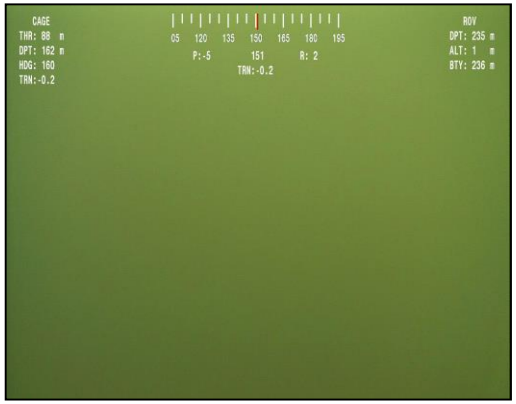
RPS MetOcean Shell Australia

Piers Larcombe (RPS MetOcean, Perth)
Michael Garvey (Shell Australia, Perth)

Complex near-bed sedimentary dynamics in seasonally stratified waters control visibility for subsea engineering

"How to time ROV work to actually see what is needed?"



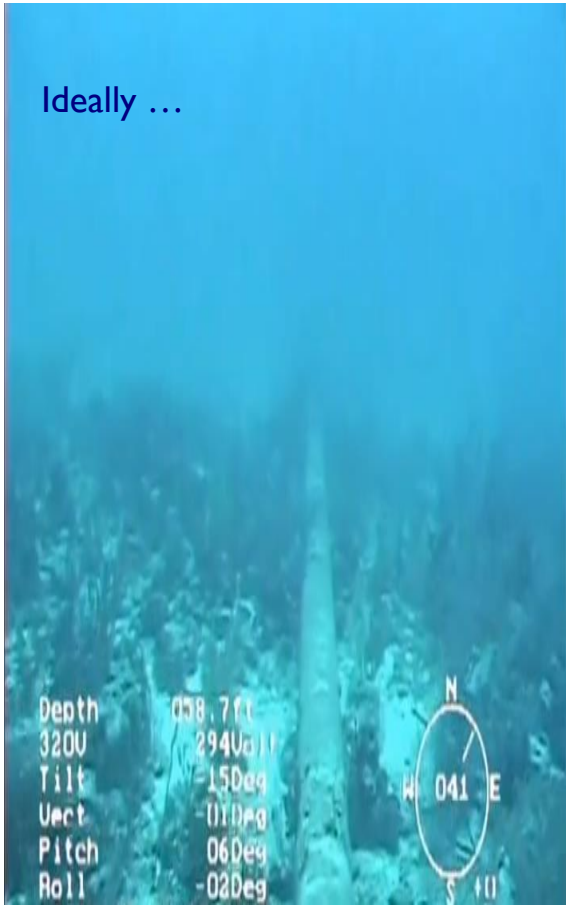
Purpose *- to understand processes controlling visibility:*

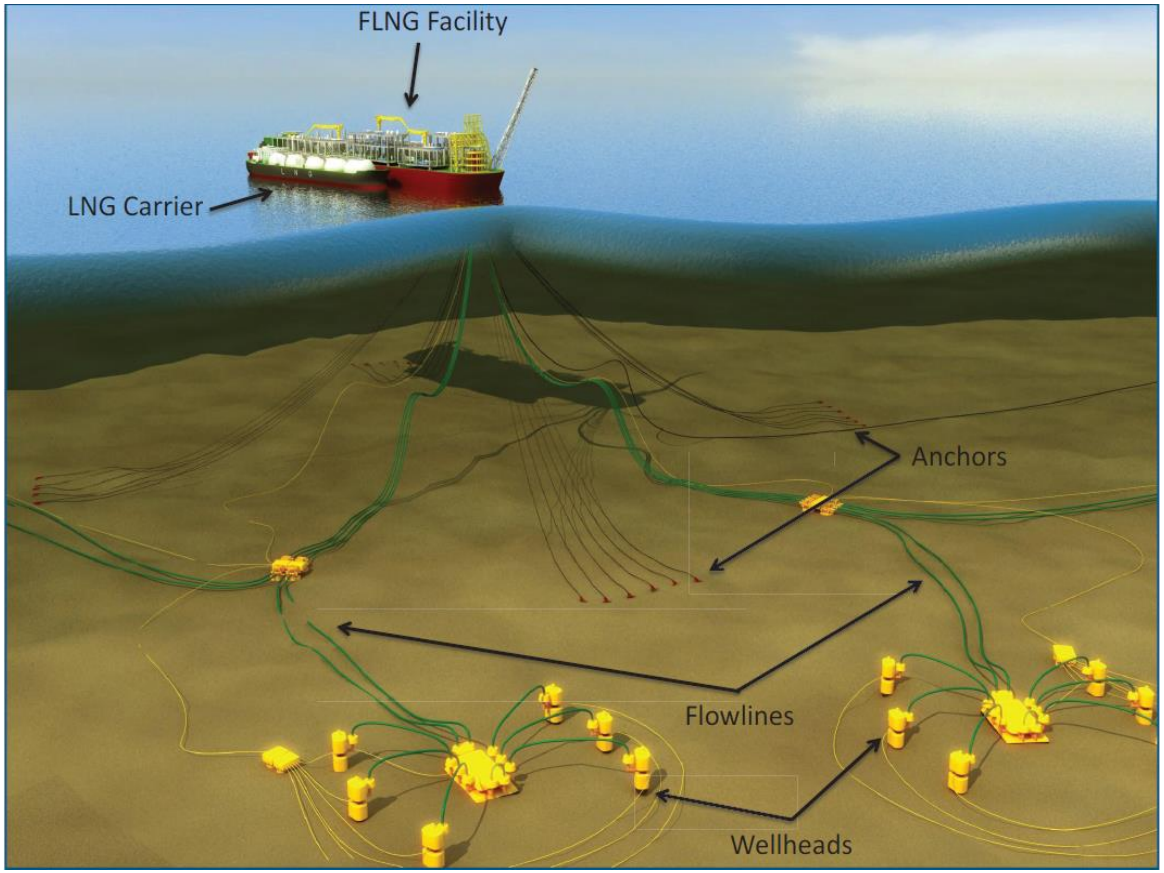
- *oceanography – incl. stratification, tides, int. waves...*
- *particles – nature, resuspension, settling, layers...*

AIM *→ predict future visibility for operations.*

FOO Fremantle,
25th July. 2017
15 + 5 mins

RPS





Subsea & sea-bed infrastructure

Needs good visibility to install, maintain & decommission

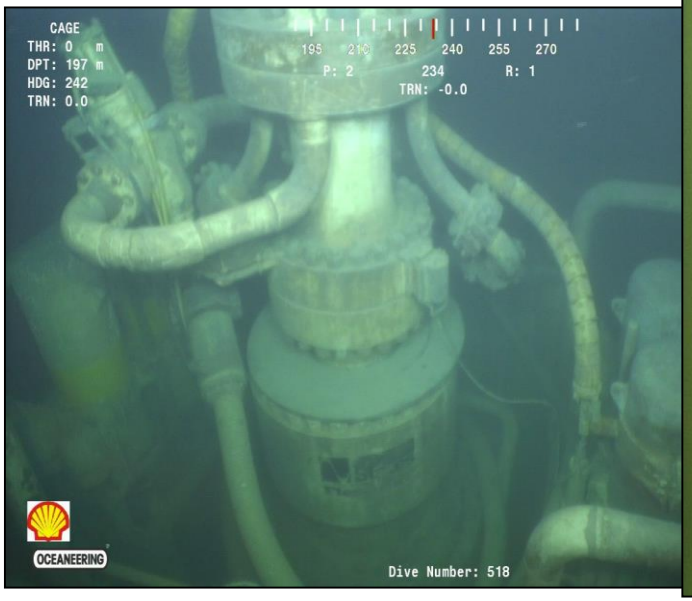
requires OPERATIONAL OCEANOGRAPHY

& applicable research

The main issue

ROV operators report:

- Very poor visibility at times
- “Strong currents”
- Visibility ‘linked’ to currents



Often unworkable for ROV due to poor visibility.

Field measurements

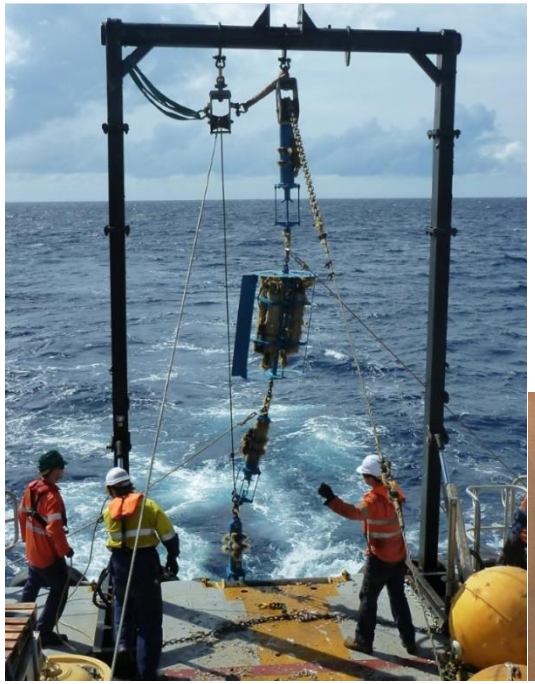
- Shell Australia Geomatics/Metocean team proposed to measure currents and turbidity to address on-going visibility issues.
- RPS MetOcean were engaged by Shell Australia for 12-month survey & analysis (sponsored by Subsea team)

Two moorings comprising:

- CM-04 current meters
- Turbidity (NTU) loggers
- Temp. loggers
- Tide gauge
- LISST (Laser In Situ Scattering & Transmissometry)

Also, & **critically**:

- Water sampling and lab analysis
- Water quality profiling (LISST, NTU, CTD)



LISST-100X

Time series

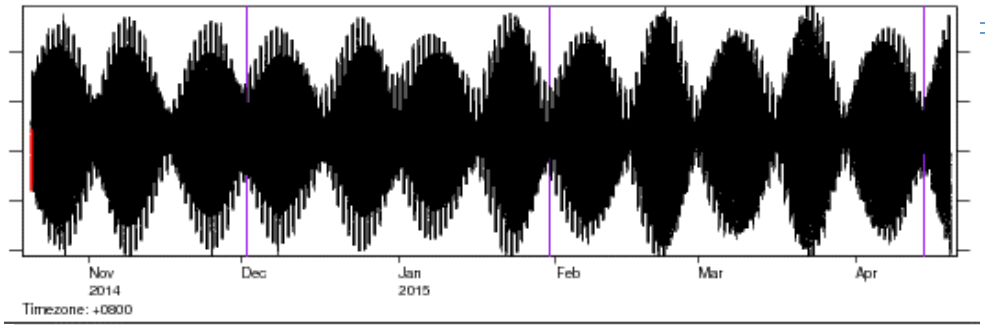
A. Strong tidal signal, so tidal constituents derived for turbidity and Beam-C data

→ Initial Predictions

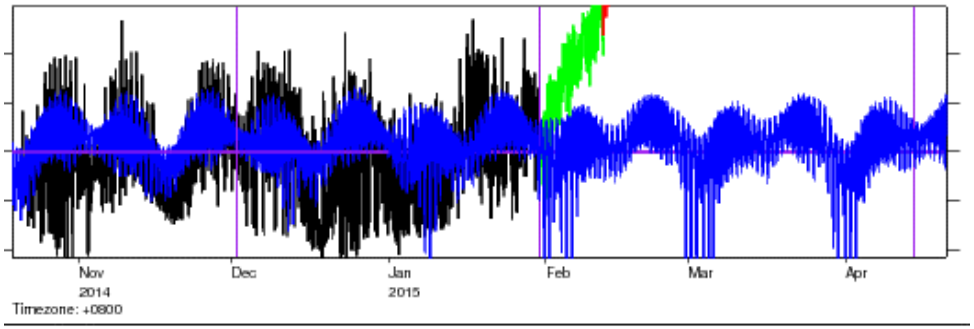
Field Data

Prediction

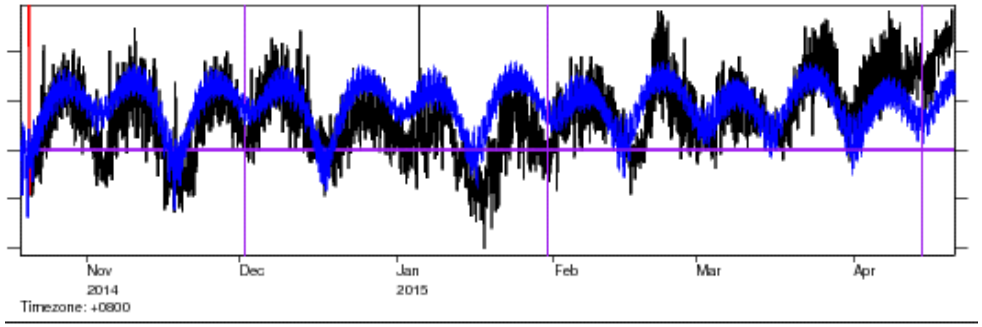
Tide height [m]



Turbidity @ 20 m ASB

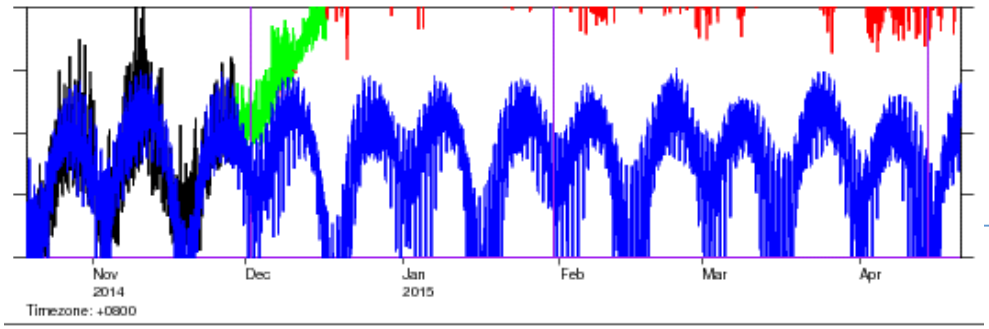


Beam-C @ 4.5 m ASB



Turbidity @ 2 m ASB

(NB log scales)



ROV information

B. Combine ROV logs with time-series data

For each depth bin, tidal relationships are modified,
using measurement-based 'rules'.

Date	Time Period		Servicing	Visibility	Current	Additional comment
12/03/2015	15:14 - 18:12		ROC at P8 to dredge	Workable	workable	*No indicators given of visibility or current, operations carried out succe
12/03/2015	18:12 - 21:31		ROV in cage	unworkable	N.A.	
12/03/2015	21:31 - 24:00		ROC at P8 to dredge	Workable	workable	*No indicators given of visibility or current, operations carried out succe
13/03/2015	00:30 - 11:33		dredge P8	Workable	workable	*No indicators given of visibility or current, operations carried out succe
13/03/2015	16:40 - 24:00		dredge P8	Workable	workable	*No indicators given of visibility or current, operations carried out succe
14/03/2015	00:30 - 11:48		dredge P8	Workable	workable	*No indicators given of visibility or current, operations carried out succe
14/03/2015	19:00 - 22:50		ROV in cage waiting on improved current and visibility prior to ADL ops	unworkable	Unworkable	
16/03/2015	11:21 - 12:00		ROV in cage at depth waiting for improved currents and vis	unworkable	Unworkable	
16/03/2015	12:30 - 13:40		P1 ADL EFL on Park receptical	Workable	workable	*No indicators given of visibility or current, operations carried out succe
16/03/2015	13:40 - 14:05		Remove recovered ADL and fix replacement	Workable	workable	*No indicators given of visibility or current, operations carried out succe
16/03/2015	14:05 - 17:30		Replace ADL installed in P1 suspension cap and AFL back on ADL	Workable	workable	*No indicators given of visibility or current, operations carried out succe
18/03/2015	02:40 - 24:00		jackhammer operations @ well 8	Workable	workable	*No indicators given of visibility or current, operations carried out succe
20/03/2015	04:00 - 12:00		dredging well 8 poor vis, heavy current	Borderline	Borderline	
20/03/2015	12:30 - 14:37		dredging well 8 poor vis, heavy current	Borderline	Borderline	
20/03/2015	14:37 - 15:47		dredging well 8 visibility worsening qucikly	Worsening Quickly	N.A.	
20/03/2015	15:47 - 15:53		Attempt to go to P8, very poor vis	Very poor	N.A.	*had to return to cage
20/03/2015	15:53 - 17:23		ROV to P8 to continue dredging	Workable	workable	*No indicators given of visibility or current, operations carried out succe
20/03/2015	17:23 - 24:00		dredging well 8 poor vis, heavy current	Borderline	Borderline	
21/03/2015	00:30 - 00:49		dredging well 8 poor vis, heavy current	Borderline	Borderline	
21/03/2015	00:49 - 05:22		standy	unworkable	Unworkable	in cage waiting on current and vis
21/03/2015	05:22 - 10:23					
21/03/2015	10:23 - 12:30		standy	unworkable	Unworkable	in cage waiting on current and vis
21/03/2015	12:30 - 13:20		Attempt to go to P8, very poor vis, return to cage	unworkable	Unworkable	
21/03/2015	13:26 - 16:15		Attempt to go to P8, very poor vis, return to cage	unworkable	Unworkable	
22/03/2015	07:50 - 08:40		Bullseye check on BOP,	low	strong	
22/03/2015	08:40 - 12:00		standy	unworkable	Unworkable	in cage waiting on current and vis
22/03/2015	12:30 - 13:10		Attempt to go to P8, very poor vis, return to cage	unworkable	Unworkable	
22/03/2015	13:10 - 18:00		standy	unworkable	Unworkable	*monitoring current, in excessof 1 knot
23/03/2015	00:30 - 01:10		standy	unworkable	Unworkable	in cage waiting on current and vis
23/03/2015	01:10 - 05:57		dredging well 8 poor vis, heavy current	Borderline	Borderline	
23/03/2015	08:05 - 13:00		standy	unworkable	Unworkable	in cage waiting on current and vis

Work comprised 2 phases:

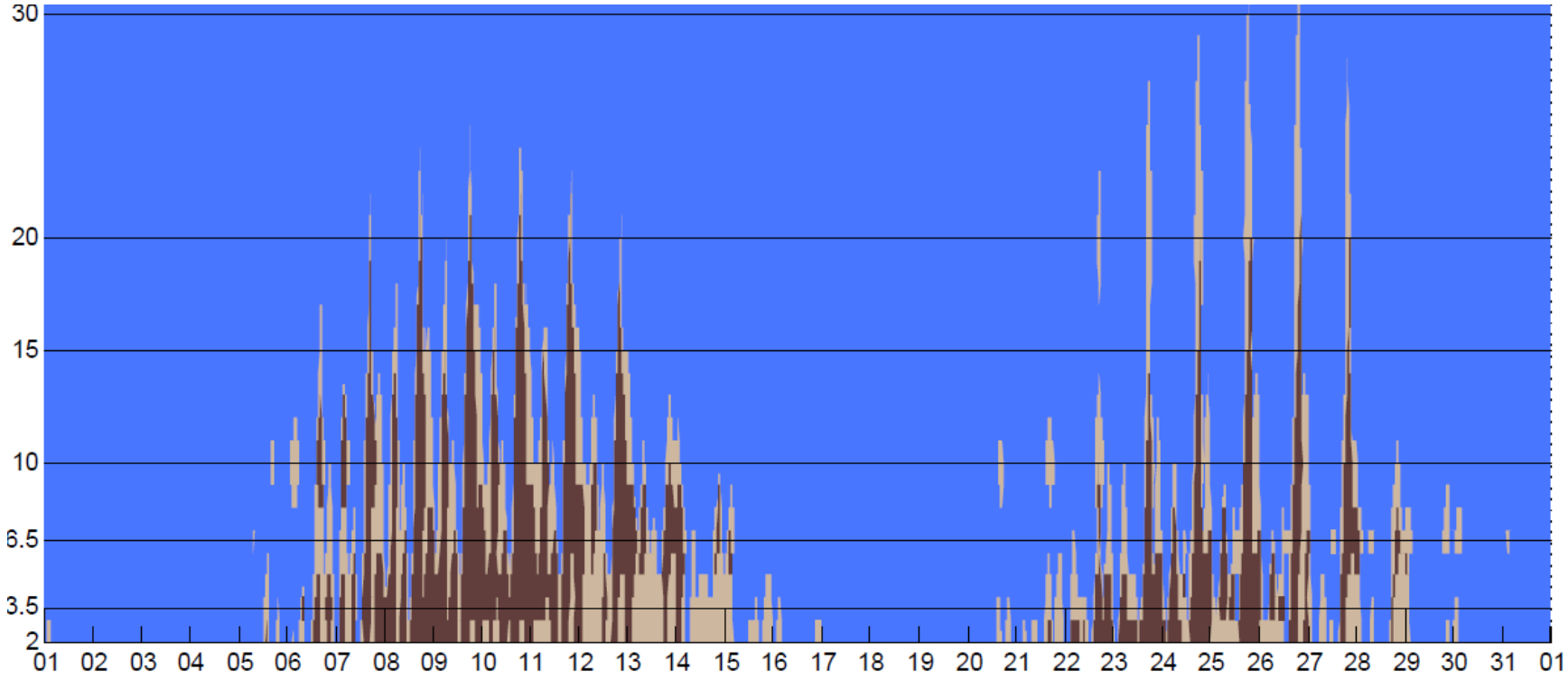
Phase 1 – Quantify 'unworkable'

Phase 2 – Quantify visibility range

General result

Visibility ~ tidally related, but:

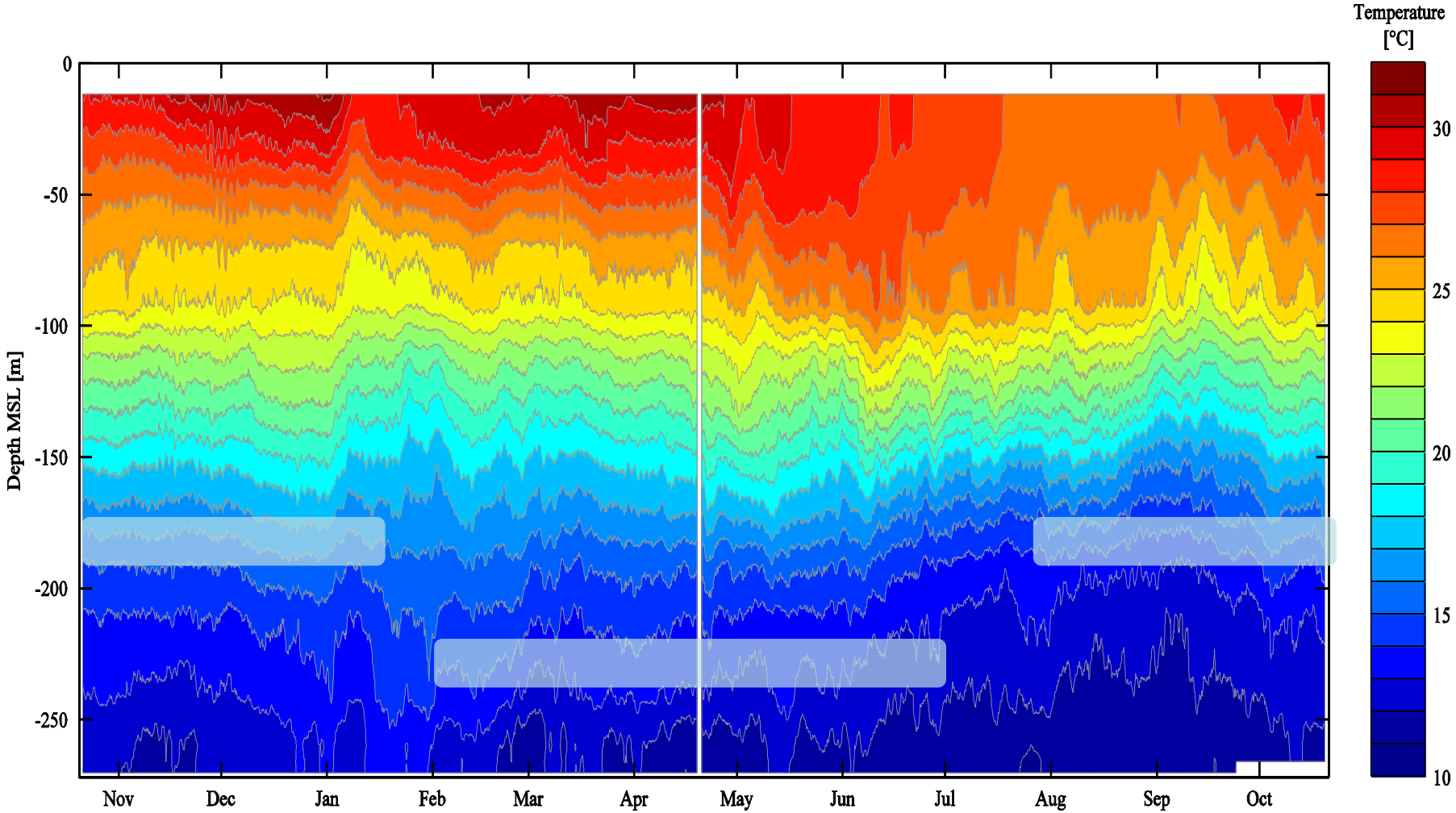
- **<u>many</u>** different sedimentary processes
  → complex signals → visibility is highly site-specific (& season-specific)



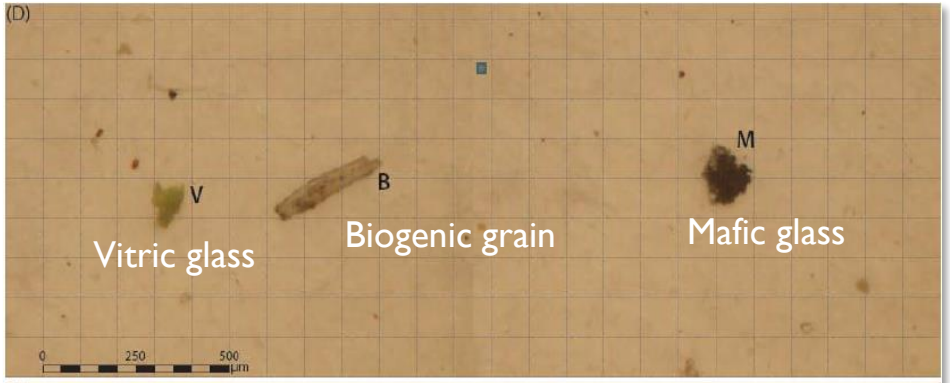
Some of the factors follow…

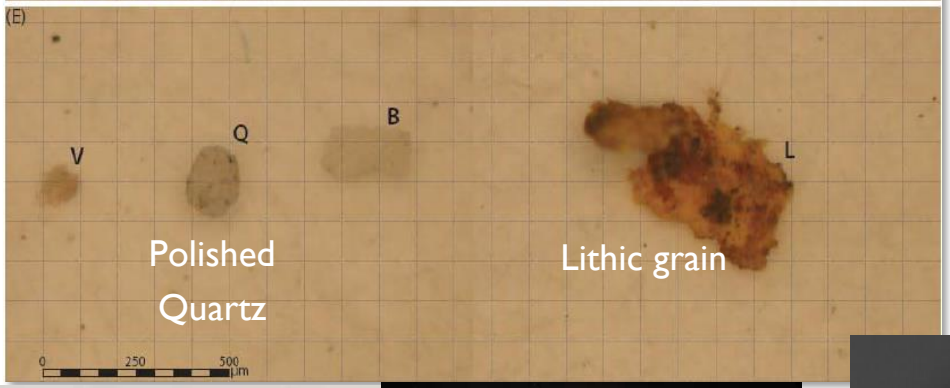
Strongly seasonal oceanography

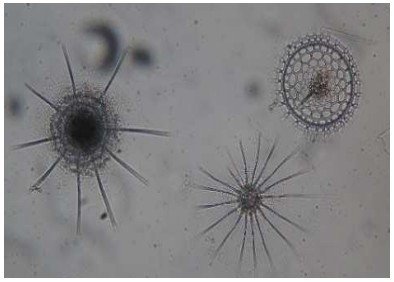
Base of thermocline at 30 – 40 m ASB for ~half the year

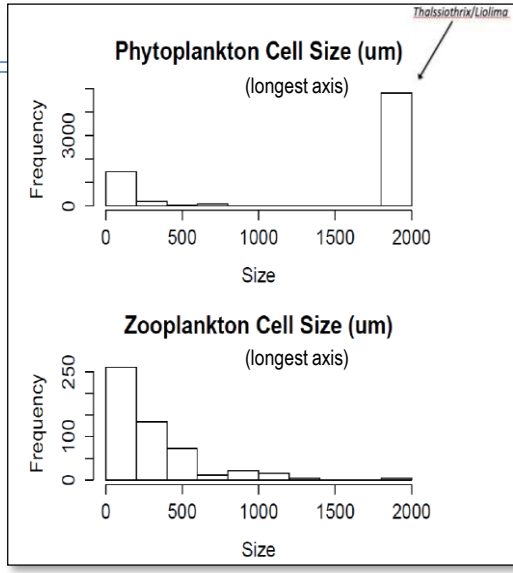


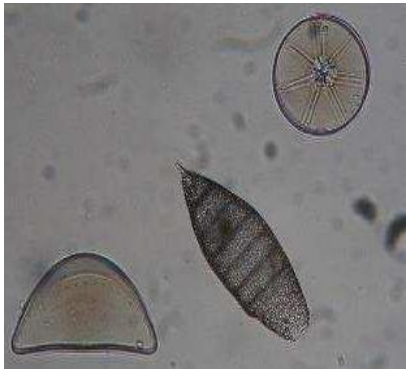
Broad variety of particles (e.g. sand-sized):
e.g. Phytoplankton, Zooplankton, Minerals





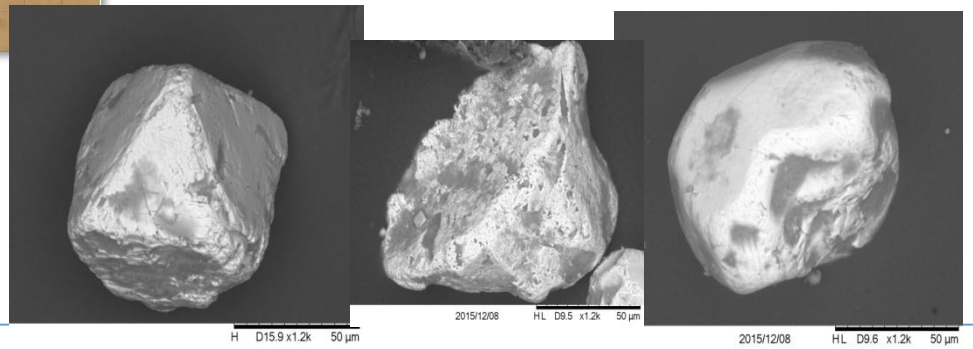






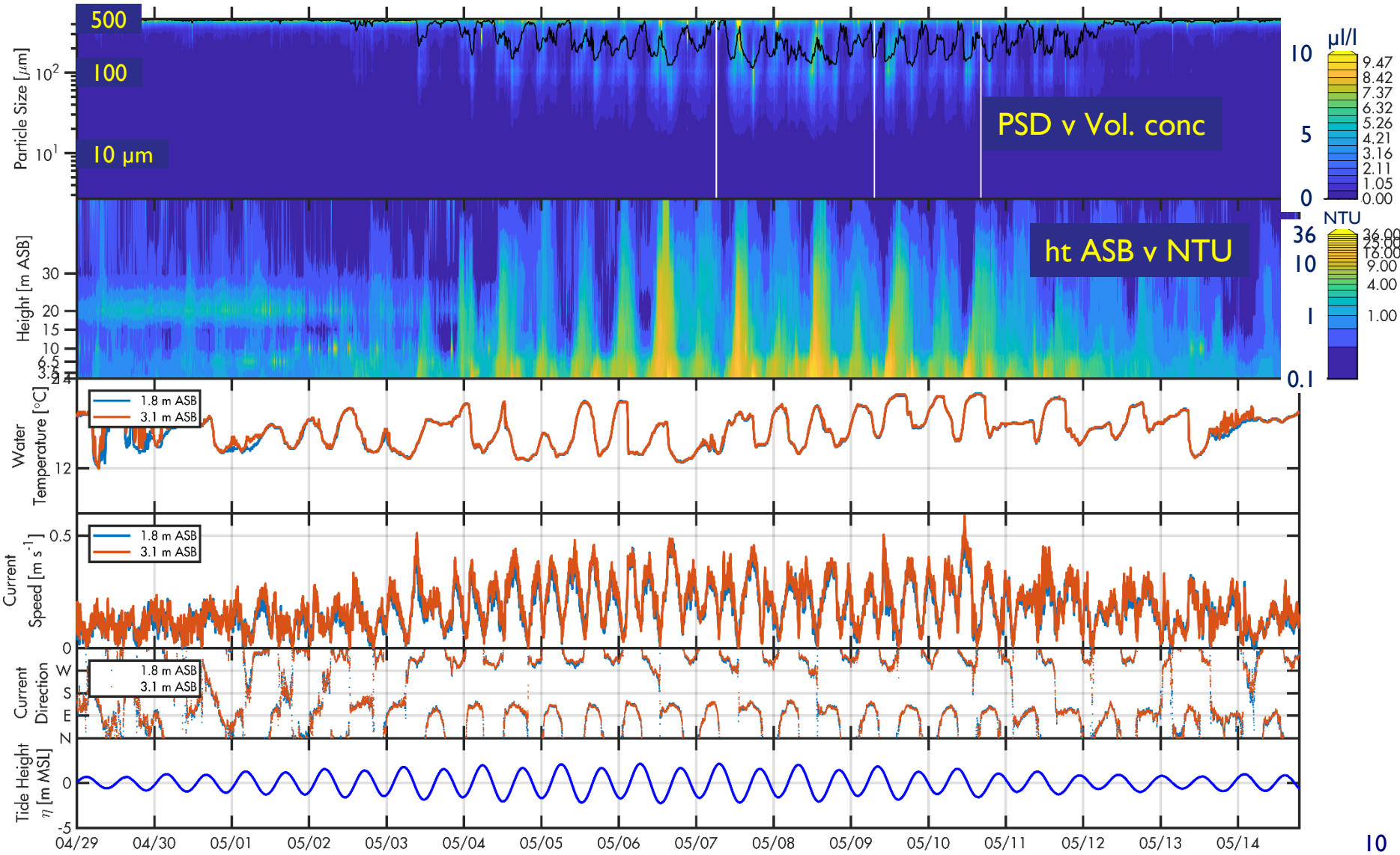
Diatoms & Radiolarians

Copepods & Tintinnids

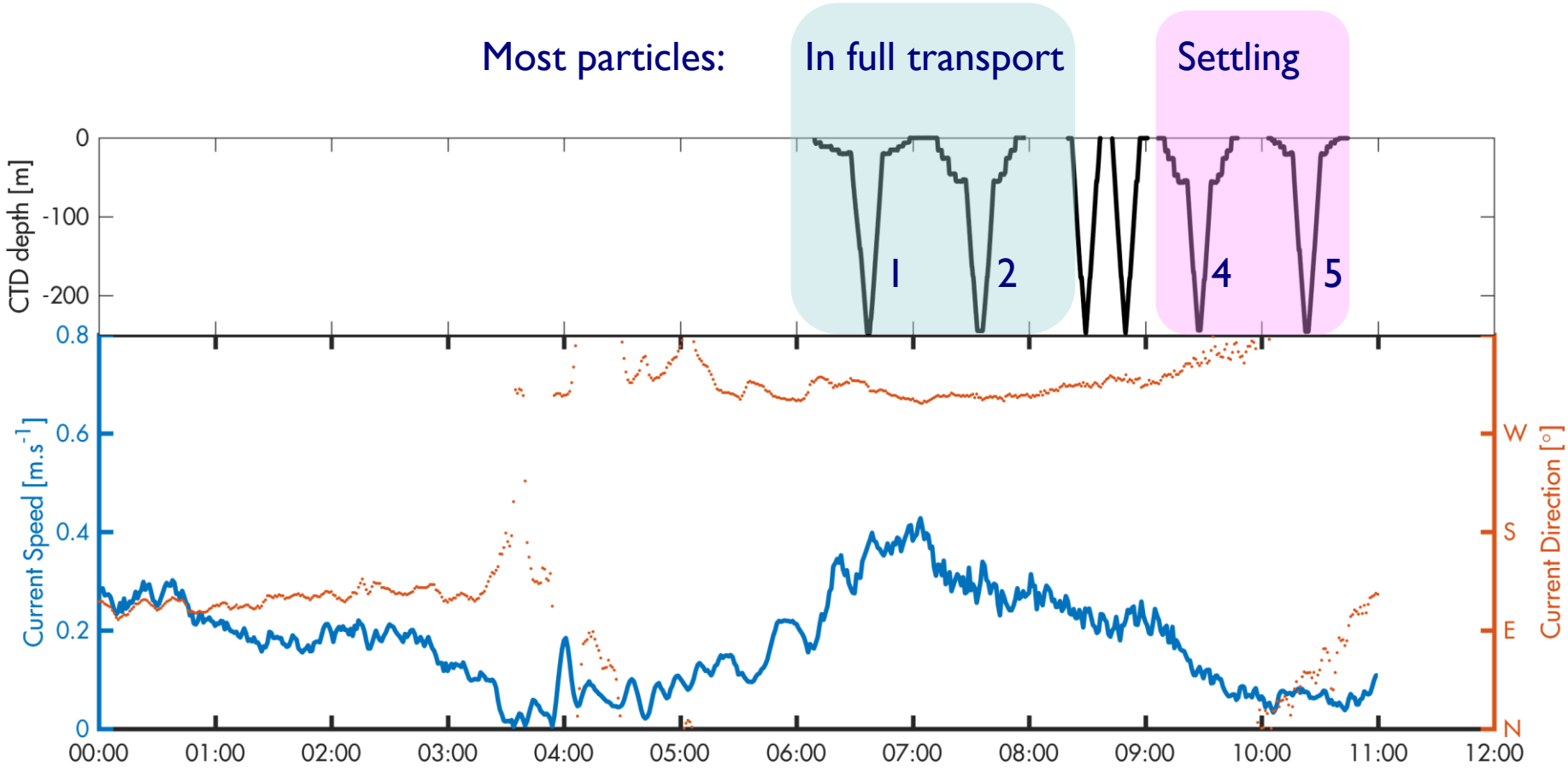


Magnetite x 2, Zircon

Example time-series measurements (2 weeks)



Vertical profiles reveal near-bed complexity



Near-bed sediment dynamics

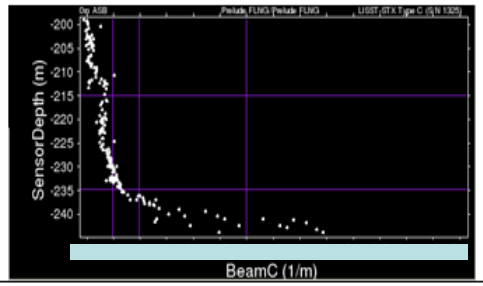
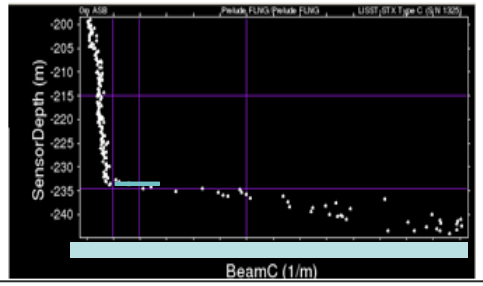
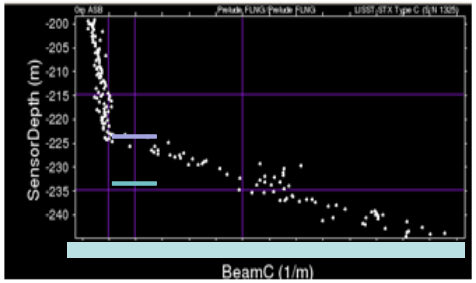
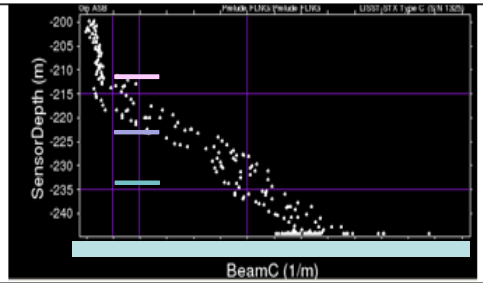
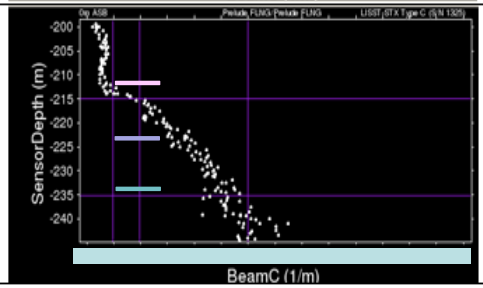
V sharp visibility gradient at ~15 m ASB

V sharp visibility gradient at ~25 m ASB

Slowing current but **upward** movement of poor visibility

and…

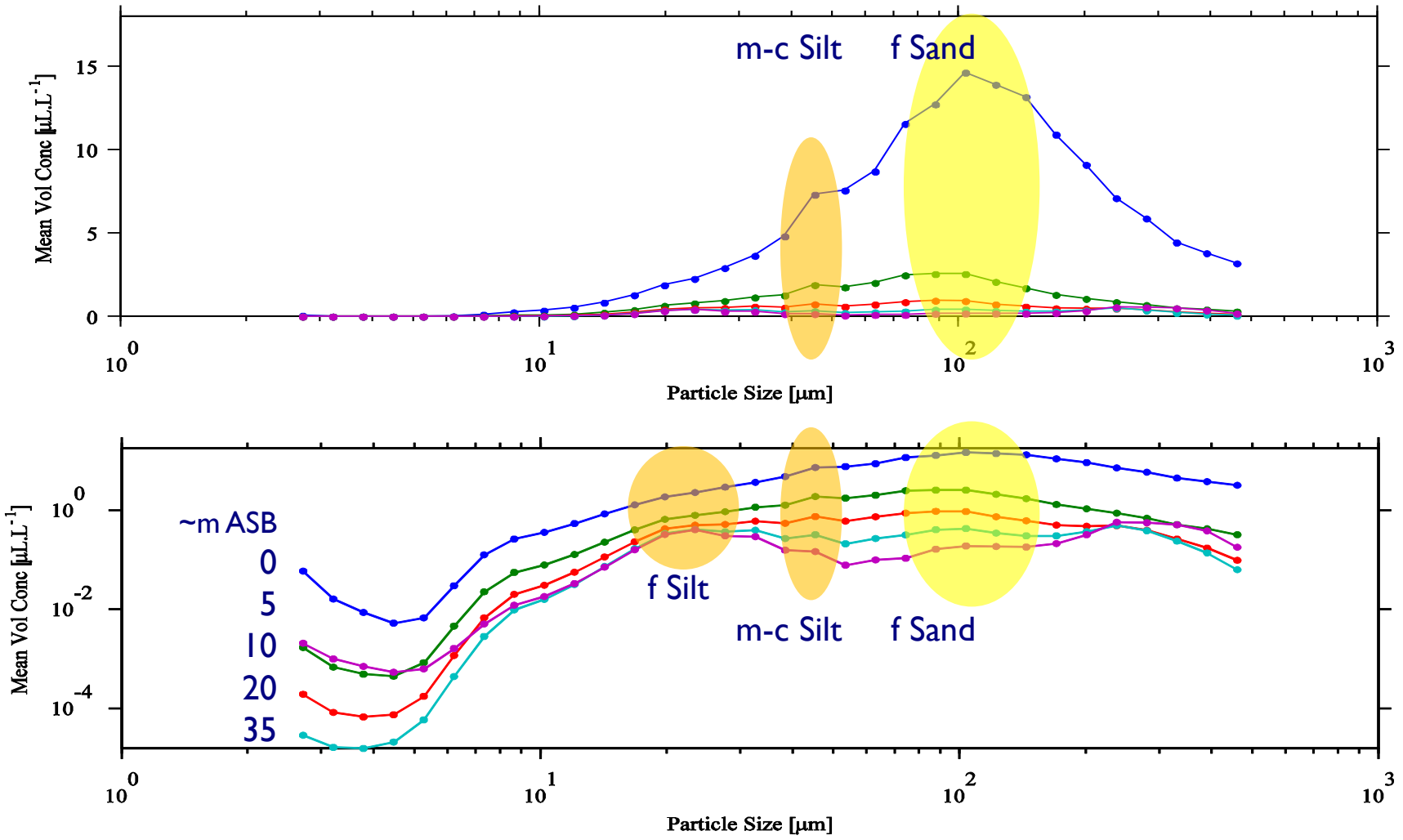
increasing visibility near the bed

1 (06:37) Flow speed 0.37 m/s.		>30 m ASB. Beam-C low 10-30 m ASB. Slight increase in lower part. 0-10 m ASB. Beam-C >10x
2 (07:35) Flow speed 0.27 m/s		>30 m ASB. Minor increase. 10-30 m ASB. Minor reduction. 0-10 m ASB. >x2 increase. Active suspension of bed sediment in the lower 10 m only.
3b (08:49) Flow speed 0.22 m/s		>30 m ASB. Slight increase at base. 10-30 m ASB. Continued upward movement of suspended sediment to ~23 m. 0-10 m ASB. x2 increase at 10 m but less closer to bed. Steepening overall gradient in lower 20 m.
4 (09:27) Flow speed 0.12 m/s		>30 m ASB. Continued slight upward movement of suspended sediment to ~30 m 10-30 m ASB. Slight Beam-C increase, and upward move in suspended sediment to ~30 m ASB 0-10 m ASB. Settling near the bed. Beam-C down by ~20%
5 (10:27) Flow speed 0.06 m/s.		>30 m ASB. Little change. 10-30 m ASB. Decreased variation and slightly lower magnitude. 0-10 m ASB. Continued near-bed settling. Beam-C down by ~25%.

Full transport

Settling

Particle size distributions – e.g. of vertical gradient in basal 35 m

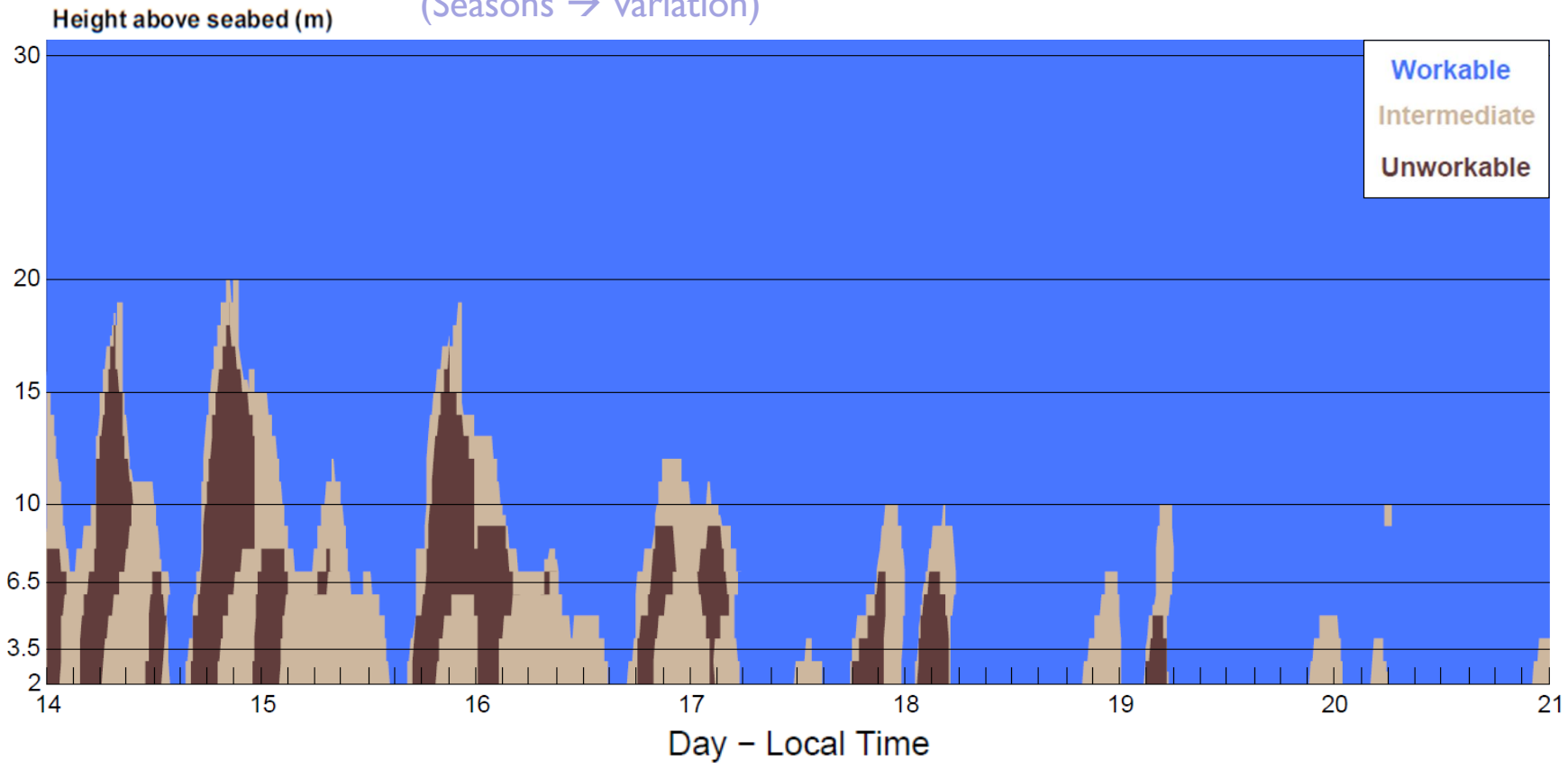


So – lots of oceanographic and sedimentary complexity…

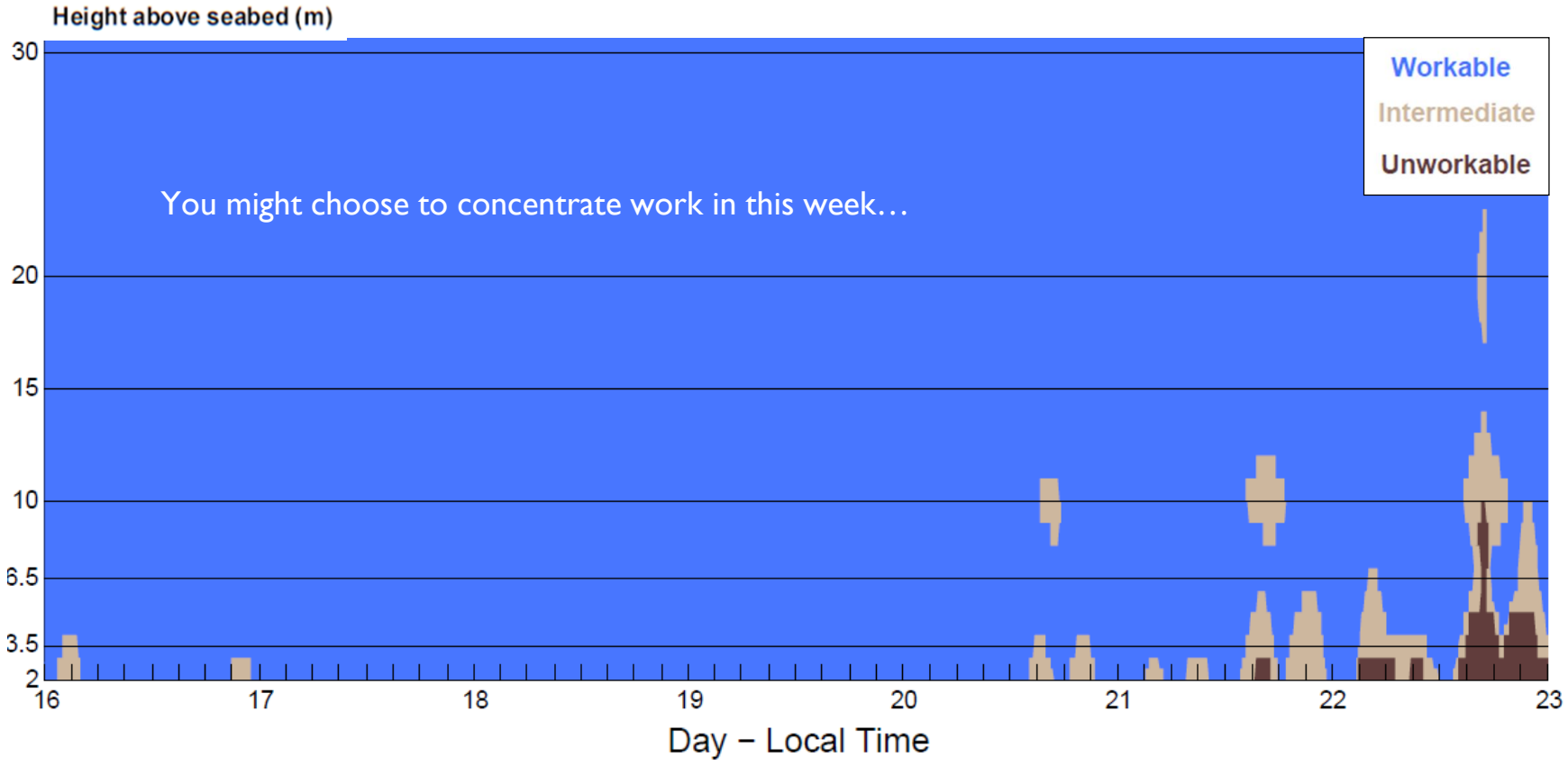
Predictions - Phase 1

- Quantify 'unworkable'

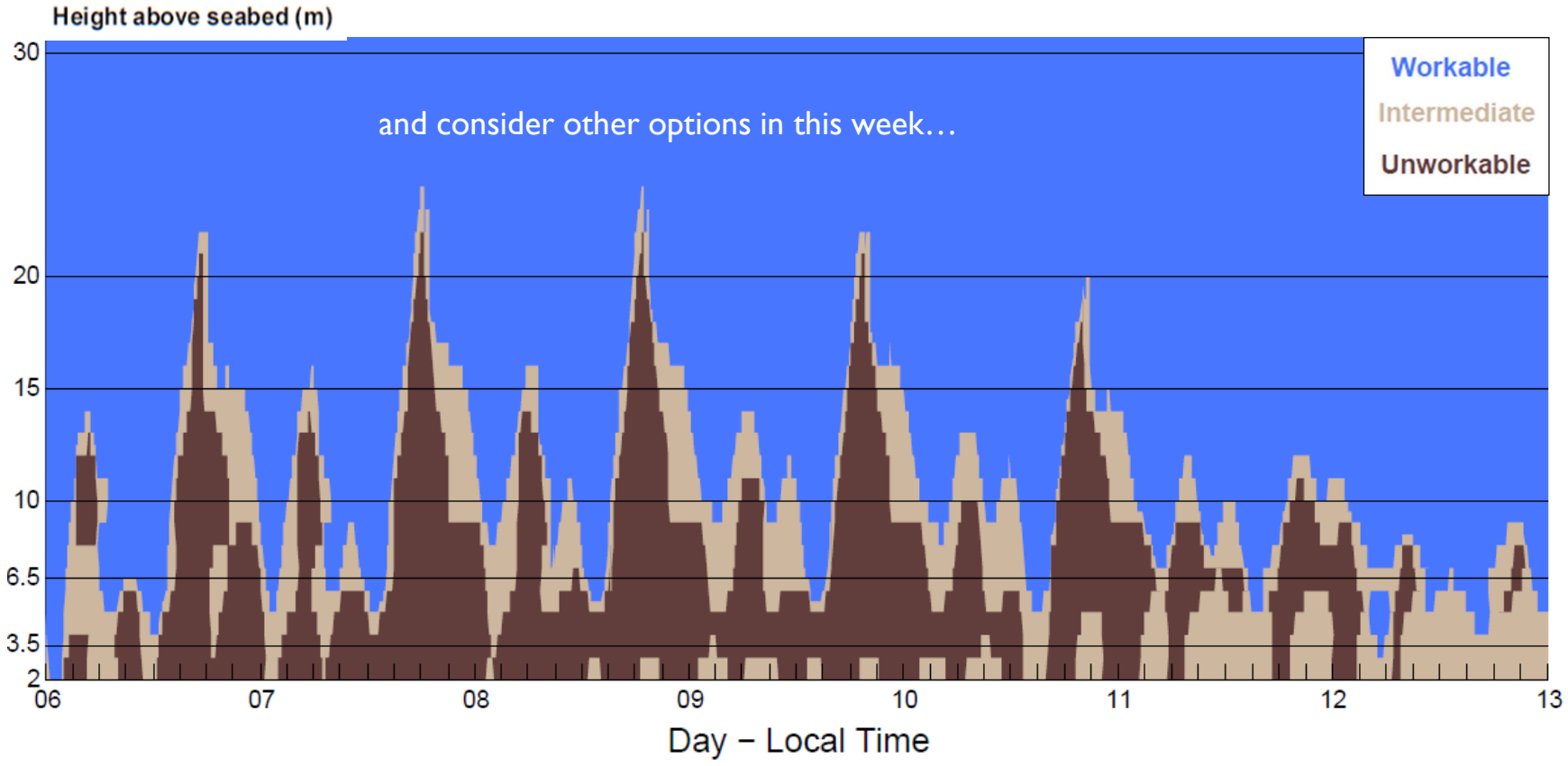
Data points ~15 minutes apart
Multiple depths
(Seasons → variation)



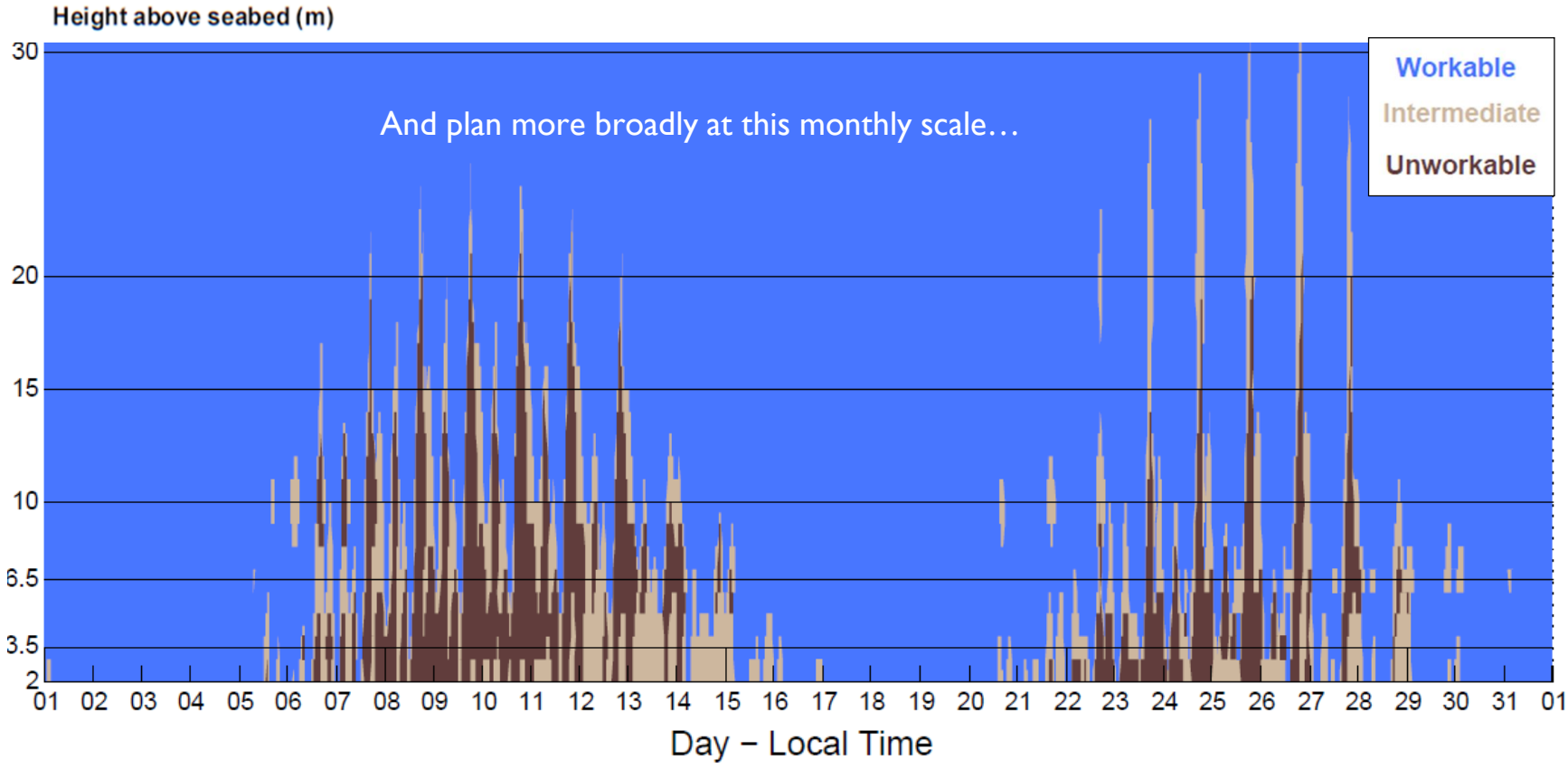
Predictions - Phase 1



Predictions - Phase 1



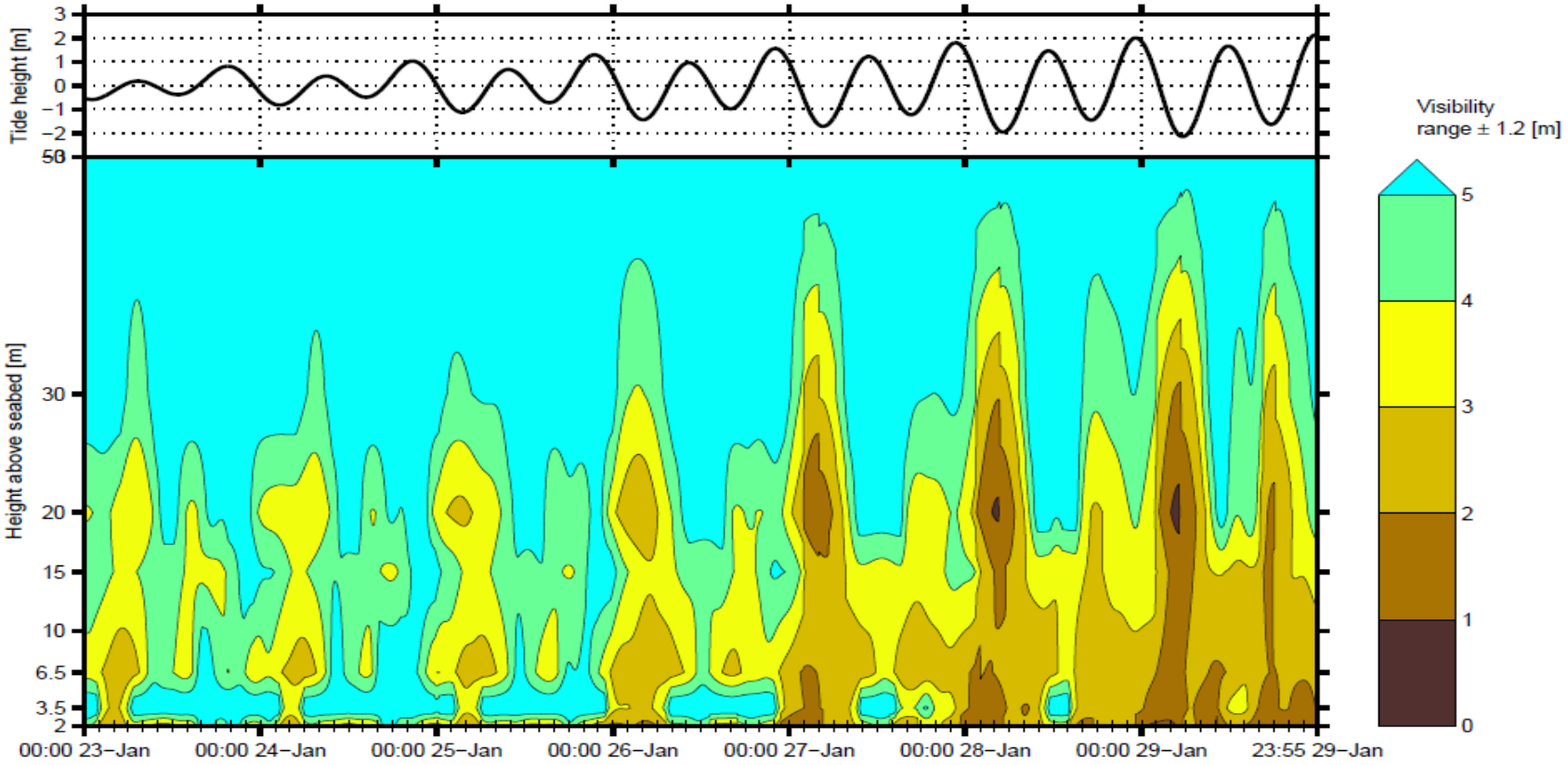
Predictions - Phase 1



Predictions - Phase 2

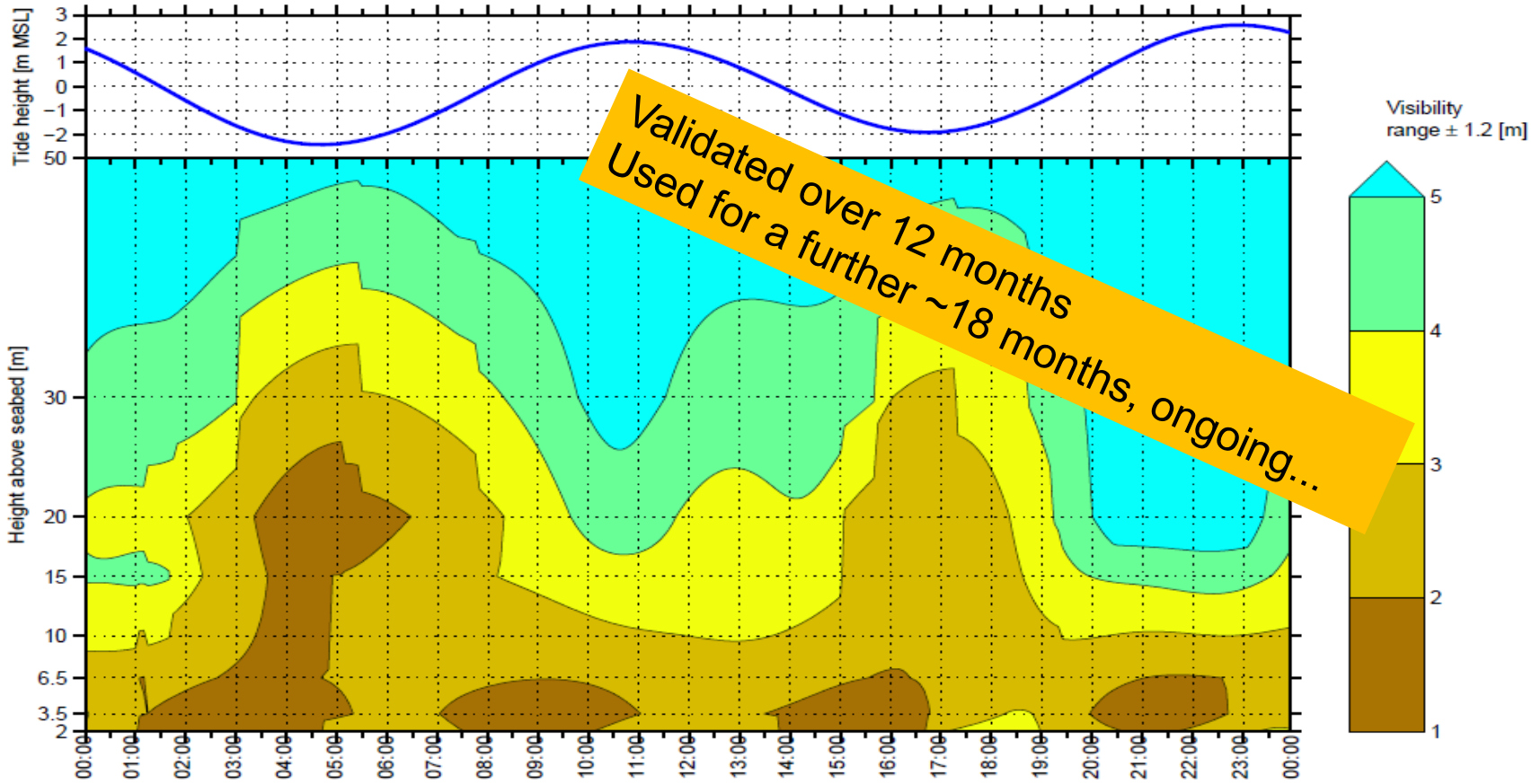
- Quantify visibility range

WEEKLY - Maximum visibility range, basal 50 m



Predictions - Phase 2

DAILY - Maximum visibility range, basal 50 m



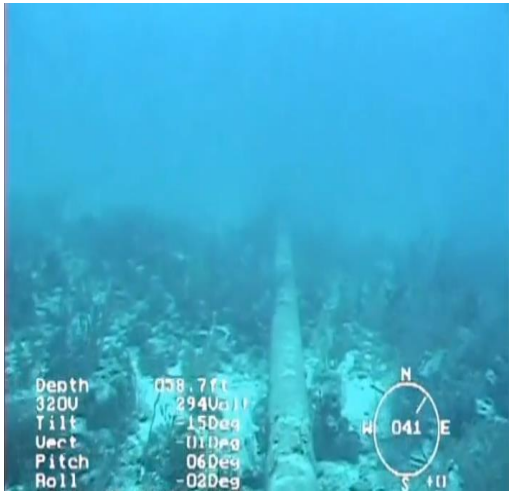
How have visibility predictions helped the project?

- *Significantly reduced downtime during multiple subsea campaigns*
  - *Incl. installation, survey and inspection.*
- *Validated on multiple campaigns*
  - *Feedback on their use and accuracy has been excellent*
- *Will be used to inform on-going inspections*
- *In initial field phases, visibility was a significant and difficult issue. It was recognised that an* ***investment in understanding the environment would lead to significant savings throughout the life of the project****.*

RPS MetOcean
Shell Australia
Piers Larcombe (RPS MetOcean, Perth)
Michael Garvey (Shell Australia, Perth)

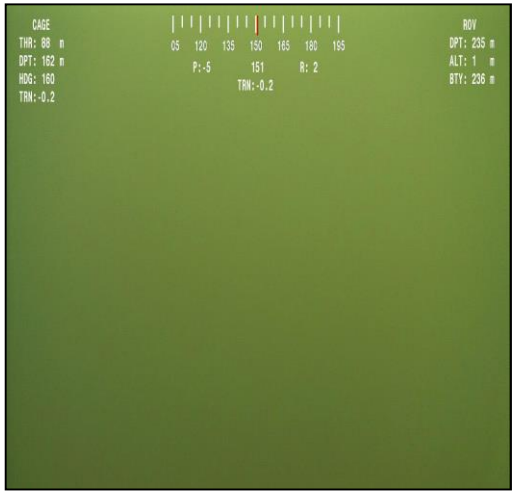
CONCLUSION

Underwater visibility for subsea engineering **<u>can</u>** be predicted to help operations.



Requires:

- appropriate measurements
- correct scientific understanding.



FOO Fremantle,
25th July. 2017
15 + 5 mins