TIGER TIDAL STREAM INDUSTRY ENERGISER

EUROPEAN UNION
European Regional Development Fund

T.1.7.3 - Test Procedure Report 4

Recommendations and lessons learnt for ADCP deployments

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0.4	13/07/2023	Final	Craig Dibb	Caroline Lourie	Carly Tait

Disclaimer

Contents

List of Figures

Abbreviations

Acronym	Meaning
AEP	Annual Energy Production
ADCP	Acoustic Doppler Current Profiler
BSI	British Standards Institute
EMEC	European Marine Energy Centre
ERDF	European Regional Development Fund
FCE	France (Channel Manche) England
GPS	Global Positioning System
HAT	Highest Astronomical Tide
IEC	International Electrotechnical Commission
ISO	International Organisation of Standardisation
JS	Joint Secretariat
LAT	Lowest Astronomical Tide
MHW	Mean High Water
MLW	Mean Low Water
PPA	Power Performance Assessment
PSG	Project Steering Group
SSG	Stakeholder Steering Group
TIGER	Tidal Stream Industry Energiser
TEC	Tidal Energy Converter
TC	Technical Committee
TS	Technical Specification
TSE	Tidal stream energy
USBL	Ultra-short baseline acoustic positioning system
UKAS	United Kingdom Accreditation Service

1 Executive Summary

This report is part of the deliverable T1.7.3 – Accredited turbine performance test procedures - under the scope of the Interreg Channel Manche – TIGER project, intended to develop a go-to pan-European energy supply chain resource in the channel region.

The purpose of this deliverable is to make recommendations and document lessons learnt for Acoustic Doppler Current Profiler deployment campaigns based on EMEC's experience. The recommendations focus specifically on campaigns at new tidal sites.

2 Introduction

The purpose of this report is to document lessons learnt and provide recommendations for Acoustic Doppler Current Profiler (ADCP) deployments.

This activity falls under the scope of the Interreg Channel Manche – TIGER project, intended to develop a go-to pan-European energy supply chain resource in the channel region.

EMEC has extensive experience deploying ADCPs at its own test sites and elsewhere. As part of the TIGER project, EMEC has carried out some ADCP deployments in new tidal sites.

It is an aim of the TIGER project to develop new supply chains. EMEC's work in the TIGER project has done this and this report will go further to provide lessons learnt and recommendations on that process.

Figure 1 | EMEC ADCP in its support frame being recovered at end of Yarmouth ADCP campaign, off the Isle of Wight 2021

3 Overview

As the tidal industry begins to commercialise and expand, new sites will begin to be developed. ADCP deployment is an essential activity at some point at a tidal site, whether for device testing or for gathering resource data.

The current state of the industry means that the burden of site development often falls onto the technology developers themselves. When considering the costs of marine operations and equipment, this can quickly become expensive.

Tidal stream sites are typically high energy by nature, which can make marine operations more difficult and increase the risk of lost equipment. Furthermore, a significant challenge when developing a new site is developing a local supply chain and infrastructure that can support an emerging marine energy sector.

EMEC has gained valuable experience carrying out resource measurement campaigns and ADCP deployments, both in Orkney at EMEC test sites, as well as at other tidal sites. This has allowed EMEC to learn some valuable lessons and streamline its methods to be reliable and cost effective, especially when deploying ADCPs at new sites.

This document aims to share knowledge gained thus far, with the intent of reducing risk and saving expense when deploying ADCPs at tidal sites.

4. ADCP Deployment and Recovery Good Practice

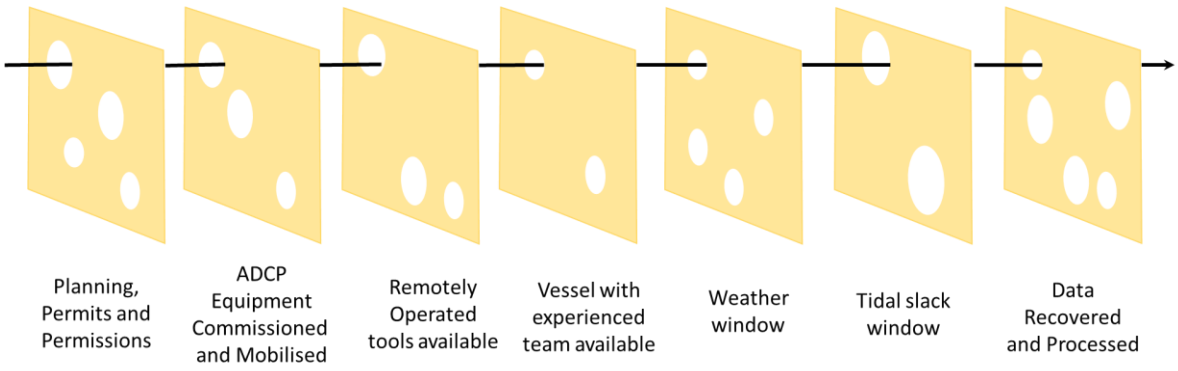

Figure 2 | Alignment of ADCP Deployment Steps

The aim of any ADCP campaign is to obtain good quality data. The choice of ADCP (make, model, type etc) should be done in consultation with the manufacturers and with

consideration of the data to be collected as well as any specific challenges at the site (bathymetry etc). Consideration may also be given to requirements from the IEC TS 62600 series where the data acquired from the ADCP deployment will be used for resource assessment or power performance assessment. It is also key to match the ADCP frame design to the site parameters, in terms of bathymetry (target location area, geophysical parameters, slopes etc.), and to the tidal currents and waves that could occur during the deployment and the resultant drag and overturning forces, frame design and mass, etc.

For this to happen in a timely manner on a tidal energy site, many things need to align as illustrated in the 'Swiss cheese' diagram above.

The following principles are good practice to carry out when deploying ADCPs at a site:

- The deployment operation and ADCP mooring configuration should be designed with the recovery in mind first.
- Wherever possible, operate in fair weather during slack windows at neap tides.
- Leave nothing on the seabed after all the operations are completed.
- The safety of the crew in the marine operations are paramount above all else.

Figure 3 | Deployment of EMEC ADCP Frame at Yarmouth Test Site off the Isle of Wight

Figure 4 | ADCP upon recovery from deployment at PTEC Site off the Isle of Wight

Figure 5 | Recovery of temporary vessel moorings at PTEC site used to hold vessel on station during ADCP frame recovery

4.1 Case Study: PTEC ADCP Campaign 2021–2022

The following case study is a timeline of recent activities at the PTEC site.

Date	Activity
August 2021	**Planning, Permits and Permissions** • Technical assessment of site and selection of appropriate ADCP deployment system. Key site differentials for the PTEC site over others were increased depth (beyond economic air diving limits), poor visibility and uneven bathymetry. • Selection of ADCP deployment method from a range of tried and tested methods to mitigate key issues. • Quotes obtained from Marine Contractors for deployment.

Date	Activity
	• Detailed planning confirming exact locations for deployment of the ADCPs and, consequently, the marker/system recovery buoys and mitigation of key risks. • Tidal predictions made and fed into marine operation planning.
September 2021	**ADCP Equipment Commissioned and Mobilised** • ADCPs programmed to desired data measurands, e.g. turbulence intensity, wave action and velocity profile at power extraction depth. • EMEC configuration QA checklist completed for each ADCP including battery checks. • Weather windows monitored and final go/no. • Equipment mustered at forward operating base on the Isle of Wight and checked. • Additional remotely operated drop camera equipment hired and mustered (just in time) and operation verified in workshop.
September 2021	**ADCP Deployment at Site** • All three ADCP systems deployed to site successfully with only a minor issue. • Cable failure on the camera system at depth prevented verification that ADCPs had landed upright. This would need to be checked later when data is processed. The data includes ADCP attitude information.
November 2021	**Planned Recovery Operations** • Pre-recovery site survey. • Problem identified (buoys crushed or missing). • Backup recovery plans initiated including deployment of small inspection class ROV. • Line failure during recovery of ADCP.
December 2021	**Recovery Operation Planning** • Identification and review of issues arising during planned recovery operations and initial backup plan. • New recovery plan initiated including trials with new suppliers to prove capability incrementally.
January 2022	• Trials at an inshore lake to prove ROV intervention methodology and new tooling up prior to deployment offshore. • Surveys planned to confirm more precisely the as-installed positions of ADCPs and associated rigging to assist future recovery operations.

Date	Activity
February 2022	• Ongoing refinement of method statements. • Waiting on weather, tide windows and marine contractor availability.
March 2022	• Waiting on weather, tide windows and marine contractor availability. • Side scan surveys undertaken of area to confirm positions of ADCPs and ground lines/clumps. • Attempts to grapnel equipment undertaken but unsuccessful.
April to June 2022	• Design undertaken on new recovery concept – Survey Fin to overcome challenges faces with previous recovery attempts. • Construction of Survey Fin. • Operations planning. • Trials with Survey Fin commenced.
July 2022	• ROV supplier now unavailable for planned tidal operating window. • Marine operation plans reconfigured. • Logistical challenges with shipping of survey equipment overcome.
August 2022	• Successful first campaign with Survey Fin. • ADCP recovered and data downloaded. • Lessons learnt for future operations and design of equipment based on new approach.
September 2022	• Further recovery campaign with Survey Fin initiated. • Weather, tide and marine contractor availability reduced available time window. Unable to recover further ADCPs in this campaign.
October 2022	• Weather and tidal and vessel availability windows diminishing. • Recovery attempts abandoned for 2022.

Table 1 | Timeline of recent activities at the PTEC site

The system deployed at PTEC has been used very successfully multiple times in Orkney on EMEC's sites. However, for the PTEC deployment, a key root cause issue was a design process/quality check failure in the surface buoys used. Although the pressure requirement had been identified, the buoys that were finally fitted had insufficient pressure rating.

Pre-considered back up plans were compounded by factors that normally frustrate marine operations such as the weather, but also factors associated with new supply chains and a new site.

The lessons learned are summarised in Section 4.

4.2 Technical Note on Marine Licensing

Many activities in and around the sea now require a marine licence.

The UK Marine and Coastal Access Act 2009 governs what activities need a licence and which do not, in the UK marine area.

The legislation is UK wide but administered by different devolved bodies depending on whether the activity is in English, Scottish, Welsh or Northern Irish waters.

Location	Licensing Authority and Enforcement Authority
England	Marine Management Organisation Planning and development: Marine licences - detailed information - GOV.UK (www.gov.uk)
Scotland	Marine Scotland https://www.gov.scot/publications/marine-licensing-applications-and-guidance/
Wales	Natural Resources Wales Natural Resources Wales / Marine licensing
Northern Ireland	Department of Agriculture, Environment and Rural Affairs Marine licensing | Department of Agriculture, Environment and Rural Affairs (daera-ni.gov.uk)

Table 2 | Licensing Authority and Enforcement Authority

ADCPs are considered scientific instruments. These and the equipment associated with such an instrument, e.g. its deployment frame, can be exempt from requiring a licence, depending on how they are deployed.

The exemption does not typically apply if:

- It is tethered to the seabed
- It reduces navigational clearance by more than 5% by reference to chart datum
- It will cause or likely to cause obstruction or danger to navigation
- It is likely to have a significant effect on a marine protected area (or the processes associated with deployment and recovery have a significant impact)
- Is made for the purposes of disposal

The full legislative text for exemption requirements under the Marine and Coastal Access Act 2009 can be found online at:

https://www.legislation.gov.uk/uksi/2011/409/part/2/made and https://www.legislation.gov.uk/uksi/2011/409/part/3/made

Even if you consider that you are exempt, you may still need to notify the relevant licensing authority about your activity and the fact that you consider it exempt.

A key advantage of using test sites such as EMEC is that deployment of a range of scientific instruments has usually been already considered within their own site licensing requirements.

Figure 6 overleaf provides guidance in flowchart format.

If deploying outside the UK, it is best to check local requirements with the relevant authorities.

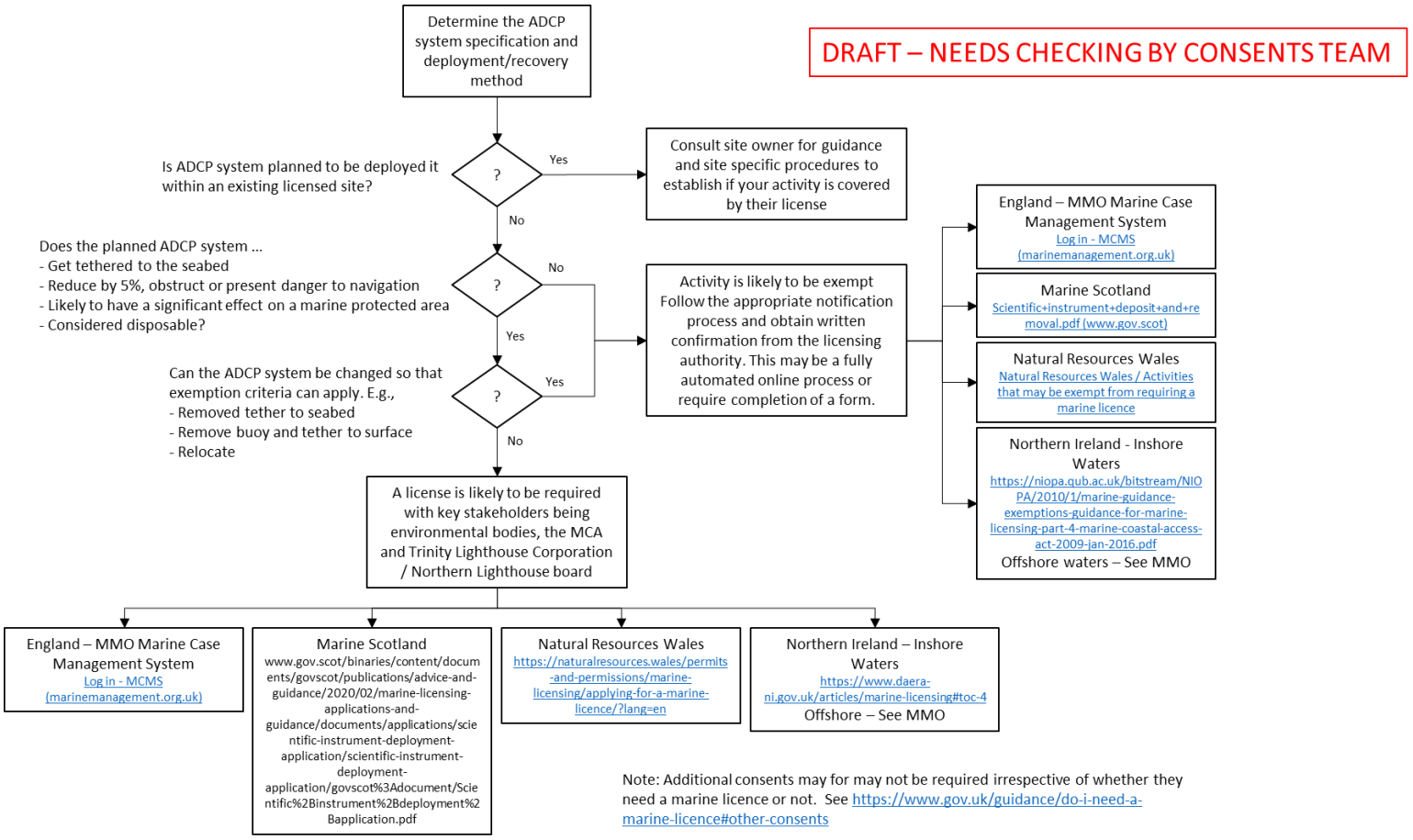

Figure 6 | ADCP deployment marine license guidance flowchart

5 Lessons Learnt and Recommendations

5.1 Process

Area	Comment	Recommendation
Risk Management	It is easy to assume that the deployment of ADCPs should be fairly 'routine', however, these factors need to be considered: • there is still a large risk due to the material cost of the equipment. • each tidal site may present new hazards and risks. • at a new site, local marine operators may not be experienced in operating in such extreme tidal streams or working with marine energy specific operations.	The risks need to be properly managed because what appears to be just a simple deployment can quickly become very costly. EMEC recommends that all aspects of the project should be risk-assessed, even where there is past experience.
Design Process	It is EMEC's experience that a rigorous authorisation and review process is necessary for design, marine operations and procurement. This is necessary all the way through the project, from initiation, throughout the deployment operations, all the way to recovery. This should be supported by in-person support of experienced personnel who are present and onboard during marine operations, HIRAs and kit checks.	EMEC recommends: • Campaign designed with recovery method in mind – designing recovery first. • Plan operations around neap slacks as a principle and only operate outside of those windows when using tried and tested solutions. • Clear design authorisation and review steps necessary. • Clear storyboard and engineering drawings which is primarily written by the marine contractor. • Experienced representatives should be present to supervise the process. • Design in redundancies and consider rescue recovery

Area	Comment	Recommendation
		methods before deployment, designing them from start to finish. • Determine seabed conditions from available information – a pre-deployment survey may be required and, indeed, some level of survey is an essential planning requirement.
Supply Chain	It is common to be working with marine contractors who are inexperienced at working in fast tidal streams.	EMEC recommends: • Manage expectations of marine contractors. • In-person representation by experienced persons to develop relationships with contractors and supervise project. • Ensure that there are clear authorisation steps for all aspects of the project. • Aim to train several local companies in operations so that operations are not limited by contractor availability.

Table 3 | Lessons Learnt and Recommendations - process

5.2 Procurement

Area	Comment	Recommendation
Instrument and Equipment Rentals	Renting ADCPs is typically only cost effective for extremely short deployments. The risk of project overrun can be high due to all sorts of factors but predominantly weather risks and availability of assets to recover deployed ADCPs. For most measurement campaigns of a meaningful length (2-3+ months) it will be more effective to purchase the instrument or contract a third party to carry out the entire operation with their own instruments (after 90 days of rental, ~40% of the value of the instrument would have been paid for at typical rental prices). The ongoing rental costs can be a risk to project budget if there are delays of any kind, especially if the kit is unable to be recovered from the seabed for whatever reason.	EMEC recommends: • Carefully consider the financial options available to acquiring ADCP equipment for a project and the financial risks associated with each option. Things to consider when negotiating contracts: • Negotiate with the supplier to have the rental charge only apply after delivery. • Negotiating standby charges will also reduce the impact of rental costs building if the deployment is delayed, but these will likely not apply if the equipment is deployed and recovery is delayed. • Negotiate a payment limit, e.g. the cost of a new unit, at which point rental charges cease.
Shipment, Delivery and Storage	Tidal sites are often remote, at the end of supply chains which can become costly in terms of time and money.	EMEC recommends: • Ensuring a good understanding of the infrastructure to allow planning for delays and accounting for extra costs. • Develop good relationships with local couriers so that urgent delivery can be expedited if possible.

		• Negotiate rental not to be charged during delivery, or standby charges for that period, as the rental costs for items in shipment can build up.
Equipment Rating	Typically ancillary equipment such as mooring/rigging and riser lines are specified for the duration of the deployment. However, in tidal sites there is significant risk that recovery operations will be delayed, meaning the equipment could be on the seabed for periods of time well in exceedance of that planned. Wear from abrasion, metallurgical reaction, and marine growth could compromise equipment integrity.	EMEC recommends: • Specify equipment for a significantly longer time than anticipated, e.g. if a 2-month deployment planned at a benign site then 4 months could be reasonable, but if at an exposed site over winter months then recovery could be delayed by ~6 months. • Review all material types and ensure no interaction points. • Consider potential damage points to equipment when planning recovery methods. • Ensure specification suited to application, e.g. consider chain for ground lines to ensure they remain in place on bed, and that floating lines are only used for risers.

Table 4 | Lessons Learnt and Recommendations - procurement

5.3 Marine Operations

Area	Comment	Recommendation
Rigging Configuration	Buoys can be used in the rigging configuration to mark the location of ADCPs and to facilitate cost effective recovery. For buoys to be on the surface all the time, they need to be scoped to be substantial enough to stay on the surface during high tidal flows and should be lit. This adds to the price of the deployment significantly (due to size and specification of equipment). Note that there is still a risk of marine traffic collision with passing vessels even with fully lit buoys on the surface. Pressure rated buoys, that are pulled under as flow increases, and their rigging systems are more cost effective. Depending on the rigging configuration, they could be submerged at low flow rates and in any significant tidal flow will be pulled to a safe depth (thereby minimising collision risk for passing vessels). There is still collision and entanglement risk during slack water but this may be demonstrated to be minimal during risk assessment. It is EMEC's experience that this method is most effective in sites with low marine traffic.	EMEC recommends: • If operating in a low traffic site, consider the configuration where the surface floats are pulled under during tidal flow. This will require pressure rated buoys and consulting the local regulators. Such surface floats are not dissimilar in appearance to the small buoys used by many inshore fishermen to mark their creels.

Area	Comment	Recommendation
Supervision	Employing new contractors, whether experienced or not, brings an unknown element to the operation and onboard representation during the operation helps to verify competency, develop new contractors and conduct root cause analysis if there are any problems.	In person representation by an experienced individual who is present for all marine operations in a supervisory capacity. This is especially crucial for root cause analysis if an issue arises, and rescue recovery operations need to be employed.
Accuracy	Accuracy in positioning is achieved through a combination of deployment methodology, survey equipment specification, and operator experience. Improving each of these aspects will ensure the most accurate deployment locations.	EMEC recommends: • Check methodology to ensure that deployment locations can be realistically achieved, e.g. over boarding method and recording ADCP position relative to known GPS position. • Ensure equipment enables accurate positioning and is appropriately designed for the site deployment, e.g. legs on frames, gimbals, USBLs, surface transponders. • Use repeat contractors where possible to increase familiarity and thus accuracy.
Secondary Recovery Methods	ADCP campaigns often rely on a single recovery method which can become a single point of failure. By building in redundancies, the risk is reduced.	EMEC recommends designing backup recovery methods into the operation before commencing with deployment. By building in redundancies which have working plans and have been thought through to the end will save time and money if the primary methods do not function, for whatever reason. These could include:

Area	Comment	Recommendation
		• Two surface buoys and riser lines – one each side of a U-shaped mooring configuration, as was utilised during the Yarmouth deployments (see also 'Rigging Configuration' section above). • Acoustic releases (see also 'Acoustic Releases' section below). • Long ground chain for grappling. • Bespoke grapple hook points that increase the chances of successful grappling. As a coarse method, this needs to be coupled with a drop cam and is therefore generally only successful in areas of clear visibility at depth, which can be a limiting factor for some sites. • Bespoke hydraulic grabs of varying designs for gripping chain/chain clumps. • USBL for locating: though battery life can be an issue if recovery is delayed, an acoustic transponder could be used to awaken a sleeping USBL • Consideration of contingency for retrieval backup is recommended.
Acoustic Releases	It is EMEC's experience that acoustic release mechanisms are not a completely reliable primary method for recovery; however	Consider the use of USBL on acoustic releases to confirm correct positioning and orientation during the

Area	Comment	Recommendation
	they are suitable as a secondary back-up method to conventional moorings. They are used with USBLs, which also allow valuable data collection in the form of accurate positioning and orientation, which is useful for ensuring the instrument is upright during deployment and reducing the uncertainty of the position.	deployment operation. This is highly recommended if aiming to do an accredited measurement campaign, whether a resource assessment or a power performance assessment. Acoustic release can then be used as a secondary back-up recovery method if necessary. If not opting for acoustic release, it is still desirable to have a standalone USBL on the ADCP frame for the positional and orientation data.
Operation Time	Transit time to site, daylight hours, weather and tides all seriously limit operation windows. In the case that alternative recovery methods need to be engaged, designing methods that allow working while the tide flows will significantly increase the operation window and increase the chance of recovery.	When designing the operation and considering potential rescue recovery options, consider how to maximise the operational windows and work during tidal flow where possible. EMEC has a working solution for maximising operational windows using a multi-point mooring on a multicat vessel and a bespoke system called the 'Survey Fin' which allows methodical search in fast flow, poor visibility and depth and allows search and rescue during tidal flow. This method was trialled in more benign sites before using in a fast flow and has been proven in 1.5 m/s. This method still requires good weather especially when deployed off small vessels and targets neap tides but the operational window is greatly increased for many sites (although the window may still

Area	Comment	Recommendation
		be low for the fastest sites). The principle of operating during neap slacks is still followed for normal routine operations. Consider crew shift changes on vessels that are limited by distance to port. Accurate timings for site specific conditions maximises ability to operate at site, e.g. using any previous ADCP data to determine tide windows on surface and at operating depth.
Operations Contingency	At any point in an operation, conditions can change and contingency solutions are required. Pre-planning these enables efficient and safe retrieval and removal from site.	EMEC recommends: • Plan each stage of the operation and what the contingency is at each stage in the planning stage. • Consider vessel moorings and ability to leave site in the event of changing conditions.

Table 5 | Lessons Learnt and Recommendations – marine operations

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