Norwegian Institute for Water Research

8214-2026

Environmental monitoring during the keel access and mercury canister retrieval operation at U-864

Fedje 2026

Report

Norsk institutt for vannforskning STI

Norwegian Institute for Water Research

Serial no.: 8214-2026

ISBN 978-82-577-7952-8
NIVA report
ISSN 1894-7948

This report has been quality assured according to NIVA's quality system and has been approved by:

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Title
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Pages 51 + appendix

Date 14.08.2026

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Topic group Monitoring

Distribution Open

Client(s)
Reach Subsea

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Published by NIVA
Project number 260042

Abstract
This report presents results from environmental monitoring conducted the 19th to the 27th of June 2026 during operations for keel access and mercury canister retrieval at the U-864 submarine wreck outside Fedje. The monitoring programme aimed to document baseline conditions and to ensure early detection of particle-bound and dissolved mercury associated with the offshore activities. A baseline survey, including turbidity measurements and water sampling, was completed during the March operation and used in this study. During the first two days of the canister retrieval operation, background blank samples were measured consistently below 5 ng L^{-1}, though due to contamination of the sample vessels, blank samples during the remaining monitoring period varied between 3 and 24 ng Hg L^{-1}. Most (73 %) of analysed water samples still had total mercury concentrations below 50 ng L^{-1}. It was estimated a flux of 3.2 kg of Hg out of the operational area during this operation, of which around 38% was in its dissolved phase. The report concludes that the revised monitoring approach functioned technically as intended and provides recommendations for improvements to turbidity measurements, water sampling, and sediment trap handling ahead of future operations.

Keywords: U-864, Fedje, Environmental monitoring, Mercury
Emneord: U-864, Fedje, Miljøovervåking, Kvikksølv

Cited as: Alling, V., Staalstrøm, A., Vogt, R. D., Beylich, B., Antonsen, M. G., Brandt, U., Bryntesen, T., Gran, S., Håvardstun, J., Jørgensen, S., Frafjord, E. M., Schøyen, M., Sekkenes, M. S., Wilhelmsen, O. S. B., & Ødegaard, Ø (2026). Environmental monitoring during the keel access and mercury canister retrieval operation at U-864

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Preface

The Norwegian Institute for Water Research (NIVA) carried out environmental monitoring during the keel access and mercury canister retrieval operation at the U-864 submarine wreck outside Fedje in June 2026. NIVA was the subcontractor to Reach Subsea, and the operation was conducted on behalf of the Norwegian Coastal Administration (NCA). The monitoring programme was designed to document environmental conditions before and during the operation and to provide early detection of any spreading of particle-bound or dissolved mercury associated with seabed disturbance activities. The programme included real-time turbidity monitoring, water sampling and mercury analyses, deployment of passive mercury samplers, sediment traps, and assessments of mercury transport and fluxes.

Vanja Alling served as project manager and lead author for the project. The monitoring programme, field activities, laboratory analyses, interpretation of results, and reporting were carried out through a collaborative effort involving Vanja Alling, André Staalstrøm, Rolf D. Vogt, Bjørnar Beylich, Medyan Ghareeb Antonsen, Uta Brandt, Tina Bryntesen, Sandra Gran, Jarle Håvardstun, Susanne Jørgensen, Else Mari Frafjord, Merete Schøyen, Marianne Stave Sekkenes, Oda S. Bye Wilhelmsen (Akvaplan-niva) and Øyvind T. Ødegaard.

The scientific and technical work encompassed environmental monitoring planning, offshore operations, analytical measurements of mercury in seawater and sediment-trap material, assessment of passive sampler data, modelling of mercury fluxes, data analyses, and preparation of this report. The authors gratefully acknowledge the cooperation and support provided by the personnel involved in the offshore operations and project execution.

The scientific quality assurance of the report was conducted according to NIVA's quality system. This report has been collaboratively written by the authors listed above.

Artificial intelligence (AI) has been used as a tool in the preparation of this report in the following way: Microsoft Copilot and ChatGPT were used to suggest wording and make linguistic improvements. All content has been reviewed, edited and professionally assessed by the authors. No personal data or sensitive information has been uploaded to the AI tools. The authors are responsible for the professional content of the report. In addition, this report contains some reused text from previous NIVA reports related to environmental monitoring at U-864, used in accordance with NIVA's guidelines for text reuse.

NIVA, August 2026.

Summary

Environmental monitoring during the U-864 keel access and mercury retrieval operation

Environmental monitoring was successfully conducted from the 19th to the 27th of June 2026 despite several technical and logistical challenges. The original plan for fixed turbidity monitoring stations could not be implemented, and monitoring was instead performed using turbidity sensors mounted on two ROVs. Although this reduced the spatial coverage of the monitoring network, the mobile platform allowed active tracking of turbidity plumes and provided continuous operational support throughout the campaign.

A baseline survey conducted in March 2026 established low background turbidity (average 0.23 FNU) and mercury concentrations below the analytical limit of quantification (0.001 µg Hg L^{-1}). The revised monitoring approach functioned as intended and provided continuous situational awareness during the operation.

Alarm events and operational response

The monitoring system generated several alarms during the operation, most notably on 23 June 2026 when extensive dredging activities were conducted. Elevated turbidity triggered follow-up sampling according to the established monitoring protocol.

On 23 June, multiple water samples collected in the turbidity plume down-flow of the dredging site contained elevated mercury concentrations, including three samples with concentrations of 2.17, 2.13 and 1.25 µg Hg L^{-1}, which was above the acceptance criteria of 0.05 µg L^{-1} as well as the stop value of 0.7 µg L^{-1}. These events led to repeated alarm responses, targeted follow-up sampling and temporary suspension of dredging activities until further investigation could be completed.

The monitoring team followed the agreed protocol throughout the operation, and elevated concentrations were rapidly identified, verified and communicated to the operational management team.

Mercury concentrations in seawater

Mercury concentrations differed substantially depending on the sampling location and time.

Background samples

- Total mercury concentrations in baseline survey were below 0.001 µg L^{-1}.
- During operation, the total mercury levels in most background samples remained below 0.05 µg L^{-1}.
- Background samples were affected by carryover contamination from the sampling equipment.

Turbidity plume and perimeter samples

- Generally low mercury concentrations.
- Range approximately 0.002–0.020 µg L^{-1}. Significant exceedance occurred on 23 June, with concentrations above 1 µg L^{-1} and a maximum of 2.17 µg L^{-1}
- No clear relationship between turbidity and mercury concentrations was observed.

Dredging site samples

- Typically ranged from approximately 0.02 to 0.10 µg Hg L^{-1}.
- The highest total mercury concentration measured at the wreck site was 0.614 µg Hg L^{-1}.

Passive samplers

Time-averaged concentrations of labile inorganic dissolved mercury, measured using passive DGT (Diffusive Gradients in Thin Films) samplers, provide a supplementary estimate of dissolved mercury levels in the water. However, due to substantial uncertainties, the results should be interpreted with caution.

- Background stations (TU-Ref. (5), TU-1, and TU-2) generally showed concentrations below the limit of detection.
- Very high time-averaged concentrations of DGT-labile inorganic dissolved mercury were measured at the dredging site: 38 and 32 µg Hg L^{-1} on the roof of the filter container and at the bottom of the Spider, respectively.
- Down-current of the dredging site, at the perimeter of the operational area (TU-3 and TU-4), high time-averaged concentrations of dissolved mercury were measured 2 m above the seabed (2.8 and 1.2 µg Hg L^{-1}, respectively), indicating a potentially substantial flux of dissolved mercury to the surrounding environment.

Approximately 73% of all samples analysed for mercury contained less than 50 ng Hg L^{-1}. The results further indicate that a substantial proportion (about 38%) of mercury occurred in dissolved form. Methylmercury (MeHg) concentrations remained very low throughout the monitoring programme. MeHg was below the limit of quantification (<0.03 ng L^{-1}) in the majority of samples, while detected concentrations ranged from 0.03 to 0.33 ng L^{-1}. The results indicate that the elevated dissolved mercury concentrations observed during dredging consisted predominantly of inorganic mercury rather than methylmercury.

Sediment trap results

Sediment traps deployed around the operational area collected measurable amounts of contaminated material throughout the 8 to 9 days monitoring period. The traps showed clear spatial differences in both sediment accumulation and mercury concentrations. The highest mercury concentrations were measured at stations TU-3 and TU-4, which are located NV and N of the submarine, which is downflow of the predominant water current. Here the sediment mercury concentrations ranged from

approximately 30 to 79 mg Hg/kg dry weight, whereas stations further from the dredging activities generally contained lower concentrations ranging from approximately 3 to 13 mg Hg/kg dry weight.

The collected material consisted predominantly of fine particles, with most samples containing more than 50% material finer than 63 µm. The elevated mercury concentrations observed in sediment traps confirmed that mercury-contaminated particles were transported and deposited during the operation. However, the spatial distribution also indicates that most depositions occurred relatively close to the dredging area, while lower concentrations were observed towards the outer stations.

Overall, the sediment trap results provide independent confirmation that mercury-bearing particles were released during the operation and support the conclusion that both particle-bound and dissolved mercury contributed to the observed spreading outside the immediate work area.

Daily mercury and particle fluxes

Daily modelling suggested that both particle and mercury transport varied substantially throughout the operation.

Estimated particle fluxes ranged from approximately 5–94 tonnes per day. The total flux of particles from the operational area during the work done in June 2026, was estimated to 178 tonnes.

Estimated mercury fluxes ranged from approximately 17 to 2212 g Hg/day. The largest transport event occurred during the most intensive dredging operation on 23 June, when mercury flux was estimated to be approximately 2.2 kg Hg this day.

Figure 1 illustrates the spatial distribution of Hg in water samples collected during this peak dredging event. Elevated Hg concentrations were primarily observed northwest and north of the dredging area, indicating that this was the predominant direction of Hg transport. This pattern is supported by the 10-day integrated measurements from sediment traps and DGT passive samplers, which also showed the highest concentrations of particle-bound and labile inorganic Hg in the same sector. The agreement between these independent monitoring methods indicates that the main Hg plume was transported towards the northwest and north throughout the dredging operation. Exceedances of the threshold values of 0.05 µg L^{-1} (first warning, increased monitoring) and 0.7 µg L^{-1} (stopping criterion) were restricted to locations close to the dredging area and along this dispersal corridor, whereas concentrations outside this area were generally low.

The cumulative estimated mercury spread during the operation was approximately 3.2 kg Hg. These calculations should be interpreted with caution because of uncertainties associated with plume monitoring, sampling contamination and the Hg-to-turbidity conversion used in the modelling.

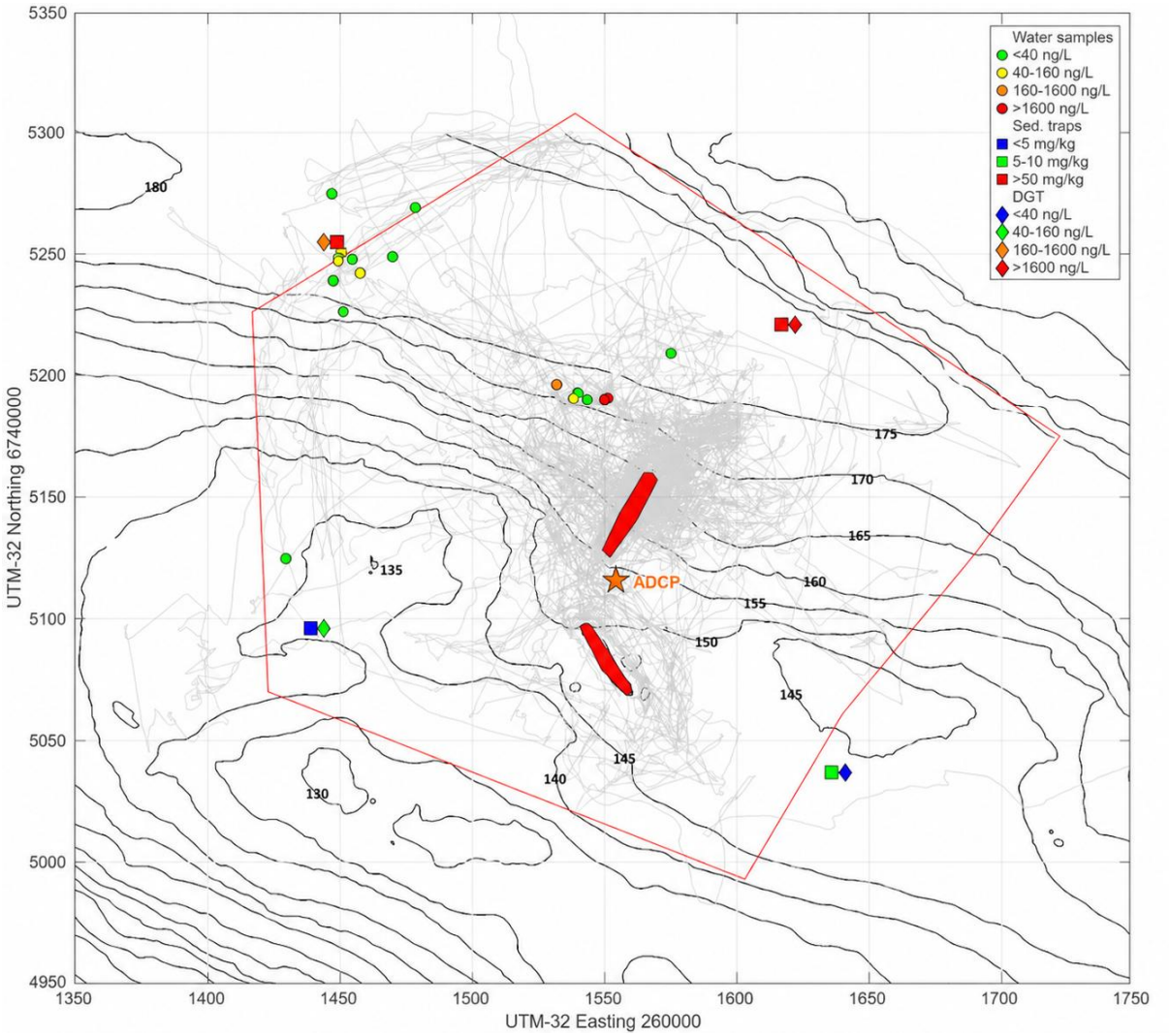

Figure 1. Summary figure of total Hg concentrations in water samples collected during the most intense dredging activity on June 23rd (marked with circles), plotted alongside particle-bound Hg levels in sediment traps (squares) and DGT-labile inorganic Hg collected by passive samplers (diamonds and star). Colour codes in symbols indicate levels of mercury. The two sections of the submarine are shown in red. The red line is the polygon used for Hg flux calculations. Thin grey lines represent the Supporter ROV track from the entire operation. The contour lines on the map are spaced at 5 m elevation intervals.

Lessons learned and recommendations

Several important lessons were identified:

1. Niskin sampling vessels are not suitable for repeated ultra-trace mercury sampling across large concentration gradients.

2. Mercury contamination of bottle materials, especially rubber closure bands, caused significant carryover effects.

3. Separate Niskin sampling vessels should be used for highly contaminated and background samples.

4. Future monitoring should include dedicated measurements of dissolved mercury.

5. Turbidity alone is not a reliable proxy for mercury concentrations at low concentration levels, or low turbidity measurements.

6. Greater spatial coverage of turbidity- and mercury fraction monitoring would reduce uncertainty in flux calculations.

7. Improved alignment between sampling systems and turbidity sensors, by positioning the sensors alongside the Niskin sample vessels, would improve plume characterisation.

8. Passive sampling of mercury using DGTs proved valuable in providing an indicator of time-averaged levels of dissolved inorganic mercury.

Overall, the monitoring programme successfully documented environmental conditions throughout the operation and identified all major mercury release events, while also providing valuable experience for improving future monitoring programmes at U-864.

Sammendrag

Miljøovervåking under kjøltilgangs- og kvikksølvbeholderoperasjonen ved U-864

Miljøovervåkingen ble gjennomført tilfredsstillende under hele operasjonen i juni 2026, til tross for flere tekniske og logistiske utfordringer. Den opprinnelige planen med faste målestasjoner for turbiditet kunne ikke gjennomføres, og overvåkingen ble i stedet utført ved hjelp av turbiditetssensorer montert på to ROV-er. Selv om dette reduserte den romlige dekningen av overvåkingsnettet, gjorde den mobile løsningen det mulig å aktivt spore turbiditetsskyer og sikre kontinuerlig operasjonell støtte gjennom hele kampanjen.

En referanseundersøkelse gjennomført i mars 2026 viste lave bakgrunnsnivåer av turbiditet (gjennomsnittlig 0,23 FNU) og kvikksølvkonsentrasjoner under analysemetodens kvantifiseringsgrense. Den reviderte overvåkingsmetoden fungerte som tiltenkt og ga kontinuerlig situasjonsforståelse under operasjonen.

Alarmer og operasjonell respons

Overvåkingssystemet utløste flere alarmer i løpet av operasjonsperioden, særlig den 23. juni 2026 da det pågikk omfattende mudringsaktiviteter. Forhøyede turbiditetsmålinger utløste oppfølgende prøvetaking i henhold til etablert overvåkingsprotokoll.

Den 23. juni viste flere vannprøver tatt nær operasjonsområdets yttergrense forhøyede kvikksølvkonsentrasjoner, inkludert tre prøver med konsentrasjoner på henholdsvis 2,17, 2,13 og 1,25 µg Hg/L. Dette var over grenseverdiene på 0,05 µg L^{-1} og stoppgrensen på 0,7 µg $L^{-}1$. Disse hendelsene førte til gjentatte alarmresponser, målrettet oppfølgende prøvetaking og midlertidig stans i mudringsaktivitetene inntil nærmere undersøkelser kunne gjennomføres.

Overvåkingsteamet fulgte den avtalte protokollen gjennom hele operasjonen, og forhøyede konsentrasjoner ble raskt identifisert, verifisert og kommunisert til operasjonsledelsen.

Kvikksølvkonsentrasjoner i sjøvann

Kvikksølvkonsentrasjonene varierte betydelig avhengig av prøvetakingslokalitet.

Bakgrunnsprøver

- Konsentrasjonene under referanseundersøkelsen var lavere enn 0,001 µg L^{-1}.
- Under operasjonen hadde de fleste bakgrunnsprøvene konsentrasjoner under 0,05 µg L^{-1}.
- Enkelte bakgrunnsprøver tatt mot slutten av operasjonen ble påvirket av kontaminasjon fra prøvetakingsutstyret.

Prøver fra turbiditetsskyen

- Generelt lave kvikksølvkonsentrasjoner.

- Konsentrasjonene var vanligvis i området 0,002–0,020 µg L^{-1}. Betydelige avvik ble imidlertid observert 23. juni, med konsentrasjoner over 1 µg L^{-1} og en maksimumsverdi på 2,17 µg L^{-1}.

- Det ble ikke observert noen tydelig sammenheng mellom turbiditet og kvikksølvkonsentrasjon.

Prøver fra mudringsområdet

- Konsentrasjonene lå typisk mellom omtrent 0,02 og 0,10 µg L^{-1}.

- Den høyeste konsentrasjonen målt ved vraket var 0,614 µg L^{-1}.

Passive prøvetakere

Tidsmidlede konsentrasjoner av DGT-labilt uorganisk løst kvikksølv, målt med passive DGT-prøvetakere, gir et supplerende estimat på nivåene av løst kvikksølv i vannet. På grunn av betydelige usikkerheter må resultatene imidlertid tolkes med forsiktighet.

- Bakgrunnsstasjonene (TU-Ref. (5), TU-1 og TU-2) viste generelt konsentrasjoner under deteksjonsgrensen.

- Svært høye tidsmidlede konsentrasjoner av DGT-labilt uorganisk løst kvikksølv ble målt ved mudringsområdet: henholdsvis 38 og 32 µg Hg L^{-1} på taket av filtercontaineren og nederst på Spider-enheten.

- Nedstrøms for mudringsområdet, ved yttergrensen av operasjonsområdet (TU-3 og TU-4), ble det målt høye tidsmidlede konsentrasjoner av løst kvikksølv 2 m over sjøbunnen (henholdsvis 2,8 og 1,2 µg Hg L^{-1}), noe som indikerer en potensielt betydelig fluks av løst kvikksølv til omgivelsene.

Omtrent 73 % av alle analyserte prøver inneholdt mindre enn 50 ng Hg L^{-1}. Resultatene indikerer videre at en betydelig andel (rundt 38 %) av kvikksølvet forekom i løst form. Konsentrasjonene av metylkvikksølv (MeHg) holdt seg veldig lave gjennom hele overvåkingsprogrammet. MeHg var under kvantifiseringsgrensen (<0,03 ng L^{-1}) i de fleste prøvene, mens de påviste konsentrasjonene lå mellom 0,03 og 0,33 ng L^{-1}. Resultatene tyder på at de høye konsentrasjonene av løst kvikksølv som ble observert under mudring, bestod hovedsakelig av uorganisk kvikksølv og ikke metylkvikksølv.

Resultater fra sedimentfeller

Sedimentfellene som ble utplassert rundt operasjonsområdet samlet opp målbare mengder forurenset materiale gjennom hele overvåkingsperioden. Analysene viste tydelige romlige forskjeller både i sedimentakkumulering og kvikksølvkonsentrasjoner. De høyeste kvikksølvkonsentrasjonene ble målt ved stasjonene TU-3 og TU-4. Disse er lokalisert NV og N for ubåtvraket. Dette er nedstrøms den dominerende strømningsretningen. Her inneholdt sedimentene omtrent 30–79 mg Hg/kg tørrvekt. Stasjoner lenger fra mudringsaktiviteten hadde generelt lavere konsentrasjoner, typisk i området 3–13 mg Hg/kg tørrvekt.

Det innsamlede materialet besto hovedsakelig av finkornede partikler, og de fleste prøvene inneholdt mer enn 50 % materiale finere enn 63 µm. De forhøyede kvikksølvkonsentrasjonene i sedimentfellene

bekrefter at kvikksølvforurensede partikler ble transportert og avsatt under operasjonen. Samtidig indikerer den romlige fordelingen at størstedelen av partikkelavsetningen skjedde relativt nær mudringsområdet, mens lavere konsentrasjoner ble observert ved de ytre stasjonene.

Samlet sett gir sedimentfelleresultatene en uavhengig bekreftelse på at kvikksølvholdige partikler ble frigjort under operasjonen. Resultatene støtter konklusjonen om at både partikkelbundet og løst kvikksølv bidro til den observerte spredningen utenfor det arbeidsområdet.

Daglige flukser av kvikksølv og partikler

De daglige modellberegningene viste at både transporten av partikler og kvikksølv varierte betydelig gjennom operasjonsperioden. Den estimerte partikkelfluksen varierte fra omtrent 7 til 145 tonn per dag, med en total estimert transport ut av operasjonsområdet på omtrent 279 tonn partikler.

Den estimerte kvikksølvfluksen varierte fra omtrent 17 til 2212 g Hg per dag. Den største spredningshendelsen inntraff mens den mest intense muddringsaktiviteten pågikk den 23. juni, da kvikksølvfluksen ble estimert til omtrent 2,2 kg Hg per døgn. Dette oversteg den operative grenseverdien på 375 g per døgn. Denne dagen sto for størstedelen av den totale estimerte kvikksølvtransporten.

Figur 1 viser den romlige fordelingen av kvikksølv (Hg) i vannprøver som ble samlet inn under perioden med maksimal mudringsaktivitet (23. juni). Forhøyede Hg-konsentrasjoner ble hovedsakelig observert nordvest og nord for mudringsområdet, noe som indikerer at dette var den dominerende transportretningen for Hg. Dette mønsteret støttes av integrerte 10-døgnsmålinger fra sedimentfeller og passive DGT-prøvetakere, som også viste de høyeste konsentrasjonene av partikkelbundet og labilt uorganisk Hg i samme sektor. Samsvaret mellom disse uavhengige overvåkingsmetodene indikerer at hovedskyen av Hg ble transportert mot nordvest og nord gjennom hele mudringsoperasjonen. Overskridelser av grenseverdiene på 0,05 μg L^{-1} (første varselnivå, økt overvåking) og 0,7 μg L^{-1} (stoppkriterium) var begrenset til lokaliteter nær mudringsområdet og langs denne spredningskorridoren, mens konsentrasjonene utenfor dette området generelt var lave.

Den kumulative estimerte spredningen av kvikksølv under operasjonen var omtrent 3,2 kg Hg. Disse beregningene bør tolkes med forsiktighet på grunn av usikkerheter knyttet til sporing av skyen, og omregningen mellom kvikksølv- og turbiditetsmålinger som ble benyttet i modelleringen.

Erfaringer og anbefalinger

Flere viktige erfaringer ble identifisert:

1. Niskin-flasker er ikke godt egnet for gjentatt prøvetaking av ultralave kvikksølvkonsentrasjoner over store konsentrasjonsgradienter.

2. Kvikksølvforurensning av flaskematerialene, spesielt gummibåndene i lukkemekanismen, førte til betydelige carryover-effekter.

3. Separate prøvetakingsbeholdere bør benyttes for sterkt kontaminerte prøver og bakgrunnsprøver.

4. Fremtidige overvåkingsprogrammer bør inkludere egne målinger av løst kvikksølv.

5. Turbiditet alene er ikke en pålitelig indikator for kvikksølvkonsentrasjoner ved lave konsentrasjoner eller lave turbiditetsnivåer.

6. Bedre romlig overvåking av turbiditets- og kvikksølvfraksjoner vil redusere usikkerheten i fluksberegningene.

7. Bedre samlokalisering av prøvetakingsutstyr og turbiditetssensorer, ved å plassere sensorene ved siden av Niskin-prøvetakningsbeholderne vil gi en mer representativ karakterisering av turbiditet/Hg forholdet.

8. Passiv prøvetakning av kvikksølv ved bruk av DGTer, som indikerer nivåene av gjennomsnittskonsentrasjonen over tid av løst uorganisk Hg, har vist seg å gi nyttig informasjon.

Samlet sett dokumenterte overvåkingsprogrammet miljøforholdene gjennom hele operasjonen på en vellykket måte og identifiserte alle større hendelser med frigjøring av kvikksølv. Programmet ga samtidig verdifull erfaring som kan bidra til å forbedre fremtidige overvåkingsprogrammer ved U-864.

1 Introduction

The aim of the environmental monitoring component of the project was to ensure that offshore operations were carried out in a manner that prevents unacceptable spreading of mercury contamination beyond the immediate surrounding marine environment. The focus was on particle-bound and dissolved mercury fractions. The monitoring programme was designed to document baseline mercury levels, monitor mercury levels in the water during operations, and provide timely data to support operational decision-making and regulatory compliance.

In March 2026 a baseline survey was conducted to establish background levels of turbidity, mercury concentrations in water, and prevailing current conditions. These baseline data serve as a reference against which all subsequent measurements are assessed. During the June operation, the monitoring programme provided almost continuous measurements of turbidity along with regular and alarm-triggered water sampling for analysis of mercury fractions. Passive mercury samplers were mounted on subsea equipment during the operation. Sediment traps were deployed in the perimeter throughout the operational period to quantify particle flux and accumulated mercury, allowing post-operation estimation of total contaminant spread.

A central objective of the monitoring was early detection of any exceedance of acceptance criteria defined by the Norwegian Coastal Administration (NCA). Real-time data transfer and automated alarm systems ensured that elevated turbidity, indications of potential mercury release, was rapidly identified. This enabled prompt verification through targeted water sampling and analysis of mercury fractions that supported immediate implementation of mitigation measures or suspension of activities when necessary.

In addition to safeguarding the environment during execution, the monitoring programme aimed to provide a transparent, well-documented record of environmental performance. This included daily reporting, quality-controlled measurements, and post-operation assessments, ensuring compliance with regulatory requirements, and supporting evaluation of the overall environmental impact of the project.

2 Materials and methods

2.1 Sensors and sampling equipment

NIVA equipped both work-class ROVs, Supporter (S27) and Constructor, with CTD sensors for continuous monitoring of water column conditions during the dredging operation. The Supporter ROV served as the primary platform for NIVA's environmental monitoring programme, carrying CTD instrumentation, turbidity sensors, and water sampling bottles for collection of samples during periods of elevated turbidity. The Constructor ROV was primarily assigned to operational support tasks related to dredging, wreck access, and seabed investigations, but functioned as a backup monitoring platform whenever the Supporter ROV was unavailable. This ensured continuity of real-time environmental monitoring throughout the operation. The two NIVA deployed CTD (conductivity, temperature and depth) systems were equipped with Seapoint optical turbidity sensors during the monitoring operations. An Idronaut Ocean Seven 316Plus (OS316+) CTD sensor along with Seapoint turbidity

sensor was mounted to the Supporter ROV for continuous measurements of conductivity, temperature, pressure/depth, salinity, and turbidity during subsea operations (Figure 1).

In addition, a SAIV SD204 CTD sensor and a Seapoint turbidity sensor was mounted to the Constructor ROV to provide supplementary real-time monitoring close to the operational area.

During operations, the downstream transport of turbid water masses, governed by local current conditions, was continuously monitored using the ROV-mounted sensor systems.

The Supporter ROV was additionally equipped with five 2 L rosette free-flushing Niskin sampler vessels (Figure 2) used for targeted water sampling within turbidity plumes originating from the dredging activities. A standard PVC Niskin type sampler was used. This is made of grey PVC (RAL 7011) with a spring closure made of latex tubing. Water samples were collected by closing the two lids on the vessels within the plume identified through video inspection and real-time turbidity measurements.

Aliquots of the collected water samples were retained onboard the ship for subsequent immediate laboratory analysis of mercury fraction levels.

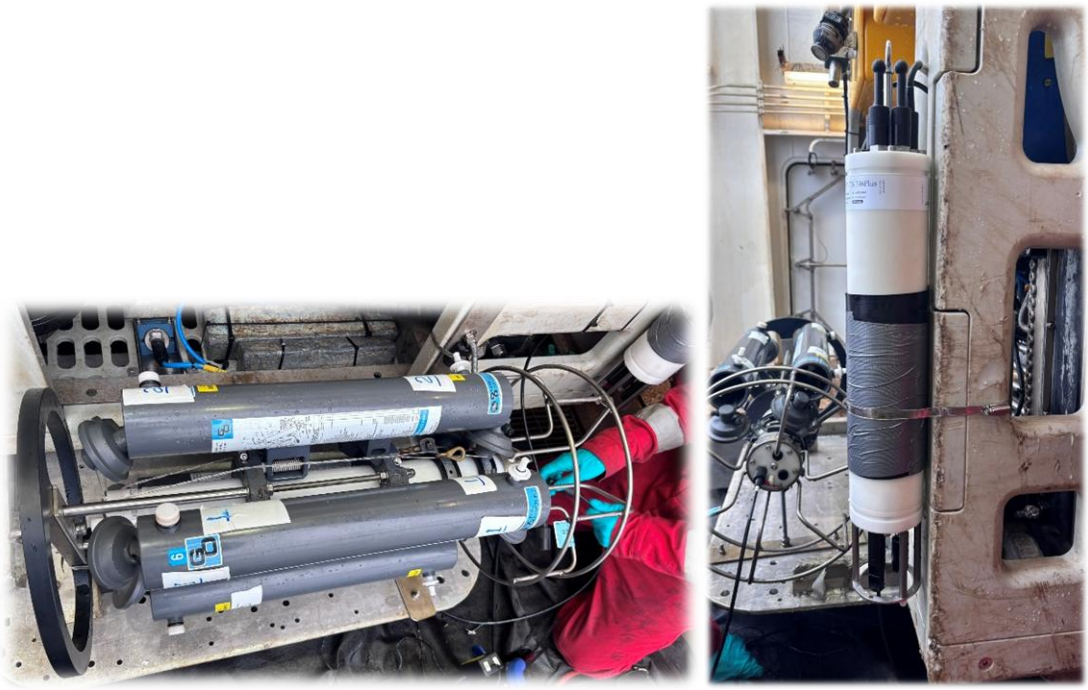

Figure 2. Niskin water sampling vessels and Idronaut Ocean Seven 316Plus (OS316+) CTD with Seapoint turbidity sensor mounted on the bottom and top of the Supporter ROV, respectively.

2.2 Chemical analysis

2.2.1 Analysis of water samples

Onboard analysis of mercury in water samples was conducted using cold vapour atomic absorption–based instrumentation (RA7000A with an EMP-3 Gold+ as backup instrument).

Samples for onboard total mercury analysis were digested with suprapure nitric acid (1% v/v) for at least 15 minutes before analysis. This allowed all the mercury to be oxidized to Hg^{2+} (Hg(II)). For

dissolved mercury analysis, aliquots were filtered through 0.45 µm filter cartridges before digestion. Immediately upon analysis Hg(II) was reduced to elemental form (Hg(0)) using a stannous chloride ($SnCl_2$/HCl) solution and purged from the sample into the detector using clean air. The instruments quantified spectrophotometrically by absorbance @ λ254 nm the total mass of mercury introduced to the system, based on a previous calibration curve.

Instrument calibration was verified before the field campaign, and analytical performance during the operation was monitored using blank seawater samples and matrix-matched control samples with 0.05 and 0.7 µg Hg L^{-1}. Field blanks collected during the baseline survey in March and before dredging activity in June were used to establish background mercury concentrations. All analysed baseline samples in March showed mercury concentrations below the limit of quantification (0.001 µg Hg L^{-1}), and no elevated mercury levels were detected during the March cruise. During the June operation, 80 samples from the background and perimeter locations, in the plume, and at the dredging site, as well as vertical water profile samples, were collected and analysed for mercury content. Analytical results were documented contemporaneously to ensure data quality and traceability.

As described in Chapter 3.2.2, the background samples collected during the June dredging operation were affected by carryover mercury contamination from the free-flushing Niskin sampling vessels, which had been exposed to environments with varying concentrations of dissolved inorganic mercury. A reliable correction for this contamination is not possible because the magnitude of the carryover depended on several factors, including the previous exposure history of each sampling bottle and the residence time of the water sample in the Niskin sampling vessel. These results are therefore not considered representative background values and are excluded from the assessment of mercury fluxes. Instead, the background total mercury concentration is set to between 0.001 and 0.002 µg Hg L^{-1}, based on the baseline samples collected in March, which were all below the LOQ (0.001 µg Hg L^{-1}, Chapter 3.1), together with the two background samples collected on 19 June before dredging commenced.

Samples with clearly elevated mercury concentrations, arbitrarily defined as concentrations above 0.05 µg Hg L^{-1}, are not considered to have been significantly affected by the carryover contamination. This is because these concentrations are more than an order of magnitude higher than the adopted background level and are therefore unlikely to be explained by residual mercury desorbing from the sampling bottles. In addition, the magnitude of any carryover would be constrained by the sorption–desorption equilibrium between mercury associated with the Niskin sampling vessel surfaces and the sampled water.

The dissolved mercury fraction was speciated, assuming equilibrium conditions between dissolved species, using the MINEQL+ 5.0 Chemical Equilibrium Modelling System (Schecher, 2024). For the speciation, the total molar composition of seawater (salinity = 35‰) was used at 5.5 ^{o}C with correction for ionic strength calculated by the model.

2.2.2 Estimation of time-averaged dissolved Hg from passive samplers

Diffusive Gradients in Thin Films (DGT) (DGT Research, n.d.-a) is an in situ passive sampling technique for the quantitative analysis of contaminants such as mercury. The method is based on the diffusion of ions through a hydrogel and subsequent adsorption to a binding medium (Noh et al., 2016; Garmo

et al., 2003; Davison & Zhang, 1994; Davison et al., 2000; Zhang & Davison, 2000, 2001). This approach measures the concentration of labile metal species – the sum of free ions, inorganic metal–ligand complexes and some metal–organic material complexes – depending on their size, diffusion coefficients, stability and kinetics of association and dissociation.

LSnB-AP loaded DGT devices for mercury in solution (DGT Research, n.d.-a) were attached to equipment and deployed at the seabed during the operation (Chapt. 4.3). After the operation, the passive samplers were collected. The total content of accumulated mercury in the absorbent material was determined at NIVA using the RA7000A mercury analyser (Chapter 4.2.1).

The time-averaged concentration of inorganic labile mercury was then calculated based on the equation:

$$C_{DGT} = \frac{M \cdot \Delta g}{D \cdot A \cdot t}$$

Where,

C_{DGT} is the concentration in the solution (µg L^{-1})
M is the measured mass of Hg in the absorbent (ng)
Δg is the thickness of the gel and membrane (0.094 cm)
D is the diffusion coefficient at a given temperature (cm^2 s^{-1})
A is the surface area of the DGT membrane (3.14 cm^2)
t is the exposure time (s)

The assumed mercury diffusion coefficient at an average 7.85 ^{o}C, taken from the DGT-Research (n.d.,b) website was integrated to $4.77 \cdot 10^{-6}$ cm^2 s^{-1}.

It should be noted that the diffusion coefficient of mercury in DGT applications is somewhat uncertain (DGT Research, n.d.-b). The DGT method should therefore only be considered as a supplement to the existing environmental monitoring program, rather than a replacement. Nevertheless, the DGT results contribute to documenting the presence of DGT-labile inorganic mercury and guiding the overall mass balance for mercury.

2.2.3 Analysis of sedimented material

Dry substance

The sediment trap material was collected in 1 L plastic bottles at the end of the fieldwork, and the water samples were transported to NIVA Oslo. The bottles were sorted on a tabletop where the sediment material was allowed to resettle at the bottom of the bottles. Water was then decanted from the top of each bottle by use of a full pipette, taking care not to disturb the sediments in the bottom of the bottles.

The contents of each bottle were then transferred into pre-weighed 150 mL glass containers, using small quantities of Type 1 water to rinse out sediments sticking to the inside of the original bottles. The samples were once again allowed to settle for a few hours before more water was decanted from the glass containers using a pipette. After the process was finished, each container had approximately 25 mL of water in addition to the sediments.

The glass containers were then placed in a freezer to fully freeze over before freeze-drying for two days. Freeze-drying was chosen over drying in an oven in order to avoid losing mercury from the material.

The samples were then weighed once more. The amount of dry substance was then calculated by subtracting the weight of the glass containers from the weight of the glass containers + the dried material.

The initial plan was to analyse dry substance accredited using a subcontractor. However, due to the very small amount of material obtained, it was agreed with the NCA that the analysis could be performed non-accredited at NIVA. This was especially important since the material obtained in the dry substance analysis was to be analysed for several parameters later on.

While the analysis is not accredited at NIVA, the quality was assured by using a balance which has been calibrated by Mettler Toledo (accredited calibration laboratory). In addition, the balance has a control chart where a weight is measured and noted for each day the balance is used.

Total mercury

Total mercury in small amounts of dried, sedimented sample was determined at Akvaplan-niva in Tromsø using a DMA-80 direct mercury analyser, based on US EPA method 7473 (SW-846). Due to the small amount of material obtained from the sediment traps, there was not enough material to send it to a subcontractor which could have analysed the total mercury accredited.

Total organic matter

A portion of the dry sedimented material was analysed for total organic carbon using a Thermo Flash 2000 elemental analyser. The analysis was performed accredited, by NIVA. The method follows the principles from ISO 10694:1995. A small amount of material is weighed into a tin capsule. HCl is added to the material in order to remove inorganic carbon, before the capsules are closed and combusted in the instrument. The carbon left in the sample is then measured as CO_2.

Grain size distribution

To perform an accredited grain-size analysis, a minimum of 10 g of material was required. Because only small amounts of dry material were available, it was decided to determine the grain-size distribution at NIVA instead.

A subsample of the dry substance was weighed and transferred to a sieve with a mesh size of 63 µm. The material was then rinsed with water, allowing particles <63 µm to pass through the sieve while particles > 63 µm were retrained. The retained fraction was collected on pre-weighed filter papers, dried overnight, and weighed the following day.

The increase in filter-paper weight was used to determine the mass of material > 63 µm. The mass fraction <63 µm was calculated by difference from the initial dry sample mass

While the analysis is not accredited, the balance used for weighing the samples has been calibrated by Mettler Toledo (accredited calibration laboratory). In addition, the balance has a control chart where a weight is measured and noted for each day the balance is used. A measurement uncertainty of up to ± 5% must be assumed.

2.3 Fieldwork and sampling

During the previous operation in 2016, five turbidity rigs were deployed at the perimeter around the wreck and at a reference location. During the cruise in March 2026, five sediment traps were deployed at approximately the same positions (Figure 3). Each rig had sediment traps and DGT passive inorganic mercury samplers at 2 and 10 meters above the seafloor. Each sediment trap consisted of two tubes (diameter = 19 cm) mounted on a steel holder. These traps were placed at the monitoring stations named TU-1 to -4 and TU-Ref. (5)) (Figure 3). The original plan was to also deploy turbidity sensors at these positions.

The sediment traps and DGTs were left on the seafloor until the June operation. The sediment traps were then inspected and emptied by having a ROV tilt and flush them on June 18th at hr. 12, before the operation started. One of the tubes was discovered to be damaged at the start of the June operation (after 3 month in the sea) and could not be used (one of TU-2 from 2 m depth).

During the start of the June operation, new DGTs were installed on the turbidity rigs when the sediment traps were rinsed (18.06 at hr. 12), as well as on the two ROVs, Spider, currency meter (ACDP), and on the roof and inside the filter container (Figure 1). Old and new DGTs were all sampled at the end of the June operation. Sediments in the sediment traps and DGTs on the turbidity rigs were collected on 26. – 27.06

The filter container was supposed to trap all the dredged material that was pumped into it. Inside the container, the plume was expected to settle and thereby reduce the mercury that was spread. The container was, however, not operational.

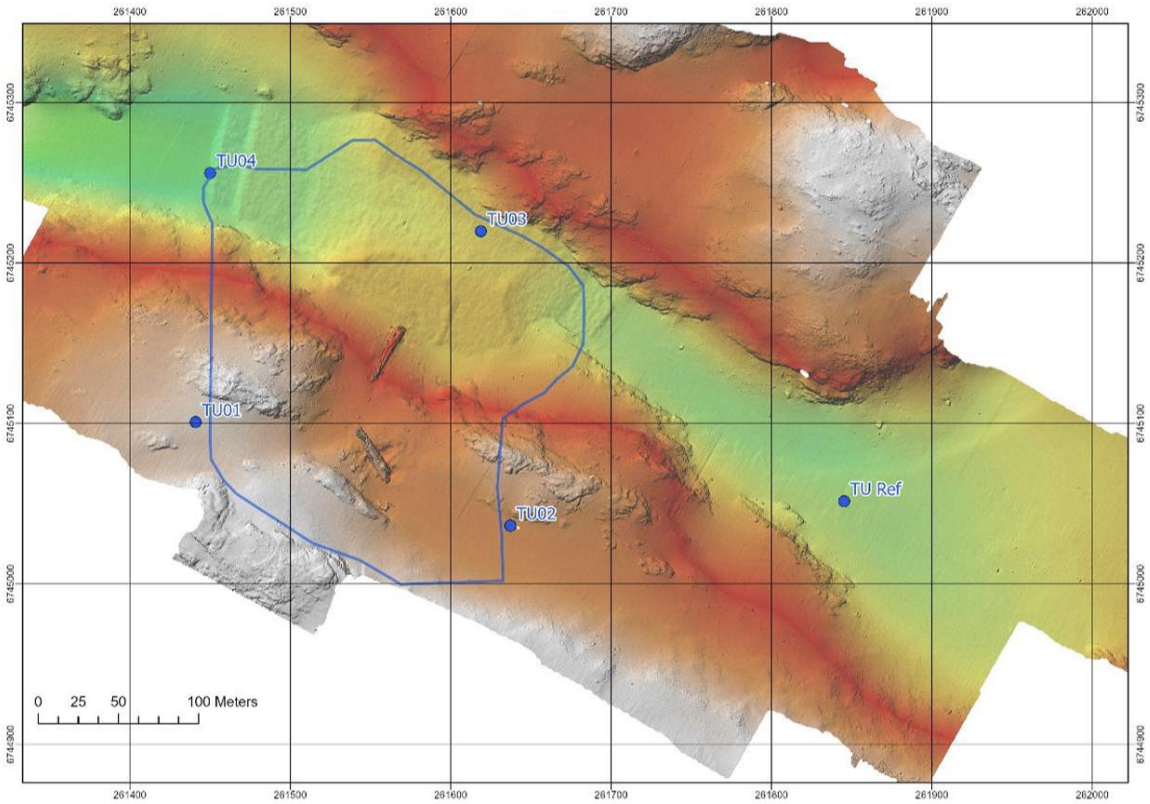

Figure 3. Location of rig stations used for sediment traps and DGTs. TU Ref is also called TU-5 in the report.

2.4 Change of turbidity measurement method

Due to failure to place the online turbidity measurement rigs in the sea, it was decided to utilise the ROVs to monitor turbidity rather than the originally planned turbidity measurement rigs. This change is documented in REACH-600096-MOC-009 and approved by the NCA.

This method utilised only the turbidity measurements from the CTD mounted on the Supporter ROV to measure turbidity (Chapter2.1) rather than the 10 points (5 locations and 2 depths) used in the original plan, with the backup from the CTD on the constructor ROV. However, as the CTD/turbidity meter was mounted on ROVs, they were mobile. The Supporter ROV was designated to monitor turbidity on the edge of the future capping area and was to be positioned downstream of the work area based on current measurements from the ADCP. However, the ROV was limited by the length of its tether, as well as other seafloor equipment and tethers. Due to this, the ROV was not always able to be positioned at or close to the perimeter. In addition, the supporter ROV was on several occasions needed for other subsea tasks. The ROV was also able to patrol back and forth in order to catch a potential cloud of turbidity. These turbidity measurements were the basis both for triggering alarm conditions of increased turbidity as well as being the only turbidity measurements contributing to the calculation of spreading of particles outside the future capping area (Chapter 3.4). If the alarm threshold was exceeded—defined as turbidity levels averaging more than 10 FNU above the background level (established during the baseline survey) over a 20-minute period—the Supporter ROV was mobilised to collect water samples and perform a vertical turbidity profile of the water

column before returning to the vessel for laboratory analysis of the water samples. During alarm conditions, the Supporter ROV was no longer available for continuous turbidity monitoring. In such situations, the Constructor ROV was repositioned to maintain turbidity monitoring along the boundary of the defined "operational area" indicated by the blue line in Figure 3.

These calculations were then used together with current measurements from the ADCP and total mercury data from the water samples vs. turbidity for the same samples to estimate the spread of mercury on a daily basis.

An additional turbidity measurement point was mounted on the *Constructor* ROV. This ROV operates in close proximity to the subsea work area, with its position determined by the ongoing operation. Turbidity data collected by the *Constructor* ROV in the immediate vicinity of the work area were not used for modelling the spreading of mercury but served as an early-warning indicator of potential exceedance of the alarm threshold.

2.5 Modelling the daily flux of Hg

The daily flux of mercury out of the operational perimeter (shown with red polygon in Figure 3), with unit g Hg/day, were calculated based on (described in more details in procedure 260042-6 Procedure for Hg-flux calculations):

1. Current measurements, where the east-west and the north-south components, are measured continuously.
2. Online turbidity measurements from the CTD/turb unit mounted on the Supporter ROV (ROV dedicated to monitoring). Thus, turbidity will only be measured at one point at a time, rather than the original plan using 5 stations and two depths pr station.
3. The estimated mercury/turbidity ratio.

For calculation of the spreading of mercury from the wreck area, the area was enclosed by a polygon shown in Figure 3 as a blue line. In the calculation, we used a polygon corresponding to the one in the map, but where the polygon consisted of straight lines (sections), as shown in Figure 4.

The flux of particles perpendicular to these sections away from the focus area was estimated by multiplying a background-corrected turbidity profile with a current profile perpendicular to each line segment, and then multiplying this product by the vertical area, as indicated in Figure 5.

To estimate a vertical profile from turbidity measurements from the Supporter ROV in one depth, the measured was multiplied with a vertical vector, with the value one in the depth where the Supporter ROV was measuring high values most frequent (at 158 m depth). Near the bottom this value was reduced to 50 %. The value was reduced to 60 % 3 m above, to 30 % 13 m above, to 10 % 23 m above and to 5 % 58 m above (at 100 m depth).

The resulting flux of particles (in turbidity units) was multiplied by the mercury-to-turbidity ratio (Hg:Turb) determined from the water samples. Turbidity was measured downstream using instruments mounted on the ROV.

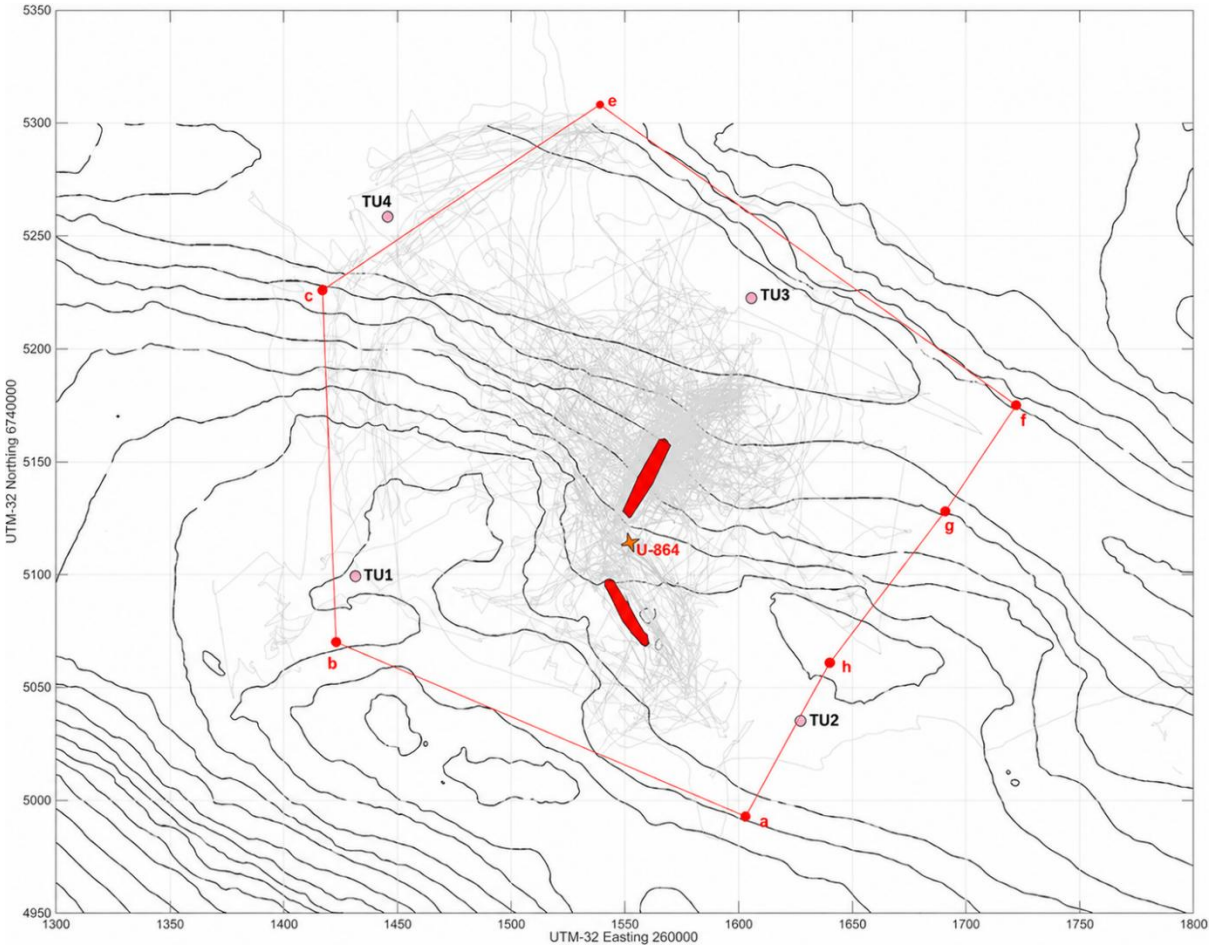

Figure 4. Map of the polygon used for Hg flux calculations. The polygon is defined by seven positions (a, b, c, e, f, g, and h), shown as red dots. Black lines indicate depth contours. The two sections of the submarine are shown in red. Thin grey lines represent the Supporter ROV track. Pink annotation indicates the location where elevated mercury concentrations were detected on 23 June. Sediment traps are marked with pink dots, and the station for current measurements with an orange star. The contour lines on the map are spaced at 5 m elevation intervals.

To determine the extent of a possible particle cloud, the Supporter ROV performed a search pattern along the boundary of the non-spread area, or as close as the Supporter ROV was able to go to the perimeter line (see gray lines in Figure 4) after the Supporter ROV operator had identified the downstream position.

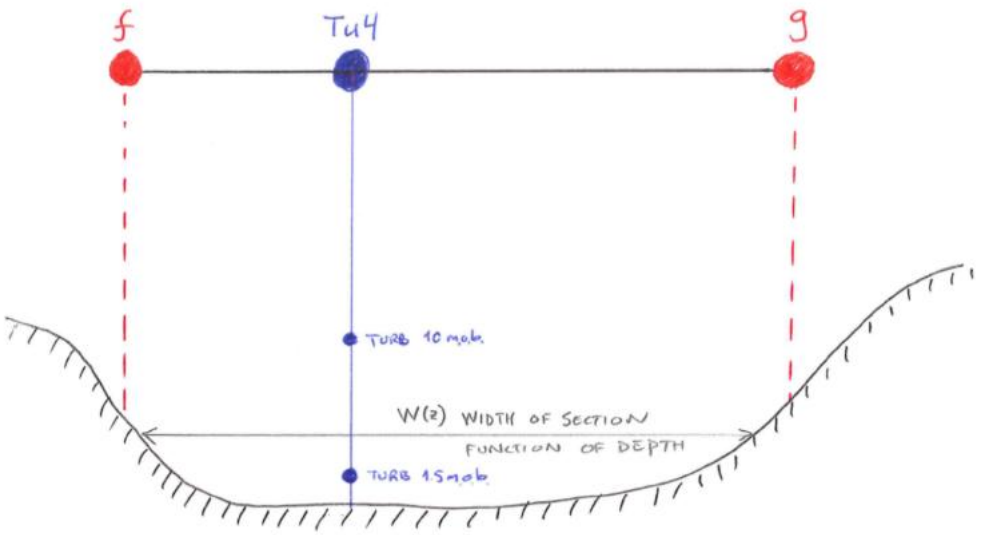

Figure 5. Sketch of one out of a total of seven sections that enclose the operation area (shown in fig 6). Turbidity was measured downstream of the working area. f and g was determined based on the lateral distribution of the turbidity cloud, see description in text.

The uncertainty in the estimated particle flux reflects natural variations in turbidity and current conditions, as well as the limitations of the measurements used in the calculations. Turbidity is expected to be the largest contributor to this uncertainty because it varies more than the current conditions.

The current velocity component perpendicular to and directed outward from the polygon, $U_n(z)$, was determined for each line segment (n) based on current measurements using basic trigonometry. Negative values, indicating flow into the polygon, were excluded from the flux calculations and assigned a value of zero, as the objective of the monitoring programme was to estimate the transport of particles out of the polygon resulting from the operation.

The following formula was used calculating the particle flux for each section n

$$F_{n,p} = \int_{seabed}^{surface} W_n(z) \cdot U_n(z) \cdot C_n(z) \cdot dz$$

Where W_n is the width of line segment n as a function of the distance from the seabed z. C_n is the particle concentration measured as turbidity. The particle fluxes were averaged over a time period, initially set to one day, and summed up for all segments n, giving the daily particle flux, F_p out of the polygon.

Turbidity plots, vertical distribution of turbidity clouds and alignment of current measwurements are found in Appendix 2.

3 Results and discussion

3.1 Baseline survey

A partial baseline survey was performed during the operation in March 2026.

The original baseline survey plan included turbidity measurements and current measurements at 5 locations and 2 depths over a 6-hour period, as well as total mercury concentrations in water samples with a known turbidity.

As the turbidity rigs were not operational, a baseline measurement over 6 hours at one point was performed by NIVA using two CTD/turbidity meters mounted on the “Supporter” and “Constructor“ ROVs. The Baseline measurements were conducted at TU-3 (Figure 6) and TU-4 (Figure 7) from 21-03-2026 22:16 until 22-03-2026 4:16 UTC.

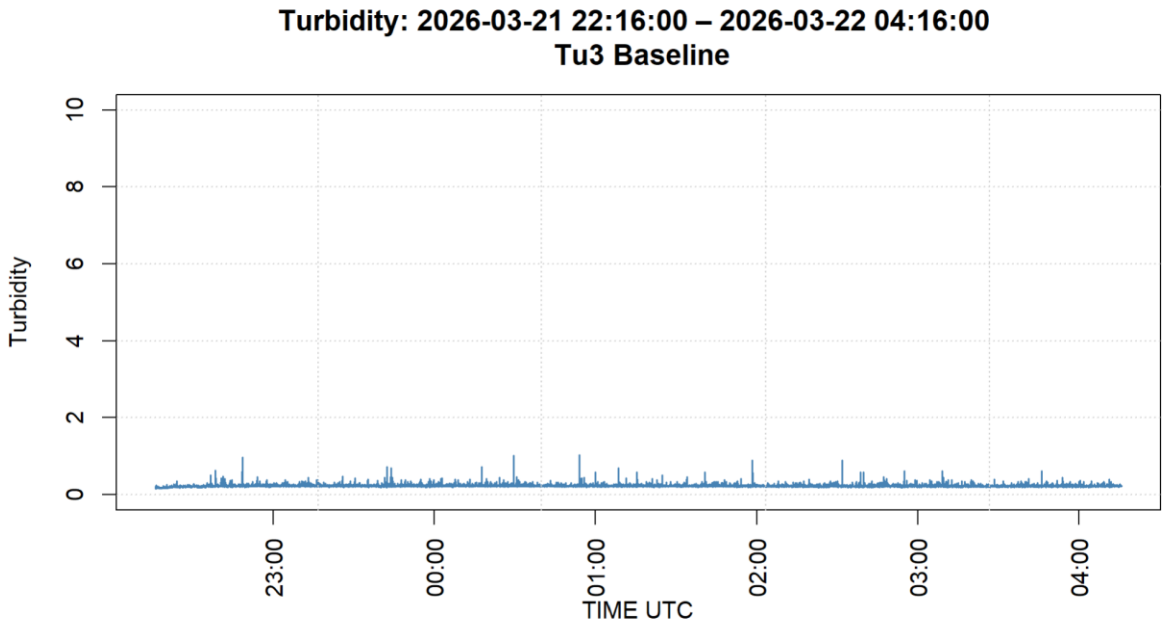

Figure 6. Baseline turbidity on TU-3, average turbidity was 0.23 FNU and the maximum was 1.0 FNU.

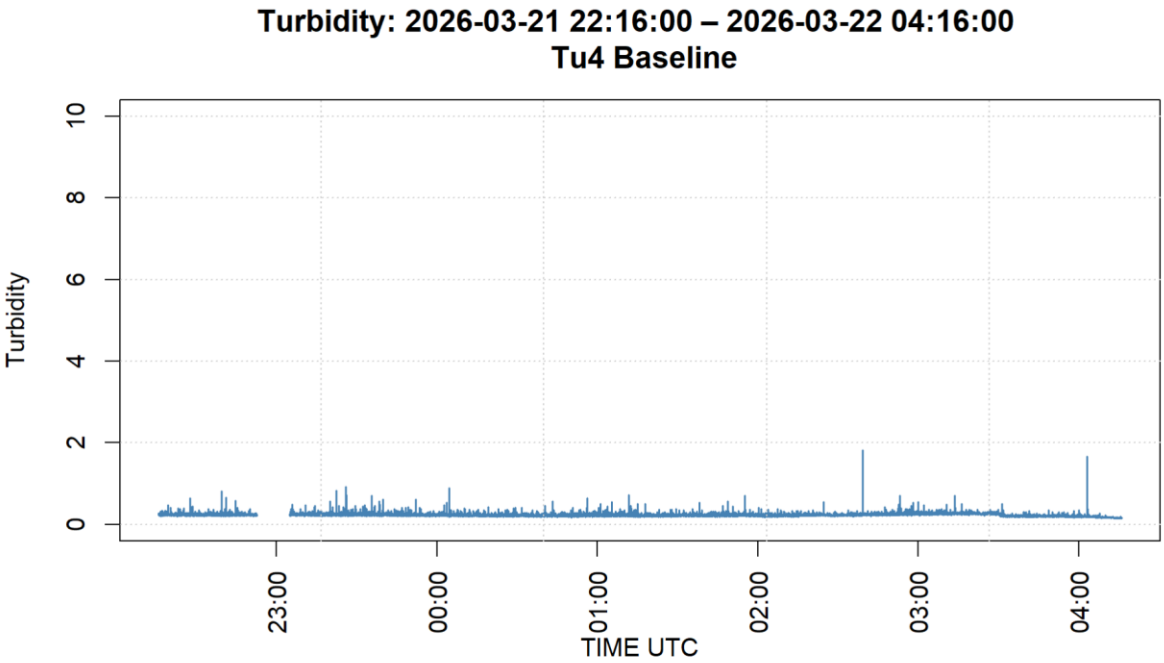

Figure 7. Baseline turbidity on TU-4, average turbidity was 0.23 FNU and the maximum was 1.8 FNU. The cause for the hole in the data around 23:00 is due to sensor or communication issues.

During the baseline survey a total of 4 water samples were collected as well as 3 samples at 35 to 50 m depth while the ROVs were returning to the vessel. All samples had a total mercury content below our limit of quantification (LOQ), which was 0.001 µg L^{-1} (see

Table 1).

Table 1. Mercury content in water samples during the baseline survey in March 2026.

Sample station	Altitude*	Total mercury content
TU-3	5 m	<0.001µg L^{-1}
TU-3	5 m	<0.001µg L^{-1}
TU-4	5 m	<0.001µg L^{-1}
TU-4	5 m	<0.001µg L^{-1}
Water column	35-50 m	<0.001µg L^{-1}
Water column	35-50 m	<0.001µg L^{-1}
Water column	35-50 m	<0.001µg L^{-1}

*meters above the seabed.

According to the agreement with NCA, it was decided that the baseline established during the March cruise was to be used in the operation in June.

3.2 Water samples - Analytical results for levels of mercury

3.2.1 Total mercury

Total mercury (Hg) concentrations were determined onboard in 80 seawater samples collected during the operation. During the campaign, it became evident that the free-flushing Niskin sample vessels mounted on the bottom of the ROVs were contaminated by exposure to elevated concentrations of inorganic mercury. This resulted in a carryover effect, causing falsely elevated mercury concentrations in subsequent background and low-concentration (< 0.05 µg Hg L^{-1}) samples. The nature and implications of this contamination are discussed in 3.2.2.

Background total mercury concentrations measured in the daily, blank, and vertical profile samples are presented in Table 2. The mean background concentration was 0.017 µg L^{-1}. However, this value is likely biased high due to carryover contamination, implying that the true background concentration was probably lower. During the Baseline survey (Chapter 5.1) all samples had a total mercury content below limit of quantification (LOQ), which was 0.001 µg L^{-1}. True background levels are thus likely between 0.001 and 0.002 µg L^{-1} as represented by samples collected during the first day before dredging had started. One water-column sample collected at a depth of 131 m (32 m above the seabed) contained 0.127 µg Hg L^{-1}, substantially exceeding the remaining background measurements as well as the acceptance criteria (0.05 µg Hg L^{-1}). The cause of this elevated concentration is unknown but may be due to the carryover effect.

While many of the fieldwork samples have likely been affected by the carryover effect, the values in Table 2 - 6 have not been corrected for carryover. As discussed in Chapter 3.2.2, the variable nature of the carryover means that no certainty can be given to any form of correction value. Trying to correct for the carryover will therefore add extra levels of uncertainty to numbers that are already uncertain.

The main challenge presented by the carryover effect was practical in nature, as the mercury concentrations sometimes got close to the alarm concentrations, which meant additional monitoring to assess the situation. The concentrations were still far away from the concentration levels which meant stopping the operation.

The carryover effect does not significantly influence the calculations used for estimating the total spread of mercury during the operation, as the blank and low concentration samples do not have a significant influence of the estimated mercury-to-turbidity ratio.

Table 2. Total mercury concentration in field blanks and vertical profile samples.

Sample no	Sampling time UTC	Sample type	Mercury (µg L^{-1})
13	19.06.2026 08:33	Test sampling at wreck site	**0.002**
14	19.06.2026 08:38	Test sampling at wreck site	**0.001**
15	19.06.2026 08:38	Test sampling at wreck site	0.012
19	20.06.2026 07:49	Field blank	0.004
25	20.06.2026 08:01	Sample at high altitude (Field blank)	**0.127**
30	22.06.2026 03:41	Field blank	0.010
31	22.06.2026 05:52	Vertical sample profile	0.019
32	22.06.2026 05:52	Vertical sample profile	0.019
33	22.06.2026 06:04	Vertical sample profile	0.020
34	22.06.2026 06:07	Vertical sample profile	0.010
36	22.06.2026 03:42	Field blank	0.005
39	22.06.2026 21:12	Field blank	0.024
40	23.06.2026 01:01	Field blank	0.007
41	23.06.2026 04:28	Field blank	0.005
42	23.06.2026 04:28	Field blank	0.015
43	23.06.2026 07:03	Field blank	0.014
48	23.06.2026 12:34	Field blank	0.009
52	23.06.2026 12:59	Field blank	0.032
80	26.06.2026 05:45	Field blank	0.015
83	26.06.2026 13:01	Field blank	0.015
84	27.06.2026 13:56	Field blank	0.003
85	27.06.2026 13:57	Field blank	0.005

Total mercury concentrations in samples collected from the turbidity plume (**Error! Reference source not found.**) before major dredging activity on June 23rd ranged from 0.002 to 0.020 µg Hg L^{-1}, corresponding to the lower end of the concentration range observed in the background samples (Table 1).

The two highest plume concentrations (0.020 and 0.013 µg Hg L^{-1}) coincided with moderately elevated turbidity (4.42 and 6.40 FNU, respectively). However, the sample with the highest turbidity (7.00 FNU) contained only 0.005 µg Hg L^{-1}, indicating no consistent relationship between turbidity and total mercury concentration at these low levels within the plume. This inconsistency may be due to the samples being collected at the bottom of the ROV while the turbidity sensor used for monitoring is located at the top. Considering the likely large spatial gradients in turbidity and mercury levels in the plume the turbidity measured 2 – 3 meters above the sampling depth may not be representative for the water samples that were collected for mercury analysis. In addition, the possible mercury contamination of the Nisking sample vessels (Chapter 5.2.2) at this early stage contributes to the lack of consistency between total mercury and turbidity levels at these low values.

Table 3. Total mercury concentration in the turbidity plume before major dredging operation (June 20 – 21).

Sample no	Sampling time UTC	Mercury (µg L^{-1})	Turbidity FNU
16	20.06.2026 05:58	0.004	1.40
17	20.06.2026 06:18	**0.020**	4.42
21	20.06.2026 19:23	0.003	1.65
23	21.06.2026 00:03	0.002	2.08
26	21.06.2026 17:58	0.005	7.00
29	21.06.2026 23:59	**0.013**	6.40

Mercury concentrations in samples collected in the turbidity plume and at the perimeter were generally low, with 62% of the samples containing less than 0.05 µg Hg L^{-1} (***Error! Reference source not found.***). However, three samples collected during dredging on 23 June between 10:00 and 11:00 contained markedly elevated concentrations of 2.17, 2.13, and 1.25 µg Hg L^{-1}. All three samples were associated with elevated turbidity (35–37 FNU) (Figure 8).

Table 4. Total mercury concentration in the turbidity plume and at the perimeter during and after major dredging activity on 23 to 27.06.

Sample no	Sampling time UTC	Mercury (µg L^{-1})	Turbidity FNU
44	23.06.2026 08:04	0.022	4.10
45	23.06.2026 10:22	**2.17**	5.13
46	23.06.2026 10:22	**2.13**	5.87
47	23.06.2026 10:55	**1.25**	12.80
49	23.06.2026 12:48	0.015	0.16
50	23.06.2026 12:49	0.066	0.15
51	23.06.2026 12:52	0.026	0.16
53	23.06.2026 16:24	0.038	3.74
54	23.06.2026 16:34	0.064	11.46
55	23.06.2026 16:36	0.123	11.53
56	23.06.2026 16:36	0.082	12.79
57	23.06.2026 18:56	0.013	0.09
58	23.06.2026 19:21	0.012	0.16
59	23.06.2026 19:26	0.104	0.40
60	23.06.2026 19:38	0.022	3.87
61	23.06.2026 19:40	0.032	0.21
62	23.06.2026 23:00	0.010	0.22
63	23.06.2026 23:04	0.010	0.21
64	23.06.2026 23:08	0.042	0.29
65	23.06.2026 23:13	0.017	0.21
68	25.06.2026 22:07	0.069	0.12
69	25.06.2026 22:08	0.049	0.12
70	25.06.2026 22:12	0.111	0.11
73	26.06.2026 01:40	0.029	0.15
74	26.06.2026 01:53	0.021	0.18
75	26.06.2026 01:54	0.051	0.17
76	26.06.2026 03:03	0.090	0.19
77	26.06.2026 03:31	0.025	0.18
78	26.06.2026 05:29	0.033	0.13
79	26.06.2026 05:30	0.020	0.14
81	26.06.2026 10:46	0.039	0.31
82	26.06.2026 12:50	0.021	0.62
86	27.06.2026 14:16	0.003	0.15
87	27.06.2026 14:16	0.003	0.15

Ten of the twelve samples collected at or in the vicinity of the dredging site contained total mercury concentrations ranging from 0.01 to 0.10 µg Hg L^{-1} (*Table 3*), corresponding to the upper end of the background concentration range. The highest concentration (0.614 µg Hg L^{-1}) was measured in a test sample collected at the wreck site on the first day of the operation.

Table 3. Total mercury concentration at the dredging site.

Sample no	Sampling time UTC	Mercury (µg L^{-1}]	Turbidity FNU
12	19.06.2026 03:06	**0.614**	0.14
20	20.06.2026 16:45	0.091	10.00
24	20.06.2026 05:57	**0.234**	5.82
27	21.06.2026 21:55	0.019	8.70
37	22.06.2026 17:32	0.100	1.59
38	22.06.2026 17:33	0.101	1.52
66	24.06.2026 10:47	0.042	0.2
67	24.06.2026 10:48	0.064	0.13
72	25.06.2026 22:21	0.017	0.67
88	27.06.2026 15:28	0.026	0.40
89	27.06.2026 15:29	0.018	0.50
90	27.06.2026 15:46	0.014	0.35

Overall, total mercury concentrations in seawater samples collected during the operation were, as expected, generally low. Nevertheless, several elevated mercury concentrations measured in the turbidity plume and at the perimeter (**Error! Reference source not found.**) exceeded the operational threshold and triggered repeated sampling and temporary suspension of the dredging activities. Follow-up sampling confirmed that the elevated concentrations were transient, allowing the operation to resume without further interruption.

Samples containing total mercury concentrations in the µg L^{-1} range (**Error! Reference source not found.**) were associated with elevated turbidity 5-13 FNU) (Figure 8). In contrast, no consistent relationship between total mercury concentration and turbidity was observed for samples containing less than 0.1 µg Hg L^{-1}. Moreover, high turbidity measurements were generally not associated with high total mercury levels.

These observations indicate that turbidity alone may not be a reliable proxy for total mercury concentrations during dredging, particularly at low mercury concentrations where particle composition and mercury content may vary substantially.

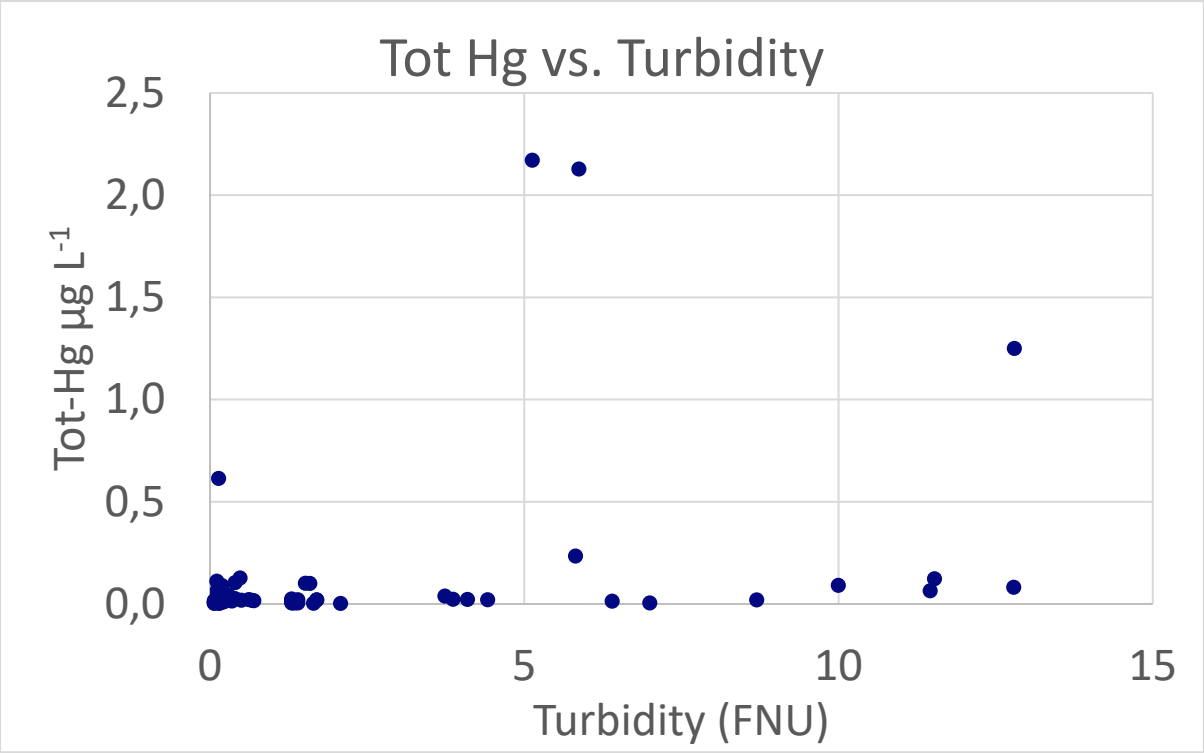

Figure 8. Measured concentration of total mercury relative to monitored turbidity by the sensor on the ROV during sampling.

3.2.2 Contamination of Niskin sampling vessels

The standard method for seawater sampling employs free-flushing Niskin sample vessels, which remain open until they are triggered to close at the sampling depth. Consequently, the internal vessel PVC surfaces, including the rubber tubing and latex closure band, are continuously exposed to ambient seawater prior to sample collection. During the operation, the sampling vessels were mounted beneath the Supporter and Constructor ROVs. Under the adopted monitoring strategy, the Supporter ROV was routinely positioned within the mercury-enriched turbidity plume, whereas the Constructor ROV, together with its sampling bottles, operated directly within the most heavily contaminated water surrounding the dredging site.

Zhang et al. (2019) demonstrated that trace concentrations of mercury can adsorb rapidly to polypropylene surfaces, making adsorption a major source of carryover contamination. This was not initially considered a significant concern during the present operation because most mercury released during dredging was expected to remain particle-bound and therefore less susceptible to adsorption. Furthermore, dissolved inorganic mercury in seawater is expected to occur predominantly as chloride complexes (primarily $HgCl_3^-$ and $HgCl_4^{2-}$), which generally exhibit a lower affinity for adsorption to polymer surfaces than uncomplexed Hg^{2+}. However, colloidal and nanoparticulate mercury possibly generated during the jet-assisted dredging process may interact differently with bottle surfaces than dissolved chloride complexes and may therefore contribute to carryover contamination.

Laboratory experiments were subsequently performed by filling rinsed sampling vessels with uncontaminated surface seawater. The experimental procedures and results are described in the Appendix. These experiments demonstrated mercury leaching from previously used Niskin sampling vessels ranging from 0.004 to 0.050 µg Hg L^{-1}, with a few vessels releasing between 0.100 and 0.200

µg Hg L^{-1}. The degree of contamination appeared to depend on both the previous exposure of the free-flushing sampling vessels to elevated mercury concentrations during the operation and the residence time of the water within the sampling vessels before aliquots were collected for analysis of mercury fractions.

The results from the laboratory experiments suggest that adsorption and desorption of mercury approach an equilibrium over time between the bottle surfaces and the enclosed water. Consequently, carryover contamination is expected to have a proportionally greater effect on samples containing low mercury concentrations than on highly contaminated samples. Conversely, adsorption to the bottle walls may also lead to slight underestimation of mercury concentrations in samples containing elevated mercury levels. Because both adsorption and desorption occur simultaneously, no robust correction procedure can be applied to the measured concentrations.

The carryover effect therefore most likely resulted in a slight overestimation of mercury concentrations in low-level background and plume samples. However, its influence on samples containing more than approximately 0.050 µg Hg L^{-1} is considered negligible relative to the measured concentrations.

The observations highlight the need for dedicated ultra-trace mercury sampling procedures when monitoring environments with large concentration gradients. Conventional free-flowing Niskin sampling bottles may be unsuitable for repeated measurements spanning background concentrations (ng L^{-1}) to highly contaminated waters (µg L^{-1}) unless rigorous decontamination or single-use sampling protocols are employed.

3.2.3 Dissolved mercury

Previous investigations provide little direct information on dissolved mercury in the water column around U-864. Most operational water samples were analysed unfiltered and therefore represent total mercury, including dissolved mercury and mercury associated with suspended particles. Elevated concentrations observed during seabed operations were strongly associated with turbidity and were interpreted primarily as particulate mercury originating from resuspended contaminated sediment. Experimental studies of the leaching and bioaccumulation of mercury, described in NIVA report 45089 – 2005, reported Total mercury in porewater centrifuged at 12 000g for 30 min. to be as high as 228 µg L^{-1} in the contaminated sediments. This may be interpreted as dissolved mercury, suggesting that a significant mobile aqueous Hg fraction is present. The magnitude and spatial transport of dissolved mercury in the water column were, however, not adequately quantified.

Dissolved mercury was determined in 68 of the 80 seawater samples collected during the operation (see appendix). The twelve samples that were not analysed for dissolved mercury were background samples collected towards the end of the operation and thus likely strongly contaminated by the carryover effect. The results indicate that, on average, 61% of the total mercury occurred in the dissolved phase (Chapter 5.2.2). However, this estimate is still likely influenced by carryover contamination of the sampling vessels, particularly in the numerous background samples containing very low mercury concentrations. Restricting the assessment to the 19 samples with total mercury concentrations exceeding 0.050 µg Hg L^{-1} yields a lower average dissolved fraction of 38%. In the three samples containing total mercury concentrations in the µg L^{-1} range, the dissolved fraction accounted for approximately 45% of the total mercury.

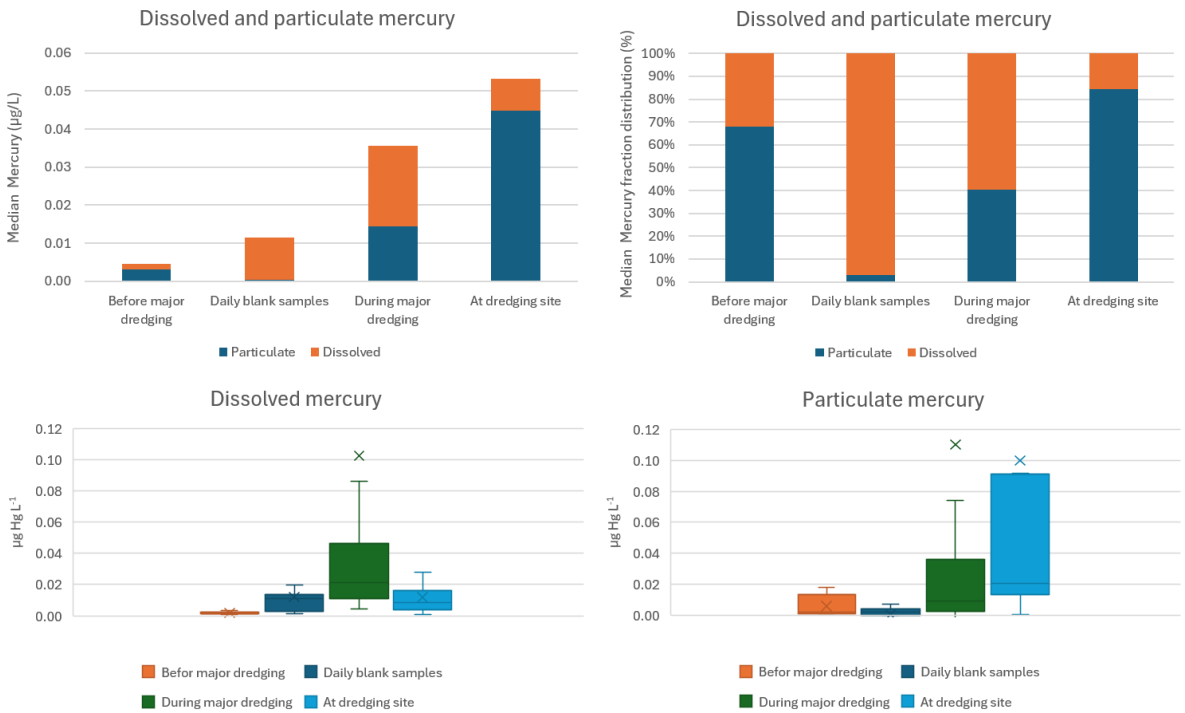

Figure 7 presents the total median concentrations fractionated into dissolved and particulate mercury across the four sample categories described in Chapter 5.2.1. As expected, in the samples with the highest median total mercury concentration observed at the dredging site, approximately 85% of the mercury occurred in the particulate fraction. During and after the major dredging operation, median total mercury concentrations in the turbidity plume and at the perimeter were considerably lower. In

these samples, approximately 60% of the mercury occurred in the dissolved phase. In samples collected from the turbidity plume before the major dredging activity were low. Nevertheless, the partitioning between particulate and dissolved mercury (approximately 70% particulate) was intermediate between that observed at the dredging site and during and after the major dredging activity in the turbidity plume and at the perimeter. In the daily blank samples, most mercury was measured in the dissolved phase, although these results are strongly influenced by carryover contamination of inorganic mercury from the sampling vessels.

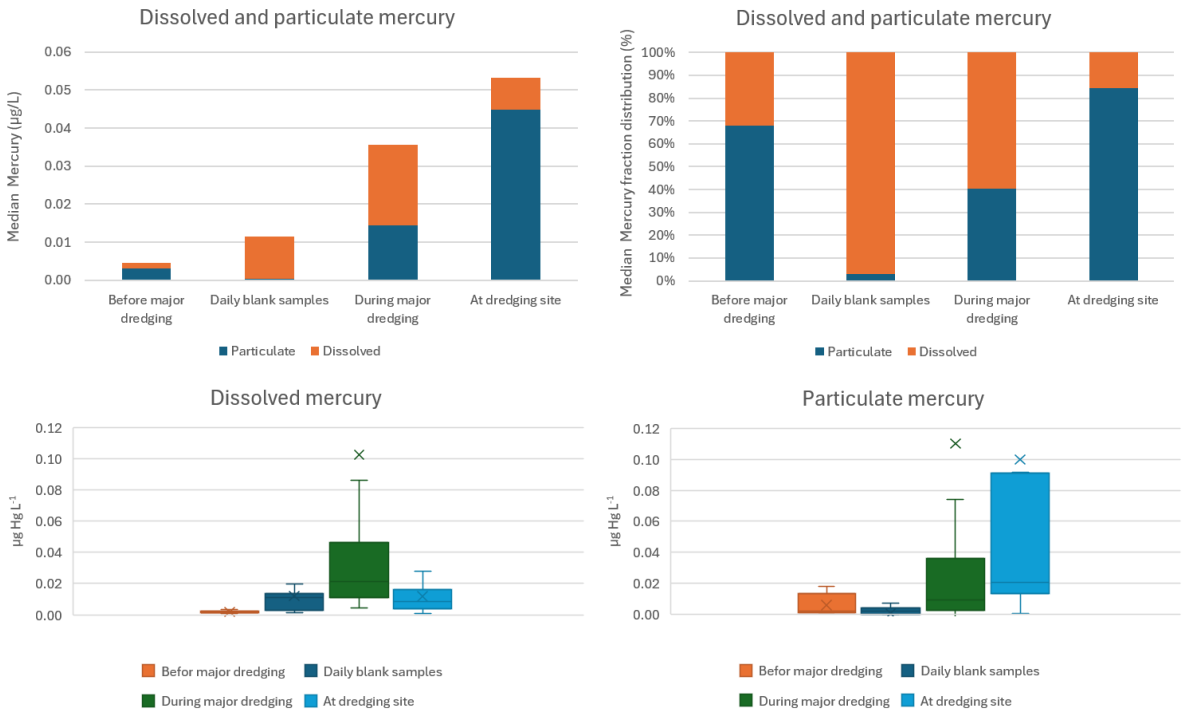

Figure 7. Dissolved and particulate mercury in different groups of seawater samples collected during the operation. Top figures: Median concentrations and median distribution. Bottom figures: Concentration distributions of dissolved and particulate Hg fraction. Line inside the box = median (50th percentile), X = mean (average), Box = middle 50% of the data (from Q1 to Q3), whiskers = range of non-outlier values.

Five of the samples collected and filtered onboard for later analysis of methyl mercury (see 3.2.5) were also analysed for total mercury by ALS, to confirm some of the on-board analysis results for dissolved mercury. The absolute concentrations reported by ALS for the three samples with the highest mercury concentrations were approximately 40% lower than those measured onboard. This difference may reflect adsorption of mercury to the glass sample bottles during transport and storage, although other analytical differences between the methods cannot be excluded.

Analysis of dissolved mercury fractions allows speciation of the dissolved phase by assuming equilibrium conditions among dissolved species in seawater. The main mercury species in solution were calculated in MINEQL+ to be $HgCl_4^{2-}$ (80.4%), $HgCl_3^-$ (15.8%), and $HgCl_2$ (2.76%). $HgCl_2$ is generally considered highly toxic as it efficiently crosses biological barriers, but is not considered toxic at these concentrations. Other species (HgBrCl, HgClOH, $HgBr_2$, HgBrOH, $HgBr_3^{-1}$, $Hg(OH)_2$, and $HgBr_4^{-2}$) comprised less than 0.8% of the dissolved fraction.

Taken together, the results indicate that a substantial fraction of the total mercury occurred in the dissolved phase. Given the very low concentrations of methylmercury (Section 3.2.6), this dissolved fraction most likely consisted predominantly of inorganic Hg(II), which in seawater is expected to occur mainly as chloride complexes (primarily $HgCl_4^{2-}$, $HgCl_3^-$ and $HgCl_2$). However, because the filtration procedure does not distinguish truly dissolved species from colloidal or nanoparticulate mercury, part of the operationally defined dissolved fraction may also have comprised Hg-bearing colloids or nanoparticles.

One possible explanation for the high dissolved mercury fraction is the dredging method itself. The jet-assisted suction system generates intense turbulence, cavitation, and mechanical fragmentation, which may burst mercury droplets and sediment aggregates, thereby increasing the reactive surface area available for oxidation and desorption. The process may also generate colloidal particles and mercury nanoparticles capable of passing the filtration step used to define the dissolved fraction. In addition, freshly exposed mineral surfaces created during fragmentation may promote rapid desorption of previously particle-bound Hg(II). Further studies are required to determine the relative importance of these mechanisms.

3.2.4 Mercury in passive DGT samplers

The total mass of mercury accumulated in the passive DGT samplers, and the corresponding estimated time-averaged concentrations of DGT-labile inorganic mercury are presented in Table 4. Accumulated total mercury in the DGT binding resin and estimated time-averaged concentration of DGT-labile inorganic mercury. The concentrations have been corrected for the field blanks The dataset comprises 21 DGT samplers mounted on equipment or monitoring installations at the seabed during the dredging operation in June, along with two field blanks.

The results confirm that mercury was present in a dissolved or otherwise DGT-labile inorganic form in the water during the operation. High concentrations were associated with the Spider dredging equipment. The three samplers mounted at different positions on the Spider—the front, rear and cab trunk—showed large differences, with estimated time-averaged concentrations of 0.51, 5.2 and 32 µg L^{-1}, respectively. The highest value was recorded on the part of the Spider positioned closest to the active sediment disturbance. The pronounced differences between samplers mounted only short distances apart indicate steep, small-scale spatial gradients in DGT-labile inorganic mercury close to the dredging point.

Large mercury masses were also accumulated in the samplers mounted on the outside of the dredging filter container. These samplers yielded the highest estimated time-averaged concentrations in the dataset, ranging from 9.5 to 38 µg L^{-1}. However, these results are subject to considerable uncertainty. The samplers were mounted on the roof of the container, which became rapidly covered by sediment generated during nearby dredging. The calculation of ambient water concentrations assumes that diffusion through the DGT membrane was not substantially affected by sediment deposition or unusual hydrodynamic conditions. This assumption was probably not fulfilled for these samplers, and the calculated concentrations should therefore not be interpreted as representative ambient water-column concentrations.

Nevertheless, the high time-averaged dissolved mercury concentrations indicate substantial exposure to DGT-labile inorganic mercury in the immediate vicinity of the dredging activity and the dredging-system exhaust. The concentrations measured outside the container were higher than those measured on most parts of the Spider. This may reflect particularly strong exposure to sediment porewater, fine

suspended material or labile mercury released during vacuum dredging and sediment handling. The results do not, however, provide a sufficient basis for concluding that vacuum dredging itself generated a larger dissolved Hg fraction.

The two samplers placed inside the dredging container yielded estimated concentrations of 0.71 and 3.5 µg L^{-1}. Their representativeness is limited because the container was only operational during dredging for a couple of hours, and was disconnected in the morning of 23 June 2026. The exposure therefore differed from that of most other samplers. Even so, the accumulated Hg indicates that DGT-labile mercury was present in water associated with the initial dredging and sediment-handling process.

The three DGT samplers mounted on the acoustic Doppler current profiler (ADCP) were not located directly within the main dredging region or plume. Their estimated time-averaged concentrations ranged from 0.08 to 0.26 µg L^{-1}, with a mean of 0.20 µg L^{-1}. These concentrations were substantially lower than those measured directly on the dredging equipment (Spider) and on the roof of the dredging filter container, consistent with more limited exposure to the plume.

At the perimeter monitoring stations on the sedimentation rigs, the estimated concentrations were below the limit of detection at TU-1, TU-2, and TU-Ref. (5), located west, southeast, and east of the dredging area (Figure 3), which is generally upstream of the predominant current direction (Figure 10). The exception is at 2 m above the seabed at TU-1, where a time-averaged inorganic mercury concentration of 0.16 µg L^{-1} was estimated. The cause of this elevated value is unclear. This may indicate that the levels of inorganic mercury measured by the DGTs may be overestimated.

The time-average concentrations of DGT-labile inorganic mercury at 2 m above the seabed at the perimeter stations TU-3 and TU-4, located northwest and north of the dredging area, were 2.8 and 1.2 µg Hg L^{-1}, respectively. Taken at face value, these concentrations are alarmingly high and would imply a substantial flux of inorganic mercury to the surrounding environment. It would also imply that the water sampling strategy, triggered by high turbidity, did not capture the plume with high levels of dissolved inorganic mercury along the seabed. However, given the considerable uncertainties associated with their estimation (see Chapter 4.2.2), these values should be regarded as supplementary information to the existing environmental monitoring programme rather than as a replacement for conventional water sampling. The true concentrations may be substantially, potentially even orders of magnitude, lower.

A clear vertical pattern was observed at several perimeter stations. Concentrations measured 10 m above the seabed were generally among the lowest in the dataset, whereas some samplers positioned 2 m above the seabed accumulated substantially more inorganic mercury. The clearest gradients occurred at TU-3 and TU-4, located downflow of the submarine. At TU-3, the estimated time-averaged concentration increased from below the detection limit at 10 m above the seabed to 2.8 µg L^{-1} at 2 m above the seabed. At TU-4, the corresponding concentrations were 0.36 and 1.2 µg L^{-1}. This is not expected, as the stations TU-3 and -4 are located at 10 m greater depth than the dredging site. This pattern indicates that the plume of DGT-labile inorganic mercury was concentrated primarily in the near-bottom water layer and transported mainly along the bottom towards the north and north-west.

Nevertheless, the elevated DGT responses constitute a clear warning signal and strongly support the need for enhanced monitoring of inorganic mercury during future operations.

Table 4. Accumulated total mercury in the DGT binding resin and estimated time-averaged concentration of DGT-labile inorganic mercury. The concentrations have been corrected for the field blanks (0.13 µg Hg L^{-1}). Values below field blanks are marked below detection limit (<DL). Considering the considerable uncertainties associated with their estimation, these absolute values should be interpreted with caution.

Deployment site	Hight above seabed (m)	Total Hg (ng) in DGT resin	Estimated time avg. DGT-labile Hg (µg L^{-1})
Field blank		14.08	0
Field blank		15.01	0
Dredging container – outside		4498	38
Dredging container – outside		2668	23
Dredging container – outside		1127	9.5
Dredging container – inside		97.45	0.71
Dredging container – inside		425.4	3.5
ACDP		47.17	0.26
ACDP		25.88	0.08
ACDP		45.72	0.25
Spider front		55.39	0.51
Spider back		455.6	5.2
Spider trunk of cab		2724	32
TU-1	2m	32.21	0.16
TU-1	10m	3.06	<DL
TU-2	2m	7.29	<DL
TU-2	10m	8.85	<DL
TU-3	2m	321.8	**2.8**
TU-3	10m	10.32	<DL
TU-4	2m	150.9	**1.2**
TU-4	10m	55.11	0.36
TU-ref. (5)	2m	Membrane damaged	
TU-ref. (5)	10m	5.01	<DL

DGT samplers with extended deployment

DGT samplers installed on the sediment traps in March were retrieved together with the samplers deployed during the dredging operation in June. These samplers had been exposed for approximately 100 days, which is substantially longer than the recommended deployment period of 3–21 days. Biofouling and progressive accumulation on the membrane are therefore likely to have affected diffusion and reduced Hg uptake. The resulting concentrations should consequently be regarded as uncertain, semi-quantitative long-term averages.

At TU-1, TU-2 and TU-Ref. (5), the calculated time-averaged concentrations ranged from 0.02 to 0.07 µg L^{-1}. These values provide an approximate indication of the long-term background exposure to inorganic DGT-labile mercury, although the extended deployment introduces substantial uncertainty. Higher concentrations were found at TU-3 and TU-4, ranging from 0.07 to 0.16 µg L^{-1}. At both stations, concentrations were higher at 2 m than at 10 m above the seabed. This is consistent with greater long-term exposure to mercury in the near-bottom water downflow of the wreck, although it

is not possible to separate the contributions from the existing contamination at the wreck site and the subsequent dredging activity.

Summary

The DGT results demonstrate that inorganic mercury occurred in a dissolved or otherwise DGT-labile form during the dredging operation. The highest accumulated masses and estimated time-averaged concentrations were measured directly on the dredging equipment and on the outside of the dredging container, identifying active sediment disturbance and sediment handling as the principal local sources. Large differences between samplers mounted only short distances apart on the Spider show that exposure varied strongly at a small spatial scale close to the dredging point.

Interpretation of the samplers mounted outside the dredging container is uncertain because they were rapidly covered by sediment, which may have affected diffusion and uptake. Their calculated concentrations should therefore not be regarded as representative ambient water concentrations, although the large accumulated inorganic Hg masses clearly indicate strong local exposure to DGT-labile mercury.

At the perimeter stations, the strongest elevations occurred 2 m above the seabed at TU-3 and TU-4, downflow of the submarine. Concentrations were generally lower 10 m above the seabed, indicating that the DGT-labile mercury plume was largely confined to the near-bottom water layer. Levels at the ADCP and at TU-1, TU-2 and TU-5 were comparatively low. Several of these low values were below the detection limit defined by the field-blank level.

The approximately 100-day deployments confirmed higher long-term exposure at TU-3 and TU-4 than at the other perimeter stations, with higher values near the seabed. However, these results are semi-quantitative because the deployment period greatly exceeded the recommended duration and biofouling may have reduced uptake.

Overall, the DGT results indicate localised dispersion of DGT-labile inorganic mercury from the dredging area, with the greatest influence close to the active sediment disturbance and in near-bottom water transported with the water current towards the north and north-west. DGT measurements represent a highly uncertain estimate of the time-integrated operationally defined labile dissolved inorganic mercury fraction. They are not a substitute for the measured dissolved mercury fraction. Still, the alarmingly high time-averaged concentrations of DGT-labile dissolved inorganic mercury recorded at the perimeter stations TU-3 and -4 dictate enhanced monitoring of inorganic mercury during any future dredging operations. Moreover, turbidity-triggered sampling of the water for total mercury analysis may not be justified.

3.2.5 Methyl mercury

Methylmercury (MeHg) concentrations were determined by ALS in 38 seawater samples. Concentrations were below the limit of quantification (<0.03 ng L^{-1}) in 27 of these samples. In the remaining 11 samples, measurable MeHg concentrations ranged up to 0.33 ng L^{-1}, with a median concentration of 0.05 ng L^{-1} (Table 5). Overall, these results demonstrate that MeHg concentrations remained very low throughout the monitoring program.

Measured MeHg concentrations were positively correlated with dissolved mercury concentrations (R^2 = 0.859; Figure 9). However, this relationship is strongly influenced by the three samples containing

the highest dissolved mercury concentrations. In addition, the samples with low concentrations (< 50 ng tot-Hg L^{-1}) are contaminated with dissolved Hg from the Niskin sampling vessel. The correlation should therefore be interpreted with caution. The generally low MeHg concentrations indicate that the elevated dissolved mercury observed during the dredging operation consisted predominantly of inorganic mercury rather than methylmercury.

Table 5. Concentrations of methyl mercury (MeHg) in samples with concentrations above the limit of quantification, along with data on total and dissolved mercury.

Sample no	Sample type	Date	Total Hg ng/L	Dissolved Hg ng/L	MeHg ng/L
25	Sample at high altitude	20.06.2026 08:01	127	4.78	0.0383
33	Vertical sample profile	22.06.2026 06:04	20	13.1	0.0471
44	Monitoring near perimeter	23.06.2026 08:04	22	10.3	0.0308
45	Monitoring near perimeter	23.06.2026 10:22	2170	960	0.235
46	Monitoring near perimeter	23.06.2026 10:22	2127	963	0.330
47	Monitoring near perimeter	23.06.2026 10:55	1250	585	0.301
50	Monitoring near perimeter	23.06.2026 12:49	66	47.1	0.0429
51	Monitoring near perimeter	23.06.2026 12:52	26	21,0	0.0432
52	Field blank	23.06.2026 12:59	32	57.9	0.0395
66	Dredge Site	24.06.2026 10:47	42	27.8	0.0665
76	Monitoring near perimeter	26.06.2026 03:03	90	86.1	0.117

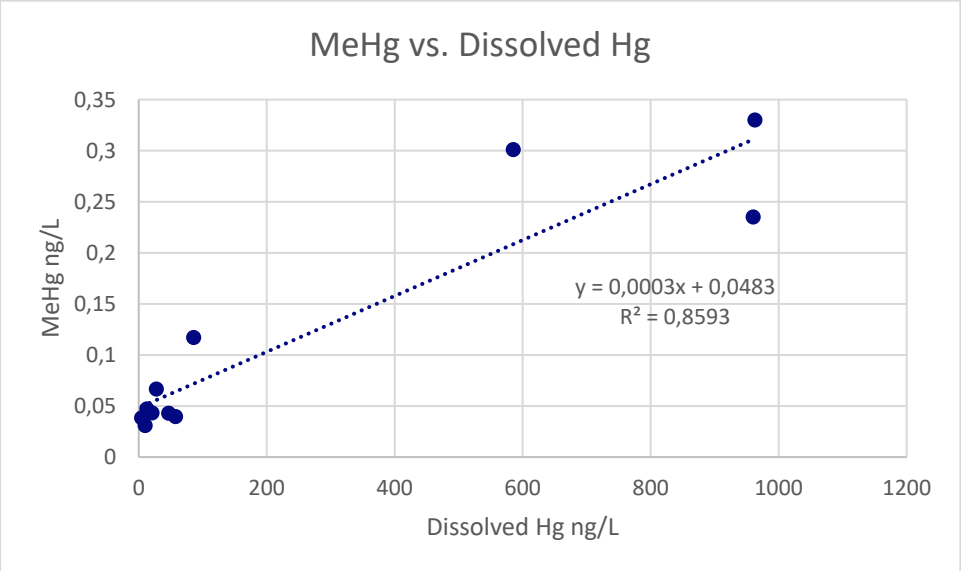

Figure 9. Correlation between dissolved mercury and methyl mercury (MeHg) in samples.

3.2.6 Major findings regarding levels of mercury in seawater

The mercury fractionation data for the water samples provide four major findings.

1. Carryover contamination of sampling bottles

Exposure of the free-flowing Niskin sampling vessels to elevated mercury concentrations resulted in carryover contamination of subsequent low-concentration samples, making background measurements uncertain. This finding demonstrates that conventional oceanographic sampling procedures are not suitable for mercury monitoring in environments spanning concentration ranges from ng L^{-1} to µg L^{-1}. Dedicated ultra-trace sampling protocols or rigorous bottle decontamination procedures should therefore be considered for future monitoring programmes.

2. A substantial fraction of the mercury occurred in the dissolved phase

An average of 38% of the total mercury occurred in the operationally defined dissolved phase (i.e., < 0.45 µm) in samples containing elevated mercury concentrations. This suggests that the dissolved fraction cannot be explained solely by equilibrium dissolution of elemental mercury (Hg^0). Instead, several processes may contribute simultaneously, including the formation of mercury-chloride complexes, as well as rapid oxidation of freshly exposed Hg^0, desorption of previously particle-bound Hg(II), and the generation of colloidal or nanoparticulate mercury caused by the venturi effect from sediment dredging.

3. Jet-assisted dredging may alter mercury fractionation and speciation

One possible explanation for the unexpectedly high dissolved mercury fraction is the dredging method itself. The jet-assisted suction system generates intense turbulence, dilution, and the Venturi effect that may lead to cavitation and mechanical fragmentation, which may increase the reactive surface area of elemental mercury droplets and sediment particles. These processes may promote oxidation, desorption, and the formation of mercury-bearing colloids or nanoparticles. Although this hypothesis, based on the monitoring results, requires experimental verification, it warrants further investigation because it may have an effect on mercury mobility during dredging operations. This will have implications for what type of dredging method should be used and for averting measures like a filter container.

5. Methylmercury concentrations were confirmed low

Despite elevated concentrations of inorganic mercury, methylmercury concentrations remained below the limit of quantification in 71% of the analysed samples, with a maximum concentration of only 0.33 ng L^{-1}. These observations indicate that methylmercury constituted only a minor fraction of the total mercury released during the operation and provide no evidence for substantial in situ methylation during the monitoring period.

The proportion of dissolved mercury appeared to increase from the dredging site, through the turbidity plume, and towards the operational perimeter and background waters. This pattern is consistent with particulate mercury settling relatively rapidly close to the dredging site, while dissolved mercury remained in suspension and was transported further from the source. This is substantiated by alarmingly high time-averaged levels of DGT-labile inorganic mercury at the perimeter stations down-flow from the dredging site (TU-3 and -4). If confirmed, this finding suggests that the principal

environmental concern during dredging may not be the transport of particulate elemental mercury itself, but rather the generation and transport of dissolved inorganic Hg(II), which is considerably more mobile and potentially more bioavailable than particle-bound Hg and Hg^0. However, in seawater, Hg(II) is expected to occur predominantly as stable chloride complexes, reducing the activity of free Hg^{2+} ions and thereby limiting acute toxicity.

The results further suggest that future mercury monitoring during dredging operations should not rely solely on measurements of turbidity and total mercury. Measurements onboard during operation of total and dissolved mercury, along with DGT techniques capable of distinguishing DGT-labile inorganic Hg, as well as analysis of truly dissolved, colloidal, and nanoparticulate mercury using size-fractionated analyses after the operation, would provide a more comprehensive understanding of mercury transport and speciation.

If confirmed, these observations indicate that dredging operations may actively modify mercury fractionation and speciation rather than simply resuspend existing mercury. This has important implications for both environmental risk assessment and the design of future monitoring programmes.

3.3 Sediment traps

Sediment traps were deployed on the turbidity rigs around the operational area (see Figure 3) throughout the dredging campaign to quantify the downward flux of suspended particulate material and the associated mercury load. The traps thereby provide information on the magnitude and spatial distribution of particle-bound mercury transported during the operation.

3.3.1 Dry substance

The amount of dry material collected in the sediment traps during approx. 8 - 9 days of deployment is presented in **Error! Reference source not found.**. The traps located north and northwest of the dredging area (TU-3 and TU-4, Figs. 2 & 3), downstream of the prevailing bottom current from the dredging site (Figure 10), accumulated substantially more material than those at the other stations. At TU-3 and TU-4, the traps deployed 2 m above the seabed collected approximately two to three times more material than the corresponding traps at 10 m above the seabed. This indicates that a substantial proportion of the transported particulate material remained concentrated close to the seabed.

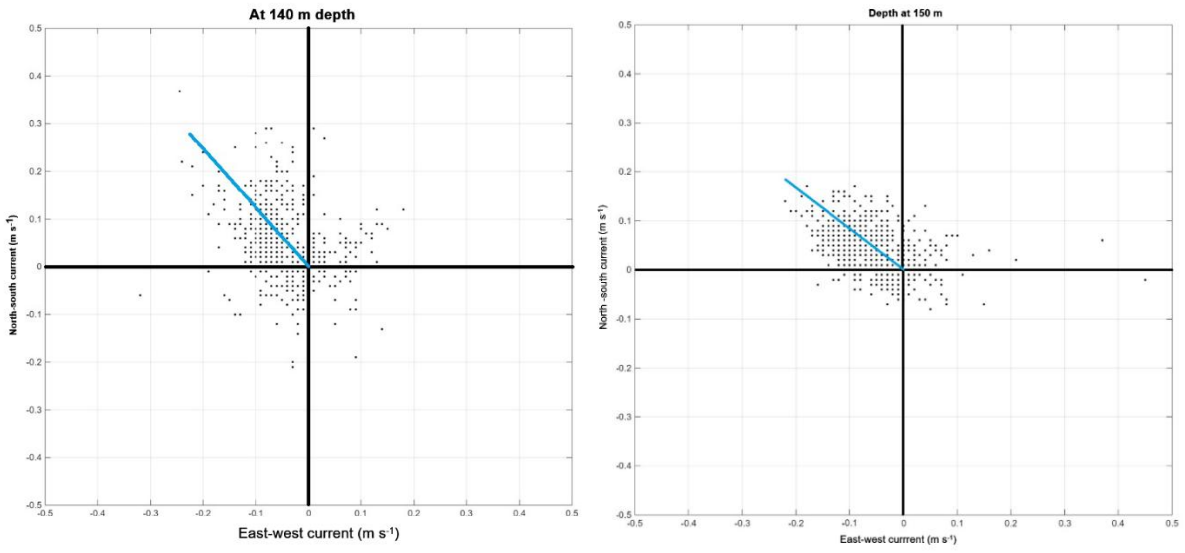

Figure 9. Scatter plot of the current components close to the seabed and at 10 m above the seabed at 150 and 140 m depth. The origo is at the location of the current sensor shown in Figure 4

The reported amount of dry substance includes not only particulate material but also salts remaining from seawater in the samples before freeze-drying. The samples were somewhat diluted by the water used to rinse material from the original collection bottles. Consequently, the measured dry substance does not represent sediment material alone.

Table 6. Dry substance in the sediment traps collected over 8 – 9 days. Sedimentation rate is based on an average deployment time of 8.5 days.

Sediment trap	Dry substance (gram)	Sedimentation rate (mg cm^{-2} day^{-1})
TU-1, 2m, replicate 1	1.64	0.68
TU-1, 2m, replicate 2	1.64	0.68
TU-1, 10m, replicate 1	0.88	0.37
TU-1, 10m, replicate 2	2.06	0.86
TU-2, 2m, replicate 1	1.40	0.58
TU-2, 2m, replicate 2	Damaged sediment trap	
TU-2, 10m, replicate 1	1.39	0.58
TU-2, 10m, replicate 2	1.63	0.68
TU-3, 2m, replicate 1	3.63	**1.51**
TU-3, 2m, replicate 2	4.28	**1.78**
TU-3, 10m, replicate 1	1.50	**0.62**
TU-3, 10m, replicate 2	2.44	**1.01**
TU-4, 2m, replicate 1	4.79	**1.99**
TU-4, 2m, replicate 2	5.30	**2.20**
TU-4, 10m, replicate 1	2.85	**1.18**
TU-4, 10m, replicate 2	3.03	**1.26**
TU-ref. (5), 2m, replicate 1	1.19	0.49
TU-ref. (5), 2m, replicate 2	1.81	0.75
TU-ref. (5), 10m, replicate 1	1.29	0.54
TU-re4f. (5), 10m, replicate 2	1.66	0.69

3.3.2 Total mercury in sedimented material

Mercury concentrations in the sediment-trap material, presented in **Error! Reference source not found.**, showed a pronounced spatial pattern. At the background station (TU-ref. (5)), average concentrations were 4.35 and 7.46 mg Hg kg^{-1} dry substance at 2 and 10 m above the seabed, respectively. Similar concentrations were generally observed at TU-1 and TU-2. The elevated concentration at TU-2 at 2 m should, however, be interpreted with caution because only one of the two replicate traps was recovered.

In contrast, substantially higher mercury concentrations were measured at TU-3 and TU-4, with average concentrations ranging from approximately 35 to 78 mg Hg kg^{-1} dry substance. These concentrations were approximately one order of magnitude higher than those at the background station. The spatial distribution therefore indicates preferential transport of mercury-contaminated particulate material in the direction of the prevailing bottom current.

Based on an average deployment time of 8.5 days, the average sedimentation rate at 2 m above the seabed at TU-3 and -4 were 99 and 164 ng Hg cm^{-2} day^{-1}. Still, most of this was likely deposited only during the 23rd of June, when the major dredging activity was performed, indicating that the sedimentation rate of particulate mercury on this day at the perimeter of the operation area was in the µg range.

The elevated particulate mercury concentrations at TU-3 and TU-4 are also consistent with the results from the co-located DGT samplers (Chapter 5.2.4), which also showed the highest concentrations of dissolved labile mercury at these stations. Together, the sediment-trap and DGT results indicate major transport of both particulate and dissolved mercury out from the operational area, with the strongest signal immediately downstream of the dredging operation.

Previous environmental monitoring at U-864 has likewise demonstrated transport of mercury-contaminated particulate material during seabed disturbance. During the 2006 dredging campaign (NIVA Report 5279/2006), sediment traps collected mercury-contaminated particles, with the highest concentrations measured closest to the dredging area and lower concentrations south and southwest of the operation. During the 2014 survey, sediment collected approximately 200 m northwest of the operation contained 4.2 mg Hg kg^{-1} dry weight.

The substantially higher mercury concentrations measured during the present study, reaching approximately 79 mg Hg kg^{-1} dry substance, indicate that the traps intercepted considerably more Hg-enriched particulate material during the present operation.

Table 7. Total mercury concentrations in sediment traps collected over 8 – 9 days. Sedimentation rate of mercury is based on an average deployment time of 8.5 days.

Sediment trap	Hg in sediment mg/kg dry substance	Avg. Hg sedimentation rate ng Hg cm^{-2} day^{-1}
TU-1, 2m, replicate 1	2.72	2.2
TU-1, 2m, replicate 2	3.84	
TU-1, 10m, replicate 1	4.10	1.9
TU-1, 10m, replicate 2	2.80	
TU-2, 2m, replicate 1	12.6*	7.3*
TU-2, 2m, replicate 2	Damaged sediment trap	
TU-2, 10m, replicate 1	5.10	2.7
TU-2, 10m, replicate 2	3.54	
TU-3, 2m, replicate 1	53.4	**99**
TU-3, 2m, replicate 2	65.8	
TU-3, 10m, replicate 1	78.2	54
TU-3, 10m, replicate 2	59.2	
TU-4, 2m, replicate 1	78.0	**164**
TU-4, 2m, replicate 2	78.9	
TU-4, 10m, replicate 1	39.6	43
TU-4, 10m, replicate 2	30.7	
TU-ref. (5), 2m, replicate 1	5.70	2.5
TU-ref. (5), 2m, replicate 2	3.01	
TU-ref. (5), 10m, replicate 1	7.12	4.6
TU-ref. (5), 10m, replicate 2	7.81	

* average of two analyses

3.3.3 Total organic carbon in sedimented material

Total organic carbon (TOC) amounts in the sediment-trap samples are presented in Table 10. Considerable differences were observed between replicate traps at several stations, and the TOC results should therefore be interpreted with some caution.

Nevertheless, a systematic spatial pattern is apparent. At TU-3 and TU-4, where both the amount of sedimented material and mercury concentrations were highest, mean TOC concentrations were approximately 8–16 mg C g^{-1} dry substance (0.8–1.6% C). At both stations, the traps positioned 2 m above the seabed had lower TOC concentrations than those positioned at 10 m. In comparison, mean TOC concentrations at the other stations were generally higher, approximately 15–29 mg C g^{-1} dry substance (1.5–2.9% C). This reflects that the re-sedimented dredged sediment material was characterised by low TOC content relative to the natural drizzle of fresh sediments from the water column. Material collected at the background stations is expected to comprise recently settling suspended particles, including phytoplankton and detrital material, together with some naturally resuspended seabed sediment. Such material would be expected to have a higher organic-carbon content than older seabed sediment in which much of the labile organic matter has been degraded.

This interpretation is supported by previous investigations of the U-864 wreck area. NIVA Report 5092 (2005) characterises the sediment in the wreck area as having a very low organic-matter content. The 65 sediment samples had an average TOC concentration of approximately 3.8 g C kg^{-1} in the upper 0–10 cm and 2.1 g C kg^{-1} below 10 cm. Thus, the relatively low TOC concentrations observed at TU-3 and TU-4 are consistent with an increased contribution of re-sedimentation of suspended seabed sediment to these traps.

The Hg-to-organic-C ratio provides additional evidence. The median molar Hg/C ratio of the 65 historical sediment samples was approximately 303×10^{-6}. Ratios measured in the TU-3 and TU-4 traps were of the same order of magnitude and were markedly higher than those at the other stations (Table 10). The combination of relatively low TOC and elevated Hg/C ratios therefore strongly supports a substantial contribution of resuspended U-864 seabed sediment to the material collected at TU-3 and TU-4.

Table 8. Total organic carbon in the sediment trap samples.

Sediment trap	g C/kg dry substance	Organic C (%)	Average organic C (%)	Hg/C molar ratio X 10^{-6}
TU-1, 2m, replicate 1	14.0	1.40	1.9	12
TU-1, 2m, replicate 2	23.7	2.37		9.7
TU-1, 10m, replicate 1	15.9	1.59	2.0	15
TU-1, 10m, replicate 2	24.5	2.45		6.8
TU-2, 2m, replicate 1	28.3	2.83	2.8	27*
TU-2, 2m, replicate 2	Damaged sediment trap			
TU-2, 10m, replicate 1	22.5	2.25	2.9	14
TU-2, 10m, replicate 2	30.4	3.04		7.0
TU-3, 2m, replicate 1	**10.6**	**1.06**	**1.3**	301
TU-3, 2m, replicate 2	**16.3**	**1.63**		242
TU-3, 10m, replicate 1	**18.3**	**1.83**	**1.6**	256

TU-3, 10m, replicate 2	**13.6**	**1.36**		260
TU-4, 2m, replicate 1	**6.58**	**0.658**	**0.8**	709
TU-4, 2m, replicate 2	**9.74**	**0.974**		485
TU-4, 10m, replicate 1	**7.42**	**0.742**	**1.4**	281
TU-4, 10m, replicate 2	**20.0**	**2.00**		92
TU-5, 2m, replicate 1	18.4	1.84	1.5	19
TU-5, 2m, replicate 2	11.5	1.15		16
TU-5, 10m, replicate 1	15.5	1.55	2.0	28
TU-5, 10m, replicate 2	24.1	2.41		19

3.3.4 Grain size distribution

The grain-size distributions of the sediment-trap samples are presented in Table 11. As for total dry substance, the fraction reported as silt and clay (<63 µm) also includes salts remaining from seawater after freeze-drying and should therefore be interpreted with caution.

Despite this limitation, the results show a clear spatial pattern. At TU-3 and TU-4, located downstream of the dredging operation, 25–54% of the measured dry substance consisted of particles >63 µm. In contrast, samples from TU-1, TU-2 and TU-Ref. (5) were dominated by the <63 µm fraction, which accounted for approximately 82–99% of the measured dry substance.

The higher proportion of coarse particles at TU-3 and TU-4 is consistent with recent resuspension of seabed sediment transported approximately 170 m from the dredging area. This interpretation is also supported by previous descriptions of sediments around the wreck as predominantly sandy material overlying hard clay, locally containing gravel and stones.

Taken together, the sediment-trap results provide clear evidence that the dredging operation caused resuspension and downstream transport of mercury-contaminated seabed material. The strongest response occurred at TU-3 and TU-4, north-west and north of the operational area and in the direction of the prevailing bottom current. These stations received the largest particulate fluxes and were characterised by high mercury concentrations, low organic-carbon content, elevated Hg/C ratios and a greater proportion of particles >63 µm than the other monitoring stations. These characteristics are consistent with the known properties of sediments in the U-864 wreck area: relatively coarse, organic-poor and strongly contaminated with mercury.

The greater accumulation in traps positioned 2 m rather than 10 m above the seabed further indicates that much of the resuspended material was transported within the near-bottom water layer.

The sediment-trap results are also consistent with the results from the DGT passive samplers mounted alongside the sediment traps, which showed the highest concentrations of DGT-labile dissolved mercury at the same two downstream stations (Chapter 5.2.4). Together, the two independent monitoring approaches indicate that the dredging operation caused measurable local dispersion of mercury in both particulate-bound and dissolved labile forms, with transport occurring predominantly downstream of the operational area and strongly influenced by the prevailing bottom-current direction.

Table 11. Grain size distribution in the sediment trap samples

Sediment trap	% < 63 µm in dry substance
TU-1, 2m, replicate 1	98 %
TU-1, 2m, replicate 2	88 %
TU-1, 10m, replicate 1	99 %
TU-1, 10m, replicate 2	82 %
TU-2, 2m, replicate 1	85 %
TU-2, 2m, replicate 2	Damaged sediment trap
TU-2, 10m, replicate 1	98 %
TU-2, 10m, replicate 2	86 %
TU-3, 2m, replicate 1	**62 %**
TU-3, 2m, replicate 2	**56 %**
TU-3, 10m, replicate 1	**75 %**
TU-3, 10m, replicate 2	**70 %**
TU-4, 2m, replicate 1	**53 %**
TU-4, 2m, replicate 2	**46 %**
TU-4, 10m, replicate 1	**70 %**
TU-4, 10m, replicate 2	**65 %**
TU-5, 2m, replicate 1	92 %
TU-5, 2m, replicate 2	93 %
TU-5, 10m, replicate 1	97 %
TU-5, 10m, replicate 2	83 %

3.4 Calculations of spreading of mercury

To calculate the flux of mercury F_{Hg}, the particle flux was calculated with a mercury-turbidity ratio, Hg:Turb

$$F_{Hg} = (Hg{:}Turb) \cdot F_p$$

The unit for mercury is ng L^{-1} and for turbidity is FNU for Hg:Turb. It is assumed that 1 FNU is approximately 1 mg L^{-1} of particles.

During the first three days of the dredging the mercury-turbidity ratio was set between 1 and 3 ng L^{-1} FNU^{-1} (see Table 9). In the morning of June 23 very high concentrations was measured by the Supporter ROV (1.3-2.1 µg Hg L^{-1}, FTU 5-13) , and the average Hg:Turb for these measurements was 220. Since the maximum turbidity measured with the Supporter ROV was 120 FNU, this ratio would have implied that concentrations of mercury in the water were as high as 26 µg L^{-1}, one order of magnitude higher than what was observed. To arrive at a more realistic Hg:Turb ratio the highest observed mercury concentration (2170 ng L^{-1}) was divided by the 99 percentile value of turbidity measured during 23 June (29.28 FNU). This gave a Hg:Turb ratio of 74.1. If we assume that one turbidity unit corresponds to a particle concentration of 1 mg L^{-1}, the unit of the ratio is the same as rightmost column in **Error! Reference source not found.** (mg kg^{-1}), and this ratio is near the highest values found in the sediment traps. During the last three days of the dredging a ratio of 8.21 was used, based on observations later in the day during June 23.

Overview of the calculations for each day is given in Table 9, and the accumulated spread during the operation is shown in Figure 10. During the dredging from June 20 to 26 it is estimated that a total of 178 tonnes of particles and 3.2 kg of mercury was spread out of the polygon shown in the map in Figure 4. Most of the measured spread of mercury was during the extensive dredging on June 23 when the daily flux exceeded the daily limit of 375 g/day. Total spread during the operation is estimated to just above the maximum spread for the whole operation (Figure 10).

Table 9. Overview of flux calculations.

Date	Particle flux, F_p (tonnes/day)	Mercury flux, F_{Hg} (g/day)	Hg:Turb ratio
20.06.2026	8.5	25.9	3.06
21.06.2026	21.1	25.5	1.21
22.06.2026	6.9	16.9	2.43
23.06.2026	29.9	2212.6	74.10
24.06.2026	12.5	103.0	8.21
25.06.2026	4.6	38.0	8.21
26.06.2026	94.4	774.5	8.21
Total flux over 7 days	177.9 tonnes	3196 g	

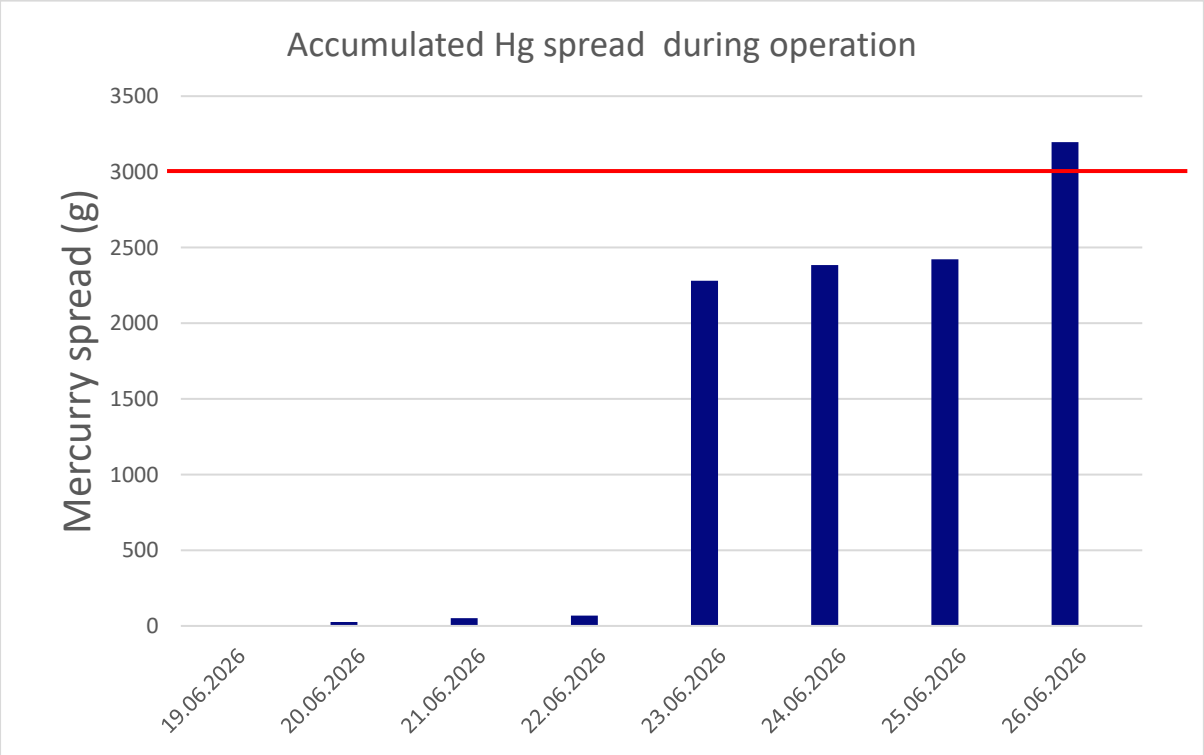

Figure 10 Cumulative estimated Hg spread during the dredging operation. Red line represents the 3 kg limit of the allowed spread during the operation.

The calculations are subject to several uncertainties. The estimated spread on the last day may be overestimated because it was driven by a short-lived but very high turbidity event. Conversely, some

plumes may have passed the monitoring perimeter undetected, meaning that the actual spread could have been either higher or lower than estimated.

The flux of particles and mercury may have been underestimated on June 24 and 25, as no turbidity observations were available between June 24 at 16:00 UTC and June 25 at 16:00 UTC. The daily flux estimated for June 26 may, in contrast, have been overestimated due to the high-turbidity event.

3.5 Discussion of the flux calculations

The flux calculations have several uncertainties associated with it. Firstly, in general it is challenging to observe particle clouds in the sea. This would be the case with all monitoring since the amount of observation points are limited. In this case it was used a mobile observation platform giving the possibility to actively search for possible particle clouds. Secondly, it was assumed a relationship between particles measured as turbidity and Hg concentrations. A Hg:Turb ratio was used to relate the two variables, and this ratio had a large variation. Thirdly, the vertical distribution of turbidity and mercury concentration was estimated from a small data set. Vertical measurements of turbidity was generally taken when particle concentrations were low, but this confirmed that our assumption that the turbidity level was at background levels at 100 m depth was reasonable. The DGT observations gave the strongest evidence of a strong vertical gradient near the bottom.

We have used the best of our knowledge and available data to try to give what we believe is the best estimate of the flux out of the operational perimeter. We have not deliberately overestimated the flux to be on the conservative side but rather tried to give a value we believe to be correct. The flux of 3.5 kg Hg can both be an overestimate and an underestimate. Most of the flux happened June 23 (2 kg/day), and it is possible that this is an overestimate since the observation was taken closer to the submarine than at the perimeter (see Figure 4). On the other hand, it is a risk that the Supporter ROV missed particle clouds during the operation, that would lead to underestimates of daily fluxes.

A large portion of the observed Hg concentration was in the form of dissolved mercury. We don't believe this affected the flux calculations significantly, since the flux was calculated as total mercury. But for the further fate of the mercury that left the perimeter of operation, the ratio between dissolved and particulate mercury is an important factor.

If we assume that the dredged sediments had a density of 2500 kg m^{-3} and porosity of 50 %, the particle flux of 178 tonnes would cover an area of 12 x 12 m^2 with 1 m of sediments, which is more than the volume that was dredged near the keel of U-864. This leads us to the conclusion that the particle flux, especially June 26, was an overestimate.

Three independent methods are used to indicate the spreading of mercury: sediment traps, passive samplers and flux estimate based on turbidity measurements, water samples and current measurements. All methods indicate a high degree of spreading, even though the results from the different methods are not comparable. The sediment traps give the vertical flux of particulate mercury at the point of observations. The passive samples give an average concentration of labile inorganic mercury at the point of observations. The flux calculations are the most complex method and have most elements of uncertainties but gives the total flux of TotHg out of the polygon. The two other methods indicate that the flux calculations underestimate the spread of mercury, rather than overestimate. The sediment traps at station TU-3 and TU-4 indicate that the mercury to turbidity ratio

should be in the range 50-60 on average. The passive sampler at station TU-4 indicates that the concentration of mercury at 10 m above the sea bed was 0.36 µg L^{-1} on average.

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5 Appendix

Appendix 1

Laboratory experiments of carryover effect of sample vessels

Introduction

During the dredging operation, total mercury concentrations measured in background samples gradually increased despite the absence of any obvious contamination source. This suggested that the Niskin sample bottles themselves had become contaminated following repeated exposure to elevated mercury concentrations during sampling. A series of laboratory experiments was therefore conducted to quantify the magnitude of the carryover effect and to evaluate possible cleaning procedures.

Method

Previously used Niskin sample bottles were thoroughly rinsed with uncontaminated seawater before being filled with surface seawater collected near Fedje. The bottles were left filled for one hour before subsamples were collected for analysis of total and dissolved mercury. For one bottle (Niskin 6), the experiment was repeated after refilling with fresh seawater to assess whether carryover persisted after repeated use.

Additional experiments were performed to evaluate possible cleaning procedures. These included:

- high-pressure washing of the bottles,
- soaking in 2.5% nitric acid,
- testing mercury leaching from the internal rubber closure band, and
- testing a new set of unused Niskin bottles supplied by the Institute of Marine Research (HI).

Results

Carryover contamination

The experiments demonstrated that previously used Niskin bottles released mercury into clean seawater (Table 1). Most of the released mercury occurred in the dissolved phase.

Bottle Niskin 6 continued to contaminate fresh seawater following repeated refilling, indicating that the adsorbed mercury was not readily removed by rinsing. Furthermore, mercury concentrations increased with increasing contact time between the water and the bottle.

Carryover contamination was considerably greater in bottles tested on 27 June than in the bottle tested on 23 June, suggesting that contamination accumulated with continued exposure to elevated mercury concentrations during the dredging operation.

Table 1. Test of carryover effect in sample vessels.

Sample	Treatment	Total Hg ng/L	Dissolved Hg ng/L	Comment
Seawater		0.92		Average of four parallels
Niskin 6	Sampled after 1 hr	13.6	10.08	Average of two parallels Test conducted 23.06
Niskin 6	Refilled - Sampled after 0.5 hr.	11.48	8.86	
Niskin 6	Sampled after 1 hr.	52.44		
Seawater		3.11		Average of four parallels
Niskin 1	Sampled after 1 hr.	108.78		Test conducted 27.06
Niskin 4	Sampled after 1 hr.	74.96		
Niskin 5	Sampled after 1 hr.	113.74		

Effect of high-pressure washing

To evaluate whether mechanical cleaning could remove the contamination, three bottles were cleaned using a high-pressure water jet before testing.

The results (Table 2) showed that the small Niskin bottle (No. 2) continued to contaminate the seawater sample, whereas the two larger bottles (Nos. 7 and 12) showed no measurable carryover.

The reason for this difference remains uncertain. It may reflect differences in exposure history during the operation, but it may also be related to differences in bottle design, as the larger bottles do not contain an internal rubber closure band.

Table 2. Test of carryover in small and large sample vessels.

Sample	Treatment	Total Hg ng/L	Dissolved Hg ng/L	Comment
Seawater		2.18	1.56	
Niskin 2	Sampled after 1 hr	54.78	58.86	Small vessel
Seawater		1.14	1.30	
Niskin 7	Sampled after 1 hr	2.96		Large vessel
Niskin 12	Sampled after 1 hr	1.66		Large vessel

Mercury leaching from the rubber closure band

To investigate whether the rubber closure band contributed to carryover contamination, a rubber band was placed in a 1-L bottle containing uncontaminated surface seawater.

Mercury concentrations increased steadily throughout the experiment (Table 3, Figure 1), demonstrating continuous leaching of mercury from the rubber material. After seven hours the mercury concentration had increased almost thirty-fold relative to the original seawater concentration.

These results indicate that the rubber closure band is likely to be an important source of carryover contamination.

Table 3. Test of leaching of mercury from the rubber band inside the small Niskin sample vessels.

Time (min)	Total Mercury (ng/L)
Seawater	1.75
5	9.22
15	15.8
30	19.56
60	31.14
150	36.86
420	49.48

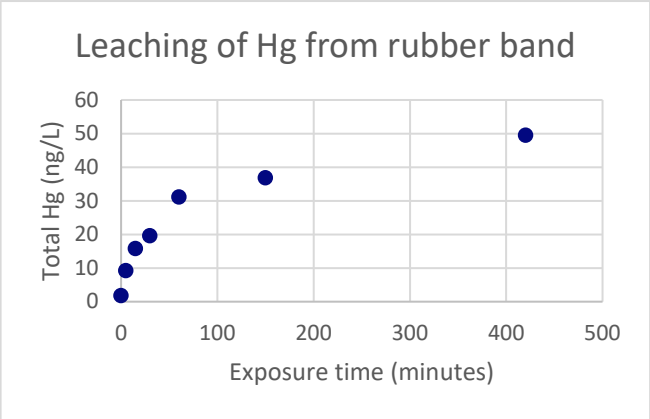

Figure 1. Increase in leached mercury from the rubber band inside the small Niskin sample vessels over time.

Effect of acid washing

The contaminated bottles were subsequently soaked in 2.5% nitric acid before being rinsed and retested. The results (Table 4) demonstrated that acid washing did not eliminate the carryover effect. Mercury concentrations in clean seawater remained between 34 and 73 ng L^{-1}, indicating that a substantial fraction of the adsorbed mercury remained associated with the bottle components.

Table 4. Test of acid washing as a procedure to clean the sample vessels to avoid the carryover

Sample	Total Mercury (ng/L)
Niskin 4	50.44
Niskin 5	33.82
Niskin 6	72.78

New Niskin bottles

Finally, six new unused Niskin bottles supplied by the Institute of Marine Research were tested. None of these bottles measurably contaminated the seawater samples (Table 5), demonstrating that the observed carryover originated from contamination acquired during the dredging operation rather than from the bottle materials themselves.

Table 5. Carryover test of new Niskin sample vessels from HI.

Sample	Total Mercury (ng/L)	Comments
Seawater	2.52	Average of 4 parallels
HI1	3.24	
HI4	3.24	
HI5	2.54	
HI2	2.40	
HI3	1.41	
HI6	2.02	

Conclusion

Laboratory experiments demonstrated substantial carryover contamination in Niskin sample bottles following repeated exposure to elevated mercury concentrations during the dredging operation. Mercury released from previously contaminated bottles ranged from approximately 4 to 50 ng Hg L^{-1}, although some bottles released more than 100 ng Hg L^{-1} into uncontaminated seawater.

The experiments further showed that:

- carryover contamination increased with contact time between the water and the bottle;
- repeated rinsing did not eliminate the contamination;
- high-pressure washing was ineffective for contaminated small bottles;
- soaking in 2.5% nitric acid did not remove the contamination; and
- the internal rubber closure band was itself a significant source of mercury leaching.

The observations suggest that adsorption and desorption of mercury approach an equilibrium between the bottle surfaces and the enclosed water. Consequently, carryover contamination has the greatest proportional influence on samples containing low mercury concentrations, while adsorption to the bottle surfaces may simultaneously cause slight underestimation of samples containing elevated mercury concentrations. Because adsorption and desorption occur simultaneously, no robust correction procedure can be applied to the analytical results.

The experiments demonstrate that conventional Niskin bottles are not well suited for repeated ultra-trace mercury sampling across the large concentration gradients encountered during the dredging operation. Future monitoring programmes should therefore employ dedicated ultra-trace mercury sampling equipment or use separate bottles for contaminated and background samples to minimise carryover contamination.

Table A2. Measured concentrations of dissolved mercury.

Sample type	Date	Dissolved Mercury µg L^{-1}
Test sampling at wrecksite	19.06.2026	0.003
Daily sample	19.06.2026	0.002
Daily sample	19.06.2026	0.001
Daily sample	19.06.2026	0.012
Monitoring in the plume	20.06.2026	0.003
Monitoring in the plume	20.06.2026	0.002
Near container when dredging	20.06.2026	0.007
Monitoring in the plume	20.06.2026	0.001
Monitoring in the plume	21.06.2026	0.001
At dredge site	21.06.2026	0.001
In the water column	21.06.2026	0.005
Monitoring in the plume	21.06.2026	0.002
At dredge site	21.06.2026	0.004
Monitoring in the plume	21.06.2026	0.001
Vertical sample profile	22.06.2026	0.004
Vertical sample profile	22.06.2026	0.006
Blank sample	22.06.2026	0.013
Blank sample	22.06.2026	0.009
Daily sample	22.06.2026	0.002
At dredge site	22.06.2026	0.011
At dredge site	22.06.2026	0.009
Blank sample	22.06.2026	0.019
Blank sample	23.06.2026	0.003
Blank Sample	23.06.2026	0.005
Blank Sample	23.06.2026	0.003
Blank Sample	23.06.2026	0.011
Monitoring near perimeter	23.06.2026	0.010
Monitoring near perimeter	23.06.2026	0.960
Monitoring near perimeter	23.06.2026	0.963
Monitoring near perimeter	23.06.2026	0.585
Blank Sample	23.06.2026	0.017
Monitoring near perimeter	23.06.2026	0.012
Monitoring near perimeter	23.06.2026	0.047
Monitoring near perimeter	23.06.2026	0.021
Blank Sample	23.06.2026	0.058
Monitoring near perimeter	23.06.2026	0.011

Monitoring near perimeter	23.06.2026	0.009
Monitoring near perimeter	23.06.2026	0.025
Monitoring near perimeter	23.06.2026	0.008
Monitoring near perimeter	23.06.2026	0.012
Monitoring near perimeter	23.06.2026	0.010
Monitoring near perimeter	23.06.2026	0.059
Monitoring near perimeter	23.06.2026	0.004
Monitoring near perimeter	23.06.2026	0.018
Monitoring near perimeter	23.06.2026	0.008
Monitoring near perimeter	23.06.2026	0.009
Monitoring near perimeter	23.06.2026	0.040
Monitoring near perimeter	23.06.2026	0.016
Dredge Site	24.06.2026	0.028
Dredge Site	24.06.2026	0.038
Monitoring near perimeter	25.06.2026	0.054
Monitoring near perimeter	25.06.2026	0.034
Monitoring near perimeter	25.06.2026	0.072
Dredge Site	25.06.2026	0.004
Monitoring near perimeter	26.06.2026	0.025
Monitoring near perimeter	26.06.2026	0.017
Monitoring near perimeter	26.06.2026	0.044
Monitoring near perimeter	26.06.2026	0.086
Monitoring near perimeter	26.06.2026	0.028
Monitoring near perimeter	26.06.2026	0.022
Monitoring near perimeter	26.06.2026	0.018
Blank sample	26.06.2026	0.012
Monitoring near perimeter	26.06.2026	0.033
Monitoring near perimeter	26.06.2026	0.016
Blank sample	26.06.2026	0.013
Dredge Site	28.06.2026	0.011
Dredge Site	28.06.2026	0.018
Dredge Site	28.06.2026	0.008

Appendix 2

Background plots for the flux calculations

Plot of turbidity during the operation

During the observation turbidity was measured from the Supporter ROV (se Figure 1). The data is an average over 10 minutes. When data from the Supporter ROV was not available a background value of 0.23 FNU was used.

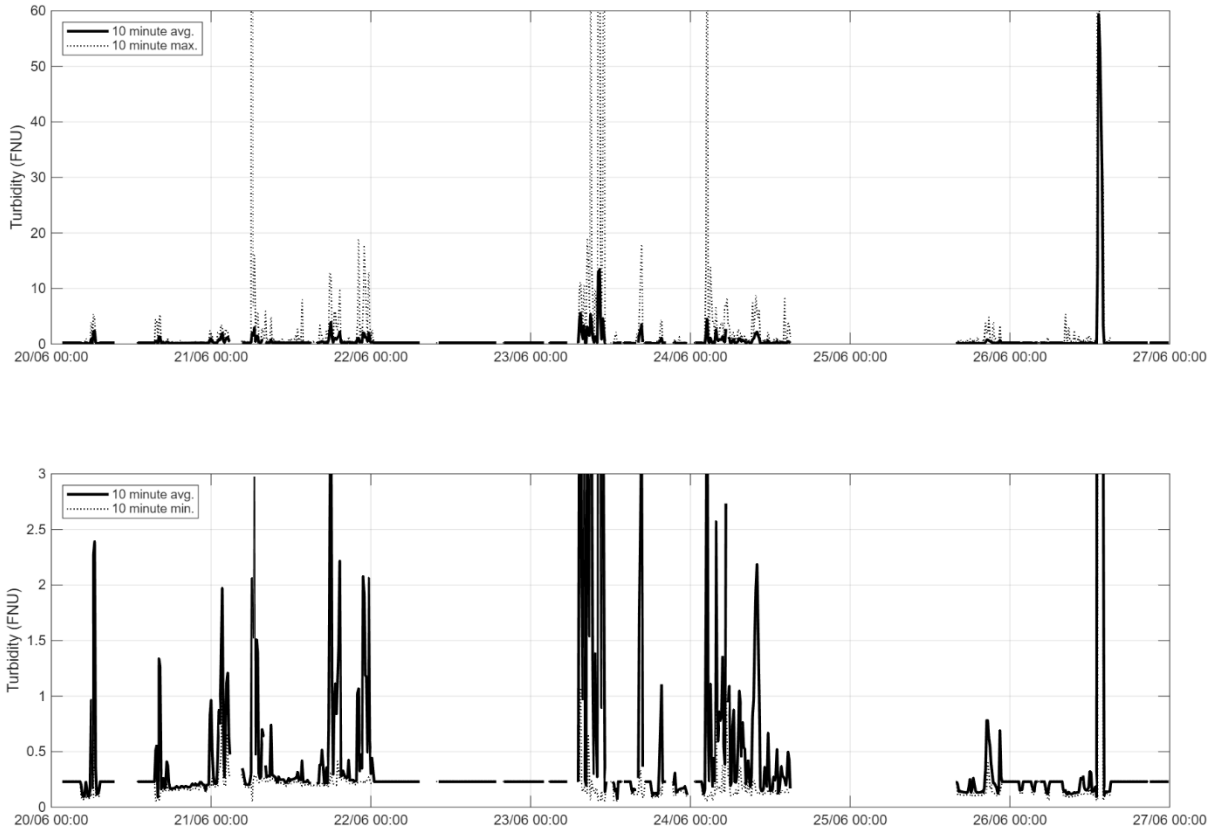

Figure 1. Turbidity observations during the operation where turbidity is averaged for every 10 minutes. Upper panel shows the average turbidity (thick black line) together with the highest observation during the 10 minute averaging period (thin broken line). In the lower panel the y-axis is zoomed in on the lower values. The average turbidity is shown together with the lowest observation during the averaging period (thin broken line).

Vertical distribution of turbidity and mercury

Figure 2 show all turbidity observations from the Supporter ROV (black dots). Based on this a vertical distribution factor is made up. This factor is multiplied with the observed turbidity, to make an estimate of the vertical distribution of the particle distribution at any given time. In the figure the value is shown for two examples, when the observed value is 2 and 10 FNU.

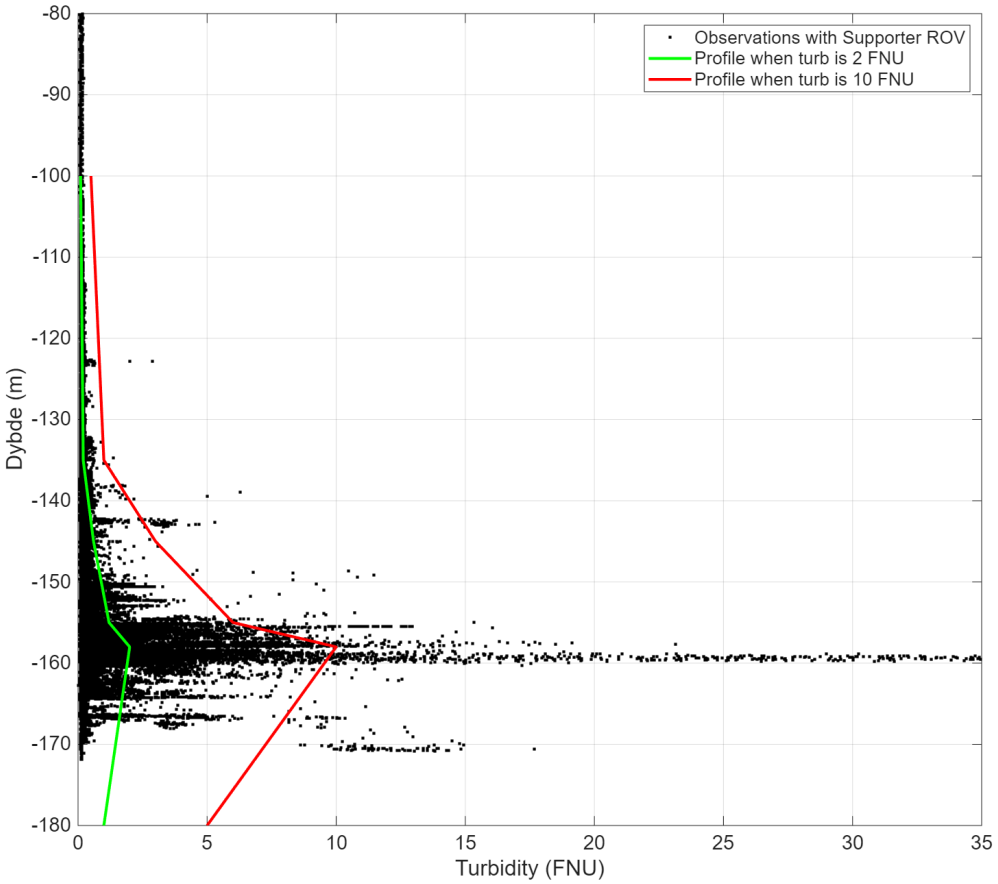

Figure 2. Vertical distribution of all turbidity observations from the Supporter ROV. The green line shows the distribution that is used when observed turbidity is 2 FNU, and the red line shows the distribution when observed turbidity is 10 FNU.

Filling in missing values in the current measurements

In Figure 3 the available current measurements are show. White areas show where current measurements are missing. During the operation a constant value was used for the daily reports. In Figure 4 a dataset is constructed by using data from the periods near in time. This data is put in so it fit the tidal cycle. For the day June 22 data from June 21 is used, but since the tidal range is smaller this day, current speeds from June 21 is multiplied with a factor 0.85.

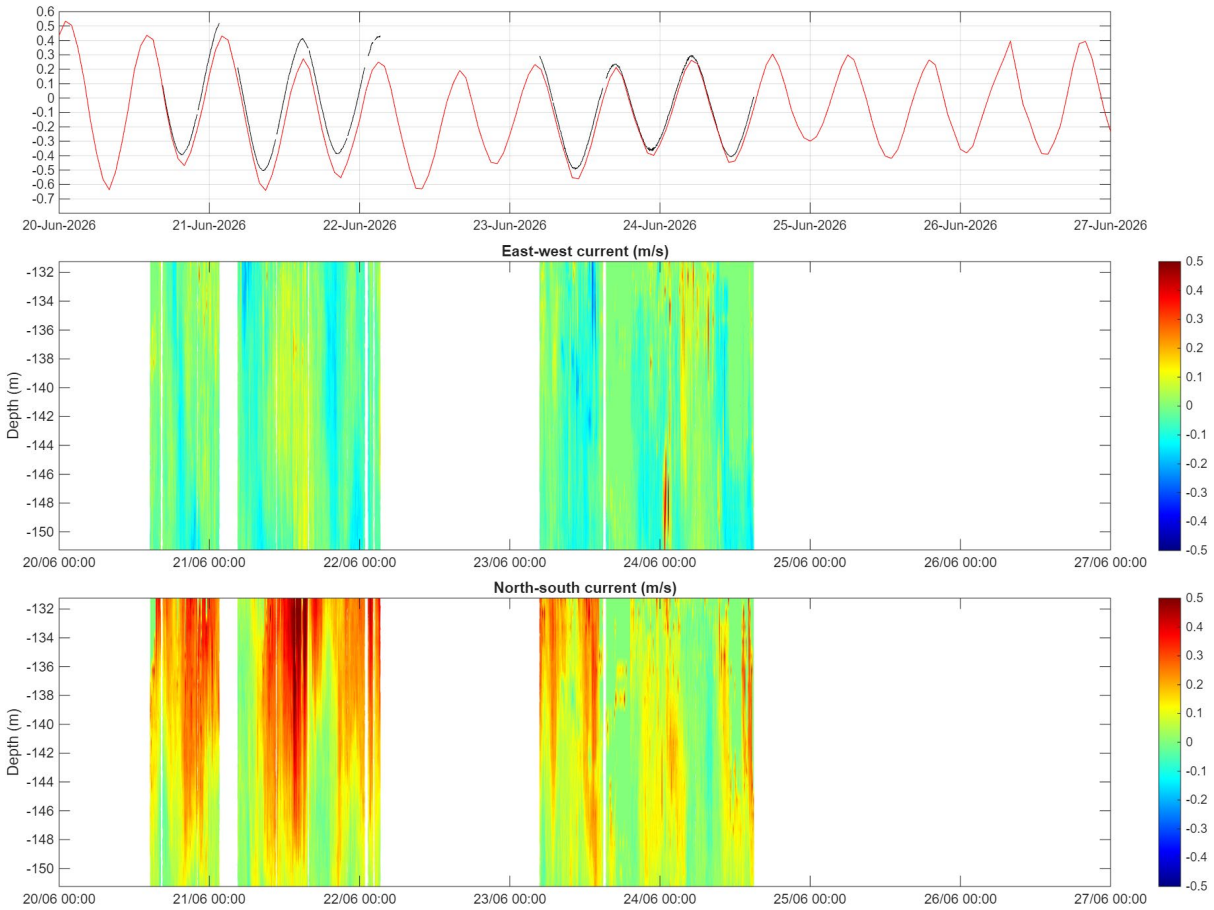

Figure 3. Current measurments during the operation. The upper panels show the sea level observed in Bergen (red line) and position of the current meter (black line). Middel panel show currents along the east-west axis. The lower panel show currents along the north-south axis.

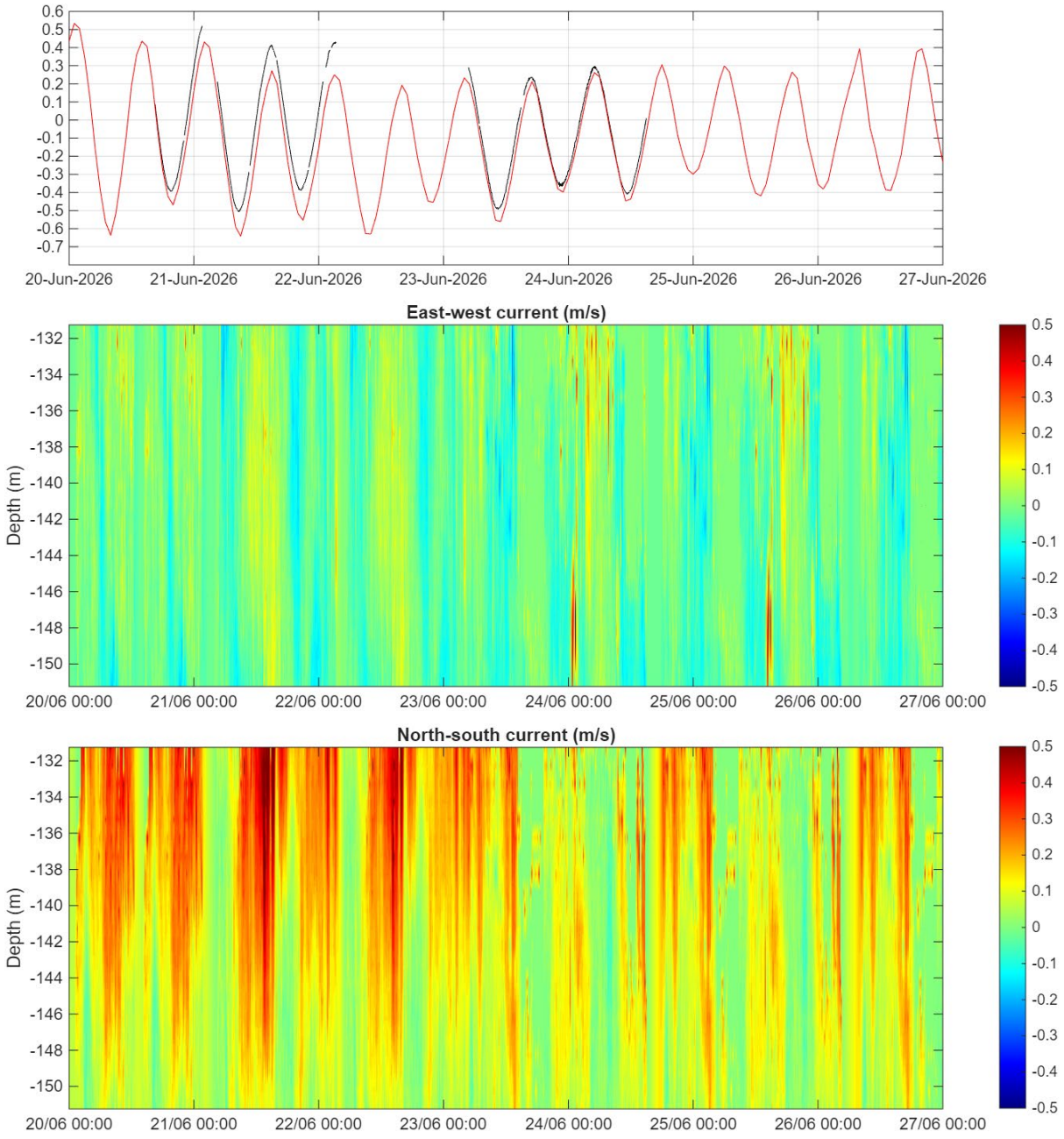

Figure 4. Current measurments used in the calculations. The upper panels show the sea level observed in Bergen (red line) and position of the current meter (black line). Middel panel show currents along the east-west axis. The lower panel show currents along the north-south axis.

Appendix 3

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		CTD									EUROFINS		OFFSHORE LAB			COMMENTS	
		Ideanaut CTD on Supporter , SAIV CTD on Constructor				GPS DATA UTM 32		SAIV / IDRON AUT DATA DATA									
SAMPLE NUMBER	Sample type	Station NAME	NISKIN BOTTLE	DATE of closing NISKIN	Time UTC (HH:MM)	Northing	Easting	Sample depth (m)	Sample altitude (m)	TURBIDITY (FTU)	Turb EF Reg1	Turb EF reg2	Mercury (ng/l)	Mercury (pg/l)	Analysis Time (UTC)	NOTES	Comments for explanation in report
1	extra sample	NA	4	26.03.2026	22:58:00	65,77016	4,62113	NA	2	-			1,43		02:45	20m from wreck	
2	extra sample	NA	3	26.03.2026	22:58:00	65,77016	4,62113	NA	10	-			<1		02:47	20m from wreck	
3	extra sample	NA	2	26.03.2026	23:01:00	65,77016	4,62113	NA	20	-			<1		02:30	20m from wreck	
4	extra sample	NA	6	26.03.2026	23:03:00	65,77016	4,62113	NA	50	-			<1		02:30	20m from wreck	
5	Baseline #1	TU 3	4	21.03.2026	23:48:00	65,77102	4,61979	163m	5	0,24			<1		07:58	niskin bottles did not have unique numbers. They were called 1-6 on supporter and 1-3 on constructor	
6	Baseline #1	TU 4	4	21.03.2026	23:44:00			173m	5	0,23			<1		09:01	niskin bottles did not have unique numbers. They were called 1-6 on supporter and 1-3 on constructor	
7	Baseline #2	TU 4	3	22.03.2026	2:03:00				5	0,23			<1		08:07	niskin bottles did not have unique numbers. They were called 1-6 on supporter and 1-3 on constructor	
8	Baseline #2	TU 3	3	22.03.2026	2:06:00				5	0,22			<1		08:12	niskin bottles did not have unique numbers. They were called 1-6 on supporter and 1-3 on constructor	
9	Fieldblank	TU 3	2	22.03.2026	3:56:00				50	0,20			<1		08:35	niskin bottles did not have unique numbers. They were called 1-6 on supporter and 1-3 on constructor	
10	Fieldblank	TU 4	2	22.03.2026	3:33:00				50	0,25			<1		08:41	niskin bottles did not have unique numbers. They were called 1-6 on supporter and 1-3 on constructor	
11	Fieldblank	TU 4	6	22.03.2026	4:19:00			35	138	0,14			<1		08:46	niskin bottles did not have unique numbers. They were called 1-6 on supporter and 1-3 on constructor	
12	Test sampling at wreck site	Constructor	7	19.06.2026	3:06:30	261569	6745145	163	3	0,14			613,86	0,614	14:45	Turbidity plume reached the sampling bottle, but not the turbidity sensor	Sampling performed while ROV was performing minor tasks near the wreck causing some turbidity, this data should not be included in modeling
13	Test sampling at wreck site	Constructor	8	19.06.2026	8:33:41	261577	6745149	163	3	0,15			2,34	0,002	14:50	Time sync between CTD and ship was 25 seconds off, corrected	Sampling performed while ROV was performing minor tasks near the wreck causing some turbidity, this data should not be included in modeling
14	Test sampling at wreck site	Constructor	6	19.06.2026	8:38:46	261573	6745151	163	3	0,11			1,30	0,001	14:55	Time sync between CTD and ship was 25 seconds off, corrected	Sampling performed while ROV was performing minor tasks near the wreck causing some turbidity, this data should not be included in modeling
15	Test sampling at wreck site	Constructor	6	19.06.2026	8:38:46	261573	6745151	163	3	0,11			11,56	0,012	15:00	Replicate analysis of sample no 14 with better shaking of sampling bottle	Sampling performed while ROV was performing minor tasks near the wreck causing some turbidity, this data should not be included in modeling
16	Monitoring in the plume	Supporter	1	26.06.2026	5:58:00	261469	6745253	166,58		1,40			4,18	0,004	11:17		
17	Monitoring in the plume	Supporter	2	26.06.2026	6:18:00	261403	6745227	163,44		4,42			19,82	0,020	11:21		
18	Monitoring in the plume	Supporter	3	26.06.2026	6:19:00	261403	6745227	164,55		1,37						The bottle did not close properly, sample missing	
19	Fieldblank	Supporter	4	26.06.2026	7:49:00	261569	6745151	113,81		1,31			4,18	0,004	11:25		Sample taken high up in the water column, blank sample
20	Near exhaust container when dredging	Constructor	8	26.06.2026	16:45:00	261589	6745115?	163	8,0	10,00			95,70	0,096	06:22		Taken near the exhaust container while dredging
21	Monitoring in the plume	Supporter	9	26.06.2026	19:23:00	261588	6745032	146	7,0	1,65			2,60	0,003	03:43		
22	Monitoring in the plume	Supporter	3	26.06.2026	21:38:00	261588	6745032	136	7,0	1,37						The bottle did not close properly, sample missing	
23	Monitoring in the plume	Supporter	1	21.06.2026	0:03:00	261575	6745228	163	7,0	2,08			1,92	0,002	03:46		
24	At dredge site, while dredging	Constructor	1	26.06.2026	5:57:00	261575	6745149	160		5,82			234,38	0,234	06:13		
25	Sample at high altitude	Constructor	6	26.06.2026	8:01:00	261575	6745153	131		0,48			126,60	0,127	06:17		
26	Monitoring in the plume	Supporter	1	21.06.2026	17:58:00	261666	6745190,0	159		7,00			4,86	0,005	01:35		
27	At dredge site, while dredging	Constructor	2	21.06.2026	21:55:00	261578	6745157	161		6,70			19,14	0,019	10:12		
28	Monitoring, not in the plume	Supporter	3	21.06.2026	22:06:00	261513	6745196	155		1,46						The bottle did not close properly, sample missing	
29	Monitoring in the plume	Supporter	4	21.06.2026	23:59:00	6745195	261507	162		6,40			12,06	0,013	01:38		
30	Fieldblank	Supporter	5	22.06.2026	2:41:06	261575	6745166	143		1,35			10,34	0,038	10:23		
31	Vertical sample profile	Supporter	2	22.06.2026	5:52:00	674105	261579	163	3,9	1,70			19,14	0,019	10:12		Sample taken while no tasks where causing turbidity
32	Vertical sample profile	Supporter	3	22.06.2026	5:52:00	674105	261579	163	3,9	1,70			19,40	0,019	10:16		Sample taken while no tasks where causing turbidity
33	Vertical sample profile	Supporter	4	22.06.2026	6:04:00	674105	261581	146	20,5	1,40			20,26	0,020	10:19		Sample taken while no tasks where causing turbidity
34	Vertical sample profile	Supporter	9	22.06.2026	6:04:00	6745105	261581	146	20,5	1,40						Closed but empty Niskin, lid may have snagged on edge of tray.	Sample taken while no tasks where causing turbidity
35	Vertical sample profile	Supporter	5	22.06.2026	6:07:00	674101	261561	115	51,8	1,35			10,34	0,010	10:23		Sample taken while no tasks where causing turbidity
36	Fieldblank	Supporter	1	22.06.2026	2:42:02	6745105	261575	144	19,0	1,35			4,86	0,005	10:08		Sample taken while constructor is working/close to the seafloor
37	At dredge site, no dredging ongoing	Supporter	3	22.06.2026	17:32:00	6745161	261587	157	10,0	1,59	1,70	0,46	99,92	0,100	18:35	Over dredging container	No operations on going on the seafloor
38	At dredge site, no dredging ongoing	Supporter	6	22.06.2026	17:32:00	6745161	261587	157	10,0	1,52	0,36		693,78	0,101	18:38	Over dredging container	No operations on going on the seafloor
39	Fieldblank	Supporter	1	22.06.2026	21:12:00	6745208	261516	161	9,4	1,30	<0,1	<0,1	23,76	0,024	02:47	no dredging, minor work on going with constructor	
40	Fieldblank	Supporter	2	23.06.2026	1:01:38	6745209	261516	162	9,9	1,34	0,37	0,39	7,32	0,007	02:50	no dredging, minor work on going with constructor	
41	Fieldblank	Supporter	1	23.06.2026	4:28:28	6745180	261577	119	49,5	1,30	<0,1		5,30	0,005	05:49		
42	Fieldblank	Supporter	2	23.06.2026	4:28:53	6745189	261577	119	49,1	1,30	0,30	0,12	14,76	0,015	05:54		
43	Fieldblank	Supporter	1	23.06.2026	7:53:00	6745185	261557	50	119,8	0,68			14,44	0,014	12:06	Sample taken on the way down after launch.	
44	Monitoring near perimeter	Supporter	2	23.06.2026	8:04:32	6745209	261575	164	4,3	4,10			22,98	0,023	12:12	Sample taken at monitoring pos , NW of excavation	
45	Monitoring near perimeter	Supporter	3	23.06.2026	10:22:00	6745181	261551	162	3,5	5,13			2170,36	2,170	12:26	Sample taken at monitoring pos , NW of excavation	
46	Monitoring near perimeter	Supporter	4	23.06.2026	10:22:21	6745189	261550	162	3,8	5,87			2527,26	2,527	12:27	Sample taken at monitoring pos , NW of excavation	
47	Monitoring near perimeter	Supporter	5	23.06.2026	10:55:00	6745198	261532	162	3,3	12,80			1249,76	1,250	11:54	Sample taken at monitoring pos , NW of excavation	
48	Fieldblank	Supporter	1	23.06.2026	12:34:55	6745126	261568	54	104,0	0,07			9,40	0,009	13:43	Sample directly after launch	
49	Monitoring near perimeter	Supporter	2	23.06.2026	12:48:07	6745186	261548	161	2,9	0,16			14,96	0,015	12:38	Sample at the last monitoring pos in previous dive	
50	Monitoring near perimeter	Supporter	3	23.06.2026	12:48:02	6745186	261538	160	5,8	0,15	0,17		65,82	0,066	13:47	Sample at the last monitoring pos in previous dive	
51	Monitoring near perimeter	Supporter	4	23.06.2026	12:52:12	6745180	261548	157	9,3	0,16	0,38	<0,1	25,56	0,026	13:52	Sample at the last monitoring pos in previous dive	
52	Fieldblank	Supporter	5	23.06.2026	12:59:26	6745126	261567	49	106,9	0,15	0,76		22,34	0,022	13:56	Sample near surface before recovery	
53	Monitoring near perimeter	Supporter	1	23.06.2026	16:16:00	6745275	261447	170	5,3	3,74	0,64	0,64	16,18	0,016	17:43	Sample taken during dredging, higher turb	
54	Monitoring near perimeter	Supporter	2	23.06.2026	16:16:00	6745201	261451	173	4,0	11,46	0,88	1,20	64,34	0,064	17:46	Sample taken during dredging, higher turb	
55	Monitoring near perimeter	Supporter	3	23.06.2026	16:16:00	6745248	261450	174	3,0	11,53	2,20	1,40	122,60	0,123	17:50	Sample taken during dredging, higher turb	
56	Monitoring near perimeter	Supporter	4	23.06.2026	16:16:00	6745247	261450	176	2,9	12,79	0,96	1,90	81,66	0,082	17:54	Sample taken during dredging, higher turb	
57	Monitoring near perimeter	Supporter	1	23.06.2026	18:56:00	6745125	261430	131		0,06	<0,1	<0,1	13,48	0,013	20:46	Follow up sample after alarm	
58	Monitoring near perimeter	Supporter	2	23.06.2026	19:21:00	6745248	261455	167		0,16	<0,1	<0,1	12,00	0,012	20:49	Follow up sample after alarm, taken on same spot as sample 53	
59	Monitoring near perimeter	Supporter	3	23.06.2026	19:26:00	6745271	264476	166		0,40	0,32		103,92	0,104	20:52	Follow up sample after alarm, taken on same spot as sample 56	
60	Monitoring near perimeter	Supporter	4	23.06.2026	19:28:00	6745259	261448	179		3,87	0,49	0,34	22,34	0,022	20:56	Follow up sample after alarm, taken at highest area/deepest turb	
61	Monitoring near perimeter	Supporter	5	23.06.2026	19:46:00	6745259	261448	147		0,21	<0,1	<0,1	31,82	0,032	20:59	Follow up sample after alarm, same spot as sample 60, but higher up in the water column	
62	Monitoring near perimeter	Supporter	1	23.06.2026	23:00:00	6745288	261478	164		0,22	0,34	0,36	9,74	0,010	00:16	Follow up sample after alarm, taken on same spot as sample 59	
63	Monitoring near perimeter	Supporter	2	23.06.2026	23:04:00	6745249	261470	164		0,21	<0,1	<0,1	10,18	0,010	00:19	Follow up sample after alarm	
64	Monitoring near perimeter	Supporter	3	23.06.2026	23:08:00	6745262	261458	166		0,29	0,34	0,33	41,92	0,042	00:22	Follow up sample after alarm	
65	Monitoring near perimeter	Supporter	4	23.06.2026	23:12:00	6745226	261451	163		0,21	<0,1	0,26	17,48	0,017	00:26	Follow up sample after alarm	
66	Dredge Site	Supporter	1	24.06.2026	10:47:56	6745136	261563	154	5,10	9,2	<0,1	<0,1	43,24	0,043	19:56	Supporter moves approx 50 m west from exc. Site. Moves 30m sideways and back to back Niskins. They were back/down, idle. Closes Niskin 1 and 3	
67	Dredge Site	Supporter	2	24.06.2026	10:48:26	6745136	261563	154	5,10	0,13	0,99	0,41	64,00	0,064	19:59	See comment above.	
68	Monitoring near perimeter	Supporter	1	25.06.2026	22:07:00	6745089	261856,9	139,53	10,2	0,12	<0,1	<0,1	68,70	0,068	01:17	Supporter moves approx 88 m east from exc. Site. Moves back and forth to rinse bottles. Take 'daily monitoring sample'. Current is east, north-east verified visually by ROV. A while before coming up, must expect some backround fig	
69	Monitoring near perimeter	Supporter	2	25.06.2026	22:08:00	6745089	261856,9	139,53	10,2	0,12	<0,1	0,69	69,04	0,069	01:20	Supporter moves approx 88 m east from exc. Site. Moves back and forth to rinse bottles. Take 'daily monitoring sample'. Current is east, north-east verified visually by ROV	
70	Monitoring near perimeter	Supporter	3	25.06.2026	22:12:00	6745089	261857	128,7	21,00	0,11	0,30	0,45	103,96	0,111	01:23		
71	Dredge Site	Constructor	6	25.06.2026	22:17:00	6745047	261563	163,5	0,4	9,5						Sample taken right up in the exc. Site, but it didn't close properly	
72	Dredge Site	Constructor	8	25.06.2026	22:21:00	6745047	261563	163,5	0,4	0,67			17,14	0,017	05:49	Sample taken right up in the exc. Because nr 6 didn't close	
73	Monitoring near perimeter	Supporter	1	26.06.2026	1:43:00	6745087	261654	163,5	9,5	0,15			29,30	0,029	03:01	Follow up sample after alarm, same location as sample 70	
74	Monitoring near perimeter	Supporter	2	26.06.2026	1:53:00	6745246	261694	166,2	10,2	0,18			20,78	0,021	03:04	Downstream northwest inside perimeter	
75	Monitoring near perimeter	Supporter	3	26.06.2026	1:54:00	6745243	261690	164,35	14,4	0,17			50,32	0,051	03:07	Downstream northwest inside perimeter	
76	Monitoring near perimeter	Supporter	3	26.06.2026	3:03:43	6745243	261654	160,4	10,3	0,19			69,36	0,069	04:55		
77	Monitoring near perimeter	Supporter	2	26.06.2026	3:31:00	6745248	261564	161,15	6,2	0,18			25,30	0,025	04:52		
78	Monitoring near perimeter	Supporter	4	26.06.2026	5:29:00	6745278	261567	156,7	6,5	0,13			33,14	0,033	06:26	Monitoring sample at northern perimeter	
79	Monitoring near perimeter	Supporter	2	26.06.2026	5:33:00	6745278	261567	156,7	6,4	0,14			20,00	0,020	06:32	Monitoring sample at northern perimeter	
80	Fieldblank	Supporter	1	26.06.2026	5:43:13	6745165	261561	93,3	109,3	0,07			15,22	0,015	06:36	Blank sample near surface	
81	Monitoring near perimeter	Supporter	5	26.06.2026	10:48:21	6745004	261551	139,4	5,2	0,31			38,60	0,039	14:18	Monitoring sample taken approx 100m SSW of Sealed Penetration Pipe (SPP) location 2 during works. Plume with estimate based on traversing east-west while monitoring with sensor data and video: 40m.	
82	Monitoring near perimeter	Supporter	1	26.06.2026	12:59:35	6745115	261512	139,4	5,3	0,62			20,86	0,021	14:21	Sample taken on ridge approx 65m NW of SPP location 4.	
83	Fieldblank	Supporter	4	26.06.2026	13:01:28	6745075	261535	93,5	90,5	0,79			13,30	0,013	14:25	Blank sample near surface	
84	Fieldblank	Supporter	H11	27.06.2026	13:56:23	6745184	261558	56,3	107,6	0,07			2,54	0,003	15:52	Blank sample on descent.	
85	Fieldblank	Supporter	H12	27.06.2026	13:57:16	6745182	261594	56,1	106,5	0,07			5,00	0,005	15:56	Blank sample on descent.	
86	Monitoring near perimeter	Supporter	H13	27.06.2026	14:16:19	6745261	261455	170,4	5,8	0,15			2,96	0,003	16:15	Sample at NW perimeter during filter (rock) bag placements.	
87	Monitoring near perimeter	Supporter	H14	27.06.2026	14:16:47	6745261	261455	170,4	5,9	0,15			3,03	0,003	16:18	Sample at NW perimeter during filter (rock) bag placements.	
88	Dredge Site	Supporter	H15	27.06.2026	15:28:52	6745187	261561	164	2,1	0,40			25,54	0,026	23:44	Sampling close to constructor flushing container filter	
89	Dredge Site	Supporter	H16	27.06.2026	15:29:17	6745187	261561	164	2,2	0,50			18,20	0,018	23:47	Sampling close to constructor flushing container filter	
90	Dredge Site	Supporter	H17	27.06.2026	15:46:42	6745187	261567	151,8	14,6	0,35			13,58	0,014	23:51	Sampling close to constructor flushing container filter	
91	Dredge Site	Supporter	H18	27.06.2026	15:46:51	6745187	261560	151,6	14,9	0,45						Niskin didn't close, empty sample	
92	In excavated Pit	Constructor	?	27.06.2026	?			?	0,5	?			6817,48		15:47	Sample taken in the excavated pit close to the wreck while ROV was working in the bo	Data about sampling missing to due logging bein forgotten

Norsk institutt for vannforskning STI (Norwegian Institute for Water Research)

We are Norway's premier research institute in the fields of water and the environment. We are experts on ecosystems in both freshwater and marine environments, from mountains, lakes and rivers, to fjords, coasts and oceans. We develop science-based knowledge and solutions to challenges related to the interaction between water and climate, the environment, nature, people, resources and society.