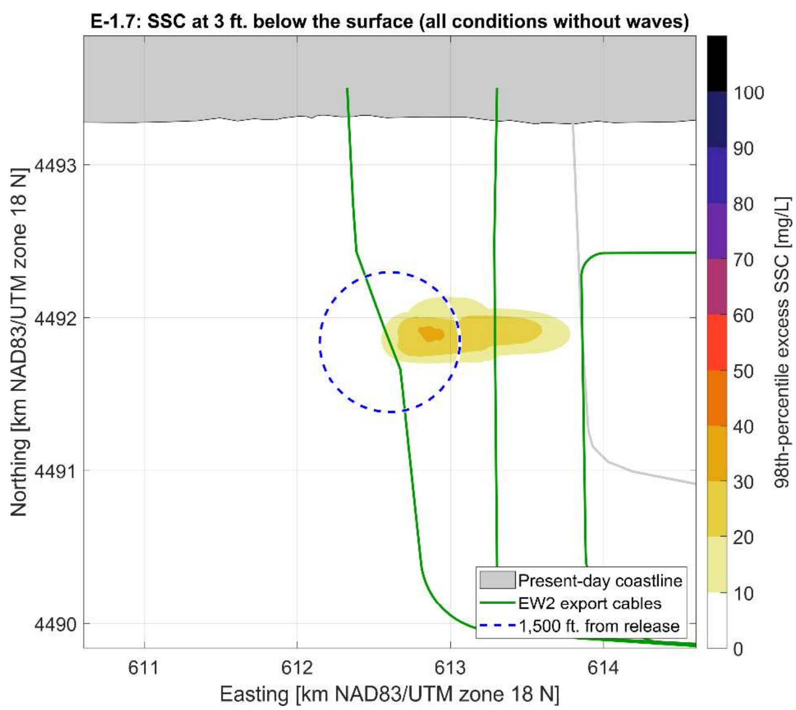


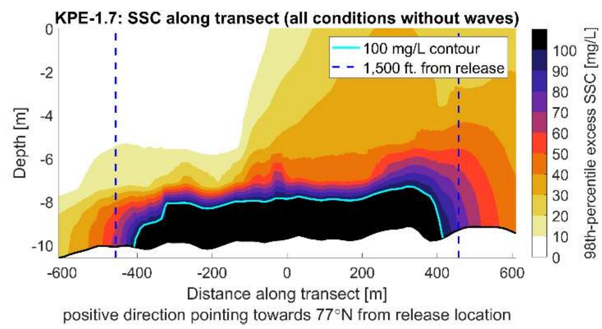
F.7.1 Sediment footprint without waves

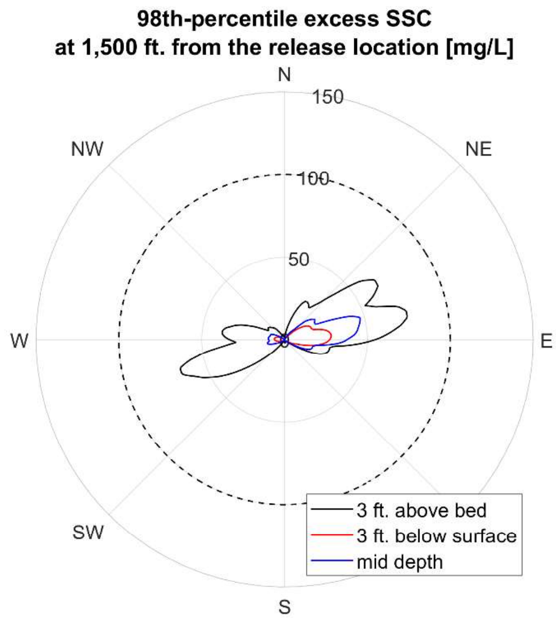


Deltares

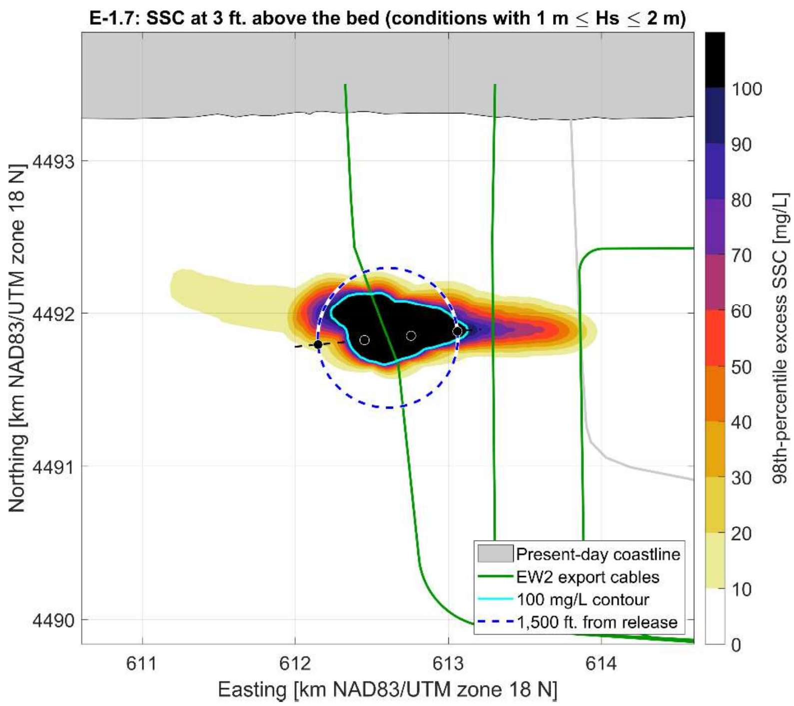

E-1.7: Mid depth SSC (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4493
4492
4491
4490
611
612
613
614
Present-day coastline
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

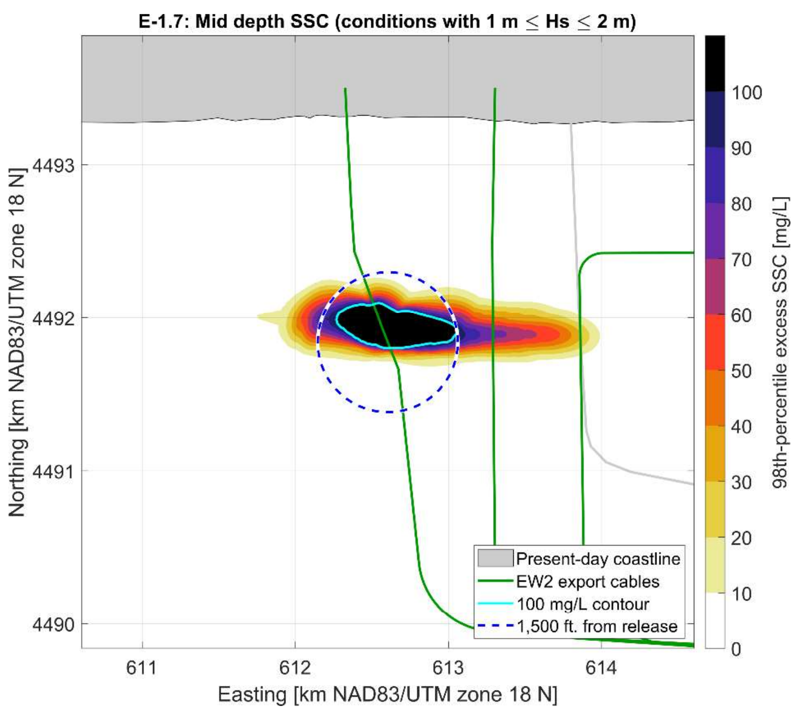

E-1.7: SSC at 3 ft. below the surface (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4493
4492
4491
4490
611
612
613
614
Present-day coastline
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

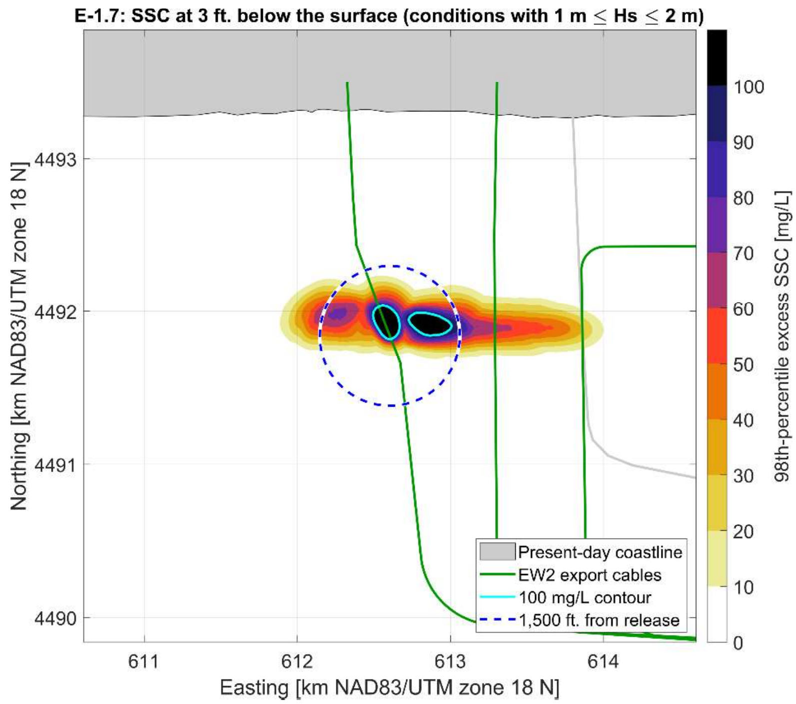

KPE-1.7: SSC along transect (all conditions without waves)
100 mg/L contour
1,500 ft. from release
Depth [m]
Distance along transect [m]
positive direction pointing towards 77°N from release location
98th-percentile excess SSC [mg/L]

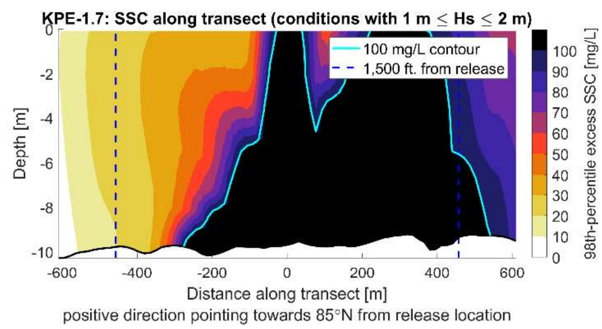

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

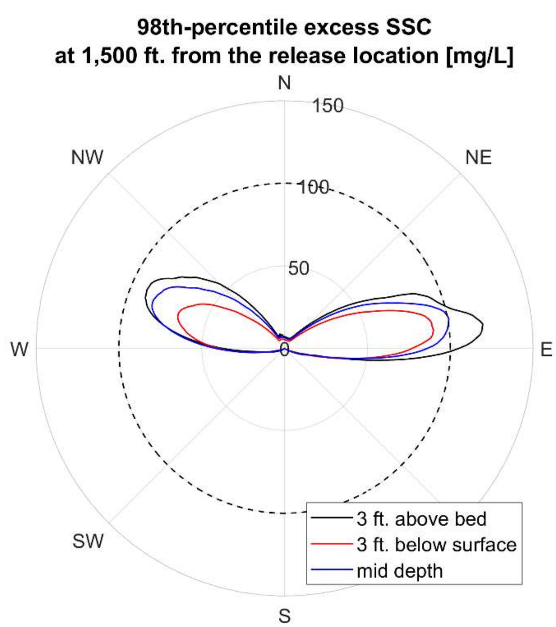
F.7.2 Sediment footprint with waves



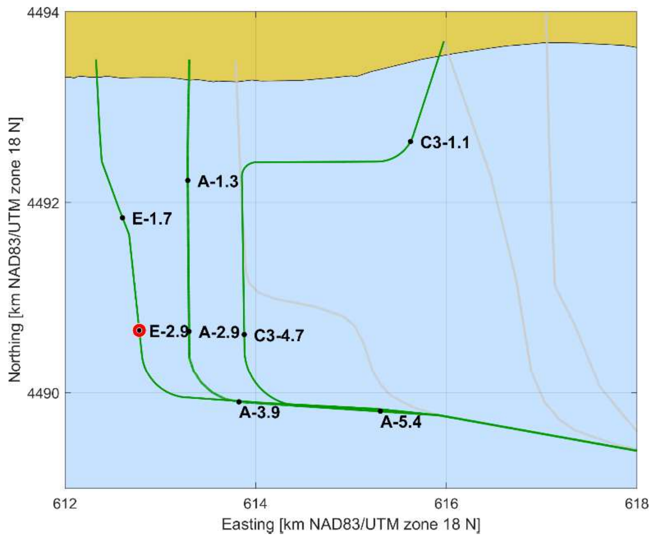



E-1.7: SSC at 3 ft. below the surface (conditions with 1 m ≤ Hs ≤ 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
Present-day coastline
EW2 export cables
100 mg/L contour
1,500 ft. from release

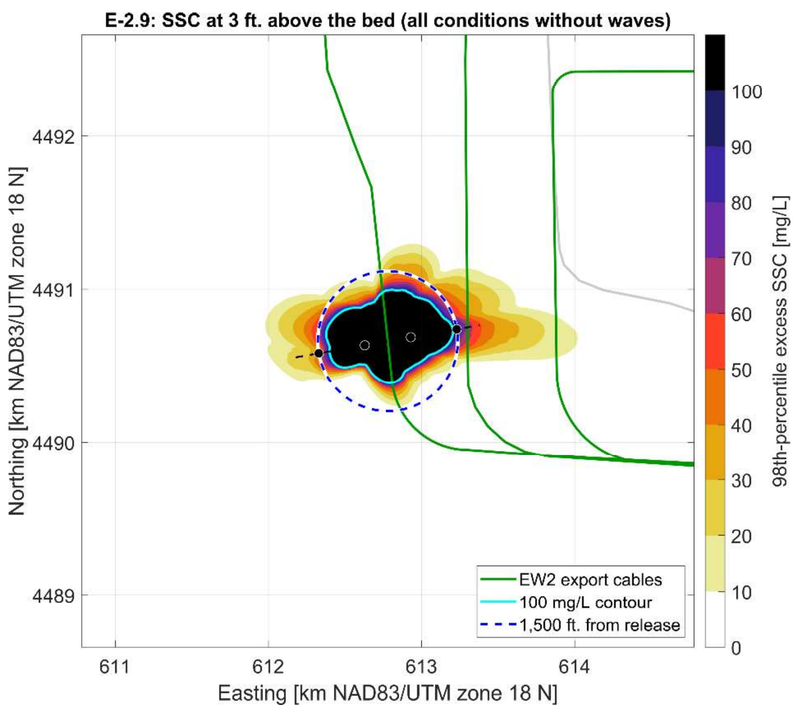

KPE-1.7: SSC along transect (conditions with 1 m ≤ Hs ≤ 2 m)
100 mg/L contour
1,500 ft. from release
Depth [m]
98th-percentile excess SSC [mg/L]
Distance along transect [m]
positive direction pointing towards 85°N from release location


98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

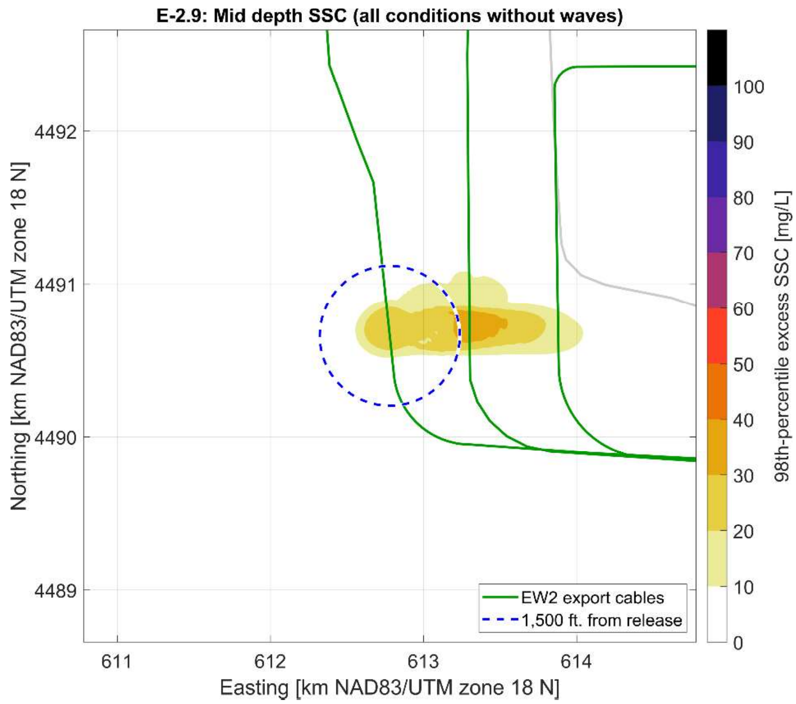
F.8 Release location E-2.9

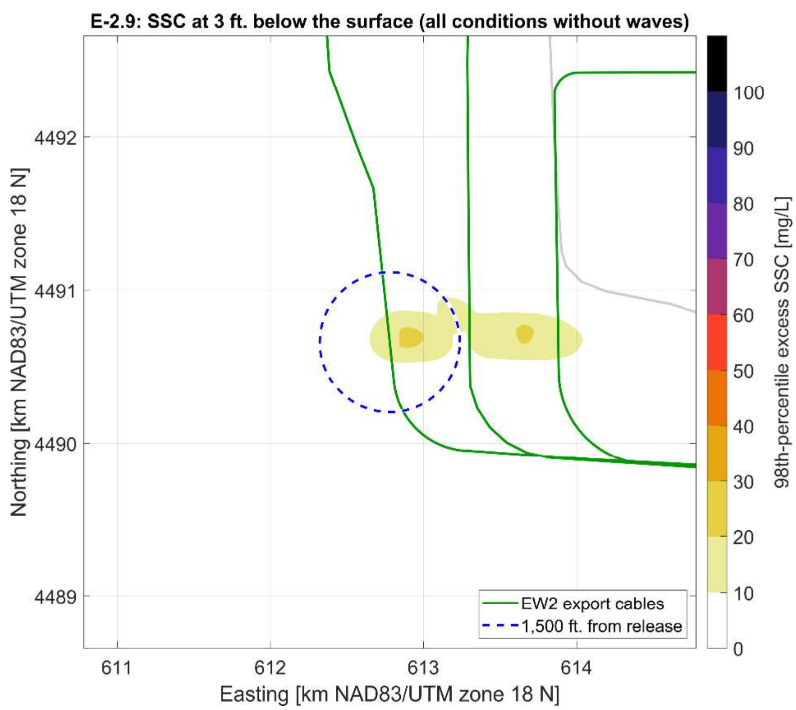


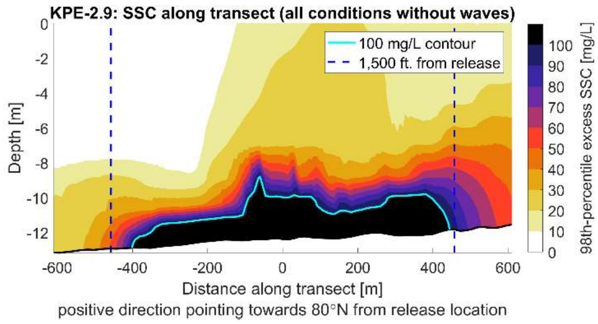
F.8.1 Sediment footprint without waves

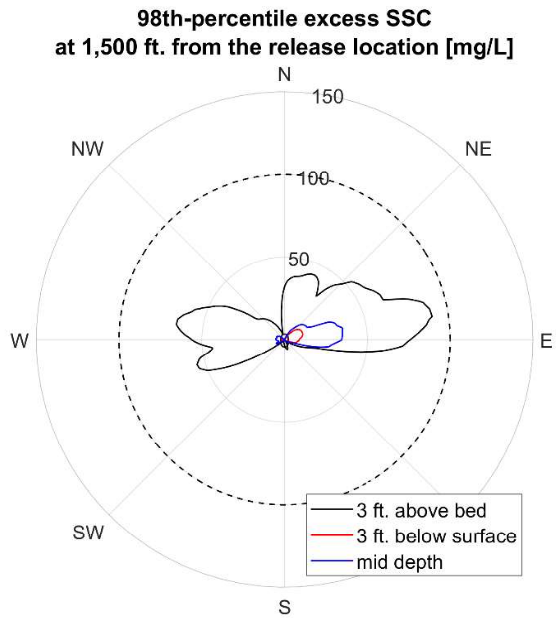


Deltares

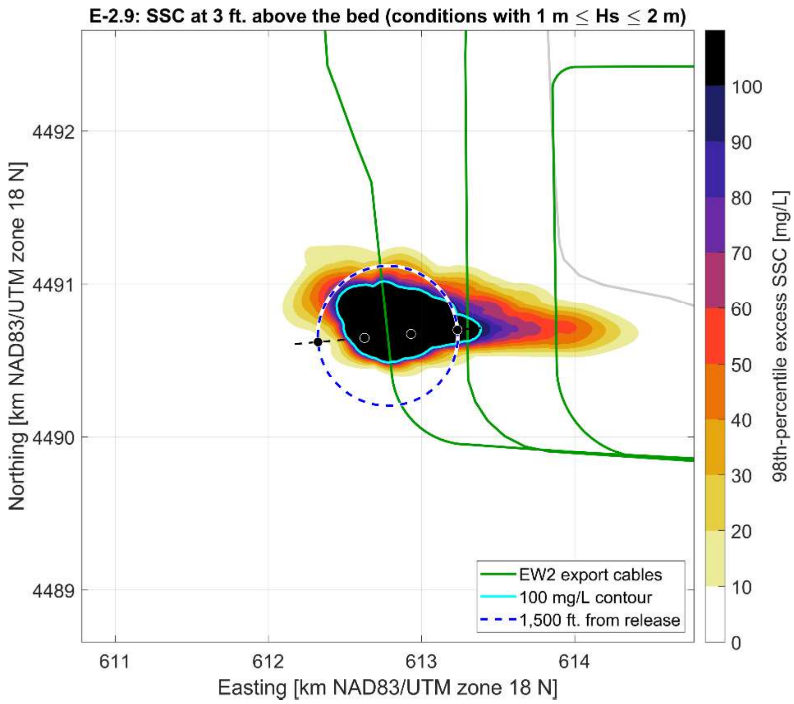

E-2.9: Mid depth SSC (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4489
4490
4491
4492
611
612
613
614
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100

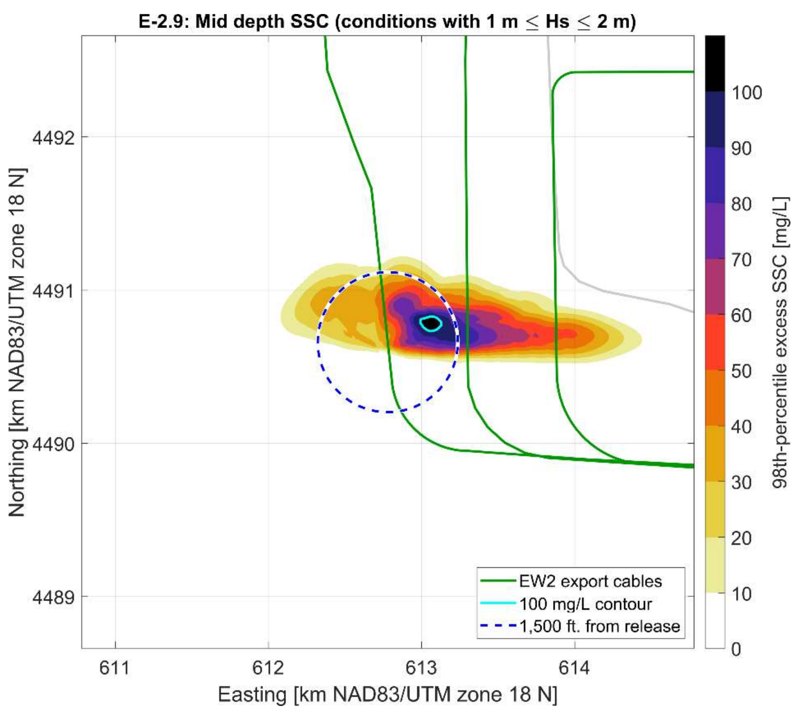

E-2.9: SSC at 3 ft. below the surface (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4489
4490
4491
4492
611
612
613
614
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100

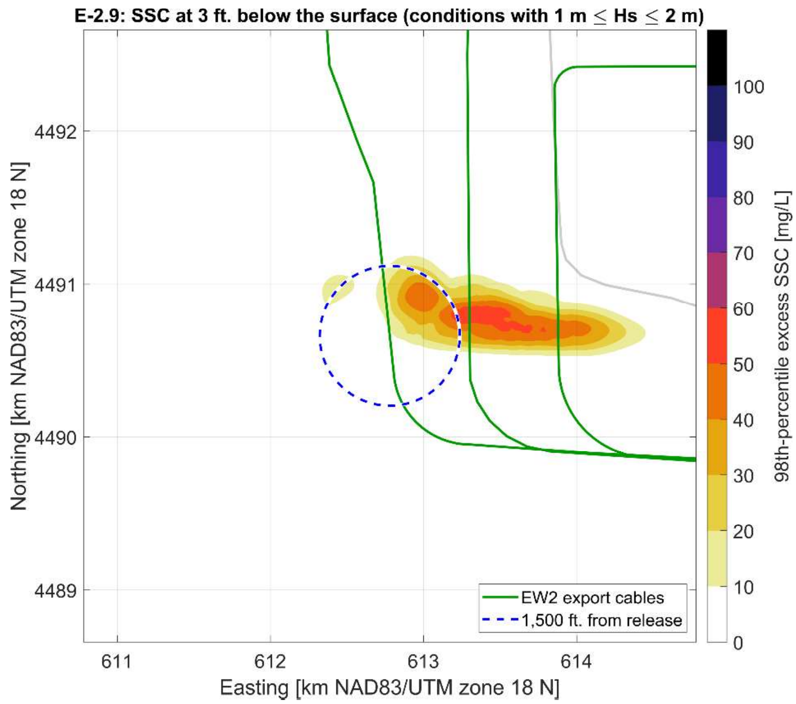

KPE-2.9: SSC along transect (all conditions without waves)
100 mg/L contour
1,500 ft. from release
Depth [m]
Distance along transect [m]
positive direction pointing towards 80°N from release location
98th-percentile excess SSC [mg/L]

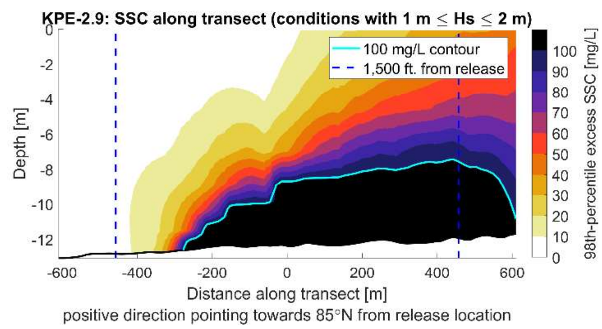

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
SW
S
W
NW
3 ft. above bed
3 ft. below surface
mid depth

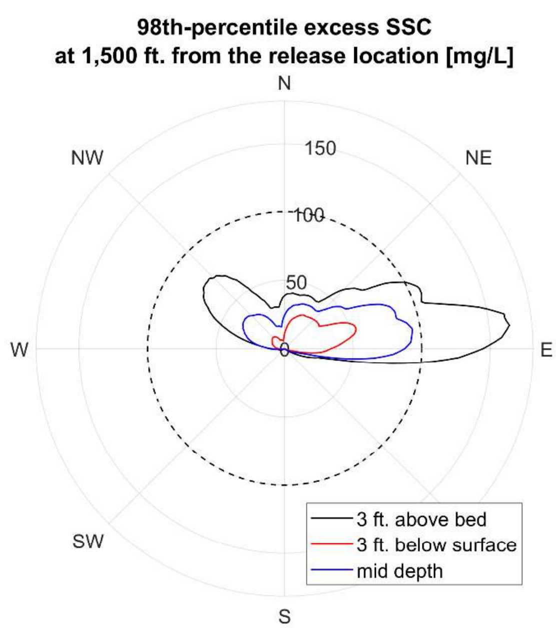
F.8.2 Sediment footprint with waves






E-2.9: SSC at 3 ft. below the surface (conditions with 1 m ≤ Hs ≤ 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
4489
4490
4491
4492
611
612
613
614
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100


KPE-2.9: SSC along transect (conditions with 1 m ≤ Hs ≤ 2 m)
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 85°N from release location
100 mg/L contour
1,500 ft. from release
98th-percentile excess SSC [mg/L]
0
10
20
30
40
50
60
70
80
90
100


98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
SW
S
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

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Attachment C-2
Sediment Transport Analysis

Empire Wind 2 Project

Sediment Transport Analysis

Prepared for:

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Stamford, Connecticut 06901

Prepared by:

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Boston, MA 02109

June 2022

TABLE OF CONTENTS

FIGURES

TABLES

ACRONYMS AND ABBREVIATIONS

BOEM	U.S. Bureau of Ocean Energy Management
cm	centimeter
cm/s	centimeters per second
Empire or the Applicant	Empire Offshore Wind LLC
ESPreSSO	Experimental System for Predicting Shelf and Slope Optics
EW 2	Empire Wind 2
ft	foot
ft/s	feet per second
in	inch
km	kilometer
Lease Area	designated Renewable Energy Lease Area OCS-A 0512
m	meter
MFE	mass flow excavation
mg/L	milligrams per liter
mi	statute mile
mm	millimeter
MOCHA	Mid-Atlantic Climatological Hydrographic Analysis
nm	nautical miles
PDE	project design envelope
POI	point of interconnection
ROMS	Regional Ocean Modeling System
Tetra Tech	Tetra Tech, Inc.
TSS	total suspended solids
USGS	United States Geological Survey

1 INTRODUCTION

Tetra Tech, Inc. (Tetra Tech) was contracted by Empire Offshore Wind LLC (Empire or the Applicant) to evaluate the potential suspended sediment, transport and deposition associated with Empire Wind 2 (EW 2) Project construction activities, including installation of submarine export cables. Disturbance of sediments during EW 2 Project construction has the potential to affect water quality through increases to total suspended solids into the water column and deposition of sediments away from the location of sediment disturbance, including potentially outside the EW 2 Project Area (i.e. submarine export cable corridor) through resuspension, dispersal, and subsequent sedimentation.

In order to provide a conservative estimate of potential maximum suspended sediment transport and deposition impacts, publicly available sediment and water circulation data covering the EW 2 Project Area was used to develop the sediment transport model. The modeling was undertaken to quantify potential maximum plume dispersion; suspended sediment concentrations; and potential maximum sediment deposition thicknesses that may occur due to EW 2 Project construction.

The sediment transport assessment contained herein includes a description of the EW 2 Project components that were evaluated (Section 1.1); a discussion of the modeling approach undertaken (Section 2); a summary of the data sources and associated hydrodynamic and sediment characteristics applied (Section 3); a description of the model runs executed (Section 4); and results of the analysis and associated conclusions (Sections 5 and 6).

1.1 EW 2 Project Description

The offshore wind farm will be located in Bureau of Ocean Energy Management (BOEM)-designated Renewable Energy Lease Area OCS-A 0512 (Lease Area), which is approximately 14 miles (mi, 12 nautical miles [nm], 22 kilometers [km]) south of the southern shore of Long Island. The EW 2 Project submarine export cables come ashore from the Atlantic Ocean within the City of Long Beach, New York (**Figure 1**).

Based on current understanding of site-specific conditions along the submarine export cable route to shore (submarine export cable corridor), Empire is currently anticipating jetting[3], mechanical plowing, and mechanical trenching as the primary cable burial methodologies. In areas where these methods cannot be employed due to deeper burial requirements or other challenges such as vessel draft requirements, dredging or mass flow excavation (MFE) may be employed. In general, the submarine export cables will be buried to a target depth of 6 feet [ft] (1.8 meters [m])[4] below the seabed surface, and installation will often be to a depth of 8 ft (2.5 m) to account for immediate sediment settling and to achieve the target burial depth.

[3] Jetting includes jet plowing and vertical injection; jet plowing is modeled as the primary jetting method as it provides more conservative values for sediment modeling.
[4] Based upon guidance provided by the U.S. Army Corps of Engineers in letters dated September 20, 2018, and August 20, 2020, submarine export cables will be buried to a minimum target burial depth of 15 ft (4.7 m) below the current (and future) authorized depth or depth of existing seabed (whichever is deeper) of federally maintained navigation features (e.g., anchorages and shipping channels).

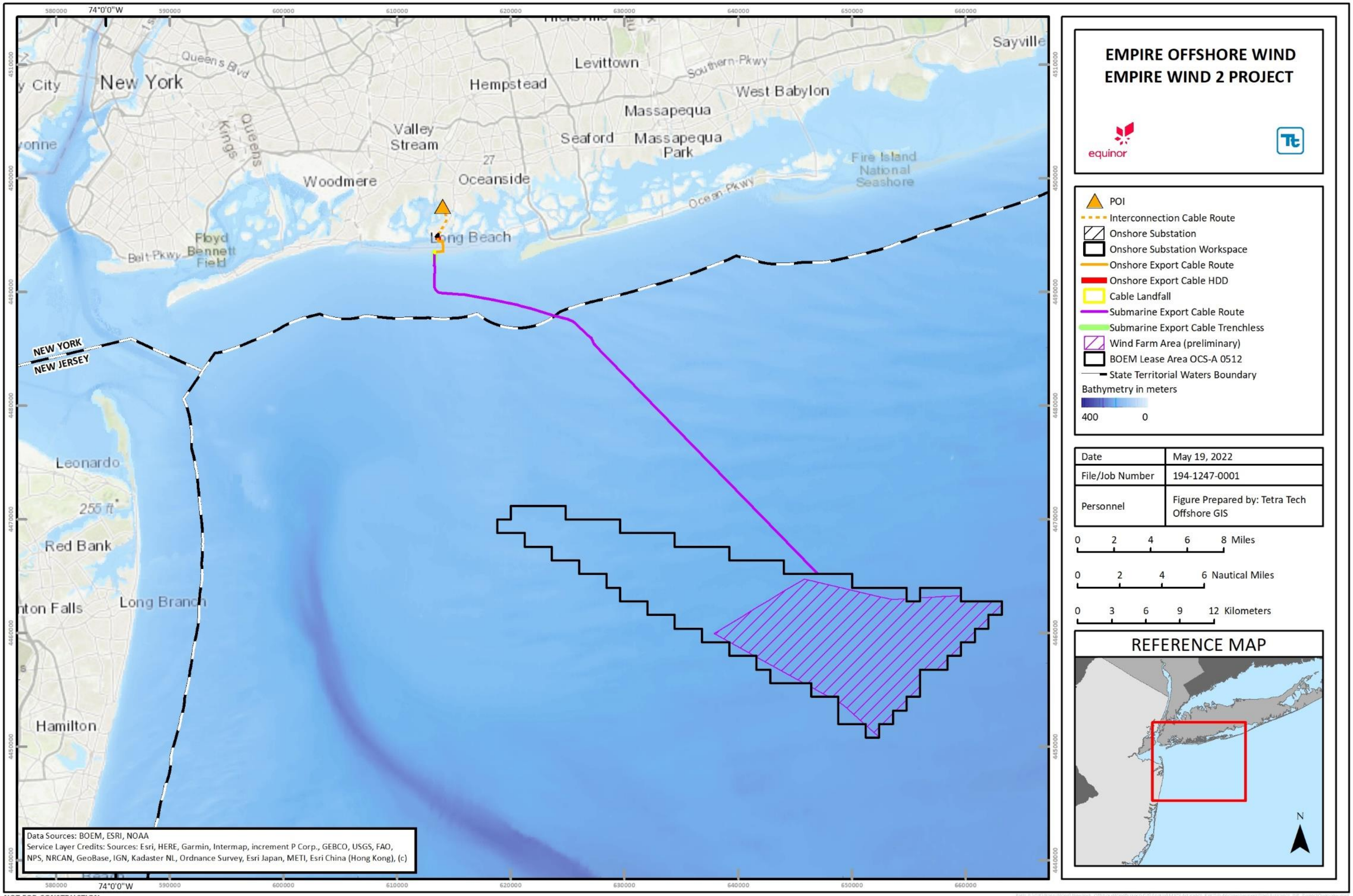

Figure 1 EW 2 Project Overview

1.2 Modeling Assumptions and the EW 2 Project Design Envelope Approach

In order to evaluate how submarine export cable installation will affect suspended sediment concentrations, and transport and deposition, Tetra Tech conducted a sediment transport analysis of the Project. Results from a previously developed publicly available hydrodynamic model were used to gather information regarding current velocity and direction in the Lease Area and submarine export cable siting corridor (EW 2 Project Area). An analytical sediment transport model was developed to predict the fate and transport of sediment suspended by cable installation along the submarine export cable routes. Tetra Tech used existing publicly available sediment data to inform the analytical model.

The analytical model adopted a project design envelope[5] (PDE) (maximum design scenario) approach to evaluate the effects of proposed submarine export cable burial activities in terms of suspended sediment concentrations in the water column and sediment transport and deposition characteristics, such as deposition depth and sediment footprint, to assess potential EW 2 Project effects on surrounding water quality and habitats. The model simulated installation impacts of one trench, although three trenches will be installed during construction and an additional run may be conducted as part of the pre-construction activities (i.e. pre-trenching); the trenches will be conducted at separate times, however. The model simulated jet plow installation, the installation method proposed to be utilized for most of the submarine export cable route, which would result in greater disturbance of marine sediments than mechanical plow or mechanical cutter installation. Jet plowing therefore provides the maximum expected disturbance of seabed sediment in the EW 2 Project Area. This approach is consistent with BOEM's *Draft Guidance Regarding the Use of a Project Design Envelope in a Construction and Operations Plan* (BOEM 2018). This approach provides the EW 2 Project reasonable flexibility to make prudent development and design decisions prior to construction. Therefore, for the purpose of this analysis, the EW 2 Project has assumed the following as the maximum design scenario:

- One proposed submarine export cable route;
- The use of a jet plow[6], since this is anticipated to be the cable installation method used for the majority of the submarine export cable installation and associated pre-installation activities (i.e. pre-trenching);
  - A trench depth for the submarine export cables of 8 ft (2.5 m);
- Activities during construction capture the maximum scenario for sediment disturbance where the disturbance is expected to be equal to or greater than that associated with operations or decommissioning activities; and
- EW 2 Project activities during operations may include inspection and repair of subsea infrastructure (i.e., cables); however, any impacts are expected to be less than those anticipated during construction since they would only involve a portion of the overall EW 2 Project. Thus, this assessment focuses on activities and impacts during the construction phase of the EW 2 Project.

[5] Empire has adopted a PDE approach to describe Project facilities and activities. A PDE is defined as "a reasonable range of project designs" associated with various components of the project (e.g., foundation and wind turbine generator [or wind turbine] options) (BOEM 2018). The design envelope is then used to assess the potential impacts on key environmental and human use resources (e.g., marine mammals, fish, benthic habitats, commercial fisheries, navigation, etc.) focusing on the design parameter (within the defined range) that represents the greatest potential impact (i.e., the "maximum design scenario") for each unique resource (BOEM 2017).
[6] The jet plow's water nozzle temporarily loosens the soil, creating a narrow trench. The cable is fed into this trench as the plow moves along the ocean floor. Marine sediment resettles upon the cable, closing the trench with minimal impact to the sea floor. However, some marine sediments may stay suspended in the water column, temporarily increasing total suspended solids, and dispersion of the sediments may cause material to deposit outside the area of disturbance.

2 MODELING APPROACH

The aim of this study is to evaluate the effects of proposed submarine export cable installation and burial activities in terms of suspended sediment concentrations in the water column and sediment deposition characteristics, such as deposition depth and sediment deposition footprint.

The modeling approach uses the publicly available Experimental System for Predicting Shelf and Slope Optics (ESPreSSO) hydrodynamic model to develop information regarding current velocity and flow direction in the EW 2 Project Area. This model has been used to obtain velocities and flows for other sediment transport models in the region (Tetra Tech 2015). ESPreSSO uses the Regional Ocean Modeling System (ROMS). ROMS is a three-dimensional, free-surface, terrain-following ocean model that solves the Reynolds-averaged Navier-Stokes equations using the hydrostatic vertical momentum balance and Boussinesq approximation (Haidvogel et al. 2000; Shchepetkin and McWilliams 2005). The ESPreSSO model domain extends from the center of Cape Cod, Massachusetts southwards to Cape Hatteras, North Carolina, with 3 mi (5 km) horizontal resolution and 36 terrain-following vertical levels. Approximately 95 percent of the EW 2 Project Area falls inside the model domain, which allows model outputs to be used to gather the circulation characteristics within the Lease Area and along the submarine export cable siting corridor. The current speed and direction from the ESPreSSO model help determine the path of the suspended sediments generated by submarine export cable jet plowing activities. More details about the hydrodynamic data used in the sediment transport model are provided in Section 3.1.

An analytical sediment transport model was developed to assess the suspended sediment water column concentrations and sediment deposition characteristics as a result of the submarine export cable jet plowing activities. Regional average sediment data such as density and grain size distribution were derived from previously conducted studies near the EW 2 Project Area (such as the Poseidon Project[7], **Figure 2**, ESS Group 2013). These sediment characteristics were used to inform the calculations of volume and concentrations of suspended sediment due to jet plowing operations.

Calculations were made along the submarine export cable siting corridors based on the different current velocities available from the ESPreSSO model and sediment characteristics from the Poseidon Project. More detail about the sediment characteristics and the analytical model is provided in Sections 3.2 and 4.1, respectively. The final results of the analytical model include the extent and duration of suspended sediment concentrations within the water column along the submarine export cable routes and the final sediment deposition thickness associated with the jet plowing operations.

[7] The Poseidon Project includes approximately 39.2 mi (63 km) of high-voltage direct-current submarine cable bundled with a fiber optic cable to be buried in the seafloor of Raritan Bay and the New York Bight with landfalls at Union Beach, in Monmouth County, New Jersey and Jones Beach on Long Island in Suffolk County, New York. This export cable route covers approximately 70 percent of the submarine export cable evaluation area within 3 nautical miles of Long Island, New York. Sediment data is available for 47 different locations along the submarine export cable route.

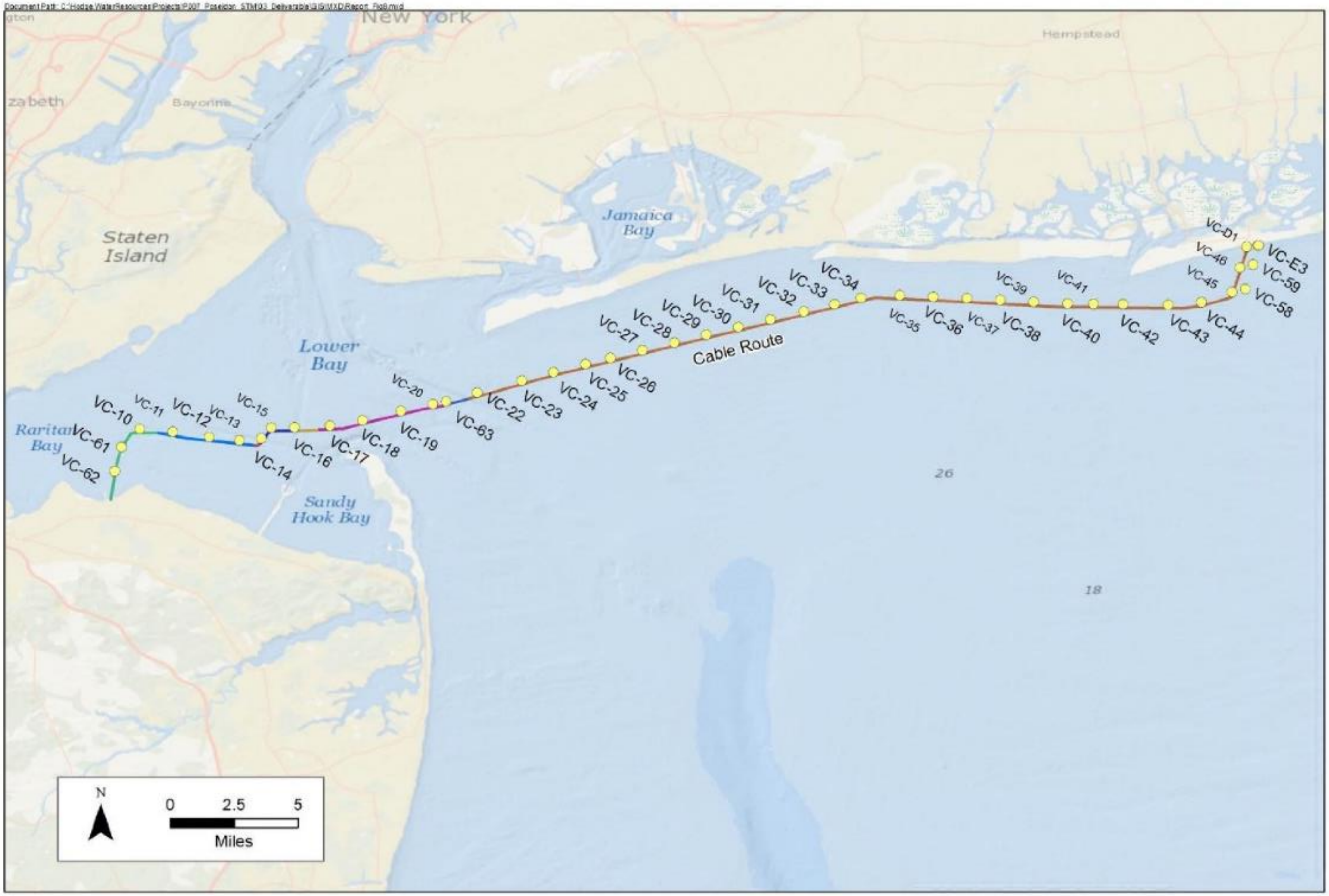

Figure 2 Location of sediment sampling locations for the Poseidon Project (Source: ESS Group 2013)

3 DATA SOURCES

3.1 Hydrodynamic Data

As part of the effort to evaluate the variability of ocean currents within the Lease Area and along the submarine export cable routes, Tetra Tech looked at the precipitation record of Eatontown 1.2 NE (Station US1NJMN0010) located in Monmouth County, New Jersey, approximately 31 mi (50 km) west of the Lease Area. Eatontown has a data coverage of 95 percent and was therefore selected to evaluate the precipitation conditions around the EW 2 Project Area, with precipitation being a proxy for freshwater outflows from major rivers (river flow volume can influence flood and ebb current speeds in nearshore areas). Precipitation data were available for 10 years (2009 through 2018). Total precipitation for each year and the 10-year average of precipitation were calculated (**Table 1**). A normal precipitation year (neither wet or dry) was selected to represent current (velocity) conditions within the Lease Area and along the submarine export cable route. The ESPreSSO model contains hourly velocity outputs from October 2009 through October 2013. To ensure that the ocean current variability was accurately represented, different years were evaluated based on their total annual precipitation and the availability of velocity outputs from the ESPreSSO model. Year 2012 was chosen as a representative year to evaluate the current conditions for the EW 2 Project Area because the velocity data was available for the full year for the ESPreSSO model and the 2012 total annual precipitation at Eatontown was similar to the 10-year total annual precipitation average calculated using data from Eatontown (i.e., normal precipitation).

Table 1 Yearly Precipitation at Eatontown 1.2 NE, New Jersey

Year	Total Annual Precipitation (in)
2009	48.86
2010	37.59
2011	54.88
2012 a/	38.56
2013	36.54
2014	53.22
2015	34.86
2016	37.66
2017	48.52
2018	70.78
Average	46.15

Note:
a/ 2012 was selected for the sediment transport analysis.

The ESPreSSO model uses ROMS, which is a free-surface, terrain-following, primitive equations ocean model widely used by the scientific community for a diverse range of applications. ROMS is an open-source model that is developed and supported by researchers at the Rutgers University, University of California Los Angeles and contributors worldwide. (Haidvogel et al. 2000; Marchesiello et al. 2003; Peliz et al. 2003). ESPreSSO open boundary values are taken from global HYbrid Coordinate Ocean Model (HYCOM) with adjustments using Mid-Atlantic Climatological Hydrographic Analysis (MOCHA) climatology and the addition of harmonic tides (Mukai et al. 2002). Meteorology forcing is taken from the North American Mesoscale model. Inflows for the seven largest rivers entering the model are from daily average U.S. Geological Survey (USGS) discharge data.

Strong constraint four-dimensional variational (4D-Var) data assimilation (Moore et al. 2011) is used to incorporate satellite sea surface height from Jason-2, satellite sea surface temperature from infrared and microwave radiometers, monthly MOCHA temperature, salinity, climatology, and hourly Coastal Ocean Dynamics Applications Radar surface currents (Zavala-Garay et al. 2012).

The ESPreSSO data set includes hourly simulations covering the period from October 2009 through February 2014.[8] The ESPreSSO model provides velocity, salinity, and temperature outputs at regularly spaced output stations throughout the EW 2 Project Area. Hourly bottom velocity outputs at ESPreSSO model stations located within the EW 2 Project Area were downloaded for the year 2012. A rolling 4-hour average velocity was calculated at each hourly time step for all stations. The 90th percentile of the rolling 4-hour average ebb and flood velocities was selected to represent the potential high velocities during these tidal periods. To represent the variability in the flow throughout the EW 2 Project Area, data from stations closest to the submarine export cable routes and Lease Area were selected and paired with the sediment data in the analytical model.

The velocity stations used in the analytical sediment transport model are shown in **Figure 3**. All stations close to the river mouth were assigned "Riverine" zone and the rest were assigned "Non-Riverine" zone (this included consideration of Hudson/Passaic river flows associated with the New York/New Jersey Harbor). All EW 2 Project stations in New York waters are considered "Non-Riverine." **Table 2** lists the representative flood and ebb velocities at all the stations in the EW2 Project Area in New York waters. Both ebb and flood velocities were used to calculate the possible maximum extent of sediment deposition and suspended sediment water column concentrations within the EW 2 Project Area under these conditions.

[8] Model information can be accessed at http://www.myroms.org/espresso/.

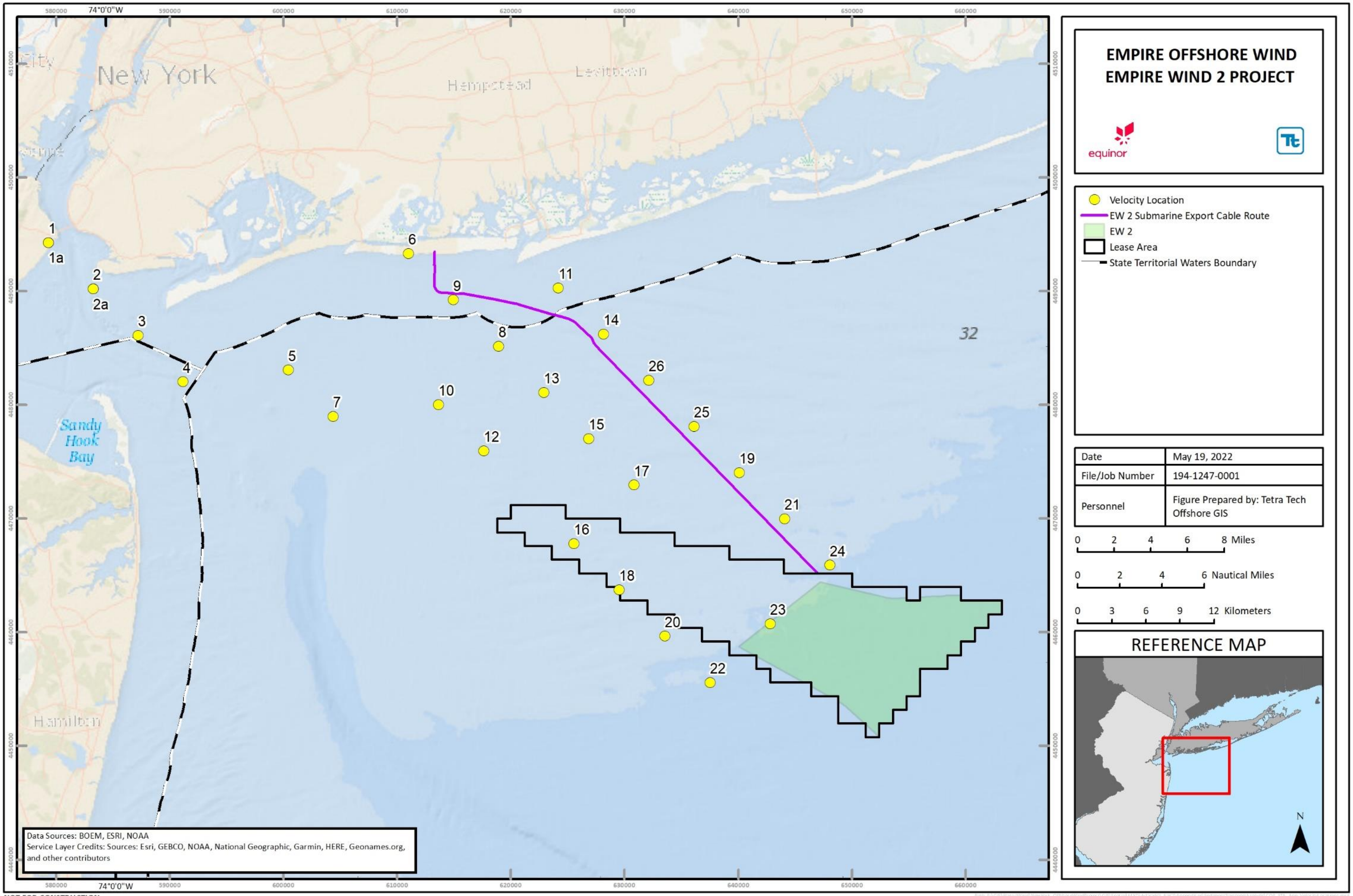

Figure 3 Velocity Station IDs

Table 2 Maximum Flood and Ebb Current Velocity from the ESPreSSO Model

Station ID	Longitude (W)	Latitude (N)	Depth (ft)	Flood Velocity (ft/s)	Ebb Velocity (ft/s)	Zone
6	-73.69	40.58	24	0.53	0.39	Non-Riverine
9	-73.64	40.55	37	0.57	0.44	Non-Riverine
11	-73.53	40.55	36	0.54	0.48	Non-Riverine

3.2 Sediment Characteristic Data

As project-specific sediment density data and grain size distribution data were not available when the model was developed, Tetra Tech used publicly available Poseidon Project sediment data to inform the analytical sediment model (**Figure 2**, ESS Group 2013). The Poseidon Project data included percent gravel, sand, and fines; specific gravity; and D50 data for 47 locations along a submarine electric cable route in Raritan Bay and the New York Bight. The Poseidon Project cable route covers approximately 70 percent of the submarine export cable route evaluation area, all within 3 nautical miles (5.56 km) of Long Island, New York.

Based on the sediment characteristics of the stations in the Poseidon Project, the stations were divided into two zones:

I. Riverine: For stations close to the river mouth, sediment characteristics were calculated by averaging all stations that were close to the river. These stations typically had high fine sediment content.
II. Non-Riverine: For stations not close to the river mouth, sediment characteristics were calculated by averaging all other stations. These stations typically had high sand content.

The EW 2 Project Area was located in the non-riverine zone. Other than percent gravel, the sediment data only provided percent sand and percent fines as the sediment breakdown, Tetra Tech made an assumption to divide the sediment equally into finer classes. The percent sand class was equally divided into percent coarse sand and percent fine sand. Fine sand was further equally divided into percent fine sand and percent very fine sand. The percent fines class was equally divided into percent silt and percent clay. This was done so that a finer scale modeling effort could be completed with the sediment distribution presented in an un-biased manner and for a broader range of size classes consistent with the full range of particle size distribution typical for marine sediments in the region. Settling velocities were assigned to these classes. Density values were calculated by averaging the density for the two different zones. **Table 3** shows the fine sediment particle percentages for the two zones.

Table 3 Sediment Particle Size Distributions

Sample	Density (kg/m^3)	Fine Sand (%)	Very Fine Sand (%)	Silt (%)	Clay (%)	Total Fine Sediment (%)
Riverine	2,746	9.38	9.38	30.87	30.87	80.49
Non-Riverine	2,692	21.93	21.93	4.79	4.79	53.44

When cables are buried using jet plowing, only fine sand and smaller particle sizes are suspended into the water column sufficiently to be transported away from the immediate trench. Larger particle sizes re-settle immediately into the trench. Therefore, the fine sand and smaller sediment particle classes were most appropriate to assess jet plowing impacts in the analytical sediment transport model and the percent gravel was not used.

Mass flow excavation (MFE) may be used in New York state waters along the EW 2 submarine export cable route in nearshore areas The MFE tool generates a large volume column of water that travels vertically down to the seabed fluidizing the sediments. For this process, only fine sand and very fine sand are assumed to be suspended into the water column and transported away due to ambient currents. This area is close to 50 percent fines, most of which is classified as fine sand and very fine sand (ESS Group 2013). MFE was not simulated for the EW 2 Project.

4 SEDIMENT TRANSPORT MODEL

This section describes the methodology followed to develop the conservative analytical sediment transport model to characterize the potential maximum sediment transport and deposition scenario for the jet plow activities. Assumptions used to develop a PDE approach for the sediment transport analysis are listed in detail in Section 4.1.

4.1 Model Setup and Parameterization

Jet plowing utilizes high-pressured water jets to fluidize soil as the machine traverses along a submarine export cable route. The submarine export cable descends into a temporary trench incised by the jetting blades and is subsequently buried as the fluidized sediments re-settle inside the trench. During jet plow operations, monitoring of burial allows the operator to adjust the angle of the jetting blades and the water pressure to obtain desired burial depth while minimizing sediment mobilization into the water column.

By design, coarser sediments settle immediately to fill the trench and bury the submarine export cable or settle in the immediate vicinity (typically within a foot) (Tetra Tech 2012, 2015; Vinhateiro et al. 2013). Earlier studies have shown that sediments coarser than 0.2 millimeter (mm) settle immediately over the trench (Tetra Tech 2015). A conservative approach was taken by assuming that sediments finer than 0.25 mm (fine sand) would be mobilized into the water column and transported by the ambient currents varying distances depending on a number of factors.

The height of the sediment plume above the seabed is dependent on local hydrodynamics, sediment size distribution, and the jet plow operating parameters. Previous studies have shown that the plume of sediment released during jet plowing reaches heights of roughly 7 ft (2 m) above the seabed (Tetra Tech 2012, 2015). The suspended sediment plume is then dispersed by local tidal currents and moves in the direction of the dominant current, which for this project could be northward during flood tides and southwards during ebb tides. Tidal conditions and currents will be dependent on current conditions during EW 2 Project construction. The analytical sediment transport model simulated transport for both the maximum flood and ebb conditions to better estimate potential transport in both directions.

Settling velocity determines the time it takes for a fine grain sediment to settle down based on Stokes Law. Based on the sediment grain size distribution, representative sediment classes were selected and settling velocities assigned to those classes (USGS 2005). However, in many instances, the fine clay and silt sediment particles become cohesive when they are forced into resuspension by the jet plow, causing them to have settling velocities similar to larger sized particles (Van Rijn 2018; Swanson et al. 2015). The settling velocities determine the duration for which the resuspended sediment stays in the water column before eventually settling to the seabed. These velocities have been assigned to each sediment class based on a USGS study (USGS 2005). **Table 4** lists the different sediment classes and the associated settling velocities used for the modeling.

Table 4 EW 2 Project Sediment Particle Diameter Classes and Settling Velocity

Sediment Class	Settling Velocity (cm/s)
Fine Sand	3.000
Very Fine Sand	1.000
Silt	0.126
Clay	0.023

4.2 Methodology

This section describes how the analytical sediment transport model was implemented to calculate the maximum suspended sediment water column concentrations and deposition depths. The approach assumes that the fine sediments released from the jet plow are released at a fixed height. The sediment particles are then transported by local tidal currents and settle down at fixed rates over the horizontal sea floor (Tetra Tech 2012, 2015; Vinhateiro et al. 2013; Swanson et al. 2015). No secondary resuspension of sediment particles was considered. Resuspension is a result of the naturally occurring bottom currents and turbulence and is therefore not directly related to jet plowing activities. The model focuses on the initial dispersion of particles due to jet plowing activities that may generate brief episodes of elevated fine sediment concentrations in the water column and the resulting transport and deposition of these suspended sediments.

The expected sediment transport was calculated for each velocity location. It was assumed that these stations would be representative of the general conditions of the Lease Area and submarine export cable routes. Each station was assigned the representative flood and ebb velocities that corresponded to the velocity station and sediment characteristics based on the project zone it fell in. The flood and ebb velocities were used to calculate the maximum extent of sediment deposition and the duration for which the sediment remained in suspension for each sediment class at all stations.

The travel speed of the jet plow was assumed at 656 ft per hour (200 m per hour). For the model analysis, it was assumed that 30 minutes of trenching activities were suspended at each time step. Based on the provided specifications, for most stations, the trench was assumed to be 328 ft (100 m) long[9], 3.5 ft (1 m) wide, and 8 ft (2.5 m) deep. Therefore, for each sediment location, the maximum volume of potential sediment fluidized in the water column was 8,830 cubic feet (250 cubic meters) if all of it is fine sand or smaller. For stations with a target burial depth of 18 ft (5.5 m), the volume of sediment fluidized in the water column was 19,423 cubic feet (550 cubic meters). This volume of sediment was assumed to be instantaneously suspended at time step 0 seconds in the analytical sediment transport model. This conservative assumption results in a higher concentration of suspended sediments in the water column than if a smaller volume of sediments at a shorter time step were suspended. However, it does not impact deposition depths.

The sediment concentration at the release location was determined based on the estimated bed sediment and the percentage of sediment in each class. The sediment concentrations of each class were added together to calculate the total volume of sediment resuspended at the release point. With time, the sediment plume was allowed to grow based on the velocity at that location. The sediment plume does not grow in the vertical direction and is always close to the bottom of the water column. The duration of suspension for each sediment class was calculated using the release height and sediment class settling velocity. The maximum extent of travel

[9] As a conservative assumption, the model assumed that all the fine material dislodged by the jet plow during the 30 minute time interval would be dispersed into the water column at the same time.

for each sediment class was calculated using the current velocity and sediment settling velocity. Sediment particles in each class were assumed to settle out of the water column at a linear rate. The suspended sediment concentrations at each location along the trench were calculated based on the sediment left in the water column at the time and the size of the plume.

The point of deposition for each particle was calculated based on the settling velocity of each sediment class. Coarser sediments with higher settling velocity settle out of the water column faster and closer to the release point as compared to finer sediments. The finer sediment classes stay in the water column for longer periods of times and are advected further than the coarser sediments. In addition, the finer clay and silt sediment particles, which are typically cohesive, undergo enhanced settling due to flocculation and settle out of the water column with large-sized particles (Van Rijn 2018; Swanson et al. 2015). Sediments were assumed to settle out of the water column at a linear rate for each sediment particle class. This assumes that varying sized sediments within each class are evenly distributed within the plume. Sediment classes larger than medium silt all deposited within an hour, while fine silts and clays stayed in suspension for several hours. In addition, the model did not explicitly simulate dispersion, which could cause some particles to be transported further than estimated and could result in a larger area of deposition. Instead, dispersion was represented by the plume growth in terms of spreading of the sediment particles based on the ambient currents and the settling velocity.

5 RESULTS

This section describes the sediment transport analytical model results in terms of suspended sediment concentrations, deposition depth, and distance at which the sediment is deposited. Results of the conservative analytical sediment transport model representing the submarine export cable route are provided.

5.1 Suspended Sediment Concentrations

Table 5 and **Table 6** list the predicted maximum suspended sediment concentrations by distance from the trench centerline at locations perpendicular to the trench centerline for sample stations for flood and ebb currents. **Figure 4** and **Figure 5** shows the estimated maximum suspended sediment concentrations at a representative "Non-Riverine" station, for maximum ebb and flood tides. **Figure 6** through **Figure 9** show the expected maximum instantaneous suspended sediment concentrations along the submarine export cable route at any given time step along the submarine export cable siting corridor.[10,11] It is important to note that these concentrations do not occur at all locations simultaneously. Due to jet plow speed, only small sections of the submarine export cable route and Lease Area would be disturbed at any given time during EW 2 Project construction and that is why the model used the volume of sediment put into suspension in 1 hour of jet plow travel (200-meter trench length). In addition, due to the depth of water within the EW 2 Project Area, the plume should not be visible from the surface.

5.1.1 Non-Riverine Stations

Overall, at the Non-Riverine stations for the EW 2 Project in New York State, which are comprised of sandier bed sediments, maximum plume distances were typically 1,640 to 3,280 ft (500 and 1,000 m). The plume

[10] **Figure 6** through **Figure 9** represent the instantaneous maximum suspended sediment concentrations at any given point of time predicted for the representative EW 2 submarine export cable routes. These concentrations do not occur at all locations simultaneously. Due to jet plow speed, only small sections of the submarine export cable siting corridor and Lease Area would be disturbed at any given time during Project construction.

[11] Sediment transport analysis **Figure 6** through **Figure 9** reflect a difference in route centerline from the proposed route that is depicted in **Figure 1**, but is representative for the EW 2 Project.

travelled further distances during the flood tide as compared to the ebb tide. The total distance the sediment plumes traveled was dependent on the current velocities. Suspended sediment concentrations were always below 500 mg/L at a distance of 820 ft (250 m) from trench centerline during flood and ebb tides. Results indicated that the plume would travel to a maximum distance of 3,280 ft (1,000 m) during the flood tide, although the maximum suspended sediment concentrations at that distance would be less than 15 mg/L. During ebb tides, the maximum plume distance travelled is typically around 1,640 ft (500 m). Expected maximum suspended sediment concentrations drop to anywhere between 22 to 42 mg/L at 1,640 ft (500 m) from the trench centerline. Maximum plume distance at any station depends on the current velocity and its components perpendicular and parallel to the direction of trench movement.

The sediment transport model predicted that maximum suspended sediment concentrations would be around $1.79*10^6$ mg/L for Non-Riverine stations in the EW2 Project Area at the release point during flood and ebb conditions. The plumes were predicted to travel 1,640 to 3,280 ft (500 to 1,000 m) from the trench centerline. For flood tides, the suspended sediment concentration averaged around 100 mg/L at a distance of 1,640 ft (500 m), and for ebb tides, the concentrations averaged around 100 mg/L at a travel distance of 1,148 ft (350 m). In addition to current velocity, the type of fine sediments at the stations impact the maximum plume concentrations. Fine sand, the coarsest fine sediment particle class that was modelled, has a settling velocity of 3 cm/s and remains in suspension for approximately one minute. Therefore, at the Non-Riverine EW2 Project Area stations, suspended sediment concentrations decreased by close to 75 percent within one minute of jet plowing operations and within 33 ft (10 m) of the trench centerline (**Figure 4**, and **Figure 5** considered representative). This reduced the amount of sediment that could be transported in the water column due to currents, and most of the fine sand deposits within 33 ft (10 m) of the trench centerline. **Table 5** and **Table 6** present the results specifically for the three Non-Riverine stations along EW 2 within New York State waters (Stations 6, 9 and 11).

5.1.2 General Observations

While the maximum suspended sediment concentrations were relatively high for both Riverine and Non-Riverine stations, these concentrations decreased rapidly with time. The coarser fine particles, such as fine sand, remained in suspension for about one minute, while the very fine sediments (clay) remained in suspension for about four hours, a relatively short period of time. In areas that consist predominantly of gravels and sands, the analysis indicates a limited extent of increased sediment concentrations, as the larger grain size sediments immediately deposit in the trench. In locations that are dominated by fine sand, silts, or clays, these sediments can be released into the water column and temporarily increase total suspended solids near the trench and cause sediment deposition outside of the trench, but eventually settle down to background concentrations (Tetra Tech 2012, 2015; Vinhateiro et al. 2013). The concentrations decreased rapidly with time, and water column concentrations are expected to return to ambient conditions within 4 hours (7,200 seconds). **Table 7** and **Table 8** presents the time varying suspended sediment concentrations for flood and ebb tides respectively for Non-Riverine stations within New York State waters for EW 2.

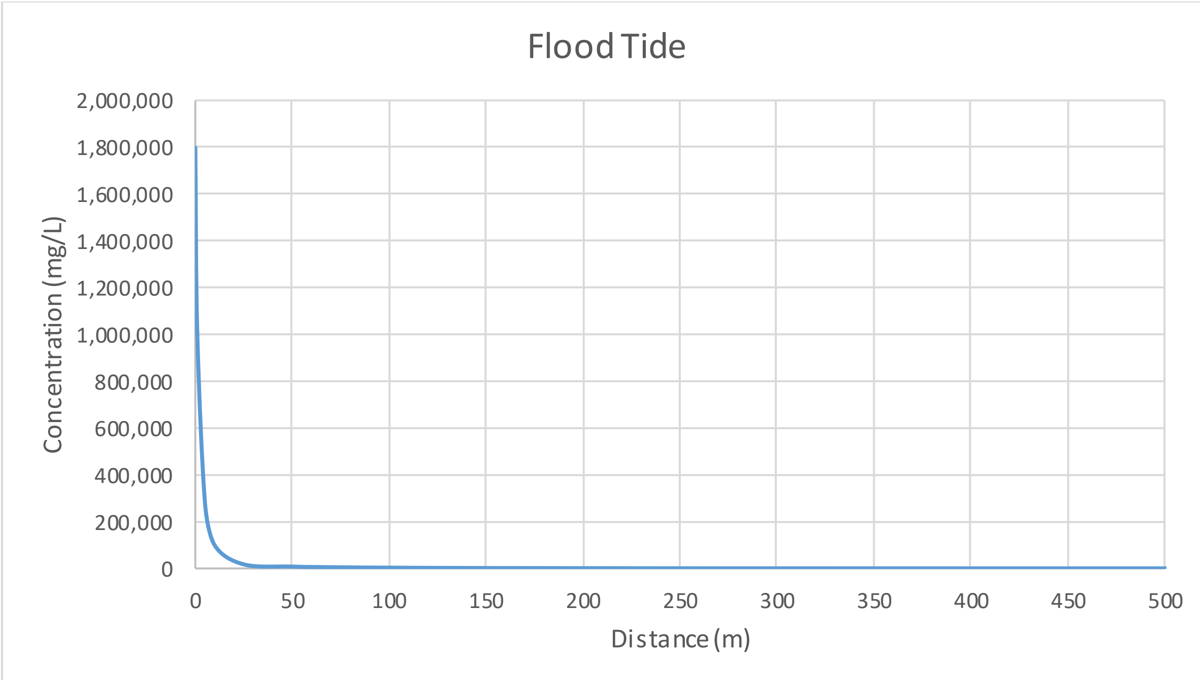

Figure 4 Maximum Flood Tide Suspended Sediment Concentrations at Representative Non-Riverine Station

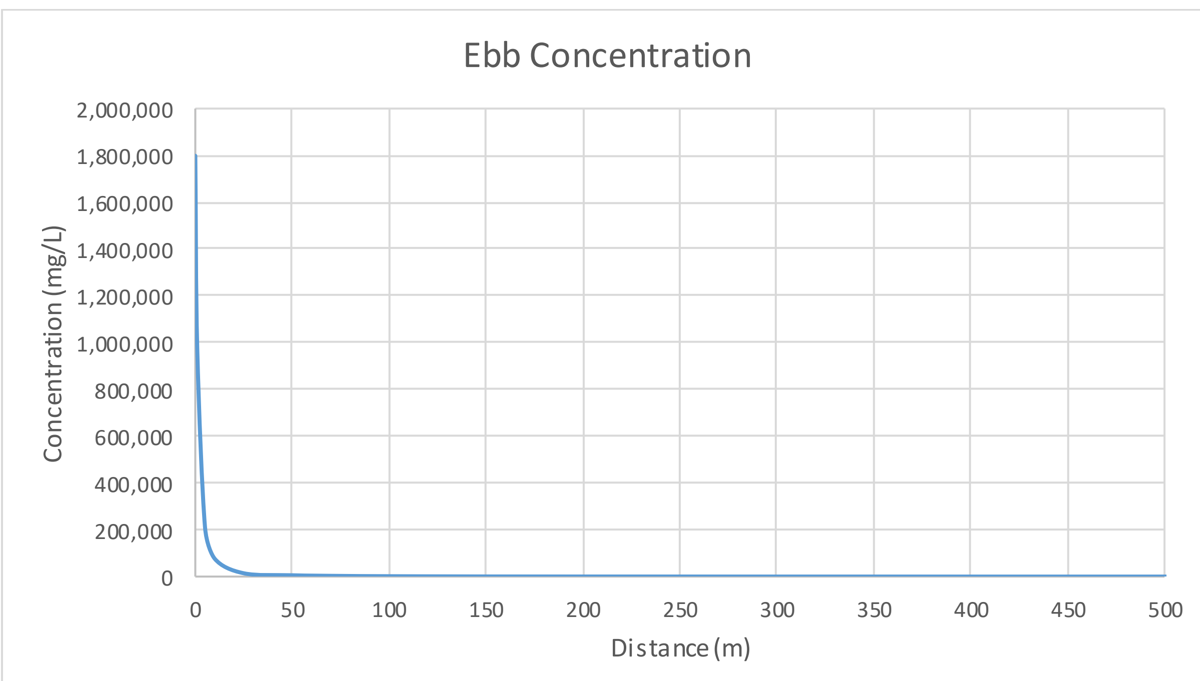

Figure 5 Maximum Ebb Tide Suspended Sediment Concentrations at Representative Non-Riverine Station

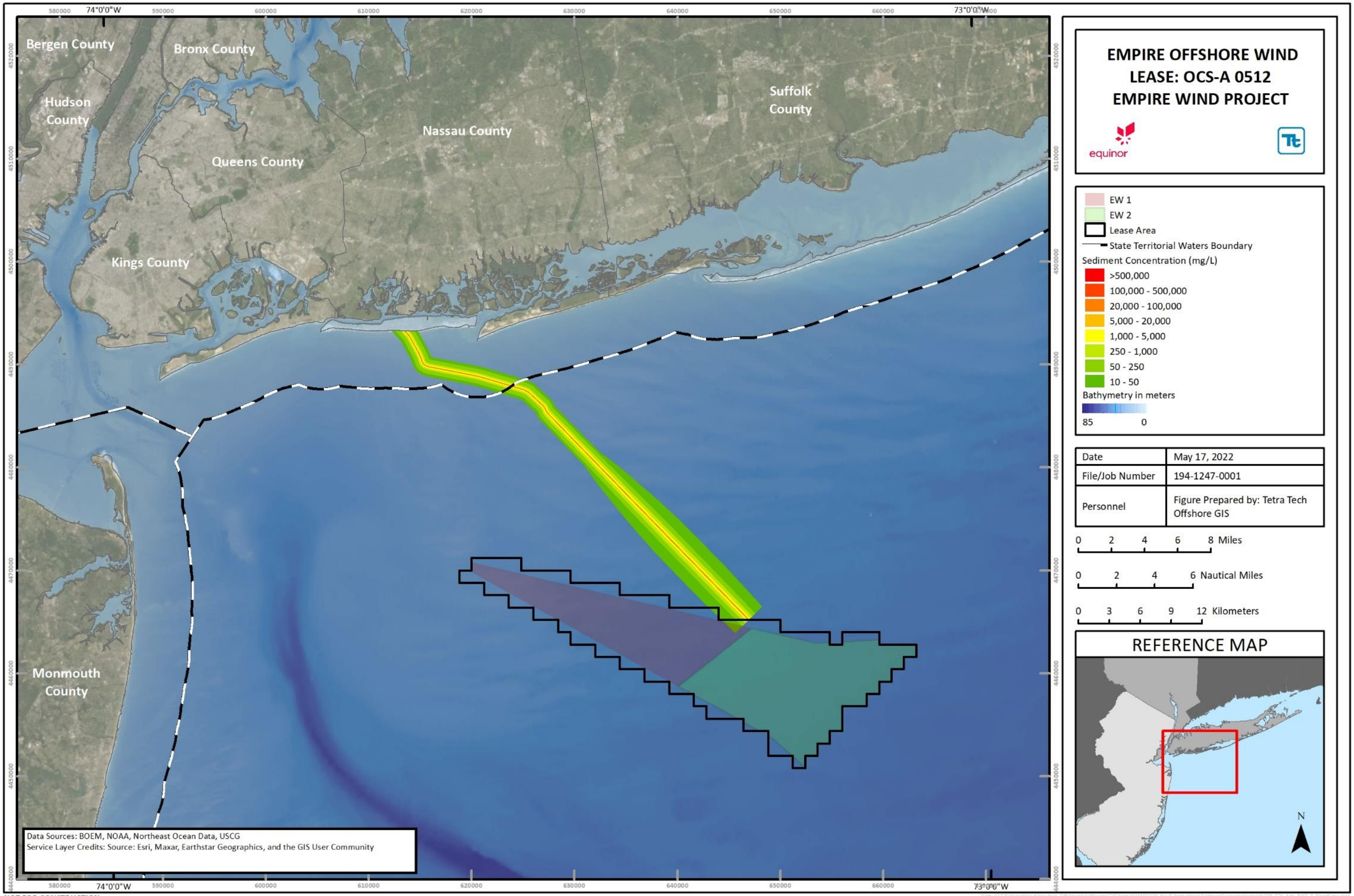

Figure 6 Maximum Flood Tide Suspended Sediment Concentrations along a Representative EW 2 Submarine Export Cable Route[10]

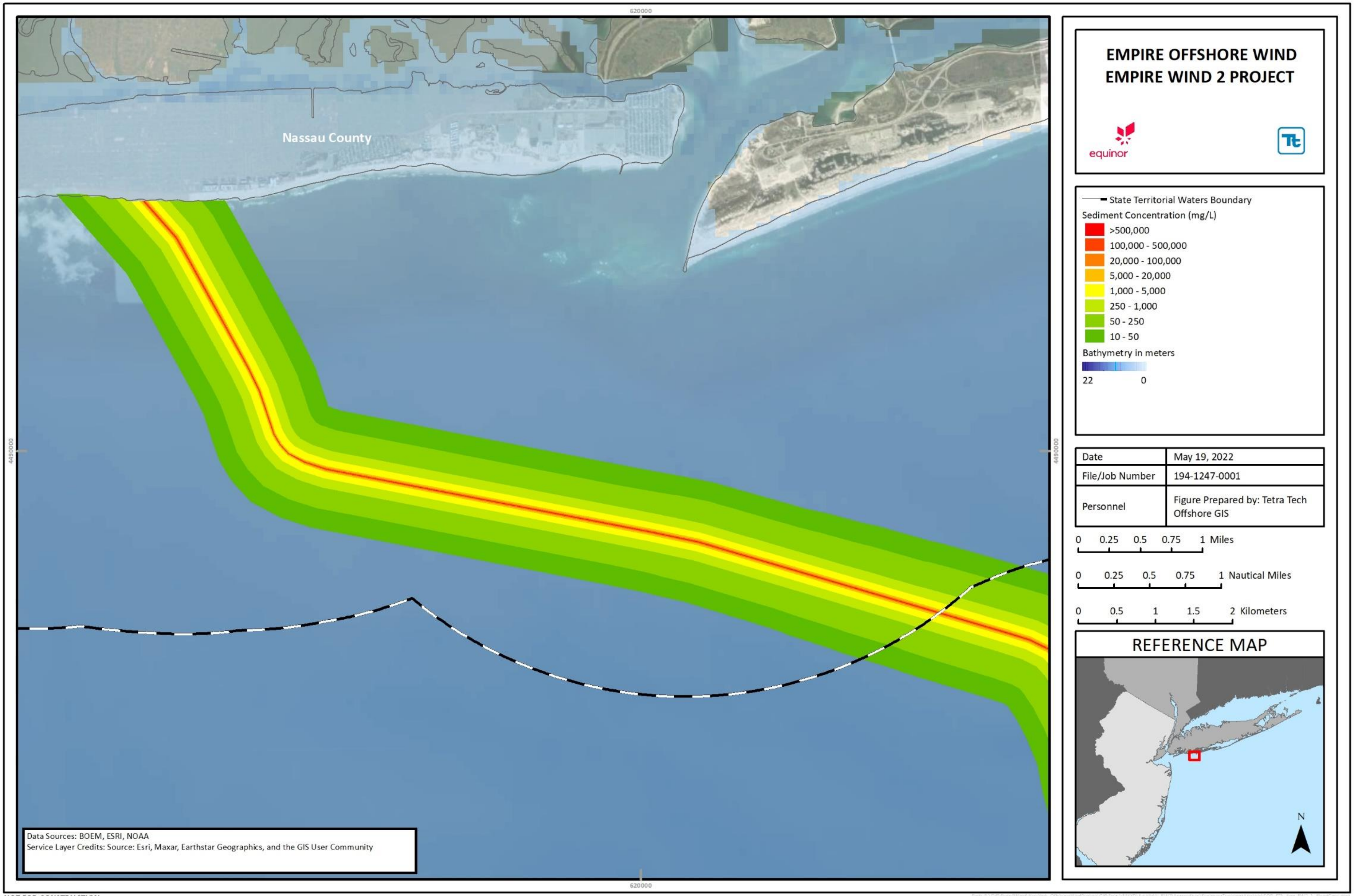

Figure 7 Maximum Flood Tide Suspended Sediment Concentrations along a Representative EW 2 Submarine Export Cable Route (NY)

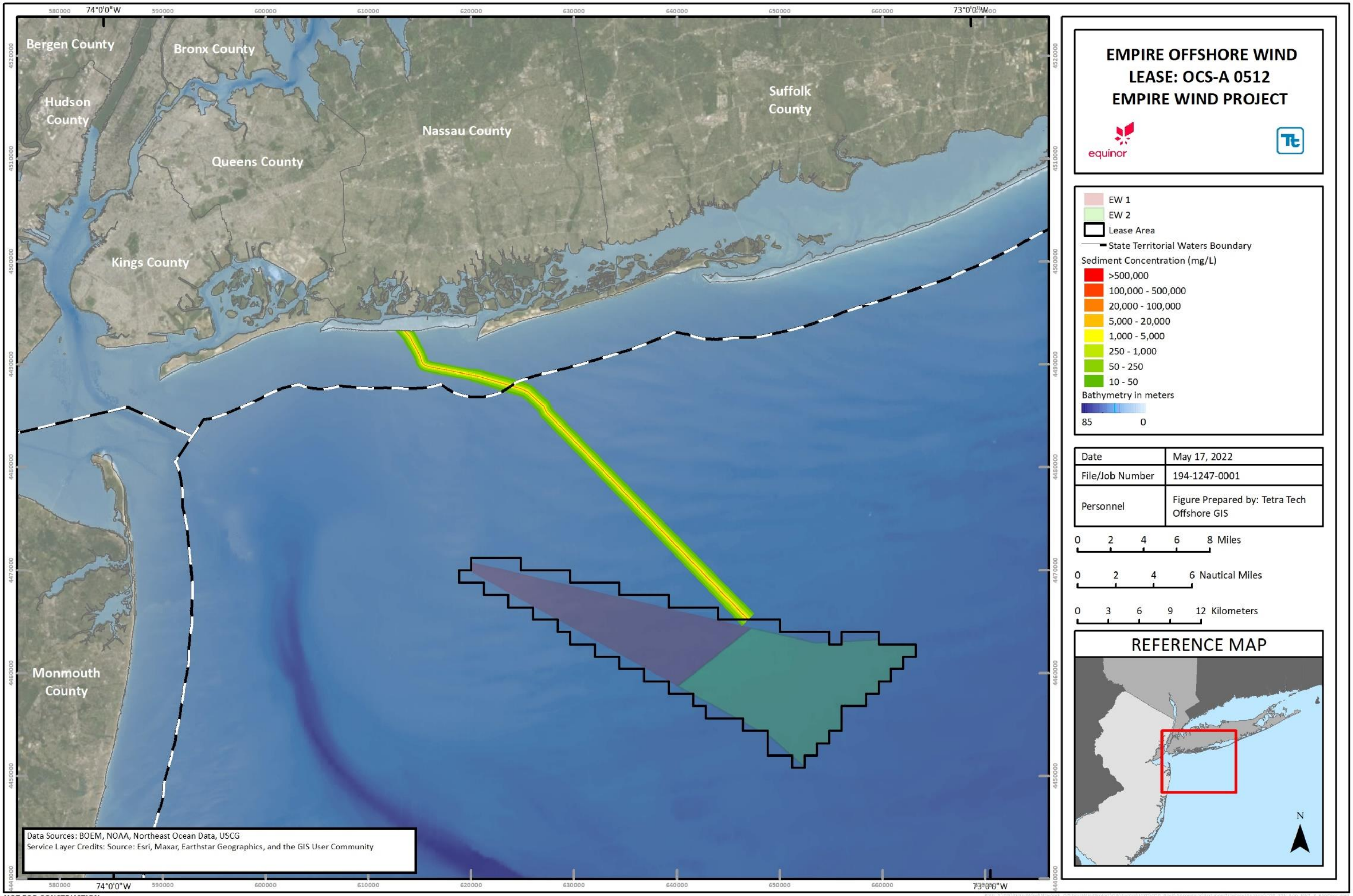

Figure 8 Maximum Ebb Tide Suspended Sediment Concentrations along a Representative EW 2 Submarine Export Cable Route

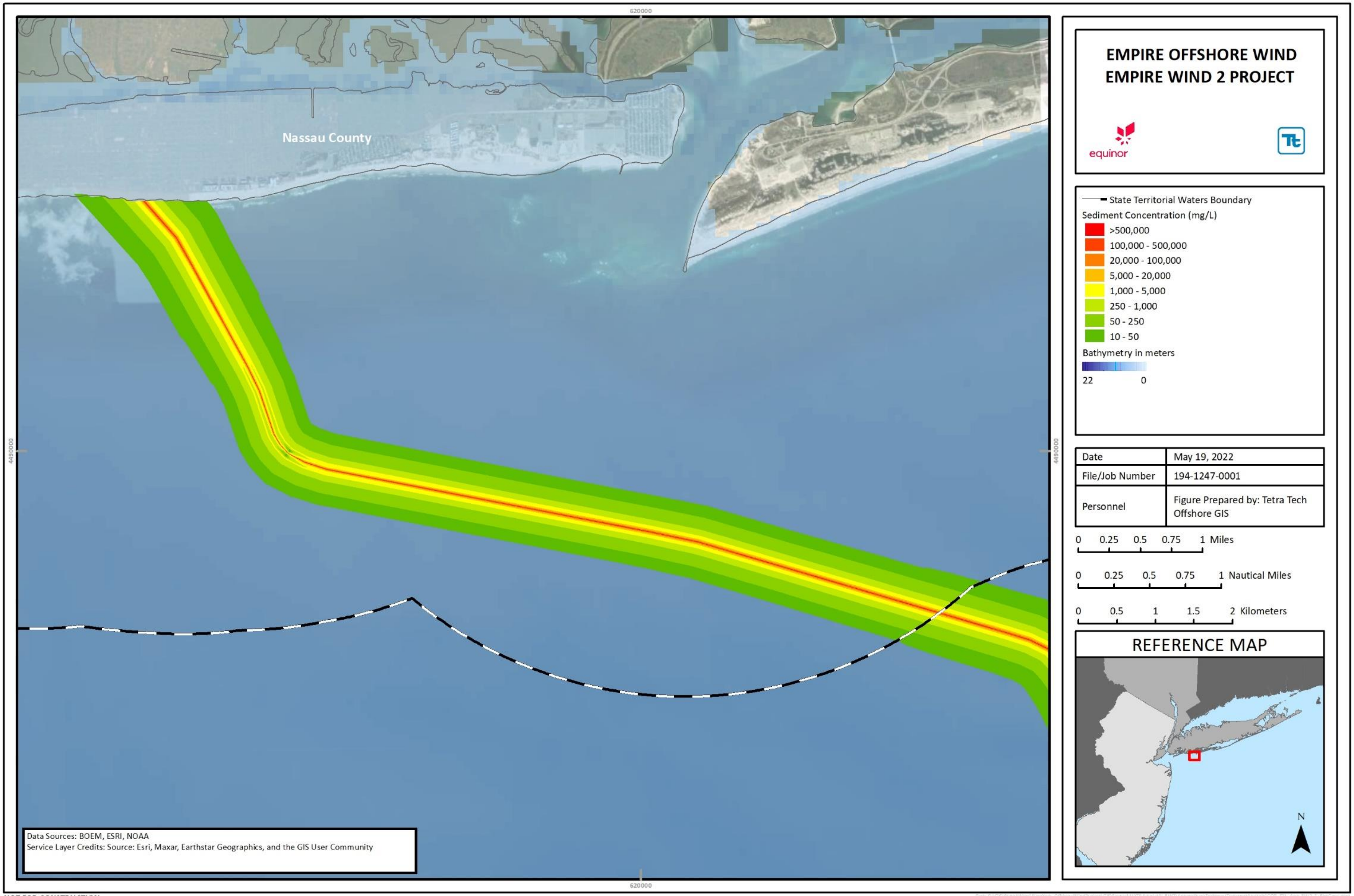

Figure 9 Maximum Ebb Tide Suspended Sediment Concentrations along a Representative EW 2 Submarine Export Cable Route (NY)

Table 5 Maximum Suspended Sediment Concentrations for Flood Conditions (With Distance) for the EW 2 Project (New York Stations Only)

Sample	Project Element	Total Fines (%)	Distance from Trench (m)															
			0	1	5	10	25	50	75	100	150	250	350	500	800	1,000	2,500	5,000
			Maximum Sediment Concentration (mg/L)															
6	Non-Riverine	53%	1,798,287	1,009,568	280,454	97,486	17,514	6,884	3,954	2,534	1,204	400	214	98	24	7	0	0
9	Non-Riverine	53%	1,798,287	1,015,346	291,471	100,685	20,766	7,014	4,072	2,641	1,294	416	226	107	29	11	0	0
11	Non-Riverine	53%	1,798,287	1,012,834	286,759	99,446	19,398	7,027	4,078	2,641	1,284	423	230	108	28	9	0	0

Table 6 Maximum Suspended Sediment Concentrations for Ebb Conditions (With Distance) for the EW 2 Project (New York Stations Only)

Sample	Project Element	Total Fines (%)	Distance from Trench (m)															
			0	1	5	10	25	50	75	100	150	250	350	500	800	1,000	2,500	5,000
			Maximum Sediment Concentration (mg/L)															
6	Non-Riverine	53%	1,798,287	954,412	180,125	66,617	13,831	5,333	2,652	1,430	623	224	95	24	0	0	0	0
9	Non-Riverine	53%	1,798,287	955,276	179,997	66,689	13,545	5,142	2,529	1,355	577	204	86	22	0	0	0	0
11	Non-Riverine	53%	1,798,287	976,992	218,313	78,591	14,231	5,690	2,969	1,715	664	254	118	42	0	0	0	0

Table 7 Maximum Suspended Sediment Concentrations (mg/L) for Flood Conditions (With Time) for the EW 2 Project (New York Stations Only)

Sample	Project Element	Total Fines (%)	Time (s)															
			0	10	20	30	60	90	120	150	240	300	600	1,200	1,800	3,600	7,200	14,400
			Maximum Sediment Concentration (mg/L)															
6	Non-Riverine	53%	1,798,287	877,659	542,370	369,121	141,545	77,939	49,906	32,507	12,065	9,269	3,677	1,085	441	112	10	0
9	Non-Riverine	53%	1,798,287	841,254	512,039	345,737	131,159	71,875	45,890	29,829	11,026	8,454	3,331	974	394	99	9	0
11	Non-Riverine	53%	1,798,287	858,269	526,217	356,710	136,119	74,828	47,883	31,183	11,578	8,900	3,543	1,052	429	110	10	0

Table 8 Maximum Suspended Sediment Concentrations (mg/L) for Ebb Conditions (With Time) for the EW 2 Project (New York Stations Only)

Sample	Project Element	Total Fines (%)	Time (s)															
			0	10	20	30	60	90	120	150	240	300	600	1,200	1,800	3,600	7,200	14,400
			Maximum Sediment Concentration (mg/L)															
6	Non-Riverine	53%	1,798,287	1,107,295	756,441	544,531	226,019	128,773	84,033	55,397	20,951	16,199	6,504	1,927	784	199	18	0
9	Non-Riverine	53%	1,798,287	1,103,110	751,815	540,251	223,372	126,874	82,567	54,292	20,391	15,699	6,193	1,790	716	177	16	0
11	Non-Riverine	53%	1,798,287	1,029,979	679,124	478,580	192,231	107,762	69,601	45,539	16,962	13,018	5,096	1,464	584	144	13	0

5.1.3 Sediment Deposition Rates

Table 9 and **Table 10** list the deposition thicknesses at locations perpendicular to the trench centerline for all stations under the maximum flood and ebb currents for the EW 2 Project in New York State waters. **Figure 10** through **Figure 13** show the maximum predicted sediment deposition along the representative submarine export cable route.[12][13] It is important to note that deposition does not occur at all locations simultaneously due to the jet plow travel speed. The sediment resuspended due to jet plow operations moves in the direction of the local ambient current and then eventually settles and deposits in a layer along the marine seabed. For the analytical sediment transport model, it was assumed that sediments finer than 0.25 mm (fine sand) would be mobilized in the water column and transported by the ambient currents, which would distribute sediments in each particle class uniformly over the marine seabed. All sediments coarser than 0.25 mm would re-deposit in or immediately adjacent to the trench (and therefore, not be considered suspended).

The deposition thickness was highest in the vicinity the of jet plow, as fine sand tends to deposit close to the trench centerline due to its higher settling rate. Most of the coarser fine sediments settled to the marine floor within 33 ft (10 m) of the trench, and deposition depths decreased rapidly.

[12] **Figure 10** through Figure 13 represent the instantaneous maximum sediment deposition at any given point of time. These depositions do not occur at all locations simultaneously. Due to jet plow speed, only small sections of the submarine export cable route and Lease Area would be disturbed at any given time during Project construction.
[13] Sediment transport analysis in **Figure 10** through **Figure 13** reflect a difference in route centerline from the proposed route that is depicted in **Figure 1**, but is representative for the EW 2 Project.

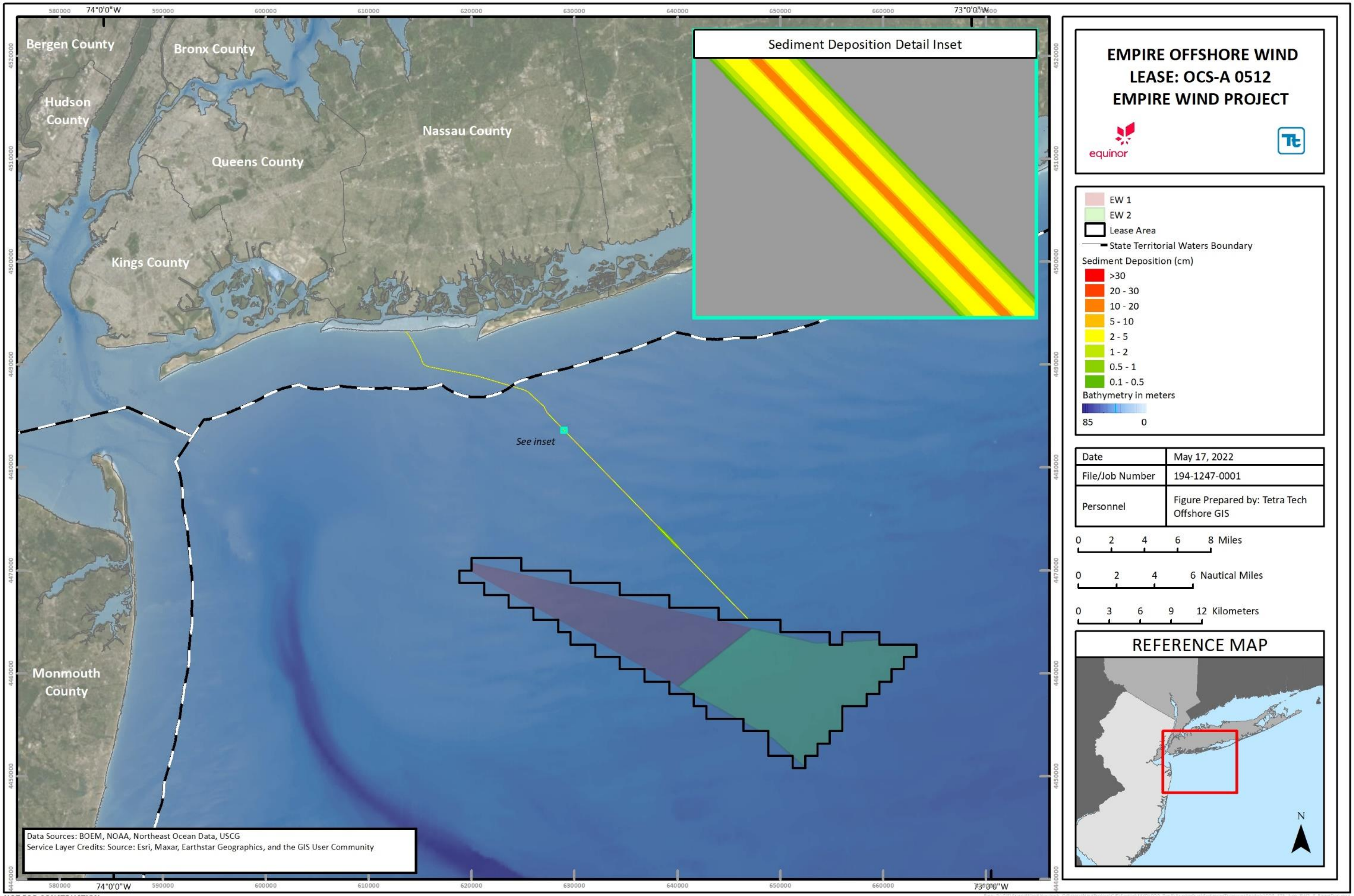

Figure 10 Maximum Flood Tide Sediment Deposition along a Representative EW 2 Submarine Export Cable Route[13]

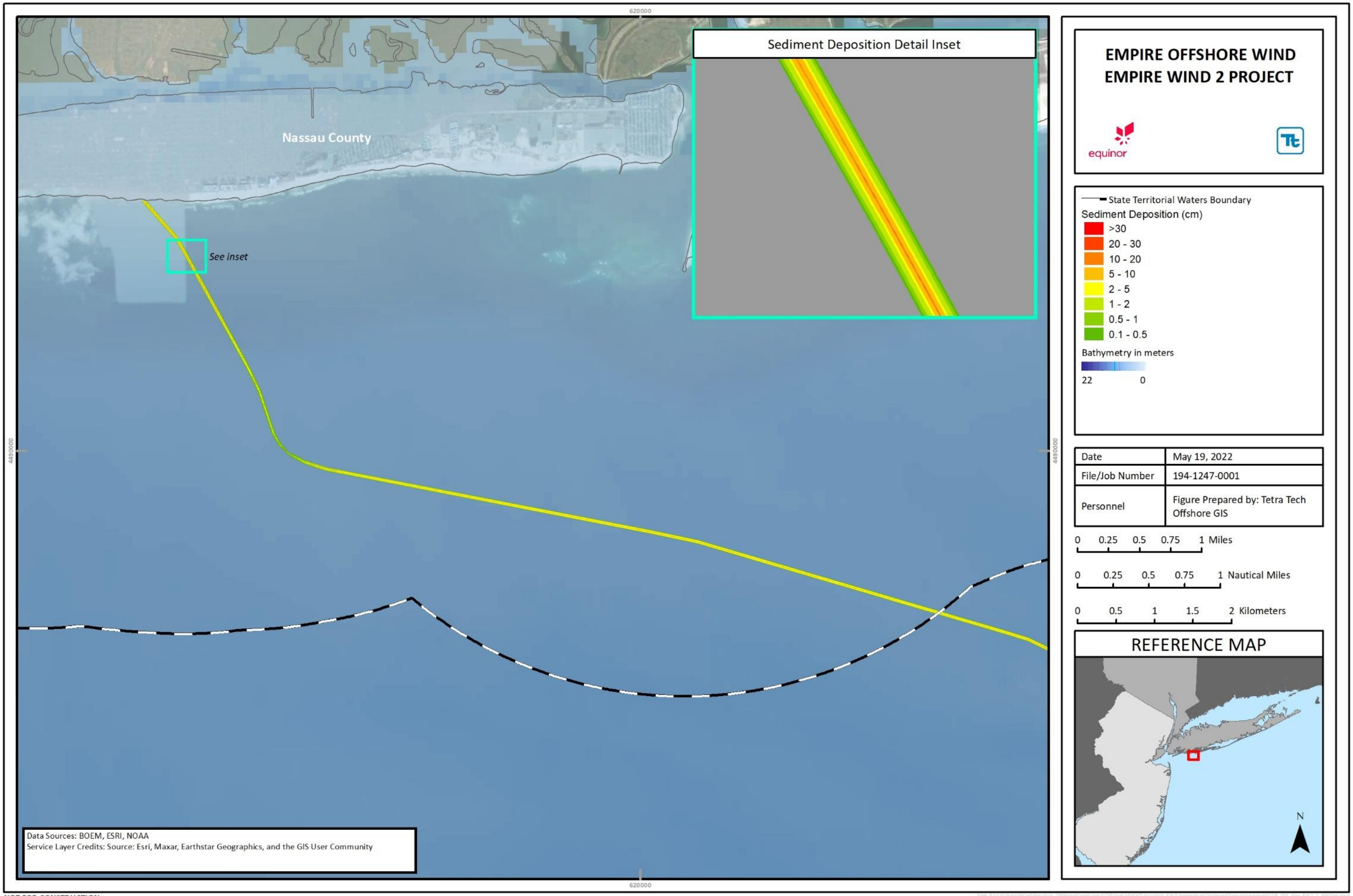

Figure 11 Maximum Flood Tide Sediment Deposition along a Representative EW 2 Submarine Export Cable Route (NY)

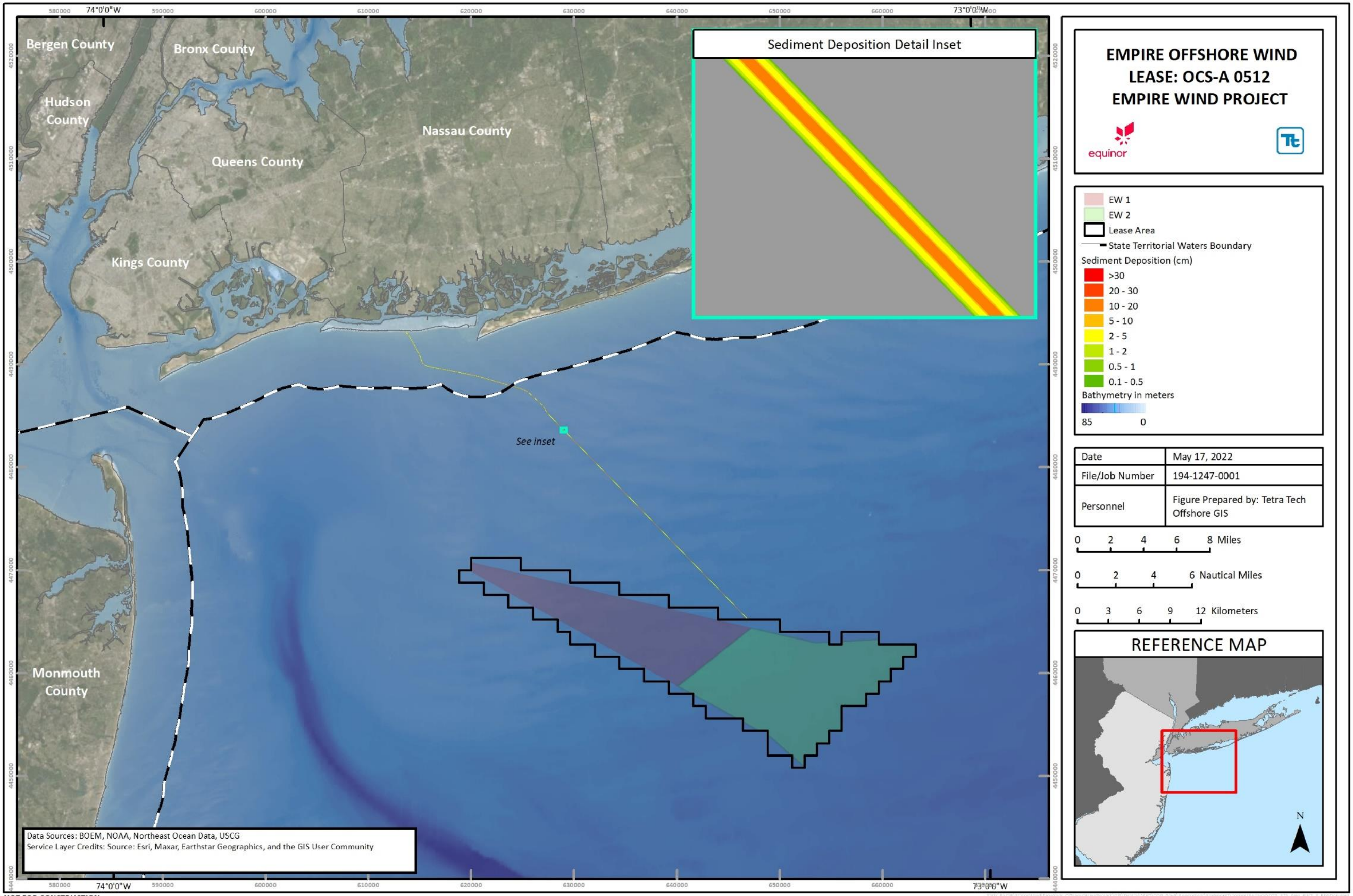

Figure 12 Maximum Ebb Tide Sediment Deposition along a Representative EW 2 Submarine Export Cable Route

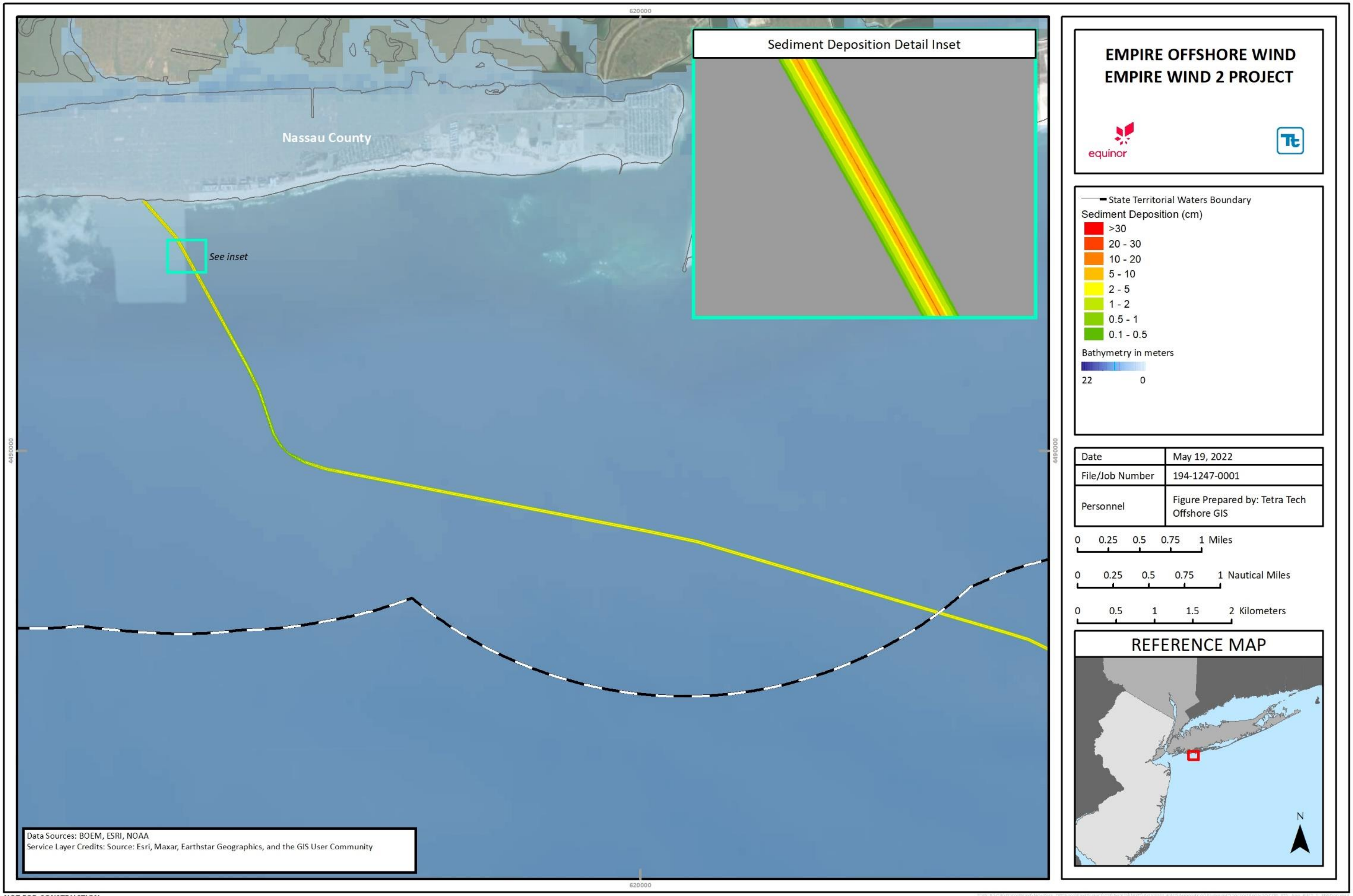

Figure 13 Maximum Ebb Tide Sediment Deposition along a Representative EW 2 Submarine Export Cable Route (NY)[12]

Table 9 Deposition Depths for Flood Conditions for the EW 2 Project (New York Stations Only)

Sample	Project Element	Total Fines (%)	Distance from Trench (m) 0	1	5	10	25	50	75	100	150	250	350	500	800	1,000	2,500	5,000
			Maximum Sediment Deposition (cm)															
6	Non-Riverine	53%	10.59	10.59	10.59	2.78	2.78	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Non-Riverine	53%	9.77	9.77	9.77	2.54	2.54	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	Non-Riverine	53%	10.17	10.17	10.17	2.66	2.66	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 10 Deposition Depths for Ebb Conditions for the EW 2 Project (New York Stations Only)

Sample	Project Element	Total Fines (%)	Distance from Trench (m) 0	1	5	10	25	50	75	100	150	250	350	500	800	1,000	2,500	5,000
			Maximum Sediment Deposition (cm)															
6	Non-Riverine	53%	17.39	17.39	4.79	4.79	0.09	0.09	0.09	0.09	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
9	Non-Riverine	53%	17.11	17.11	4.67	4.67	0.09	0.09	0.09	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	Non-Riverine	53%	14.56	14.56	14.56	3.90	0.07	0.07	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

6 CONCLUSIONS

Tetra Tech performed an analytical sediment transport study to conservatively evaluate the potential suspended sediment transport and deposition characteristics of installation of the EW 2 Project's submarine export cables. The modeling was conducted using existing available data and a PDE approach to evaluate the effects of proposed submarine export cable burial activities in terms of suspended sediment concentrations in the water column, and sediment deposition characteristics such as deposition depth and deposited sediment footprint, to allow for an assessment of potential EW 2 Project effects on surrounding water quality and habitats. The conservative model assumed maximum trench dimension parameters and that all fine sediment (fine sand and smaller grain size sediment) disturbed by the jet plow during cable burial would be suspended in the water column; however, jet plow operations, including the angle of the plow blade and water pressure through the jet nozzles, can be adjusted during cable installation and could result in less sediment mobilizing in the water column.

The analytical sediment transport model yielded the following general conclusions:

- The suspended sediment concentration, deposition depth, and area of influence is dependent upon flood and ebb current velocities, burial depth, and the percentage of fine sediments in the sediment sample;
- The very fine sediments particles (silt and clay) remain in suspension for about 4 hours after being mobilized in the water column. Coarser particles (fine sand) settle at a faster rate, about 1 minute after being mobilized;
- For jet plow during peak flood and ebb tides:
    - The initial maximum concentration at the release point is dependent on the percentage of fine particles (defined as particles in the fine sand class and smaller). Stations in the EW 2 Project Area are 53 percent fine particles, and maximum concentrations at the trench line are approximately 1.8*106 mg/L for a trench depth of 8 ft (2.5 m) and 6.1*106 mg/L. This instantaneous concentration is conservatively high and assumes that all particles finer than fine sand are instantly mobilized in the water column and remain in suspension until they settle;
    - The suspended sediment concentrations diminish rapidly away from the release point, and at most stations over 85 percent of the suspended particles deposit within 16 ft (5 m) of the trench centerline. The typical concentration at 328 ft (100 m) is about 2,500 mg/L above background concentration for flood tides and about 1,300 mg/L above background concentration for ebb tides;
    - The suspended sediment concentrations drop rapidly with time. At most locations, the concentration drops by 75 percent within two minutes of jet plowing activity. The maximum concentration at two minutes is $5.0*10^4$ mg/L for flood tide and $8.4*10^4$ mg/L for ebb tide;
    - The deposition thicknesses were predicted to be greatest closest to the centerline trench. The maximum expected sediment deposition thickness under simulated conditions is 6.74 in (17.11 cm) at 0 m from the trench centerline;
    - Deposition thicknesses were predicted to decrease rapidly away from the trench. Average deposition thicknesses were less than 1.09 in (2.78 cm) within 82 ft (25 m) of the trench centerline for flood tides and less than 0.04 in (.09 cm) within 82 ft (25 m) of the trench centerline for ebb

tides. Deposition thicknesses were less than 0.004 in (0.01 cm) at all stations within 492 ft (150 m) of the trench centerline.

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