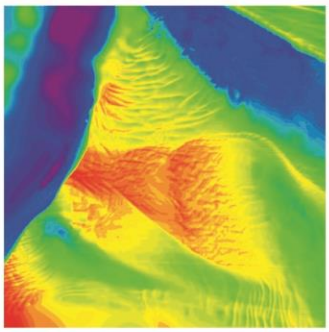
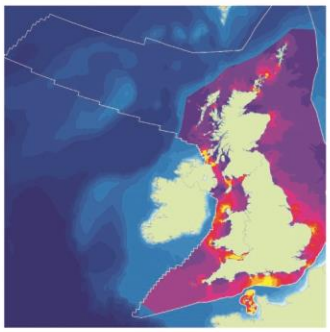
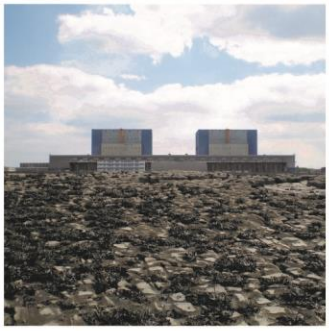
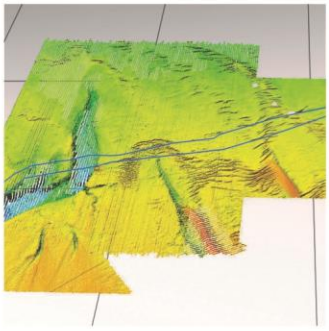
White Paper

Accounting for Weather in Marine Operations

Analysing the past to inform future decisions

September 2021

Innovative Thinking - Sustainable Solutions

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The challenge of weather downtime

The marine environment can be an unforgiving place to work. Strong winds or high waves can result in time spent waiting out unfavourable weather conditions until planned operations can recommence. This is known as weather downtime.

Excessive weather downtime can have a costly impact on operations.

Although it is impossible to completely eliminate the impact of weather on offshore operations, understanding the likelihood of successful execution offers a means of managing the logistical and financial risks.

But how can this be done? Marine operations often have to be planned and costed for periods in the future far beyond the capability of conventional weather forecasting. In the place of short-term forecasting, past weather data can give an indication of what conditions might be like for a certain area of the sea over a particular time period.

To estimate the chances of particular conditions occurring for any location and time of year, statistical hindcast analyses use past meteorological and oceanographic data. This allows decision-makers to take account of weather downtime in their programmes, potentially achieving significant cost savings in the process.

Where weather risk is passed to the contractor, such analyses are important when determining fixed delivery costs.

Calculating weather downtime

Individual operational tasks, such as deploying equipment or mooring on site, may each require a suitable amount of time to complete.

During this period, there may also be certain metocean parameters, such as wave height or wind speed, that must not be exceeded for operability or safety reasons. This is referred to as a weather window.

Weather window statistics can be produced to describe the overall proportion of time in a month or year when certain conditions are met, e.g. conditions less than a threshold value, for intervals of at least the required weather window duration.

Weather downtime: a definition

"The period when something is not in operation or when one is not working or engaged in a planned activity as a result of unfavourable weather conditions."

This definition implies that logistical and financial risks may result from excessive weather downtime as operations or activities are unable to be carried out as planned.

An awareness of expected weather conditions can help mitigate these risks and optimise operational planning procedures.

When using weather window statistics to assess cumulative weather downtime for an operation including multiple sub-tasks, a simple spreadsheet can be sufficient to combine the individual probabilities.

However, such methods make inherent assumptions about the required time order of weather windows. The nature of these assumptions typically leads to an under-estimation of the time spent waiting on weather for more complex or interrelated task schedules.

In practice, many operations consist of several consecutive and inter-dependent tasks in a specific order, i.e. transiting from location A to B, *then* mooring on site, *then* deploying a particular piece of equipment. In this case, the statistical chance of the required thresholds being met in the correct order is likely to be reduced.

Weather downtime assessments that consider an operation as a set of consecutive tasks in the intended order provide a better estimate of the expected downtime than the simpler weather windows statistics. This is known as **sequential** or **simulation-based** weather downtime.

Example task list and metocean condition thresholds for sequential weather downtime analysis

Task name	Task duration (hrs)	Weather window Required (hrs)	Wave height threshold (m)	Wind speed threshold (m/s)
Enter port	1	1	3	15
Load item 1	3	3		
Load item 2	6	6		12
Exit port	1	1	3	15
Transit to site	10	12	3	
Position and anchor	2	3	3	
Transfer item 1	3	3	2	12
Transfer item 2	6	6	2	12
Transit to next location	2	2		
Deploy equipment	2	3	2	15
Survey	6	8	2	12
Survey	6	8	2	12
Recover equipment	2	3	2	15
Transit to port	10	12	3	

Applying hindcast data

A robust weather downtime assessment not only includes all the relevant threshold parameters, but is also informed by many years of hindcast (past weather) metocean data. This is because, as the length of the data set on which the analysis is based increases, statistics should become more stable. So longer data sets give greater confidence that the statistics have adequately captured variability in the metocean climate over time.

The spatial/temporal resolution and the accuracy of the data are also important to ensure that the data and the results of the analysis are representative of the location of interest.

To take account of natural variability from year to year, a range of results should be used to provide weather downtime statistics with varying non-exceedance probabilities, typically including:

- P50, P75, P90 – the 50th (median), 75th and 90th percentile values, respectively;
- Pmean – the mean value of all years;

- Pmax – the maximum WDT value of all years (the 'worst' year), and;
- Pmin – the minimum WDT value of all years (the 'best' year).

ABPmer's Weather Downtime Express service

ABPmer's SEASTATES hindcast metocean databases were originally developed as an internal resource to characterise metocean environments to a high spatial and temporal resolution.

This information has been applied to everything from designing offshore structures and breakwaters to tactical strategies for elite yacht racing and planning safe operational weather windows.

To make our weather downtime calculations:

- We reference our exclusive hindcast database archives that hold validated historic metocean data back to 1979 for Northwest Europe and the Baltic Sea;
- We incorporate validated global metocean data from industry recognised hindcast archives such as the US National Oceanic and Atmospheric Administration (NOAA) Wave Watch III hindcast into the WDT service to allow worldwide weather assessments.
- We ask clients to provide all operational tasks, limiting metocean conditions, required weather window durations and locations.

Example task input form for ABPmer weather downtime calculator

	Location		Durations		Thresholds (not to be exceeded whilst working)			
			Task Duration	Weather Window	Wave Height	Wave Period	Wind Speed	Current Speed
Task name	Long	Lat	(hrs)	(hrs)	(m)	(s)	(m/s)	(m/s)

For each task list provided, our weather downtime express (WDTX) calculator generates statistics of overall project programme and weather downtime, categorised by start date (month) and over the full range of probabilities.

The results enable a comparison in terms of total programme duration and weather downtime, between different versions of similar task lists, and between different operational choices, for instance, choice of vessel, tooling, or port.

The tool uses a sequential (simulation based) approach. The reported weather downtime statistics therefore reflect not only the overall probability of a weather window occurring, but also the likelihood of weather windows with different thresholds and durations occurring in a specific order, closer to reality.

Calculator outputs

Weather downtime and resulting extended duration of individual tasks, cycles of work and for the whole project

Results for given start date by calendar month or week

Full range of downtime probability estimates

Breakdown of top 10 tasks contributing to weather downtime

Estimated milestone completion dates for each work cycle, partial stages of completion and for the whole project.

A range of figures and detailed tables of values for all of the above, in an easily managed and shared Excel spreadsheet format

The analysis simulates the full operation in 'real time' with the detail of time spent both working and not working. This information is subsequently statistically analysed, and reported by task, probability of non-exceedance and month or week of start date.

Multiple operations are simulated with start dates/times at every hour, e.g. in a 31-year hourly time series from our SEASTATES automated databases, the whole operation is fully simulated 271,752 times. The reported statistics are based on the whole population of simulated operations.

Data quality and confidence levels

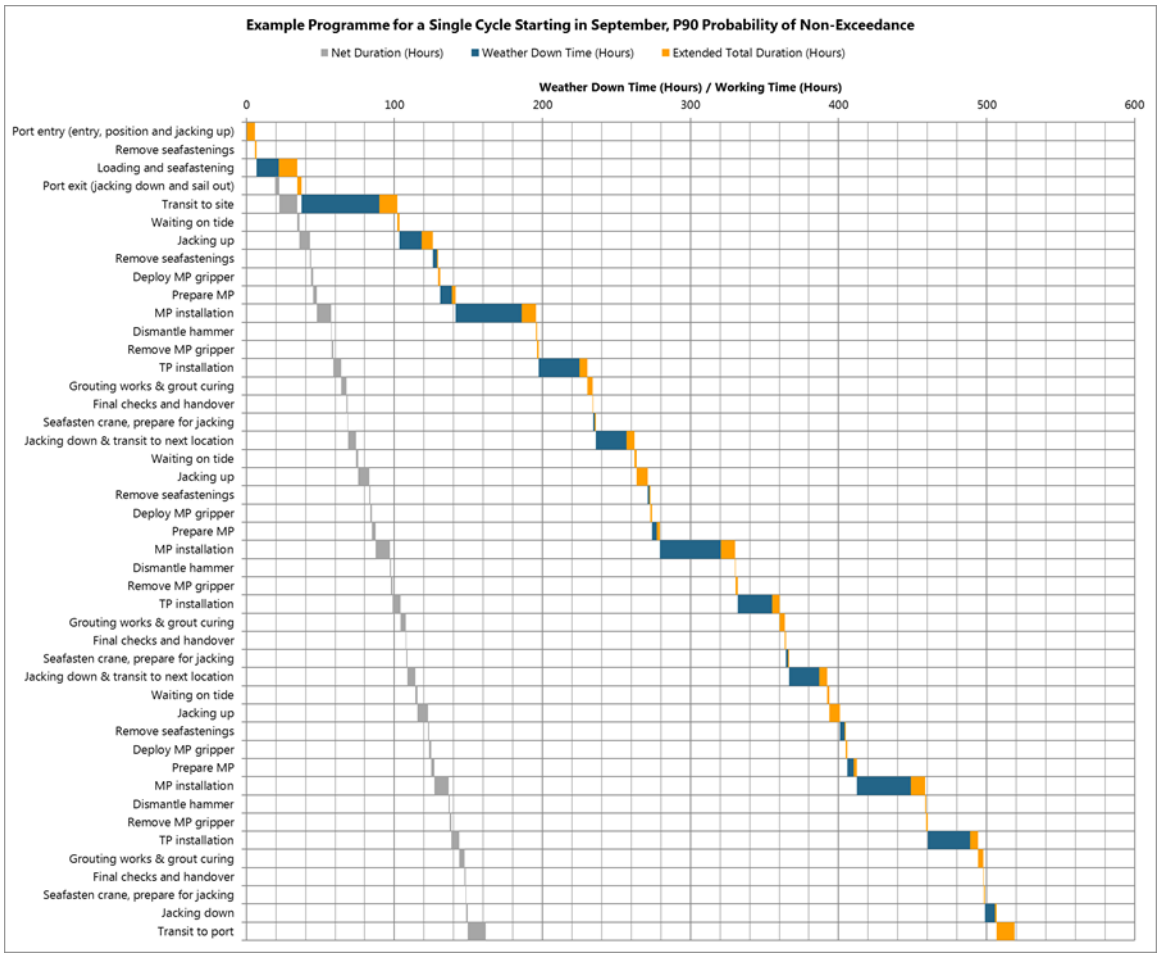
To understand temporal variability on timescales of years to decades, a reliable metocean data set of sufficient duration is key.

Our SEASTATES hindcast database holds verified metocean data back to 1979. In combination with the Wave Watch III global and regional hindcast models, which begin in the same year, the weather downtime calculator makes use of an extensive temporal and geographical database for analysis.

To view the underlying data, visit our global Data Explorer at seastates.net/explore-data/

Example outputs from WDTX calculator

Example Gantt chart output showing net programme, and programme including WDT



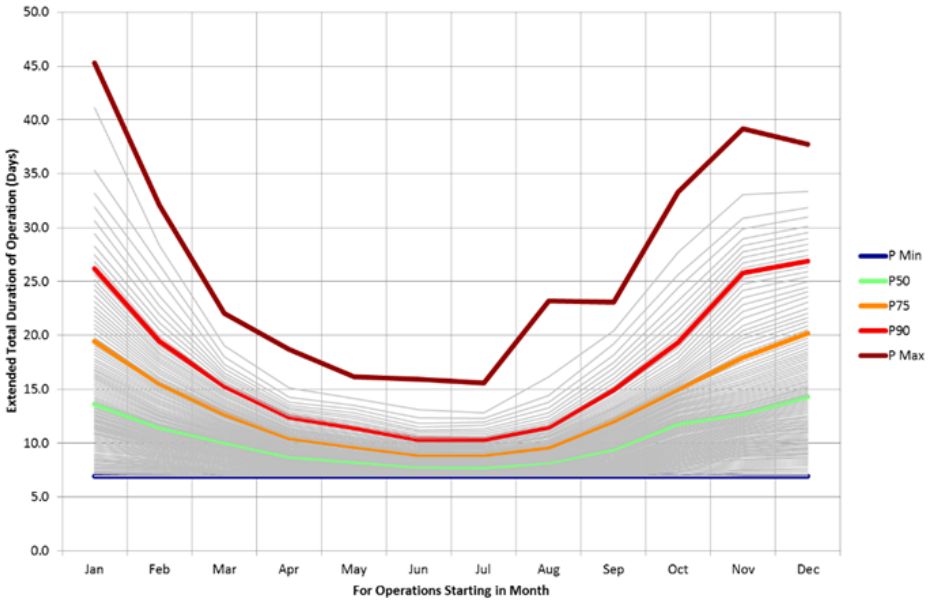
Example top 10 tasks contributing to weather downtime

All Year	
WORKING	70.2%
MP installation:	10.0%
TP installation:	4.8%
Unseafasten crane + auxiliary lifts	4.1%
Install anode cage	2.8%
Sailing to site	1.9%
Install airtight platform	1.7%
Seafasten crane, prepare for jacking	1.6%
Move MP into upend position	1.3%
Jacking operations (positioning + preloading + jacking up)	1.0%
Loading and seafastening, including surveyor control	0.3%
All Other Tasks	0.2%

Example selected entries from a probability of non-exceedance table

Weather downtime per operation (days) – for operations starting in each month													
Probability	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All Year
1%	0	0	0	0	0	0	0	0	0	0	0	0	0
2%	0	0	0	0	0	0	0	0	0	0	0	0	0
54%	7	5	3	2	2	1	1	1	3	5	6	8	3
55%	8	5	4	2	2	1	1	2	3	5	6	8	3
98%	28	20	11	7	7	5	5	7	12	19	24	25	21
99%	34	21	12	8	7	6	6	9	13	21	26	26	23
100%	38	25	15	12	9	9	9	16	16	26	32	31	38

Example weather downtime output expressed as extended duration of operation by month for various probability thresholds



WDTX in summary

Developed in conjunction with offshore construction contractors, ABPmer's Weather Downtime Express service enables **24/7 weather dependent decision-making** by providing on-demand access to ABPmer's weather downtime statistics calculator.

The email-based system allows authorised users of the software, to send a schedule of their operations which feeds into ABPmer's long-term 31-year hindcast database 'SEASTATES' for analysis. Each task list is processed by the system and the **results are emailed in a matter of minutes**.

The calculator uses simulation-based analysis to consider any combination of home ports, take account of sequential operations with multiple limiting parameters and process **any number of scenarios** around the globe.

By creating multiple versions of the task list corresponding to choices of construction/installation methodology, tooling or vessel, a user can **rapidly test options**.

Designed to help clients **make quicker operational and risk management decisions**, the outputs offer the level of detail needed to optimise schedules or provide tailored and accurate prices when bidding for work.

ABPmer's SEASTATES weather downtime statistics are regularly used by the offshore and subsea sector for operational planning and tender pricing. Clients include jack-up operators, maritime logistic companies, cable network providers, cable laying operators, offshore wind developers, project programme managers.

To arrange your free trial of SEASTATES Weather Downtime Express

visit **seastates.net/weather-downtime-express/**
email **WDT_enquiries@abpmer.co.uk**
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