FACTS ABOUT

An Information Update from the IADC

ENVIRONMENTAL MONITORING

WHAT IS ENVIRONMENTAL MONITORING?

The dictionary definition of the word “monitor” is “to maintain regular surveillance over” something (Swanell, 1986), thus monitoring in a dredging context involves collecting regular or repeated measurements in order to observe the environment. Terms sometimes used interchangeably with “monitoring” are “survey” and “site investigation”. However, neither surveys nor site investigations are necessarily regular, repeated activities, they can simply seek to measure/define specific characteristics at one specific point in time and then cease.

WHY IS ENVIRONMENTAL MONITORING NECESSARY?

Dredging has the potential to change the environment positively and/or negatively. Monitoring involves measuring and recording field parameters at appropriate spatial and temporal scales in order to fulfil one or more of the following objectives:

- Characterise and gain a good (baseline) understanding of the environmental setting;
- Detect and quantify changes in the environment arising from dredging;
- Assess compliance with permit/licence/legal/contract requirements and the designed project plan;
- Calibrate and validate numerical models which are widely used to help predict the effects of dredging and are used in the design, and management of dredging projects.

Effective/successful monitoring can provide benefits for:

- the environment,
- the project,
- the project owner,
- contractors,
- regulators, and
- other stakeholders (e.g., fishermen or NGOs)

by ensuring that environmental impacts (positive and negative) are consistent with those planned, and by identifying whether/when dredger production rates need to be decreased or can be increased.

Above: Water level depth meter in river of Biesbosch nature reserve The Netherlands

WHEN TO MONITOR DURING A DREDGING PROJECT?

Figure 1 shows the different phases of an infrastructure project and when monitoring might be undertaken relative to these. The three main types of monitoring commonly referred to in association with dredging are also identified.

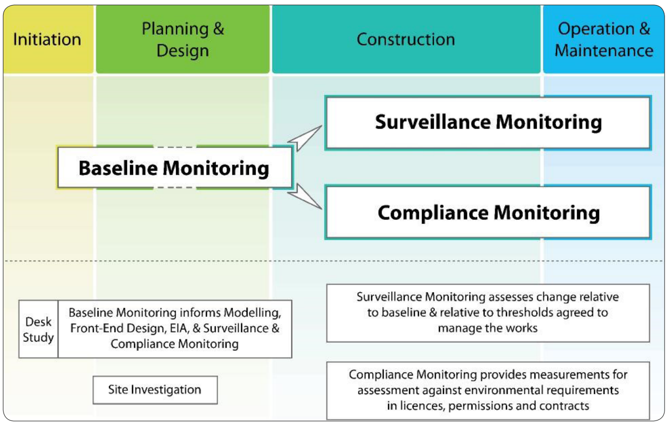


Figure 1. A schematic illustration showing when monitoring commonly occurs during infrastructure projects and the three types of monitoring commonly encountered during dredging projects.

It can be seen from Figure 1 that monitoring is commonly carried out during all four main phases of an infrastructure project. However, it is important to note that the scale of the monitoring undertaken should be proportionate to the scale of the project in question. This is one of the key principles of monitoring design.

HOW TO DESIGN ENVIRONMENTAL MONITORING?

There are four primary questions that need to be answered when designing monitoring. These are:

1. *Objectives* – What are the objectives of the monitoring?
2. *Method* – How can the objectives be achieved, what are the criteria upon which achievement will be judged and what are the actions that will be taken in the event of an objective not being met?

3. *Analysis and interpretation* – How will the data be analysed (including assessment of its quality) and presented?
4. *Completion* – When will the monitoring be stopped and what are the criteria defining this?

What are the different levels / types of design?

Monitoring design can be thought of at three levels.

High level conceptual design

In conceptual design, decisions are made about: what parameters should be measured, approximately where measurements should be made and for how long. Previously collected data or information about the site will be very valuable at this stage, as will numerical model results which predict how the environmental systems work (e.g. sediment transport models).

Scope of work for monitoring

A Scope of Works (SoW) is more detailed than a conceptual design. SOWs are documents which contain sufficient detail to allow a survey contractor to provide a meaningful quotation to undertake the monitoring work.

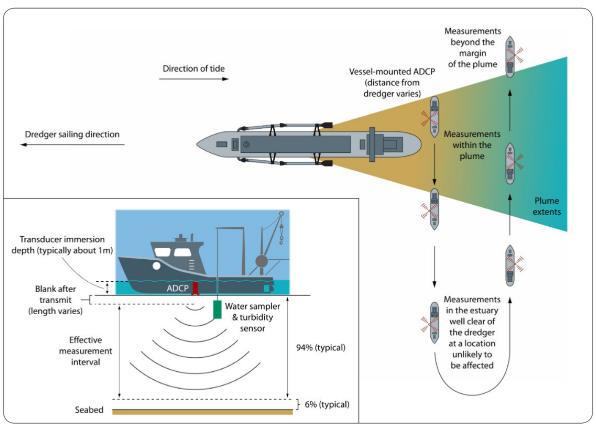
Specification or detailed method statement

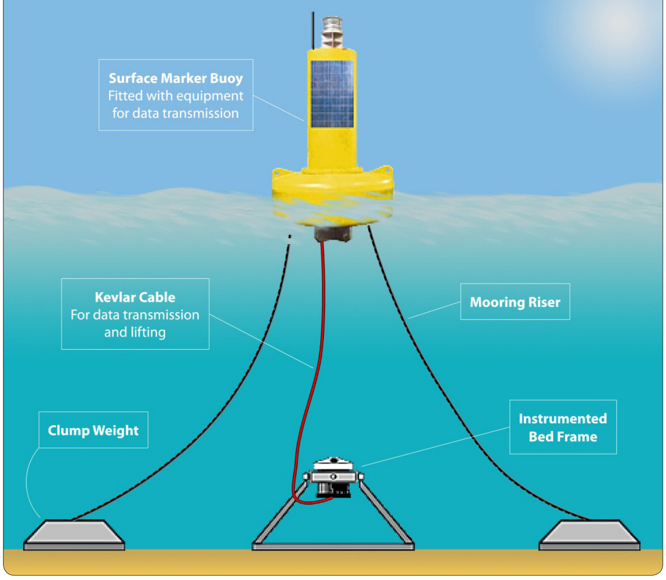
These documents set out in detail how the monitoring works must be undertaken. The level of detail is such that all controllable survey factors which could influence the success or otherwise of the works are described and defined. Production of such documents is a significant task and it may not be necessary for all projects. Instead of, or in addition to, a monitoring specification being produced for a project, reference is sometimes made to recognised codes of practice, guidance documents or standards. However, if this is not done with expert knowledge and care the result can be unsatisfactory with effort and money being wasted.

Where to monitor?

Locations where monitoring is typically carried out relative to dredging works essentially fall into three categories:

- Mobile monitoring (from a survey vessel) close to the dredging works. This is sometimes referred to as 'characterisation monitoring', but really characterisation monitoring is a particular type of mobile monitoring focused on characterising a sediment plume;
- Fixed station monitoring local to the works (e.g. fixed moorings or fixed sampling stations). These are typically at or outside the boundary of the dredging works; and
- Monitoring at the locations of nearby sensitive receptors (e.g. seagrass, corals, cooling water intakes for key assets such as power stations).

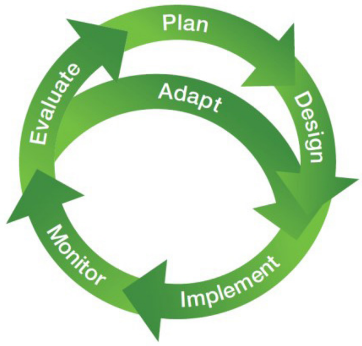




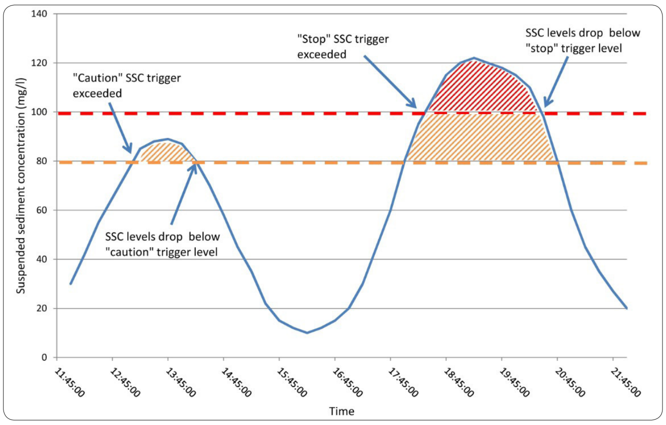
What are the considerations for designing Surveillance Monitoring?

The foundation for designing surveillance monitoring for dredging projects is identification and characterisation of the sensitive receptors which exist in the area, which might be affected by the dredging; and clearly identifying the objectives of the project with respect to these sensitive receptors. Such identification and characterization of sensitive receptors is typically carried out as part of the project's desk studies and baseline monitoring (i.e. the foundations of designing surveillance monitoring are laid during baseline monitoring). When designing a surveillance monitoring programme consideration should be given to:

- What receptors exist and what is their level of importance?
- The project's strategic (overall) objectives with respect to the receptors;
- The project's tactical (subsidiary) objectives with respect to these receptors (i.e. objectives which help to ensure that the strategic objectives are met);



- The locations of the receptors relative to the dredging;
- The changes that the dredging could induce in the environment (numerical modelling can often assist with this);
- Potential pathways between the dredging and the receptors (numerical modelling can often assist with this);
- The factors (parameters) that the receptors are sensitive to and the detailed nature of the baseline data relating to these;
- Critical thresholds for the receptors (i.e. environmental conditions (parameter levels) resulting in receptors starting to show impact) and the potential and likely impacts on them;
- Might dredging need to be actively managed based on real-time monitoring results in order to ensure that critical thresholds are not reached at receptor sites (a.k.a. Adaptive Management (see CEDA 2015))
- Practicalities, what are the practical, site specific limitations and strengths associated with particular types of monitoring in the general area and specific locations of interest, and
- Likely regulatory requirements.



What key principles should be employed when designing monitoring?

Monitoring design is site and project specific, there is no generally applicable design which can simply be scaled up or down according to the project size. However, a number of key principles exist which assist in ensuring that monitoring design is successful, these can be summarised as follows (after Lee et al., 2019):

1. Monitoring must be proportionate to the scale of the dredging project, and to the significance of the potential changes to the environment.
2. Design must be undertaken by interaction of suitably qualified and experienced individuals, and maintain a project-scale perspective.
3. Monitoring must have clearly identified and recorded objectives, which are agreed by the project owner, contractor(s) and Regulators in advance.
4. Baseline monitoring (in combination of with existing data and desk studies) must be capable of defining the natural variability of the key environmental parameters and resources such that impact assessments can be reliably undertaken during and post dredging.
5. The statistical / mathematical analysis to be applied to monitoring results in order to analyse them and detect change must be taken into account in the monitoring design.
6. Measurements for baseline monitoring, surveillance monitoring and compliance monitoring must all be carried out in a sufficiently consistent way to allow direct inter-comparison of the data (thereby allowing change to be measured).
7. Monitoring should be efficient i.e. equipment levels, study durations and numbers of monitoring sites should not exceed those needed in order to meet the monitoring objectives, and multiple usage of datasets should be planned where possible.
8. Procedures for judging whether monitoring effort should be increased, decreased or stopped should be agreed by all relevant parties (and documented) well in advance of dredging commencing.
9. Monitoring techniques specified must be robust (reliable, tried and tested) and practical (realistic to implement) if they are a key part of the monitoring design.
10. The way that data is managed and used can be as important as the data itself. Monitoring design should include provisions for: data quality assurance; collection and storage of metadata; data security; data transmission; data presentation; reporting; and data storage/archiving.

WHAT ARE THE COMMONLY MONITORED PARAMETERS & ASSOCIATED EQUIPMENT?

Position (GPS / GNSS)

There are four commonly used types of GPS, in order of reducing accuracy these are:

1. Real Time Kinematic (RTK) and Post Processed Kinematic (PPK)
2. Differential
3. Autonomous / Standard

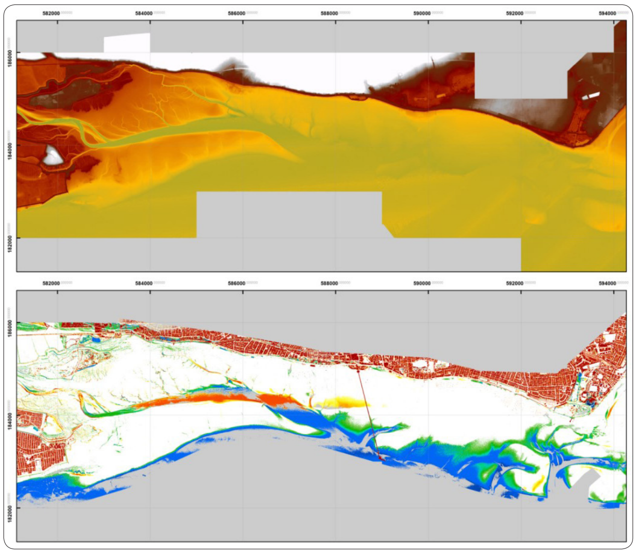
The best instruments / systems deliver centimetric accuracy, while those with the lowest specification have accuracies of order 10s of metres.

Bed Level (inc. intertidal)

A range of different approaches are available, these are:

- Echo-sounder (multibeam, single beam, dual frequency)
- RTK GNSS (intertidal)
- Total Station (intertidal)
- LiDAR (intertidal & shallow sub-tidal)

For bathymetry IHO S44 is often referred to when specifying the quality of the monitoring to be undertaken.

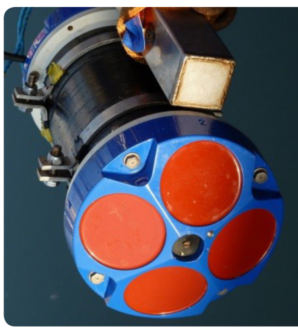


Currents & Waves

Measurements are widely obtained using Acoustic Doppler Current Profilers (ADCPs)

ADCPs measure a profile of currents through the water column (except close to the instrument and close to the bed, due to ringing & side lobe interference)

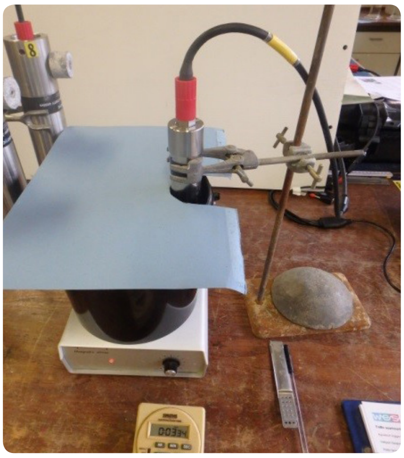
- Instrument frequency determines the profiling range & resolution (often 600kHz to 1.2MHz)
- The instruments can use a pressure sensor, near surface currents and acoustic surface tracking (AST) to measure waves
- ADCPs can be bed mounted or vessel mounted
- Wave buoys are also widely used to measure waves, often for longer term deployments



Suspended Sediment Concentration (SSC)

Turbidity sensors are widely used, they have a number of advantages, they are:

- Reliable
- Relatively low cost
- Easy to deploy
- Been in existence since 1980s so widely available and well understood



Proper calibration is critical for results to be meaningful, units should be mg/l not NTU, FTU or FNU.

SSC can also be measured via calibration of ADCP backscatter but this is fairly complex to do properly (and more expensive).

Water Quality

Multiparameter sondes are widely used for measuring water quality. The sensors deployed most frequently are:

- Conductivity
- Temperature
- Depth
- Turbidity
- Dissolved Oxygen
- Chlorophyll

Water sampling is also widely used, with samples analysed either aboard the vessel or in a laboratory ashore, lab analysis is often for contaminants.

Sediment Quality

Samples are most frequently recovered via grab sampling or coring. Samples recovered are commonly used for:

- Particle Size Analysis (PSA)
- Contaminant measurements
- Geotechnical testing (not strictly monitoring)

A wide variety of corers are available depending on the exact requirements of the investigation and the anticipated bed material type.

WHAT IS THE FUTURE OF ENVIRONMENTAL MONITORING?

There have been very important technological advances relating to monitoring over the last decade or so, these have changed the face of the discipline, they are:

- miniature sensors which are low cost, low power and high accuracy have become widely available;
- real-time data transmission has become viable and a reality; and
- remotely operated / autonomous mobile monitoring platforms for collection of measurements from the water surface have reached the market.

These developments have meant that monitoring is now:

- Cheaper
- Easier
- Safer
- Quicker and
- More flexible

than ever before, and this technology driven monitoring revolution is set to continue. The future is bright!

FOR FURTHER READING AND INFORMATION

Doorn-Groen, Stéphanie M. (2007). "Environmental Monitoring and Management of Reclamations Works Close to Sensitive Habitats". *Terra et Aqua*, nr. 108, September, pp. 3-16.

John, SA, Challinor, SL, Simpson, M, Burt, TN and Spearman, J (2000). *Scoping the assessment of sediment plumes from dredging*. CIRIA Publication C547, UK.

Dredging for Sustainable Infrastructure. Guidebook by IADC-CEDA www.sustainabledredging-book.com

US Environmental Protection Agency: www.epa.gov/emap

The IADC Knowledge Centre:
https://www.iadc-dredging.com/subject/

Facts About is presented by the International Association of Dredging Companies whose members offer the highest quality and professionalism in dredging and maritime construction. The information presented here is part of an on-going effort to support clients and others in understanding the fundamental principles of dredging and maritime construction.

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