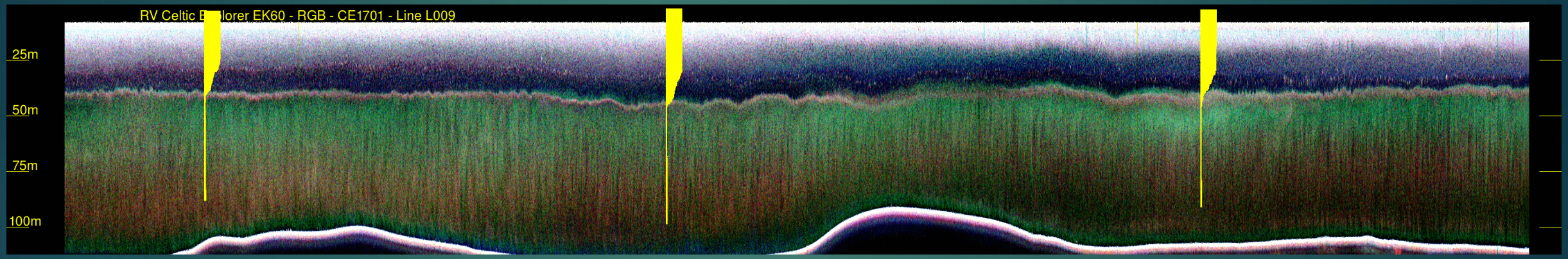
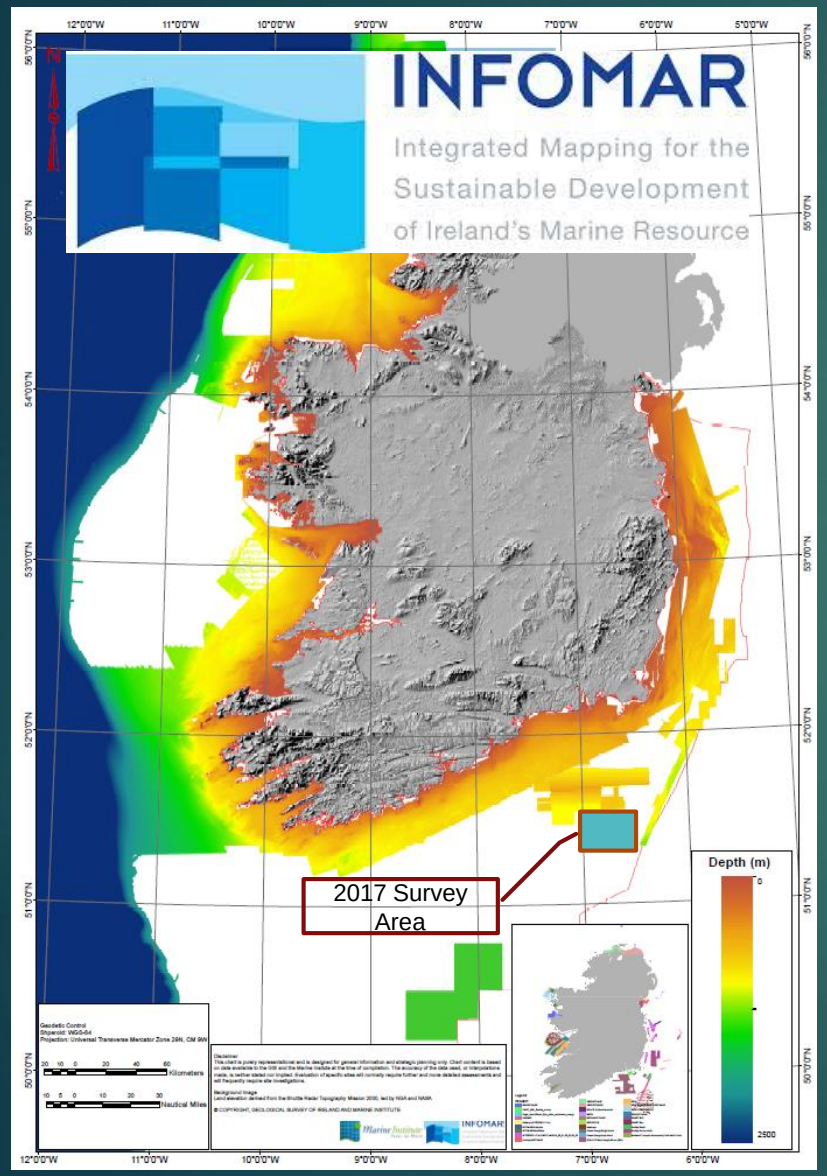
IMPROVED SOUND SPEED CONTROL THROUGH REMOTELY DETECTING THERMOCLINE UNDULATIONS



Jose Cordero, John Hughes Clarke
Center for Ocean and Coastal Mapping
University of New Hampshire.

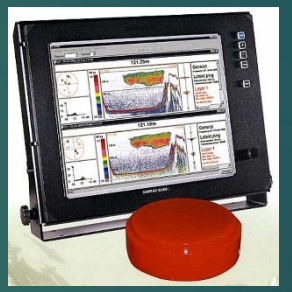
THE INFOMAR PROGRAMME



INFOMAR research area

R/V Celtic Explorer and R/V Celtic Voyager (Marine Institute, Ireland).

KONGSBERG EM2040



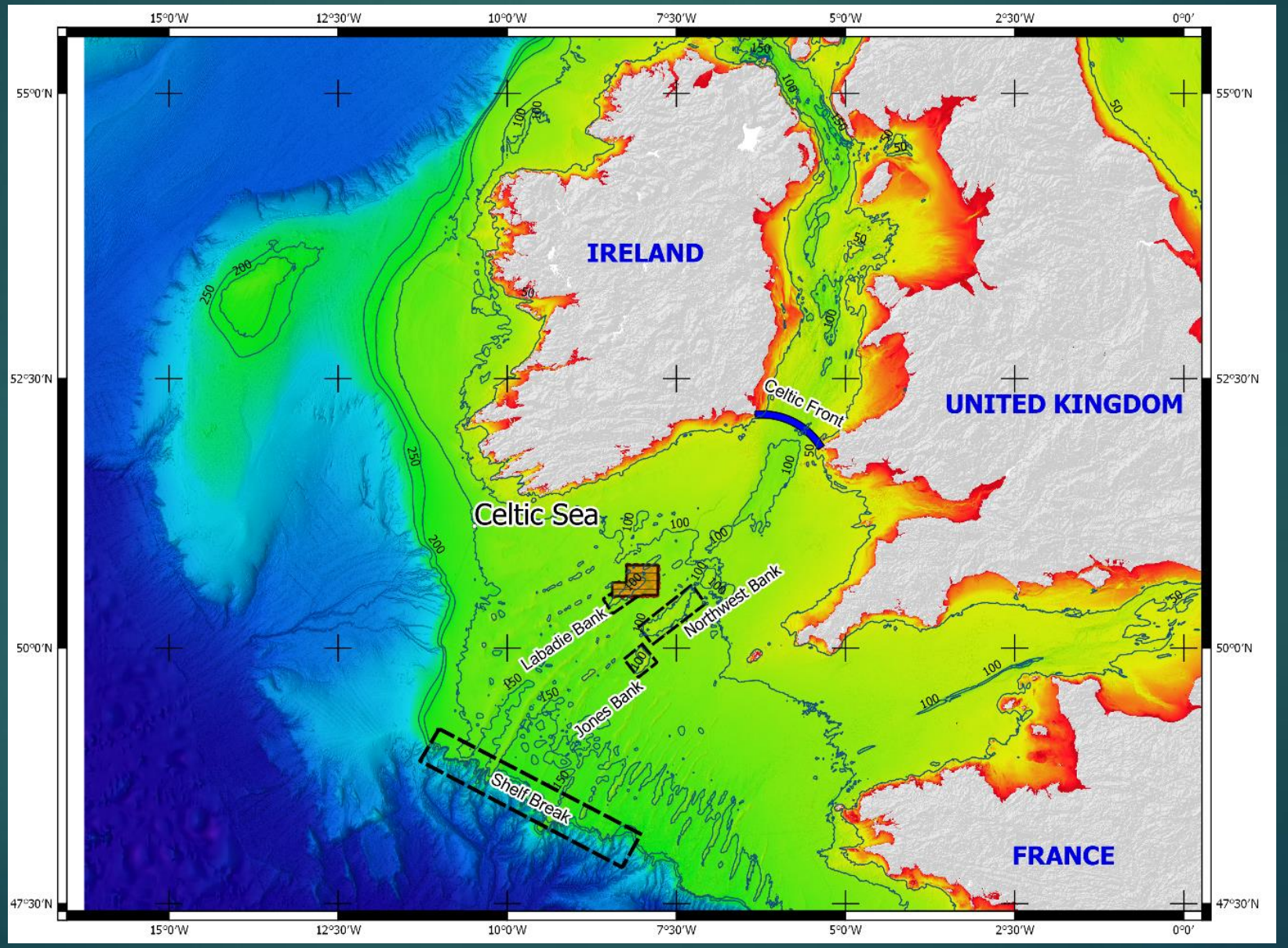
SIMRAD EK-60

AML MVP-200

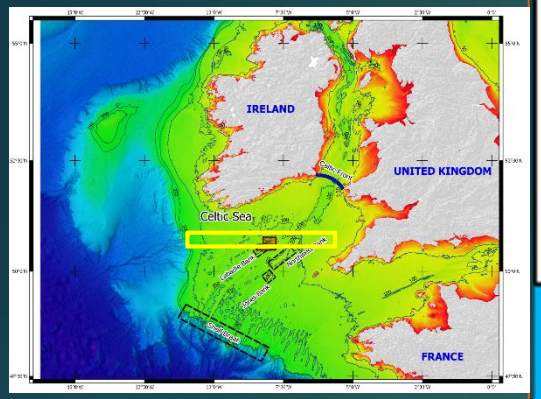
Multidisciplinary team onboard

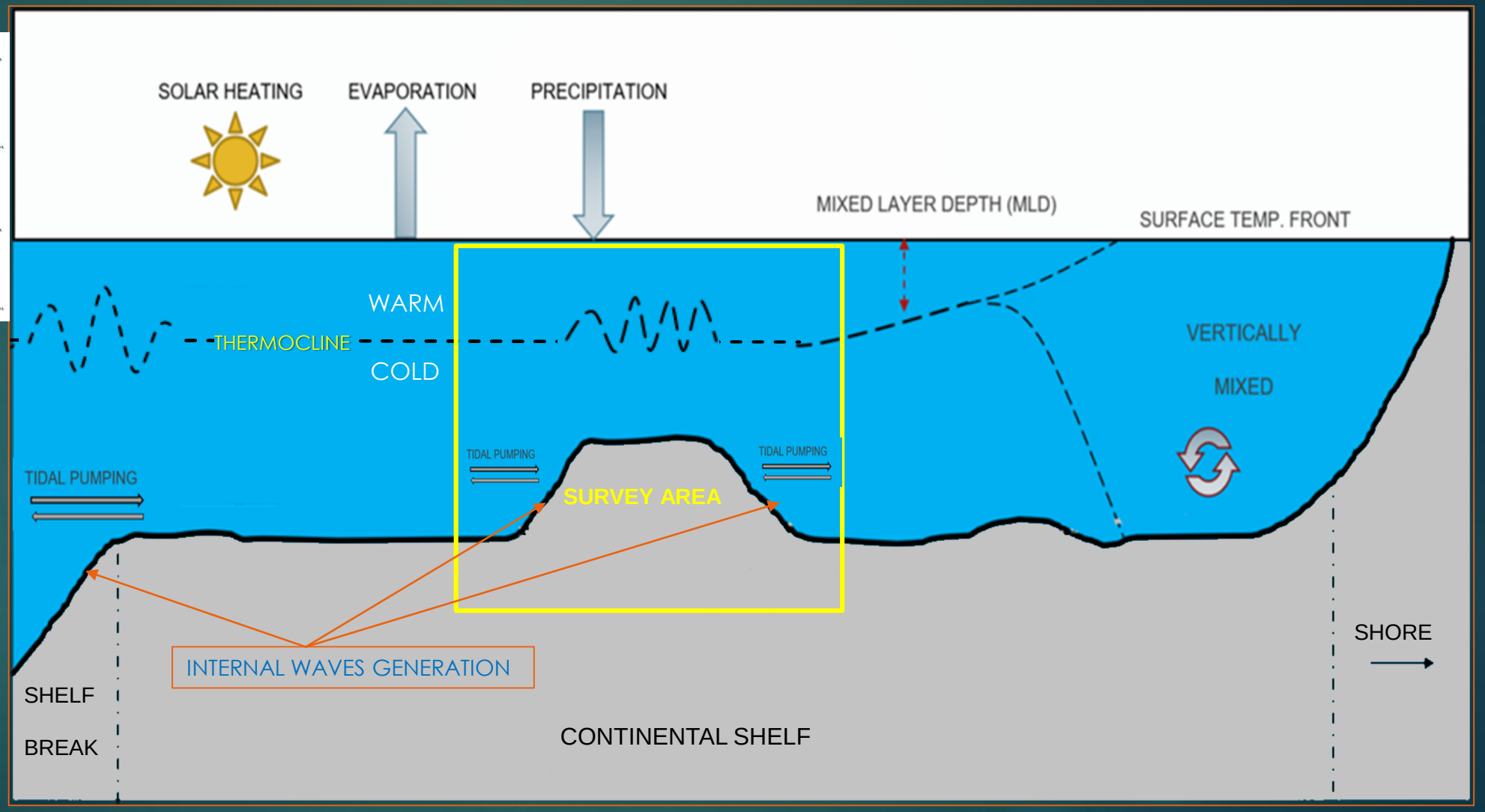
AREA OF OPERATIONS

23 July – 6 August 2017



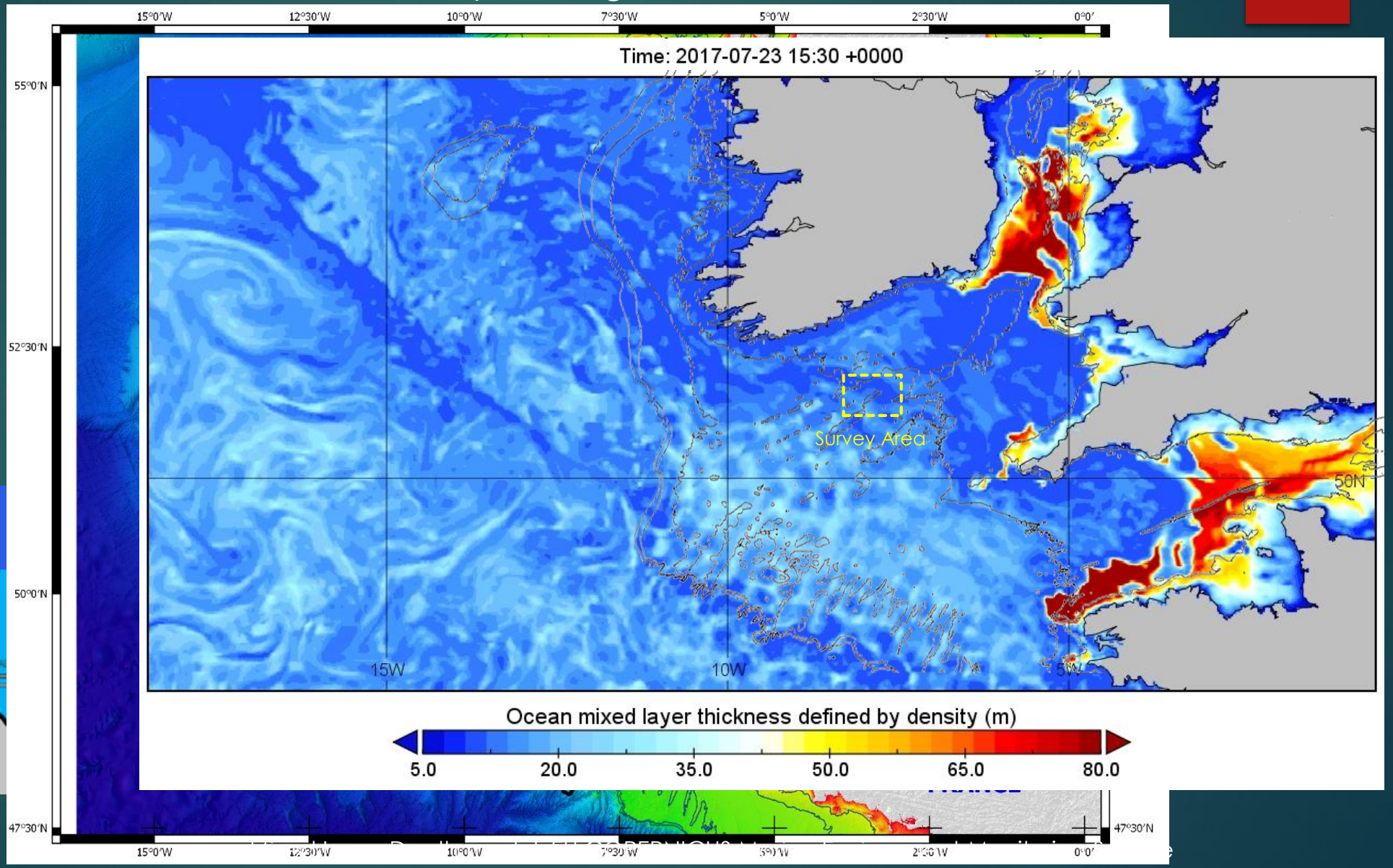
CELTIC SEA SUMMER STRATIFICATION

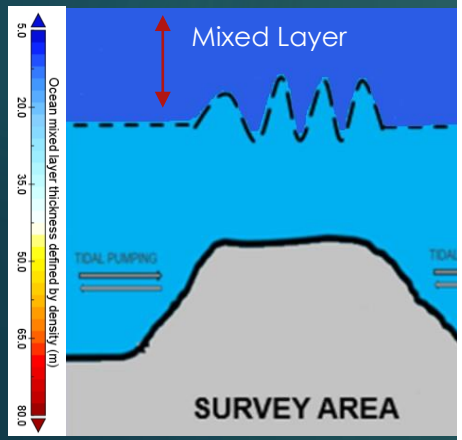




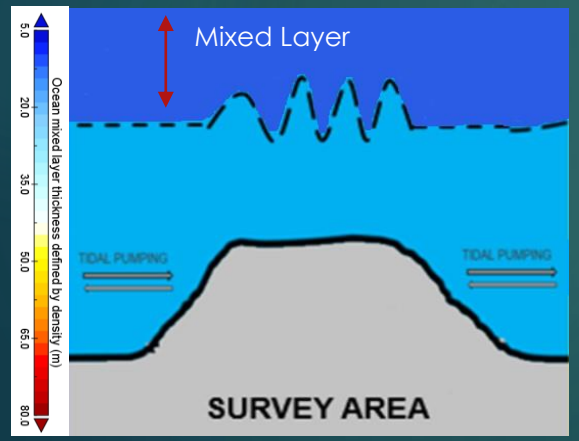
AREA OF OPERATIONS

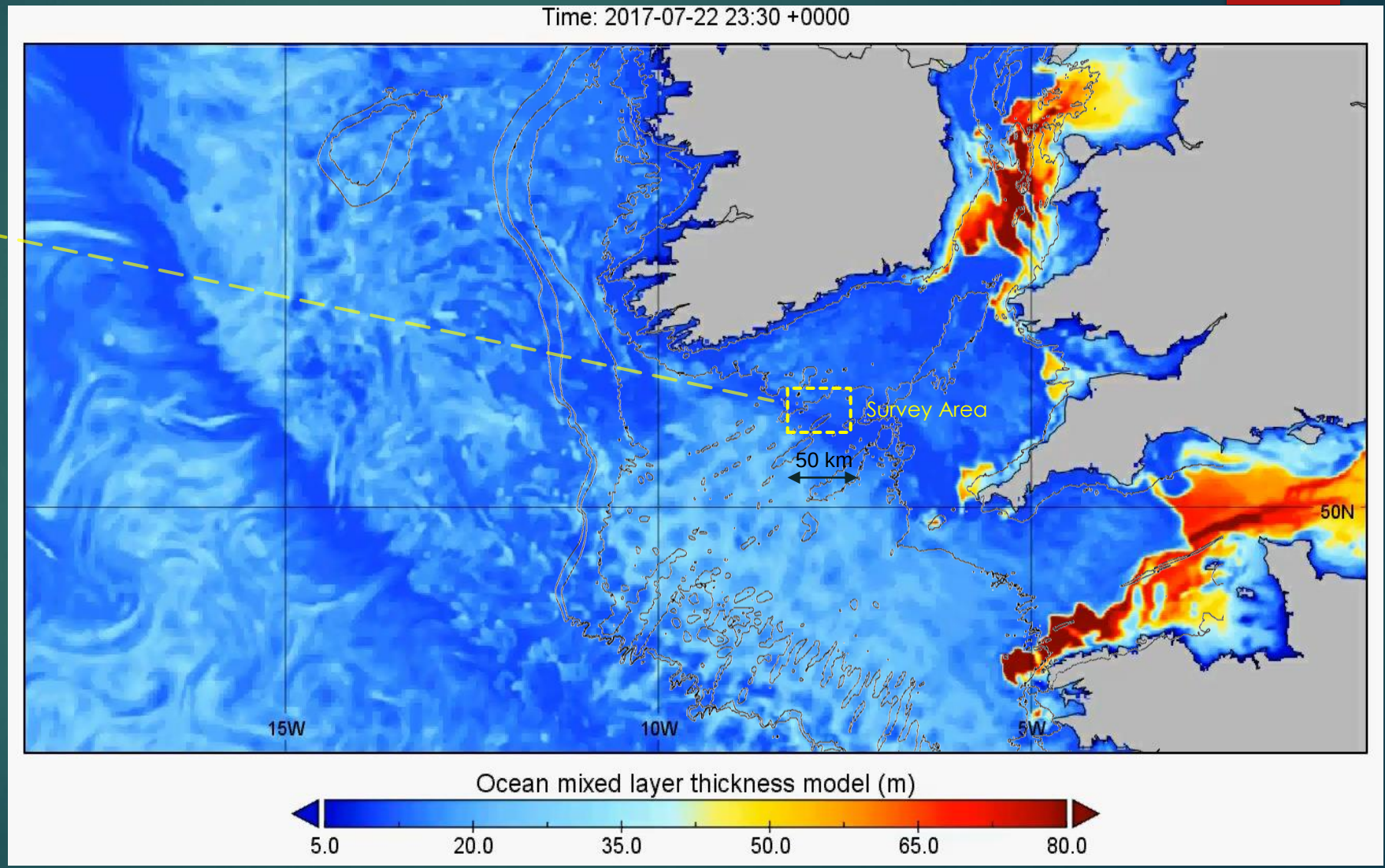
23 July – 6 August 2017





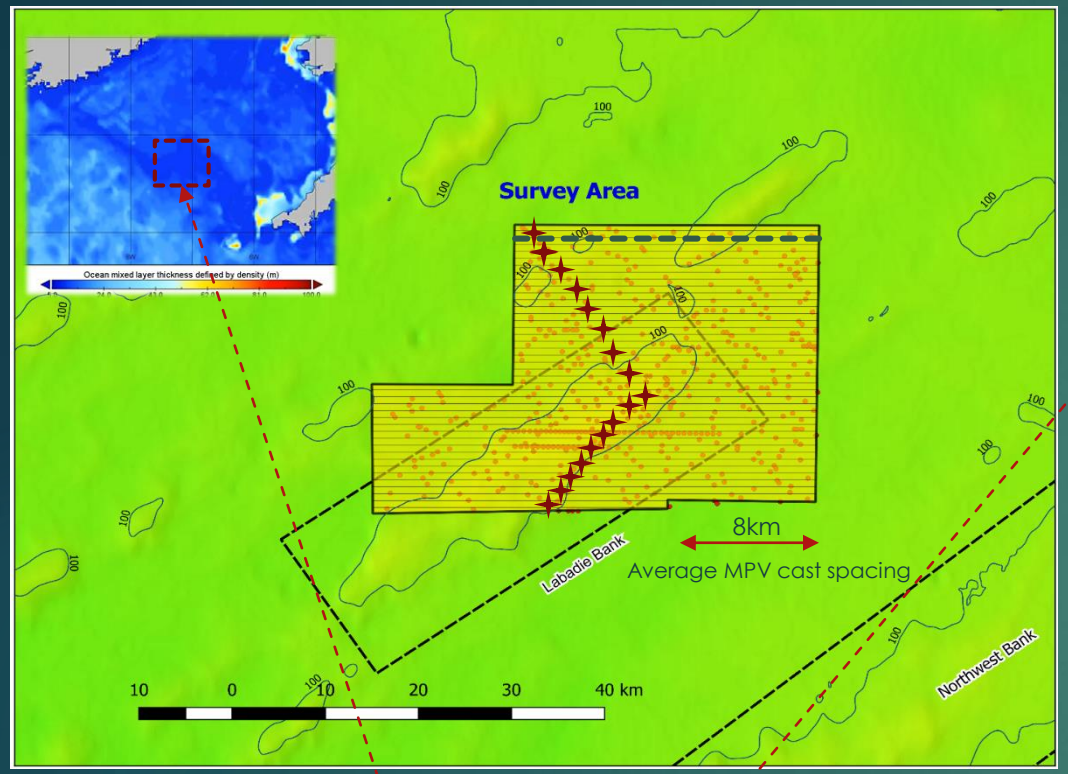
THERMOCLINE DEPTH VARIABILITY

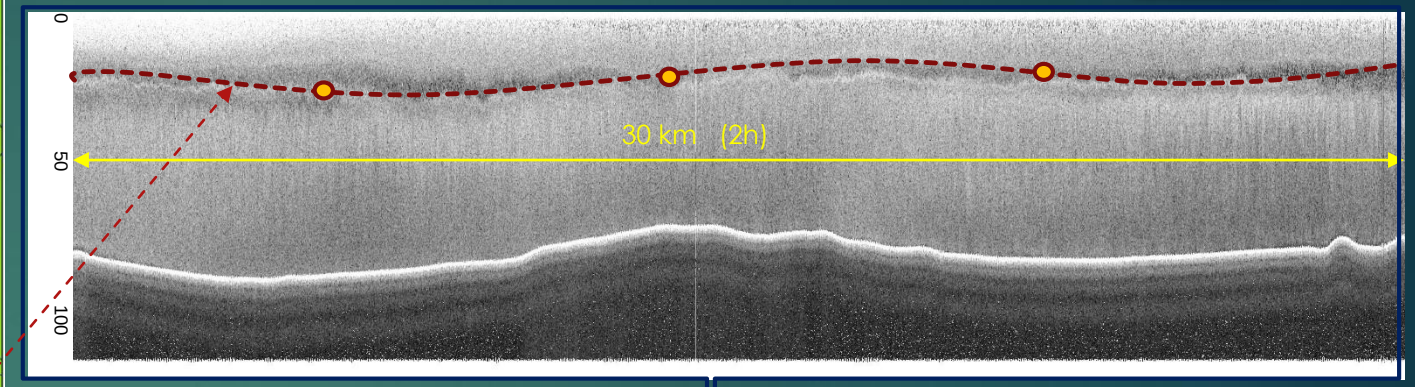




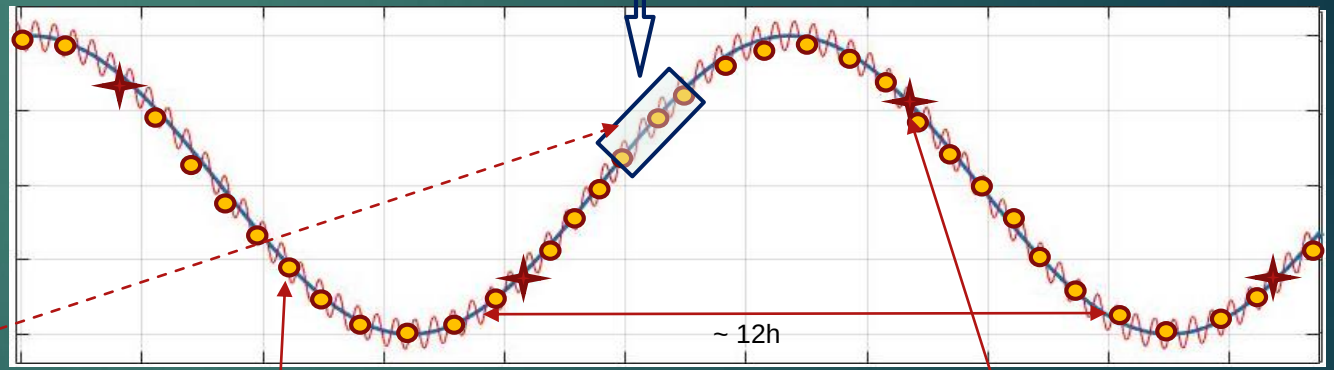
Mixed Layer Depth model. EU COPERNICUS Marine Environment Monitoring Service

DATA ACQUIRED





EK60 Raw echogram Line 038 -38kHz channel



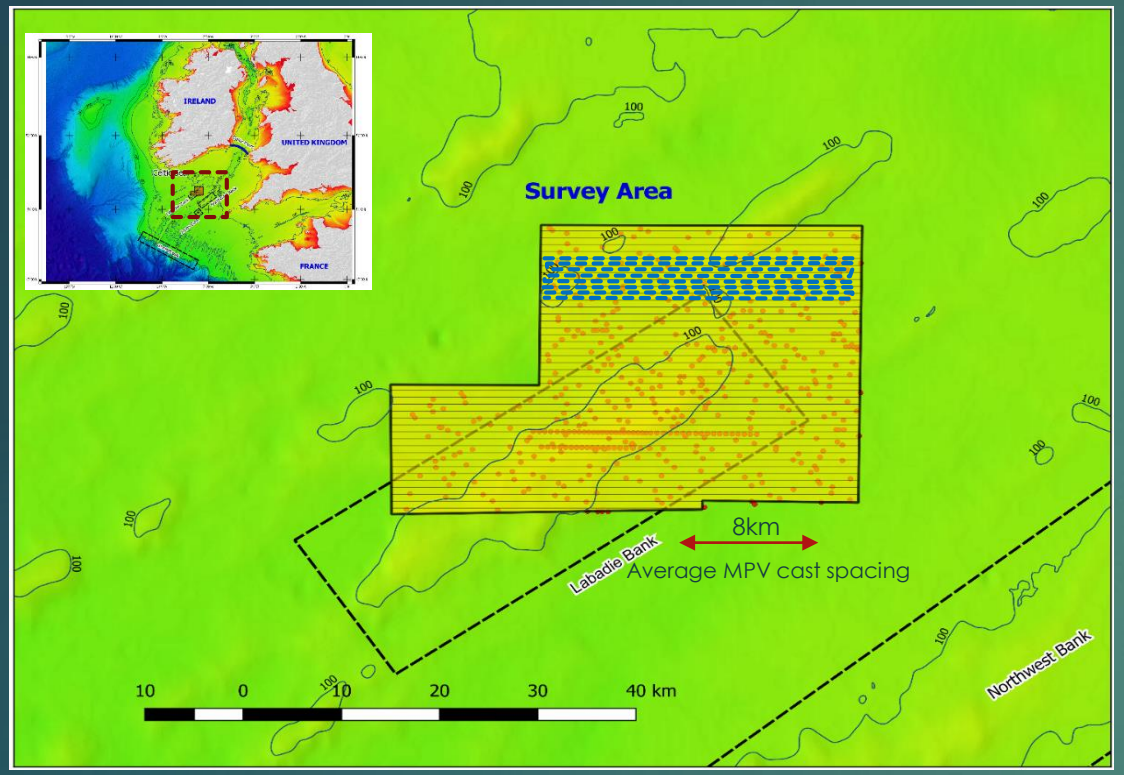
TIDE CYCLE

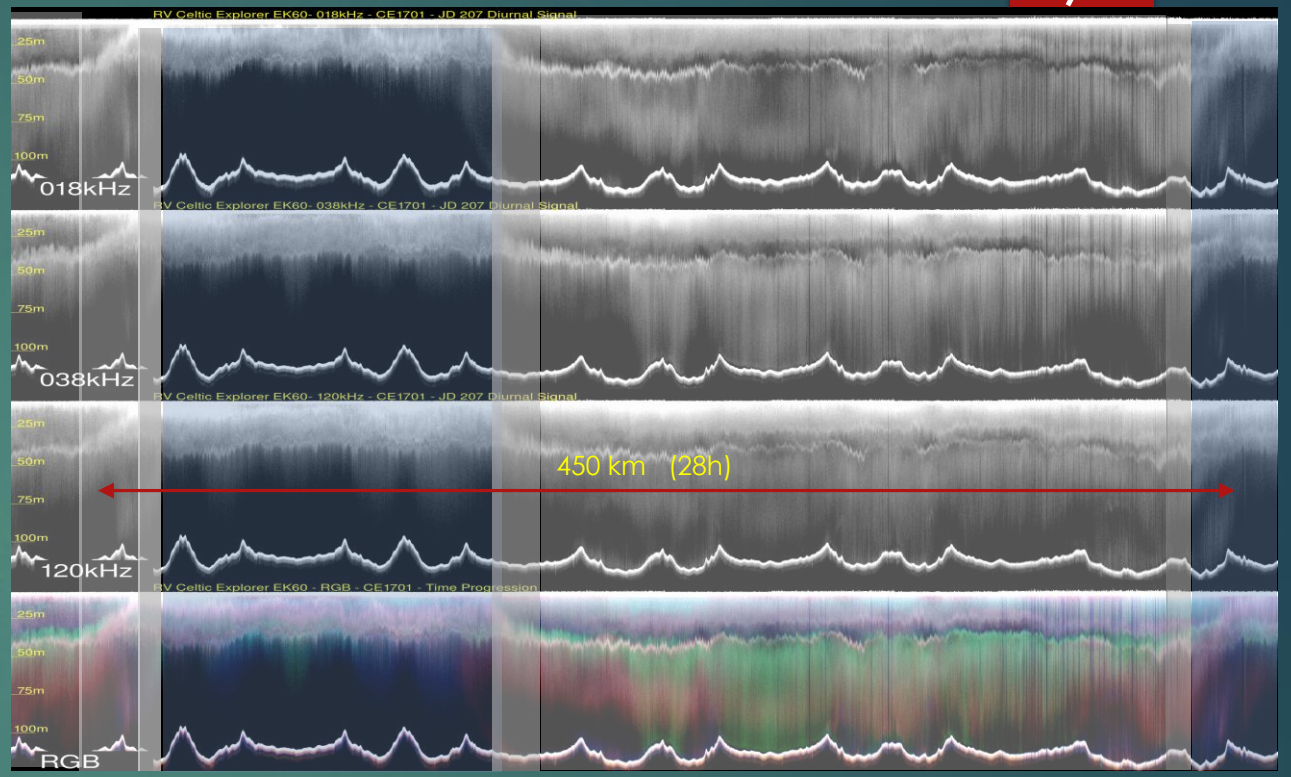
HIGH FREQUENCY UNDULATIONS

MVP CAST

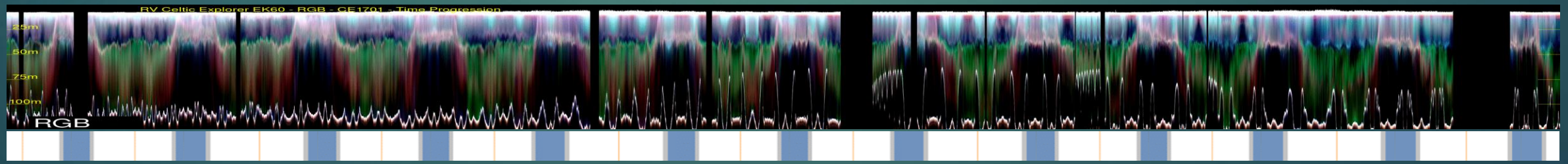
STATIONARY SVP CAST

DATA ACQUIRED





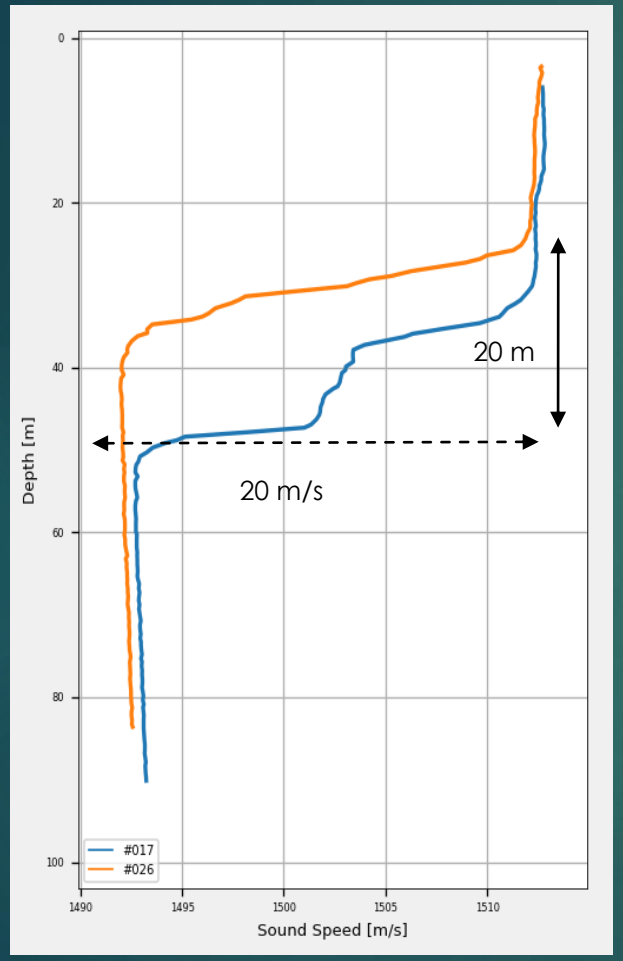
EK-60 multispectral echogram . Survey day #4.



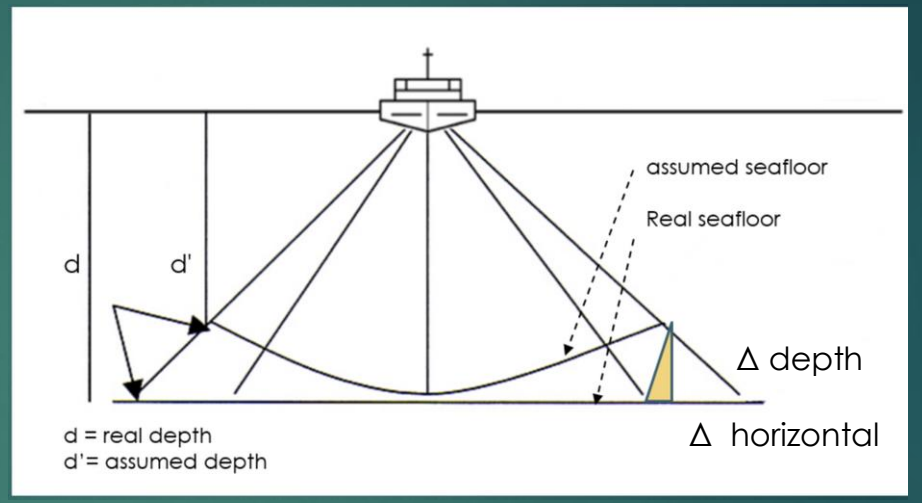
DAYLIGHT | NIGHTIME | TWILIGHT | NOON

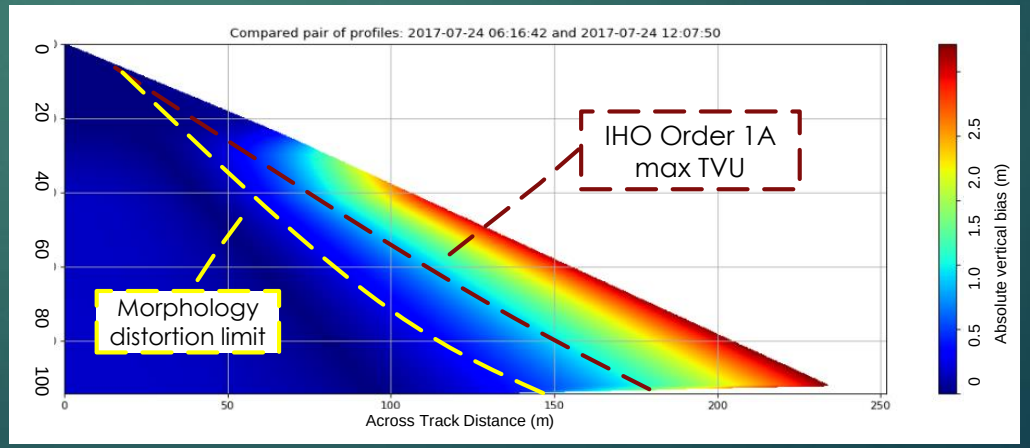
Complete survey composite EK-60 multispectral echogram .

SOUND SPEED PROFILE AND SEAFLOR MODELING



25 JUL17. 6h difference SVP comparison

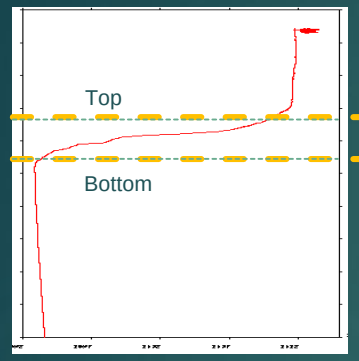




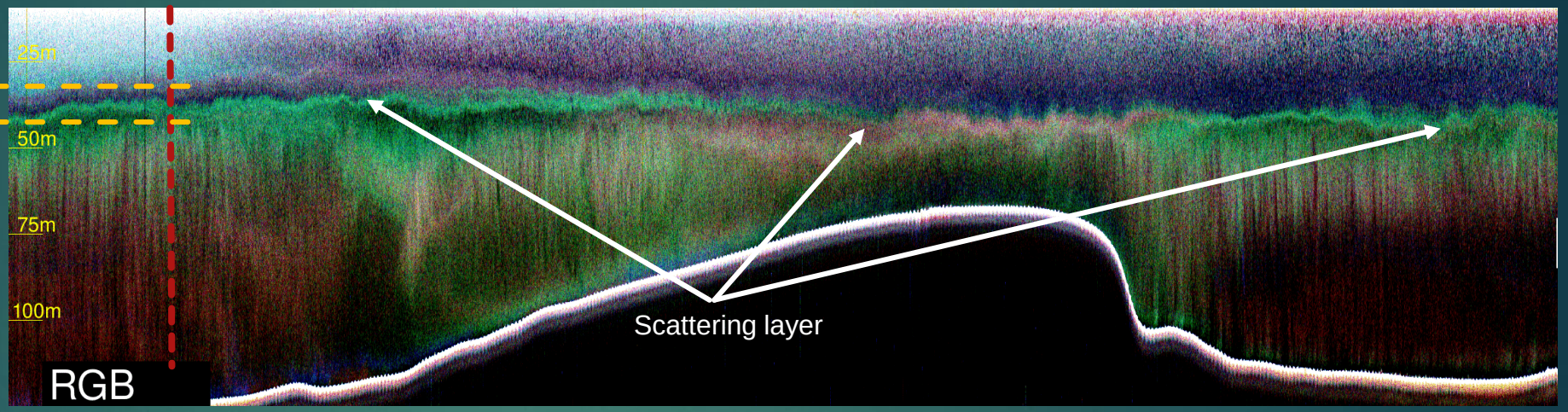
Vertical bias from 0 to 70 degrees from nadir

SOUND VELOCITY PROFILE AND SCATTERING LAYER

Thermocline

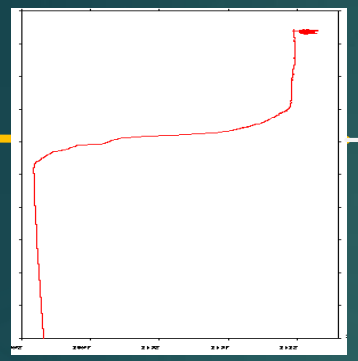


Line 068. SVP #1

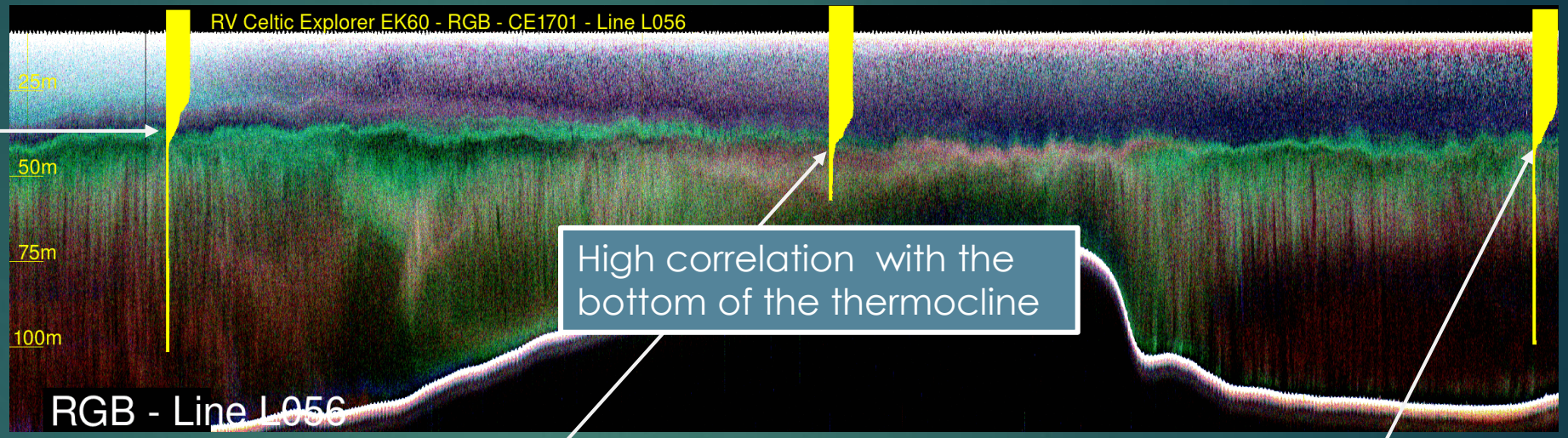


Line 068. EK-60 multi channel echogram

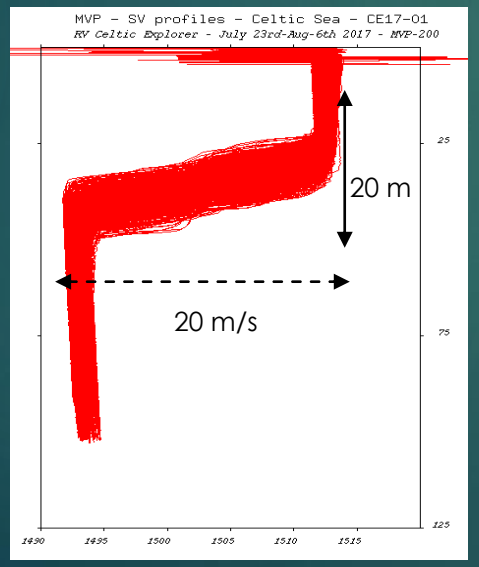
SOUND VELOCITY PROFILE AND SCATTERING LAYER



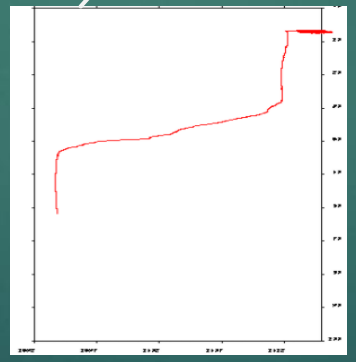
Line 068. SVP #1



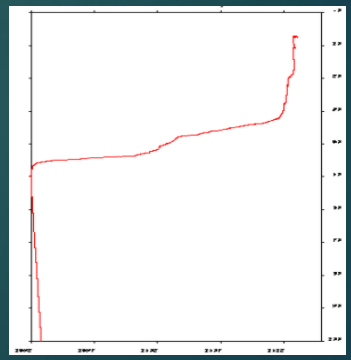
Line 068. EK-60 multi channel echogram



Full survey Sound Speed Profile composition

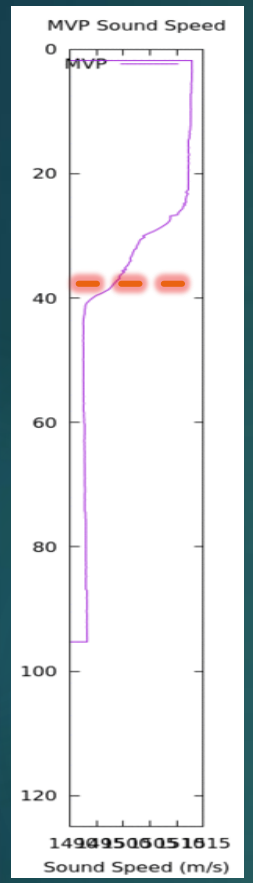


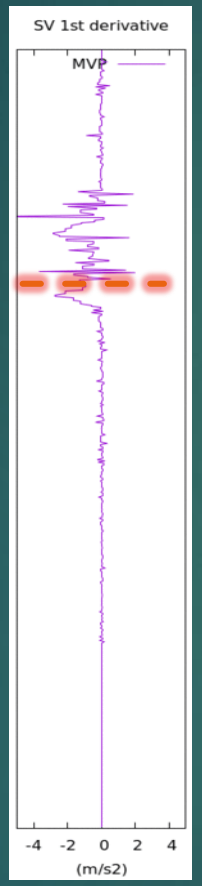
Line 068. SVP #2



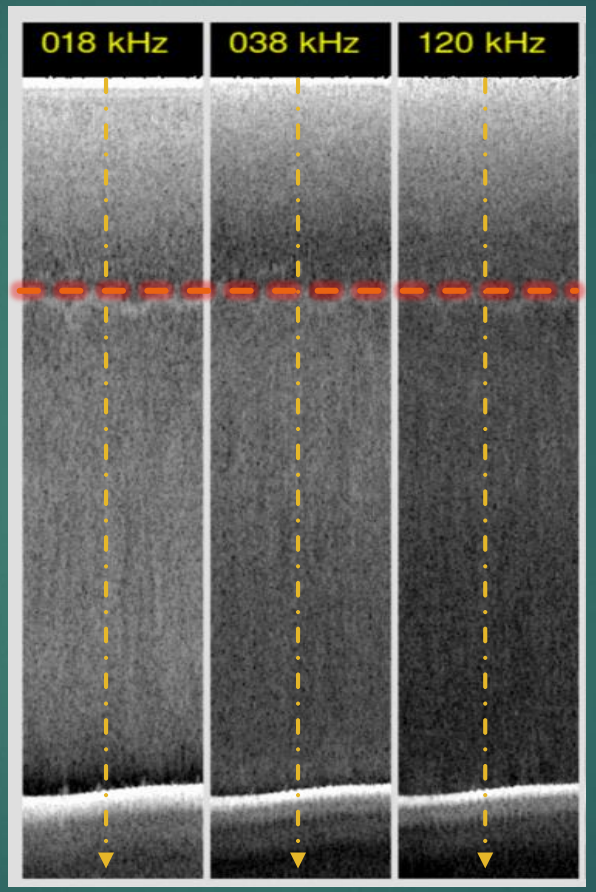
Line 068. SVP #3

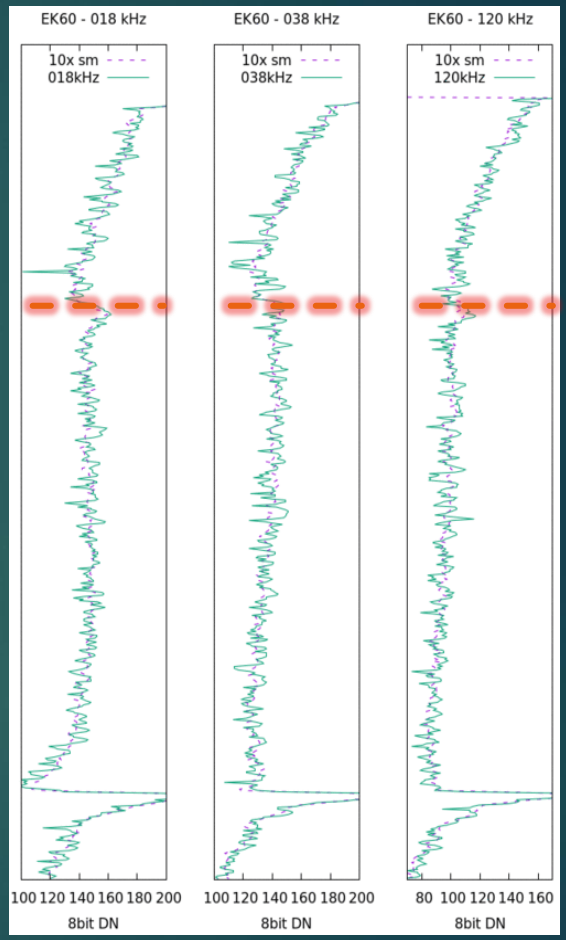
DETECTING THE THERMOCLINE





Thermocline depth





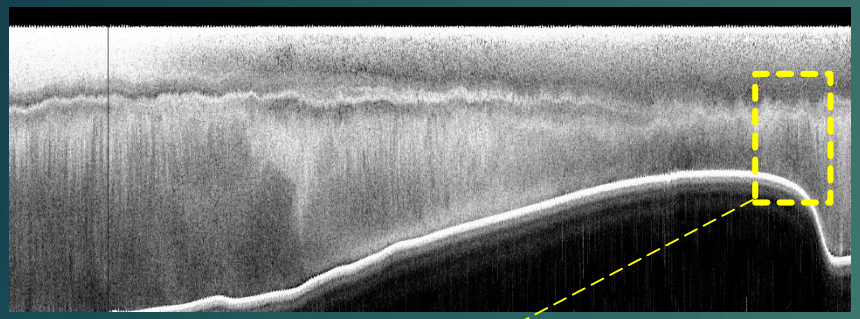
Thermocline determined through SVP first derivative

Thermocline determined through pixel intensity analysis

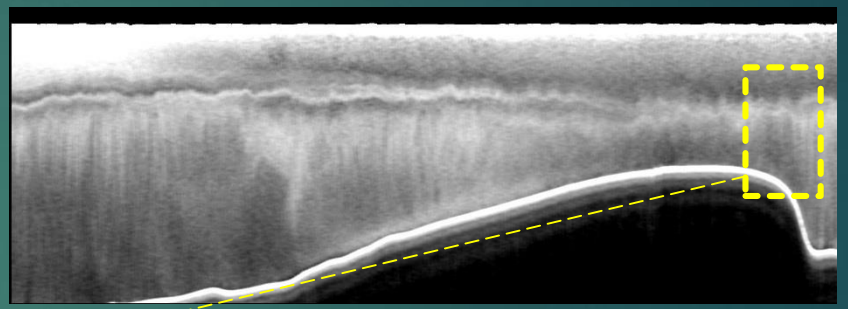
IMAGE PROCESSING

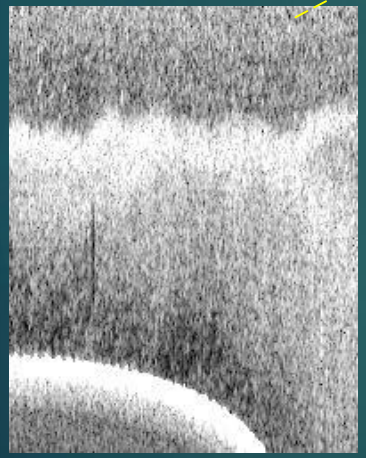
First step: Speckle removal

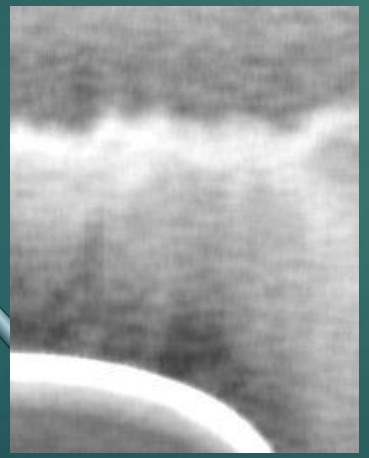
Low Pass Filter: Removes high frequency variability by averaging each pixel value w.r.t. the pixel values within a surrounding box



Box size 5x10

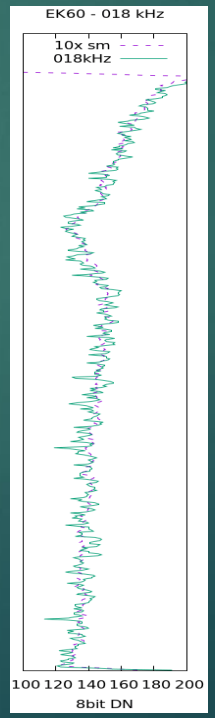






5 pixels= 1m

10 pixels= 100 m



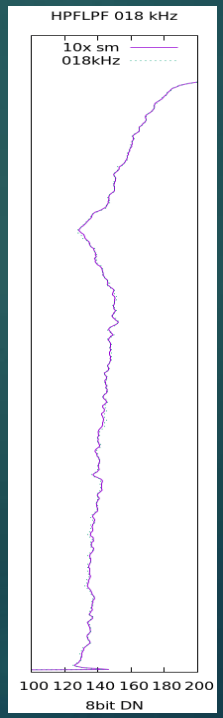
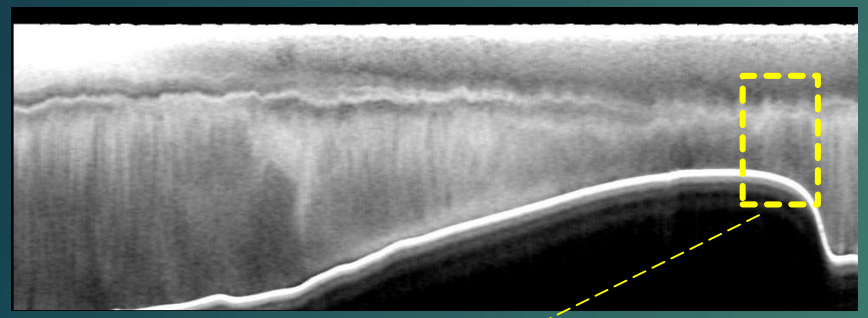


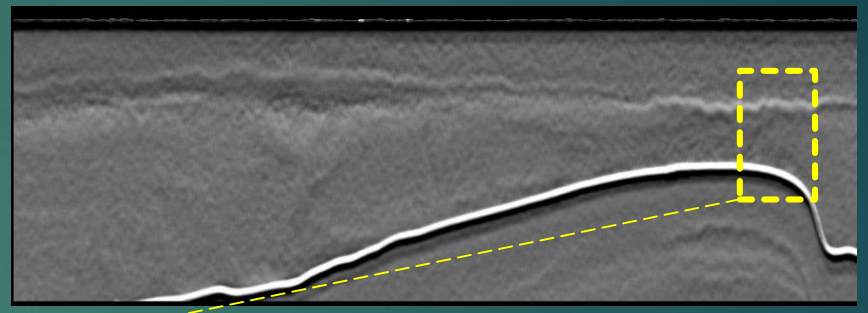
IMAGE PROCESSING

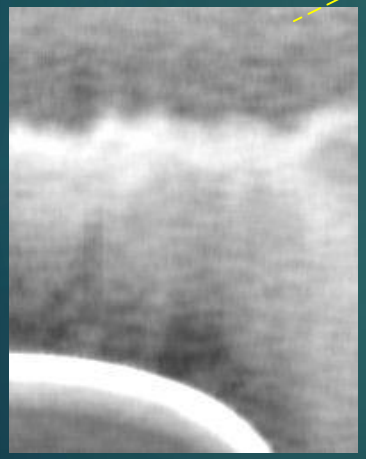
Second step: Edge detection

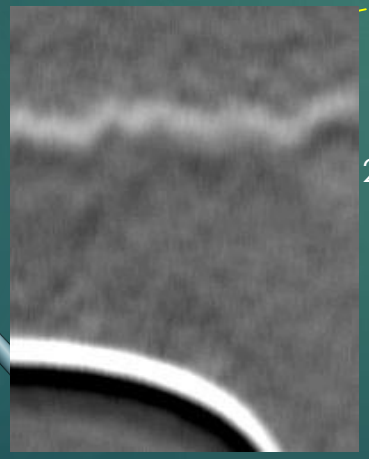
Gradient filter: Gets the peak corresponding to the first derivative of the pixel value curve in a certain direction



Box size 01x21



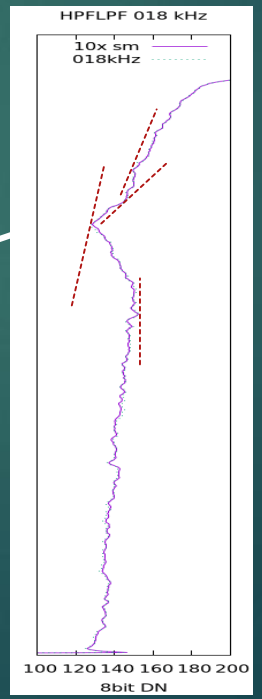




21 pixels= 4.1m

1 pixel= 10 m

Derivative (gradient) at each point in a vertical section



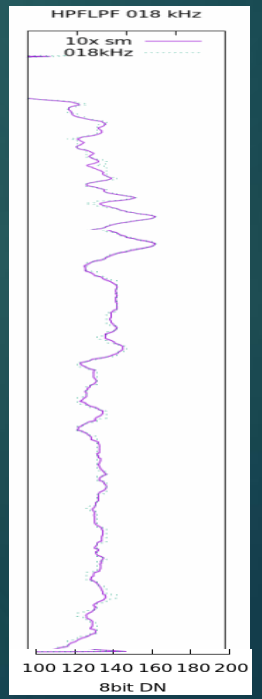
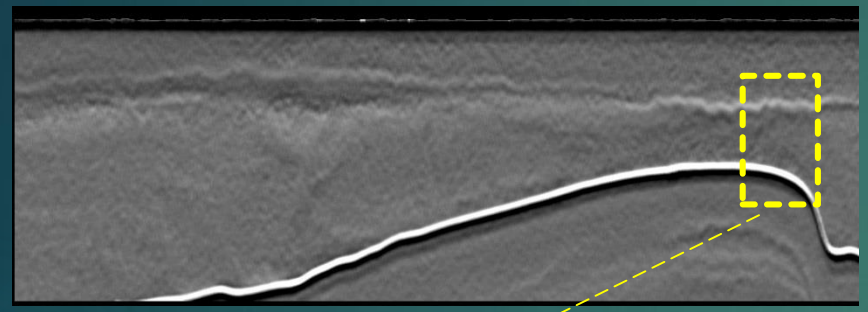


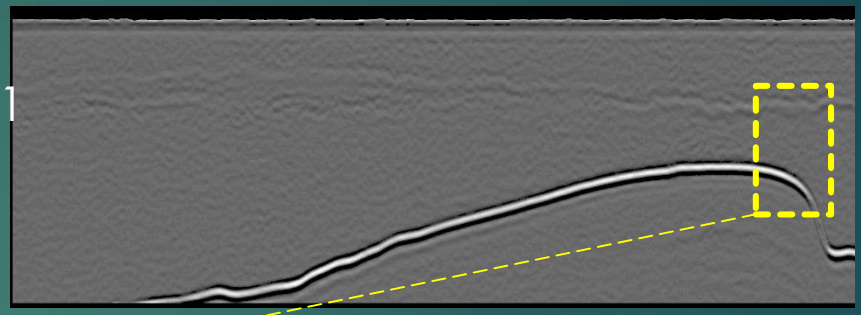
IMAGE PROCESSING

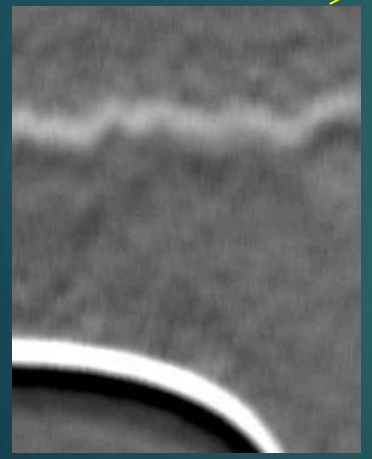
Third step: Edge enhancement

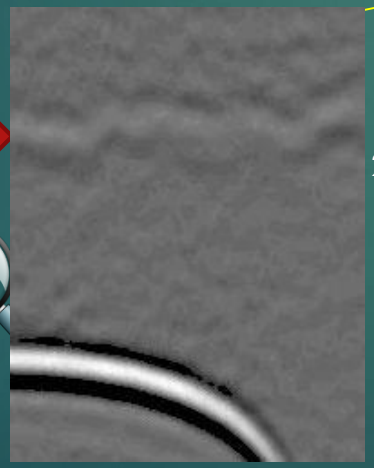
High pass filter: Gets the highest positive anomaly over a threshold by subtracting the mean value in the surrounding pixels



Box size 01x21



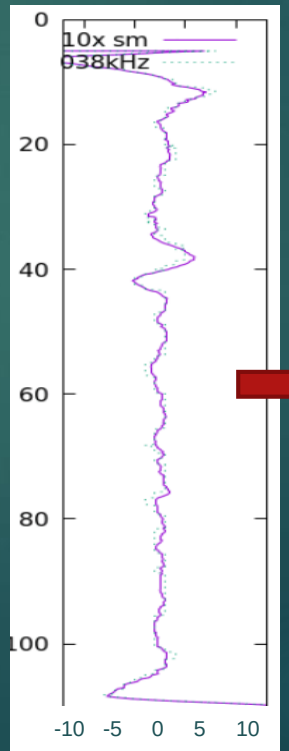


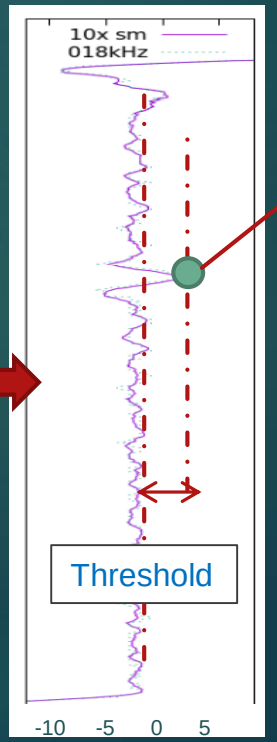


21 pixels= 4.1m

1 pixel= 10 m

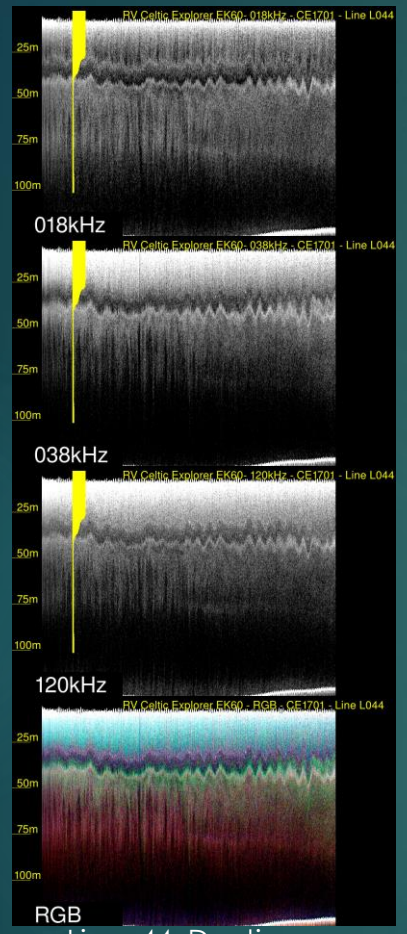
Vertical high frequency variations are enhanced



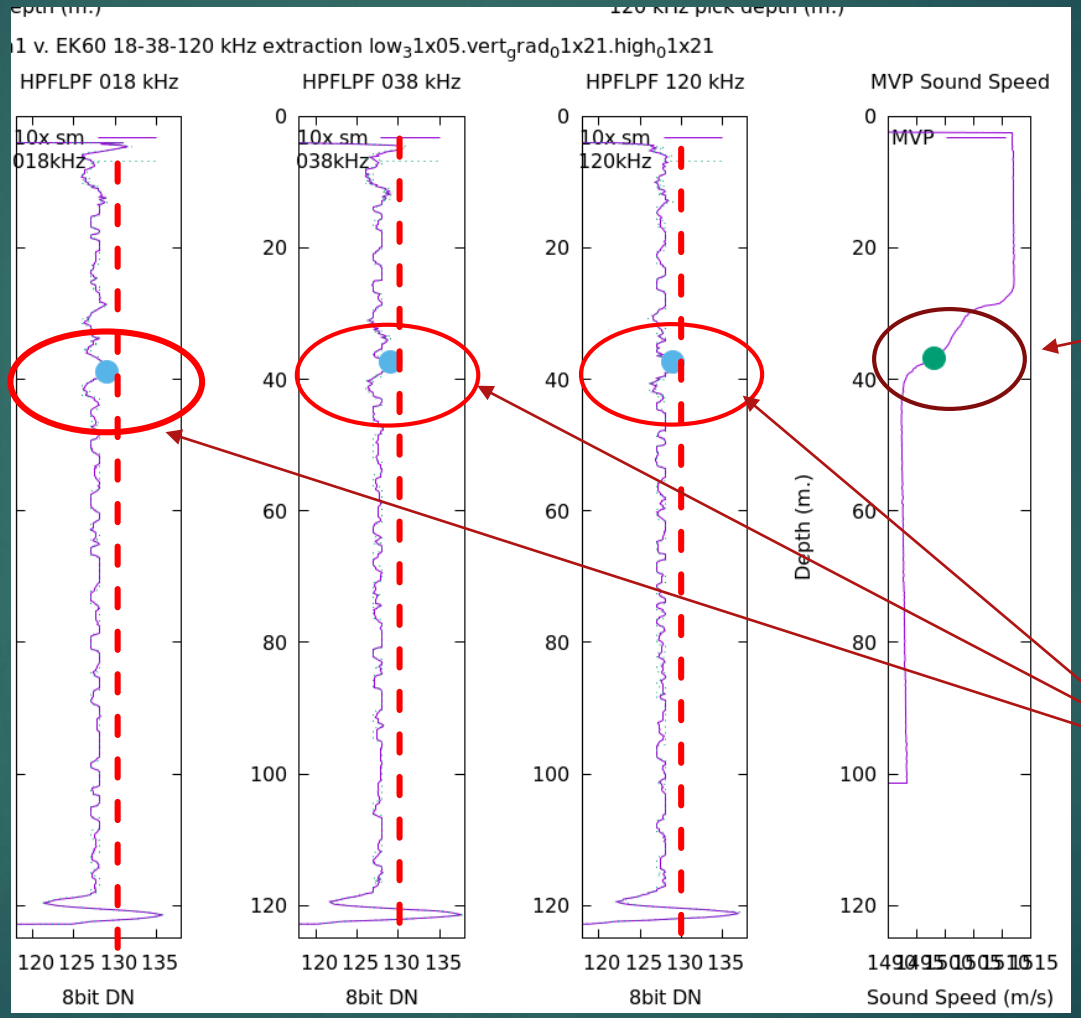


Thermocline depth

IMAGE PROCESSING VS MVP SOLUTION



Line 44. Daytime.
Original data + MVP locations

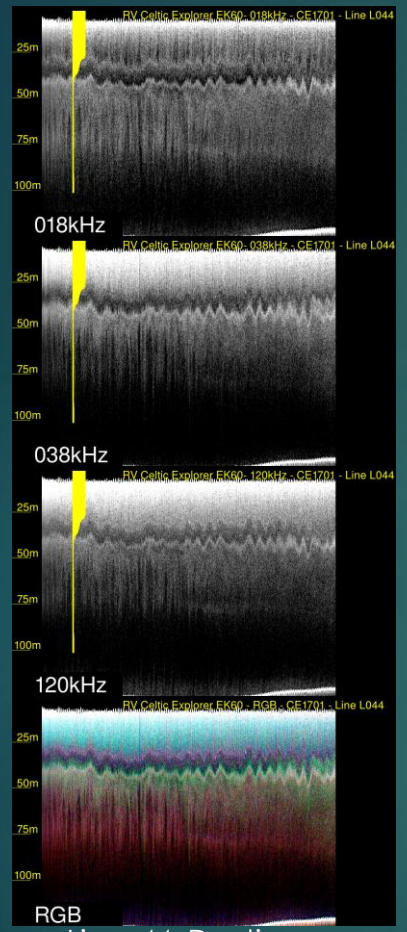


MPV solution

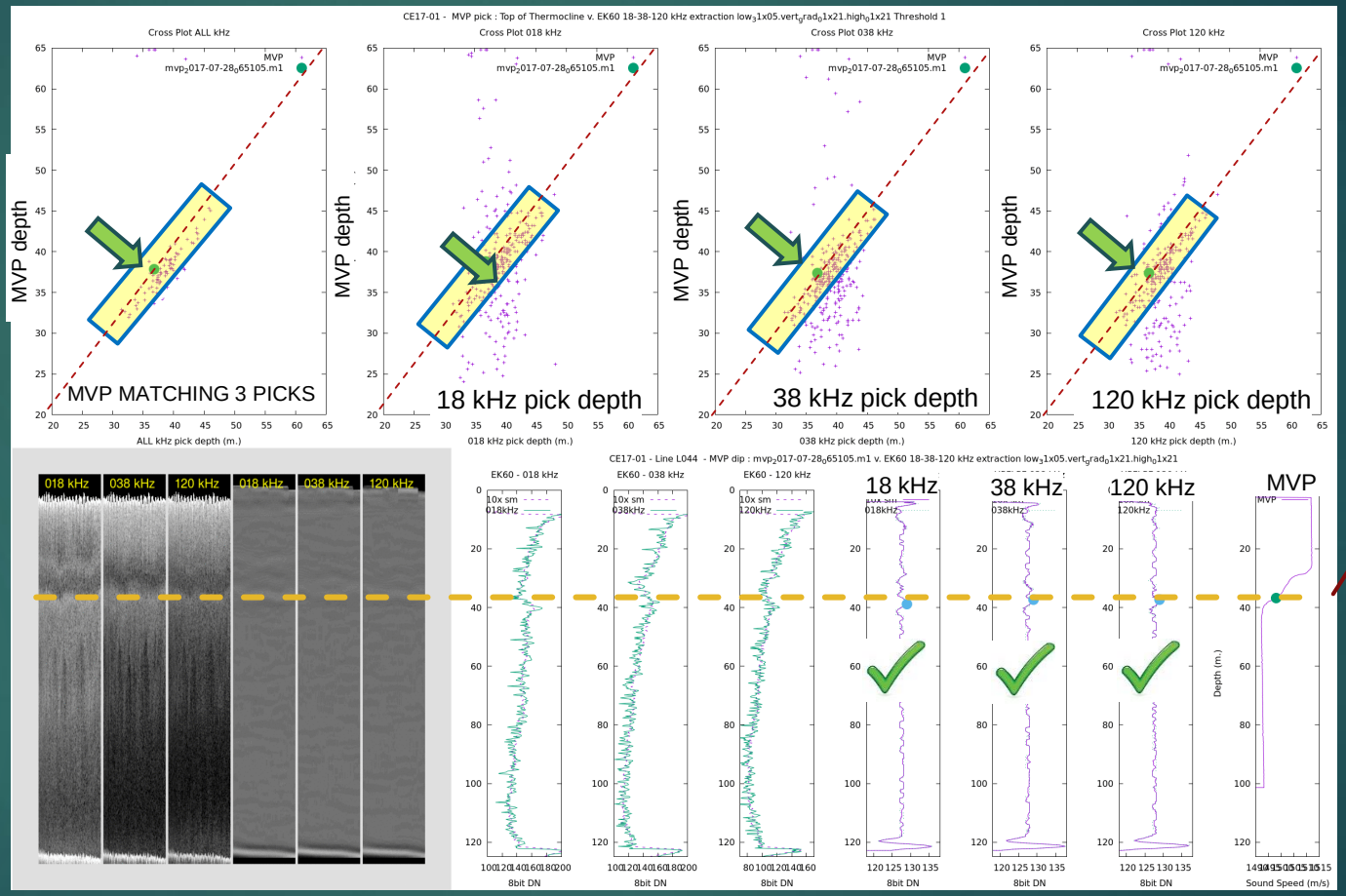
Image processing solutions. Values within threshold

THERMOCLINE DETECTION

UNAMBIGUOUS SOLUTIONS



Line 44. Daytime.
Original data + MVP locations

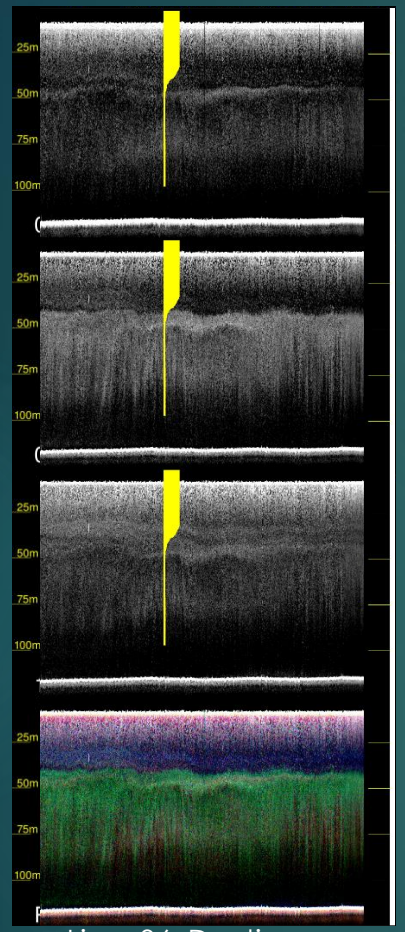


The 3 picks match the SVP thermocline

A SINGLE AND CLEAR SCATTERING LAYER IS PRESENT IN 3 CHANNELS

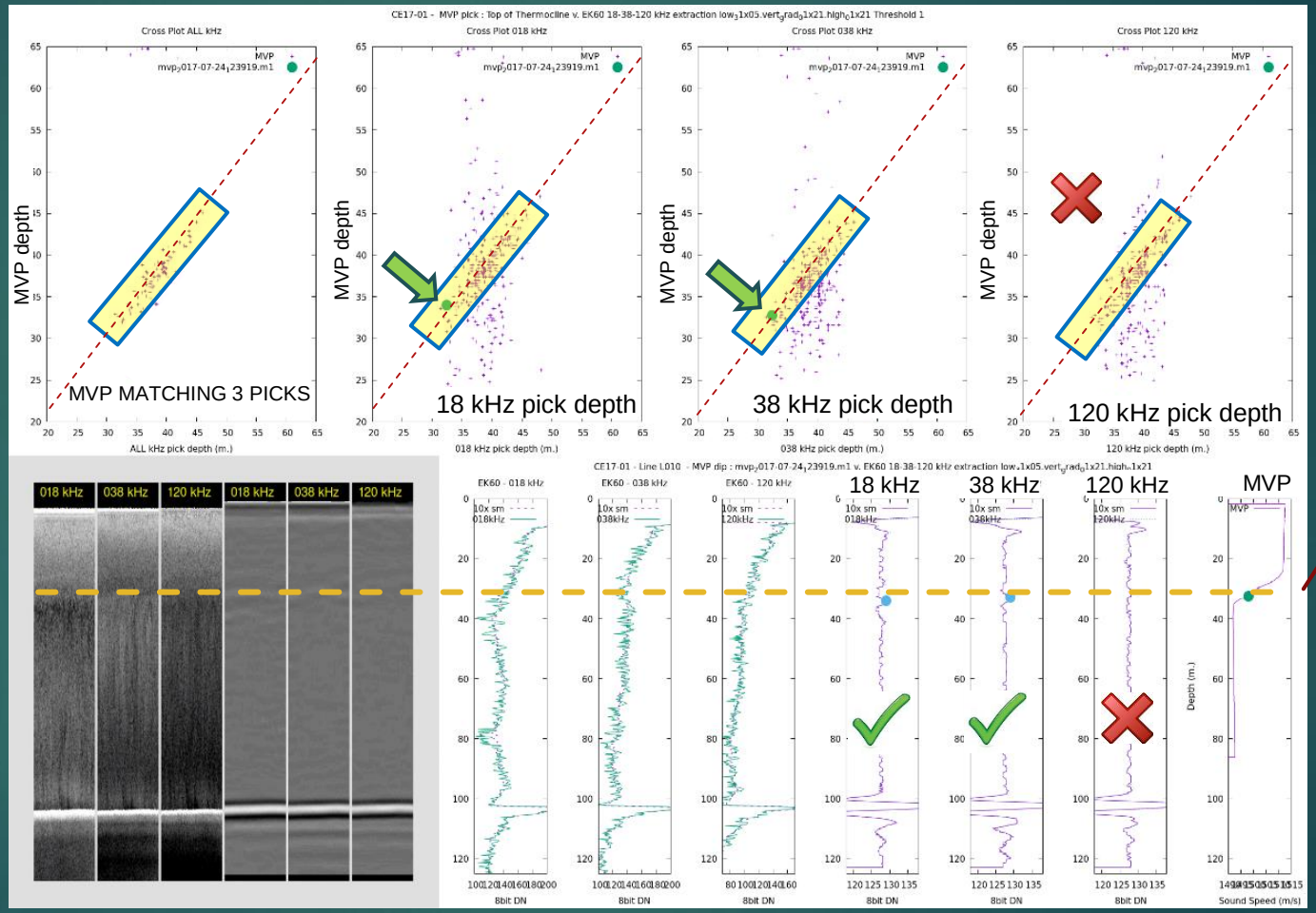
THERMOCLINE DETECTION

AMBIGUOUS SOLUTIONS



Line 36. Daytime.

Multi spectral echogram +MVP locations

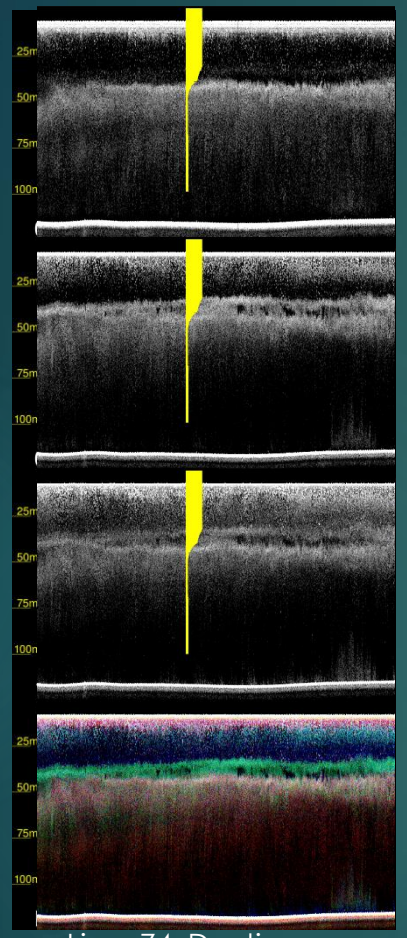


2 out of 3 picks match the SVP

A SCATTERING LAYER IS ONLY DETECTED IN 2 CHANNELS

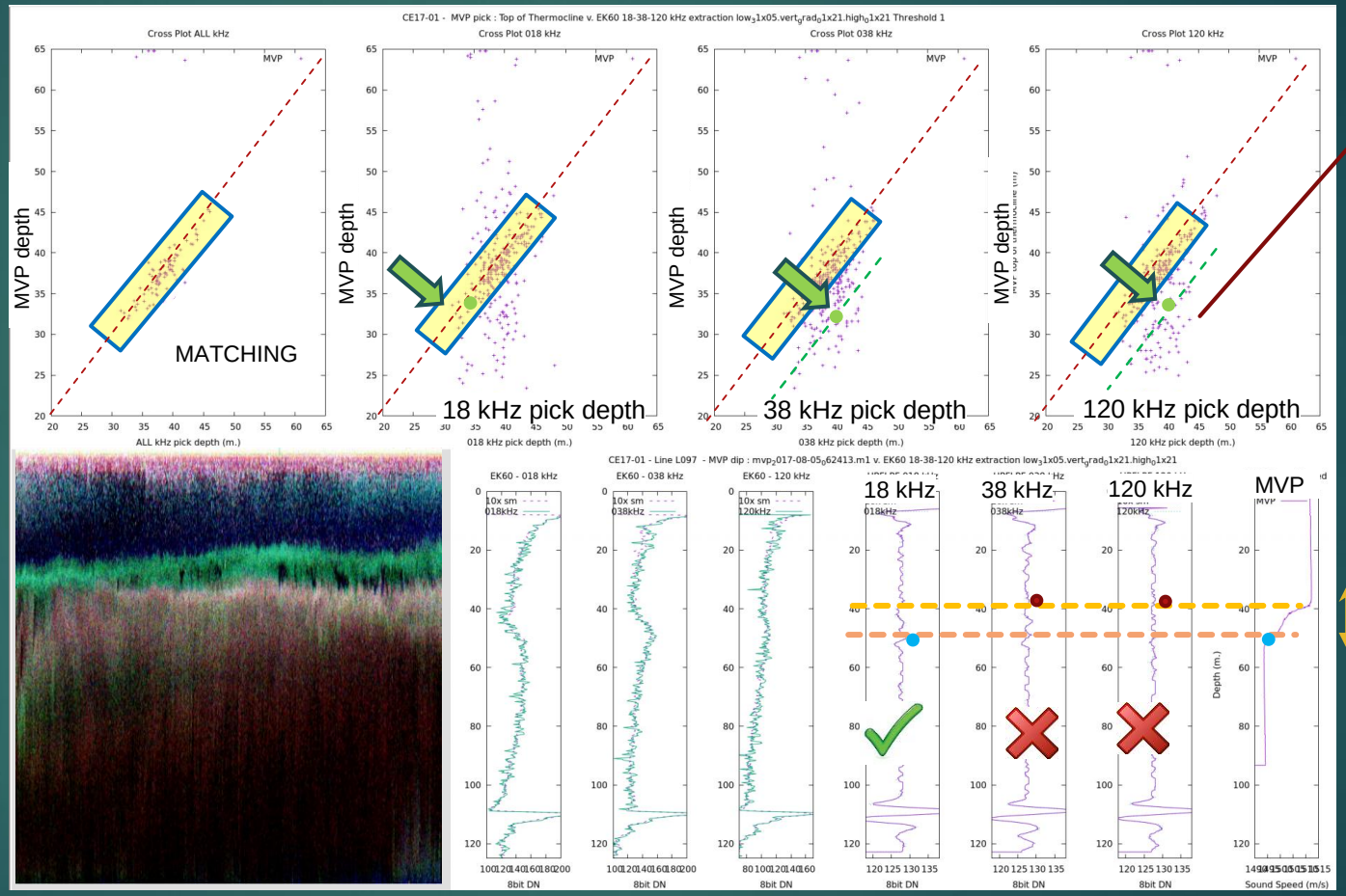
THERMOCLINE DETECTION

INCONCLUSIVE SOLUTIONS



Line 74. Daytime.

Multi spectral echogram + MVP locations



Top of thermocline trend line

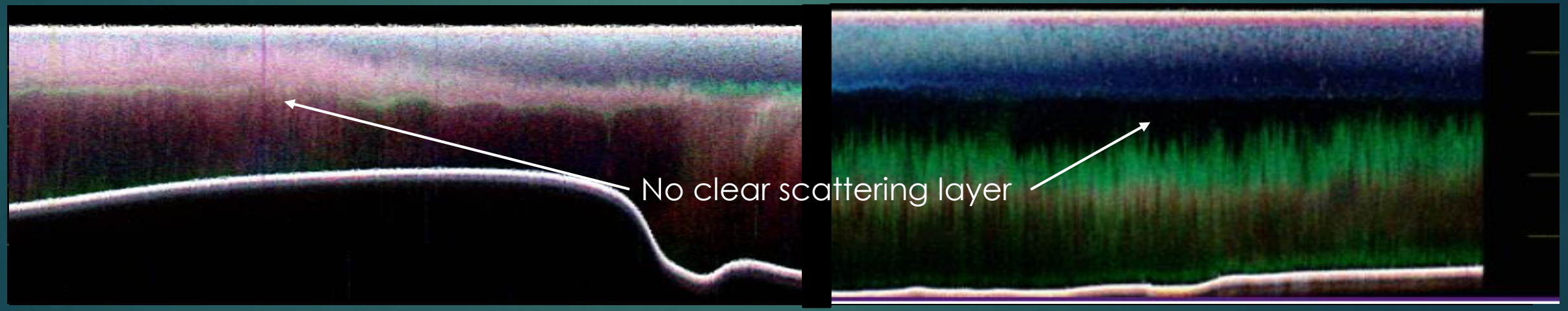
The top is detected instead of the bottom

Only 1 pick matches MVP

- THERE IS A DIFFUSIVE SCATTERING LAYER
- SCATTERING LAYER IS THICKER AND THE TOP PART IS DETECTED INSTEAD

PRELIMINARY RESULTS

PERIOD	SUCCESS RATE (At least 2 picks match MVP)
DAYTIME	85%
TWILIGHT	81%
NIGHT	54 %

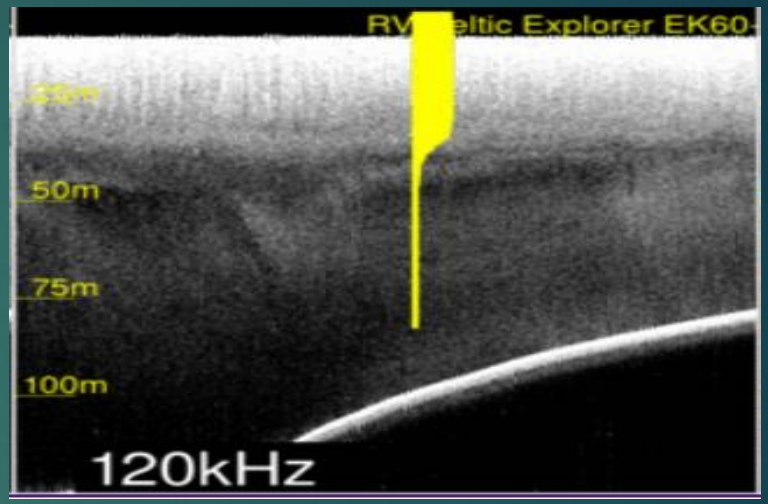


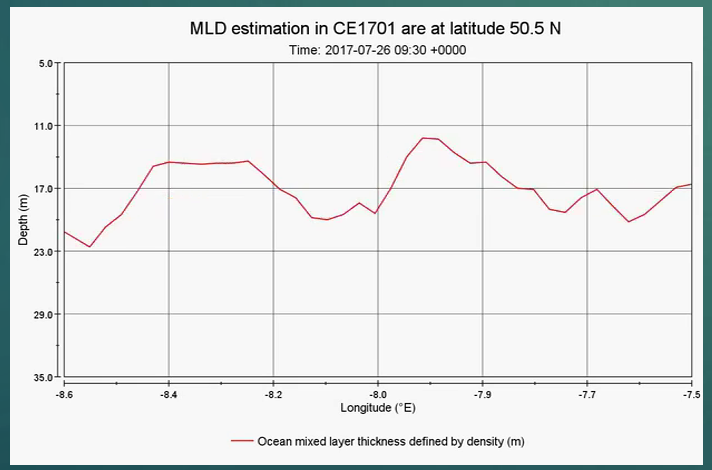
- **Clear stratification (scattering layer) has to be present**
- **Detection probability in 18 Khz was 20% higher**
- **The thermocline oscillation was successfully measured**

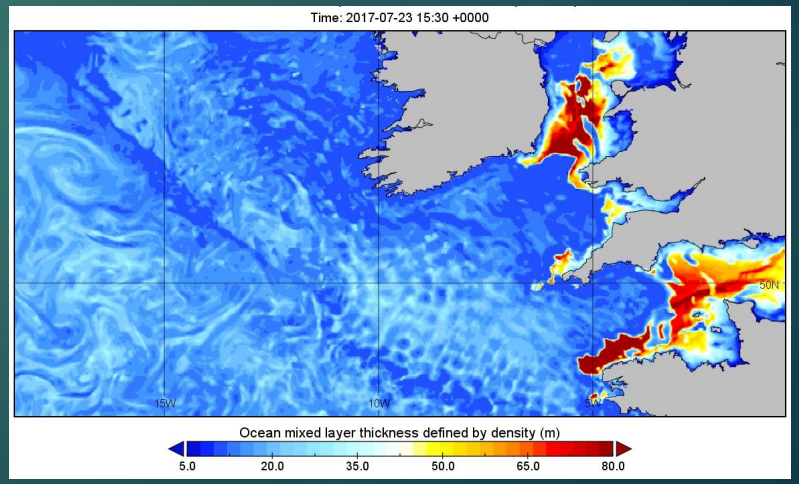
FURTHER WORK

- Improve detection algorithms , particularly for night time and “double horizon” situations.

- Compare results with databases , models and predictions (WOA and Copernicus Marine Service) and study using it in detection algorithm.

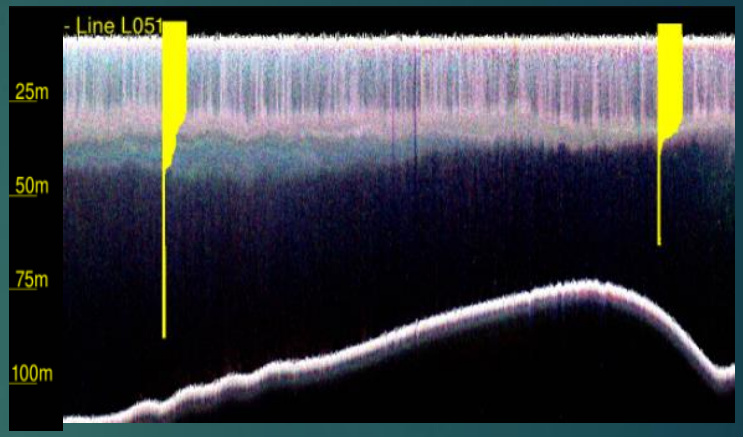




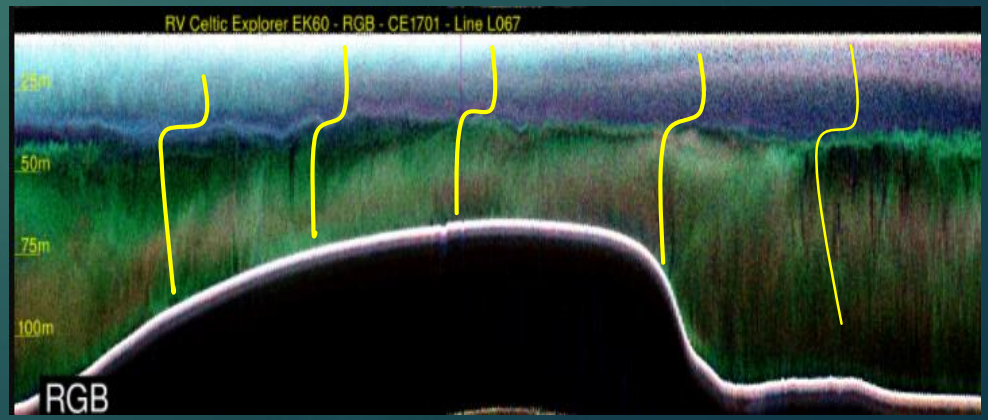


APPLICATIONS

- Alert operator the need of a new SVP cast when a thermocline change is detected.



- Possibility of creating a Near Real Time synthetic SVP to improve ray tracing:
  - -During multibeam data acquisition.
  - - In post processing.



Questions?

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Integrated Mapping for the Sustainable Development of Ireland's Marine Resource

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