Ocean Exploration and Research

NOAA SHIP *Okeanos Explorer* Sonar Synchronization (05.2019)

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NOAA Ship *Okeanos Explorer*

SYNCHRONIZATION FOR EXPLORATION

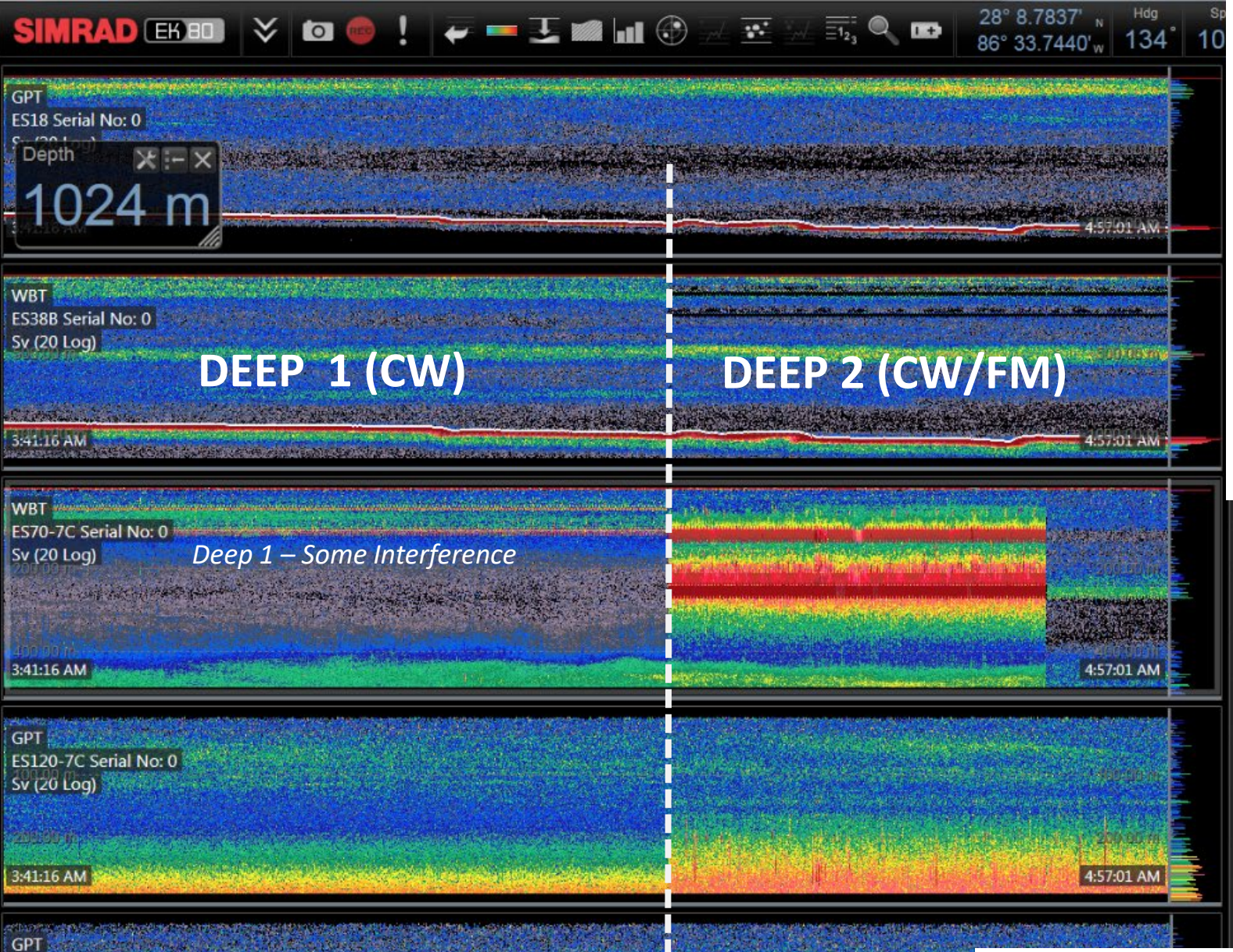
Sonars

EK Suite – 18 kHz (CW), 38 kHz (CW), 70 kHz (CW/FM), 120 kHz (CW), and 200 kHz (CW)

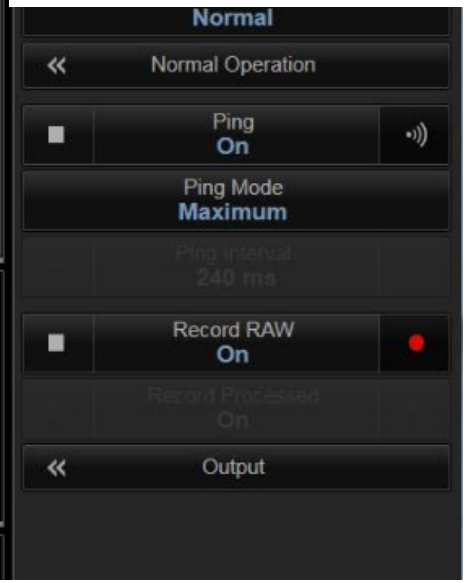
Multibeam – EM302 (30 kHz)

Subbottom – Knudsen 3260 (3.5 kHz)

EM 302 · SBP 3260 · EK 18 · EK 38 · EK 70 · EK 120 · EK 200



Effect on EK water column data from the EM 302 changing between CW and FM mode when it moves from DEEP 1 to DEEP 2 at ~ 1000 m



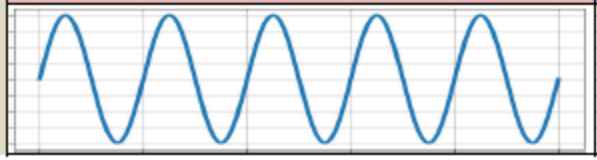
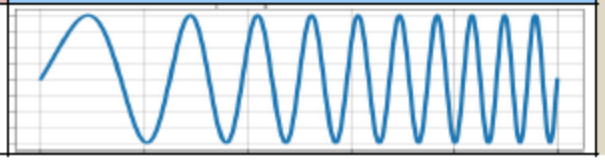
NEED TWO SYNCHRONOZATION SCENARIOS: 'SHALLOW' and 'DEEP'

Quick Guide to EM-302 Ping Modes and Sector Characteristics

Ping Mode	Depth Range	Typical Coverage	
		Degrees	Max Angles
Shallow	10 - 250	150	75 75
Medium	250 - 750	150	75 75
Deep 1 (CW only)	750 - 1000	150	75 75
Deep 2 (CW& FM)	1000 - 3300	150	75 75
Very Deep	3300 - 5000	104	52 52
Extra Deep 1	5000 - 7000	70	35 35
Extra Deep 2	7000 +	36	18 18

Leave Max Angles open unless outer-beam issues occurr.

TX Pulse (ms)							
Frequency (kHz)							
Port Sectors				Starboard Sectors			
0.7 ms		0.7 ms		0.7 ms		0.7 ms	
26.5 kHz		30.5 kHz		32.5 kHz		28.5 kHz	
2 ms		2 ms		2 ms		2 ms	
27 kHz		30 kHz		31.5 kHz		28.5 kHz	
5 ms	5 ms	5 ms	5 ms	5 ms	5 ms	5 ms	5 ms
26.5 kHz	27.5 kHz	28.5 kHz	29.5 kHz	30 kHz	29 kHz	28 kHz	28.5 kHz
100 ms	60 ms	5 ms	5 ms	5 ms	5 ms	60 ms	100 ms
26.5 kHz	27.5 kHz	28.5 kHz	29.5 kHz	30 kHz	29 kHz	28 kHz	27 kHz
	100 ms	60 ms	40 ms	40 ms	60 ms	100 ms	
	26.5 kHz	27.5 kHz	28.5 kHz	29 kHz	28 kHz	27 kHz	
		100 ms	100 ms	100 ms	100 ms		
		26.5 kHz	27.5 kHz	28 kHz	27 kHz		
			200 ms	200 ms			
			26.5 kHz	27 kHz			

Continuous Waveform (CW)	Frequency Modulation (FM)
	

SST Charlie Wilkins

TWO MAIN SYNCHRONIZATION SCHEMES

SHALLOW (CW)

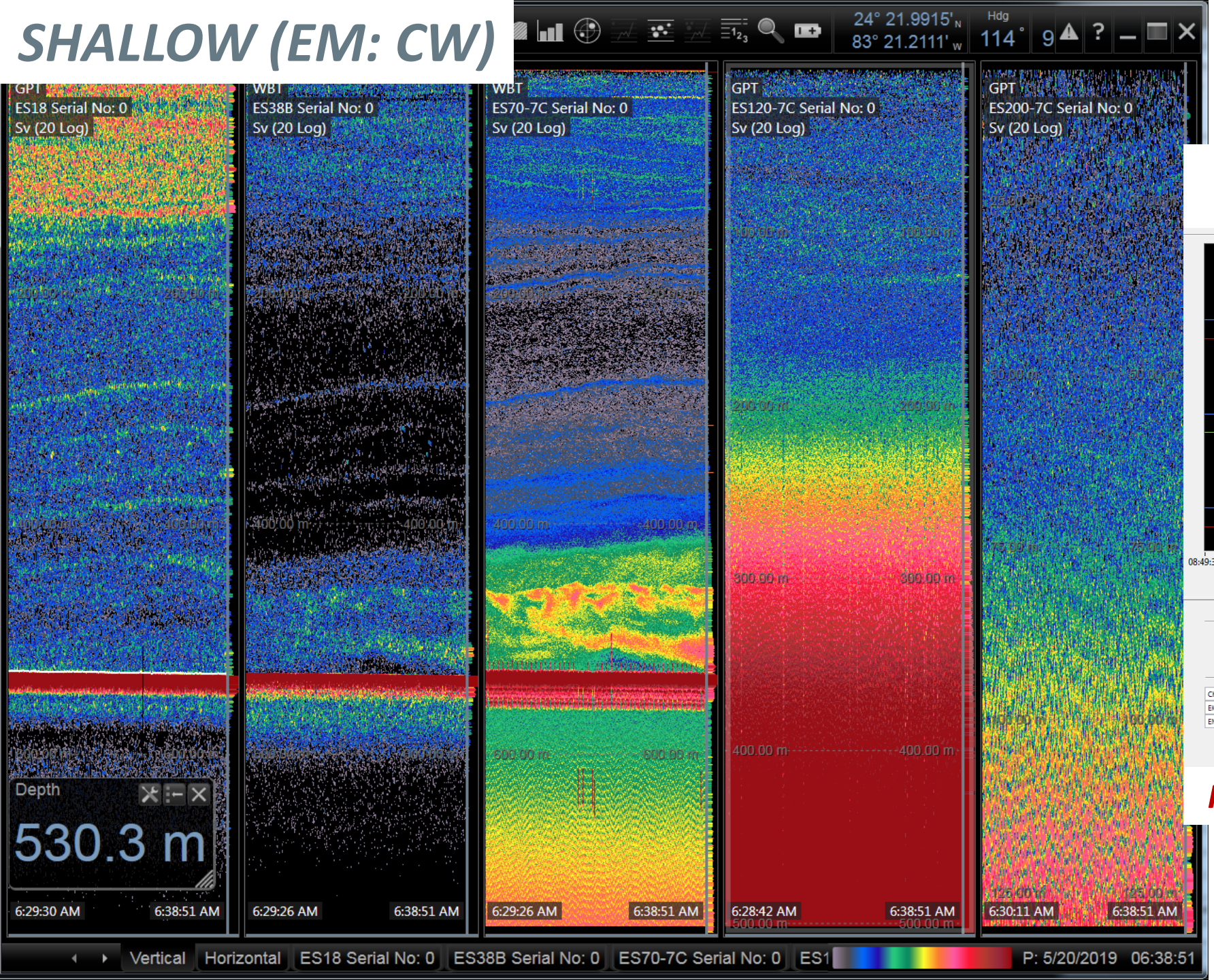
DEPTHS: ~ <1000m
EM MODES:
Shallow, Medium, Deep 1

DEEP (FM)

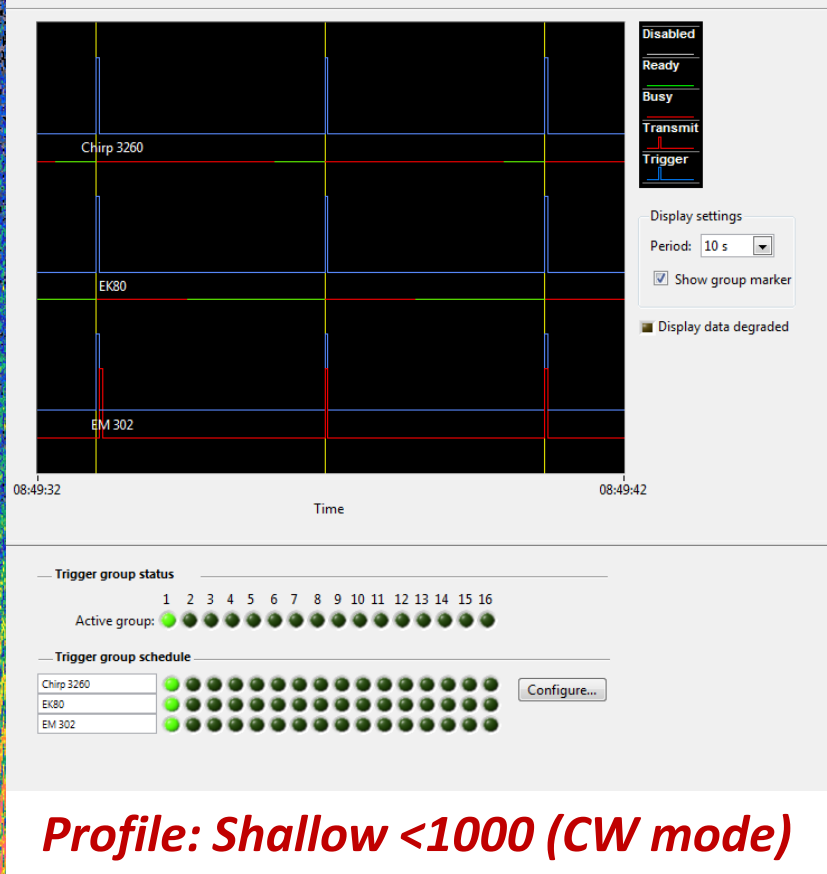
DEPTHS: ~ >1000m
EM MODES:
Deep 2, Very Deep, Extra Deep

SHALLOW (CW)

SHALLOW (EM: CW)



1 Group



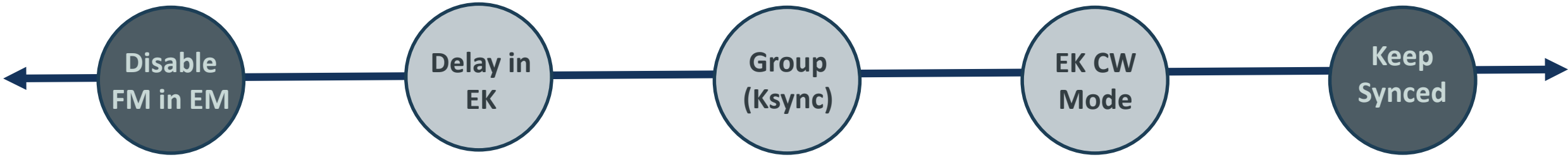
Profile: Shallow <1000 (CW mode)

When in depths < 1000 m, the optimal synchronization for **maximum ping frequency** and **minimum interference** is to have all sonars synchronized to **trigger at the same time.**

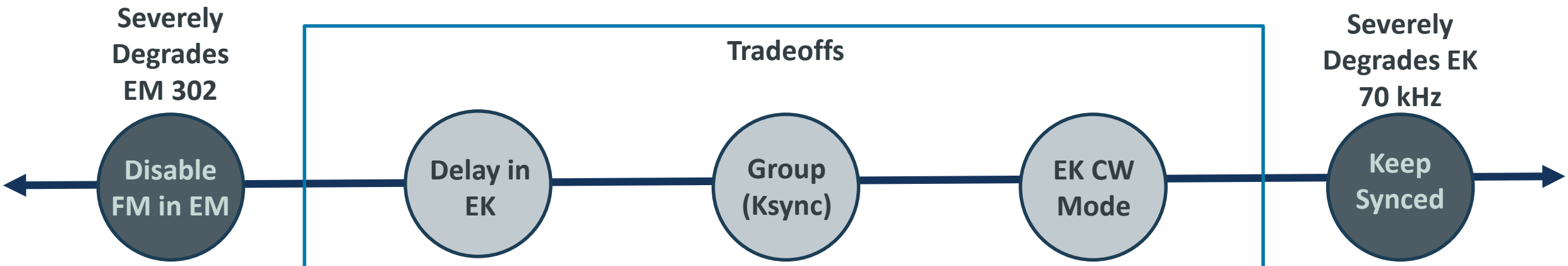
DEEP (FM)

NO WAY TO BOTH MAXIMIZE PING DENSITY AND REMOVE INTERFERENCE WHEN BOTH EM AND EK ARE IN FM MODE

MUST CHOOSE A **TRADEOFF** BASED ON OPERATIONAL PRIORITIES



DEEP FM MODE OPERATIONAL TRADEOFFS (with EK 70 kHz)



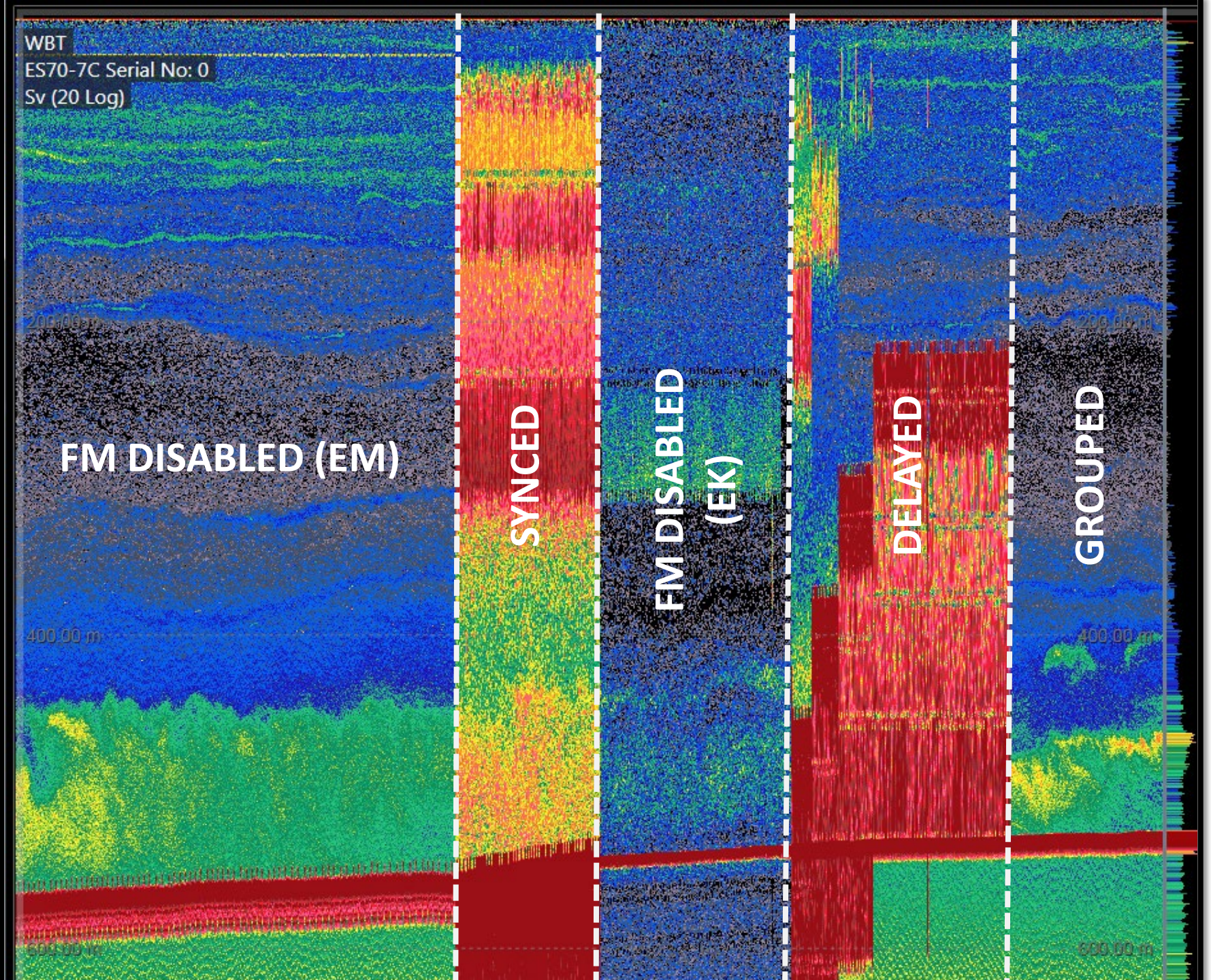
- Degrades bathy, but highest frequency and least interference in EK 70 kHz in FM mode
- Useful for targeted EK FM operations, especially over previously mapped areas

- Shift interference to a noncritical part of the water column (in EK80 software)
- Operationally intensive and site specific; delay depends on depth

- Sequential triggering minimizes interference among systems, but degrades ping density in both EM and EK

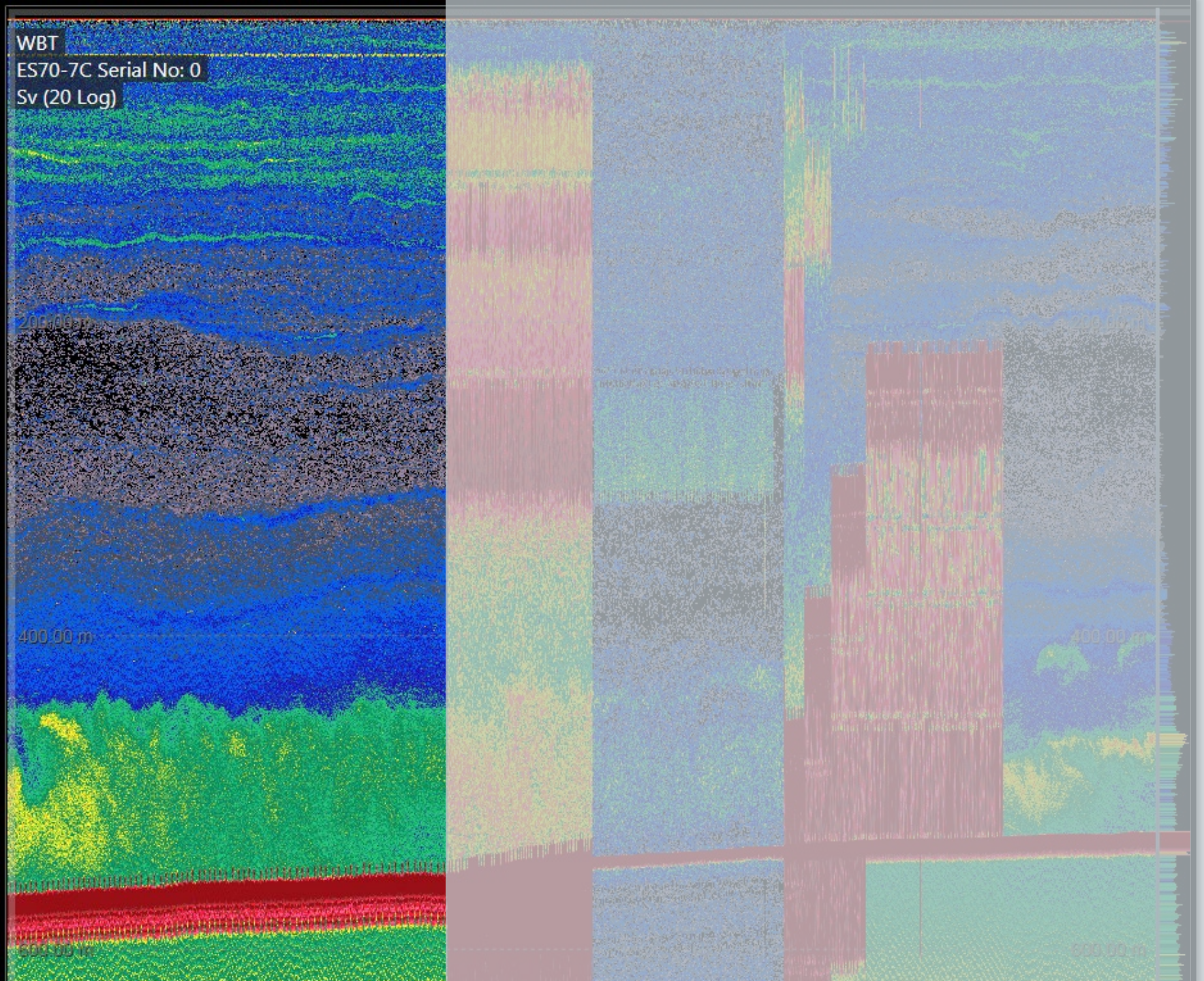
- Minimizes interference from EM, but loses wideband advantage of WBT(s)
- Could be good for normal operation in deep modes

- EM destroys much of the EK80 70 kHz upper water column (100s of meters) when in FM mode (45-90 kHz)



DEEP (FM) SYNCHRONIZATION OPTIONS

1. Disable FM in EM302
2. Synchronize all sonars to fire at once
3. Disable FM in EK80 70 kHz
4. Delay EK in EK80 software
5. Group in KSync



Operation: *Disable FM in EM302.*

PROS

- Preserve high resolution FM EK 70 throughout the water column

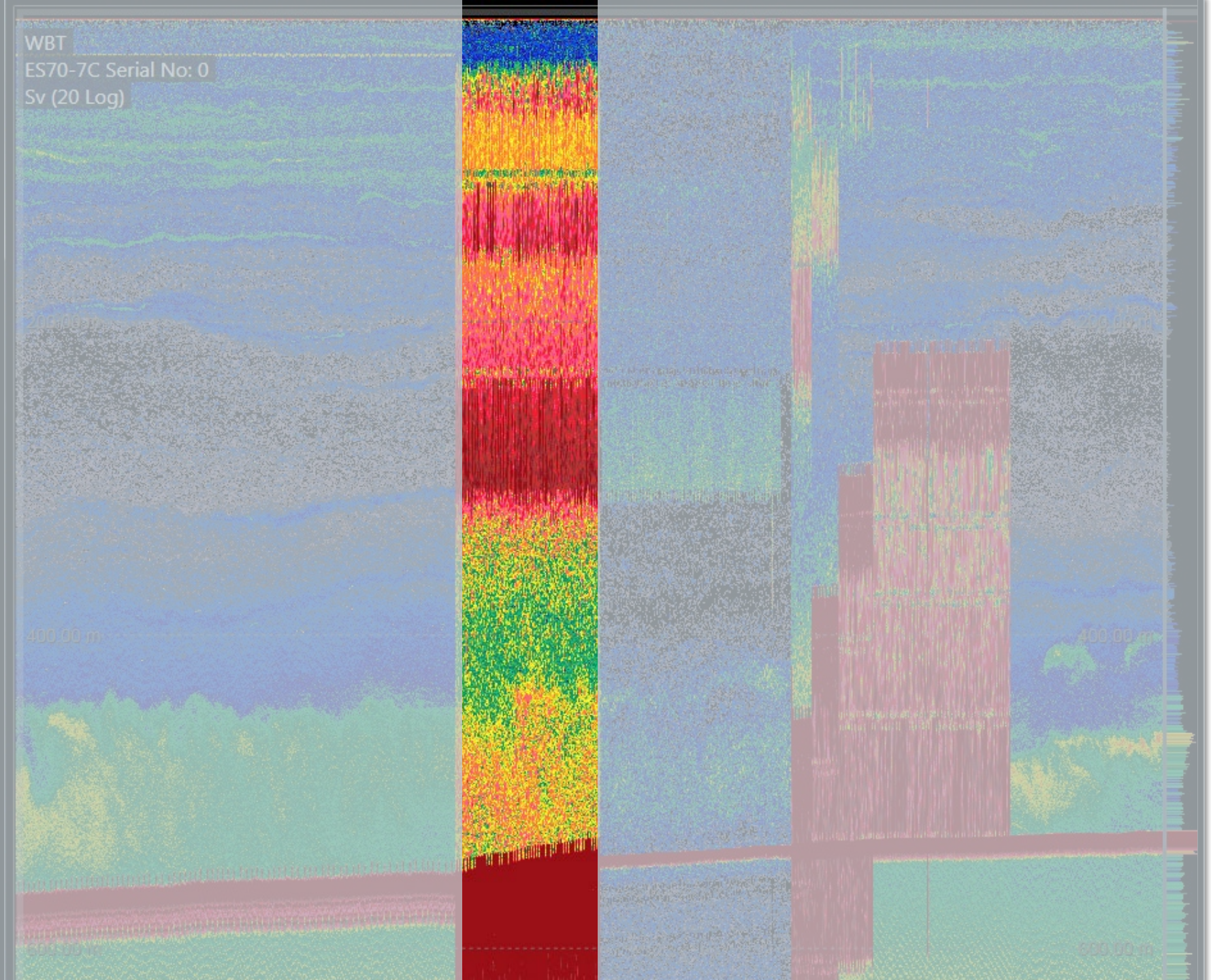
CONS

- Deep EM302 modes unable to utilize benefits of FM for coverage
- Unable to use some EM modes, and therefore limits which depths bathy can be collected.

Useful Scenarios:

When water column is of a higher priority than bathy (e.g., previously mapped areas).

Disable FM in EM



Operation: *Keep EK80 70 kHz (FM) and EM302 synced to trigger at the same time.*

PROS

- Does not interfere with EM302
- Easy operationally, as nothing changes from shallow to deep operations

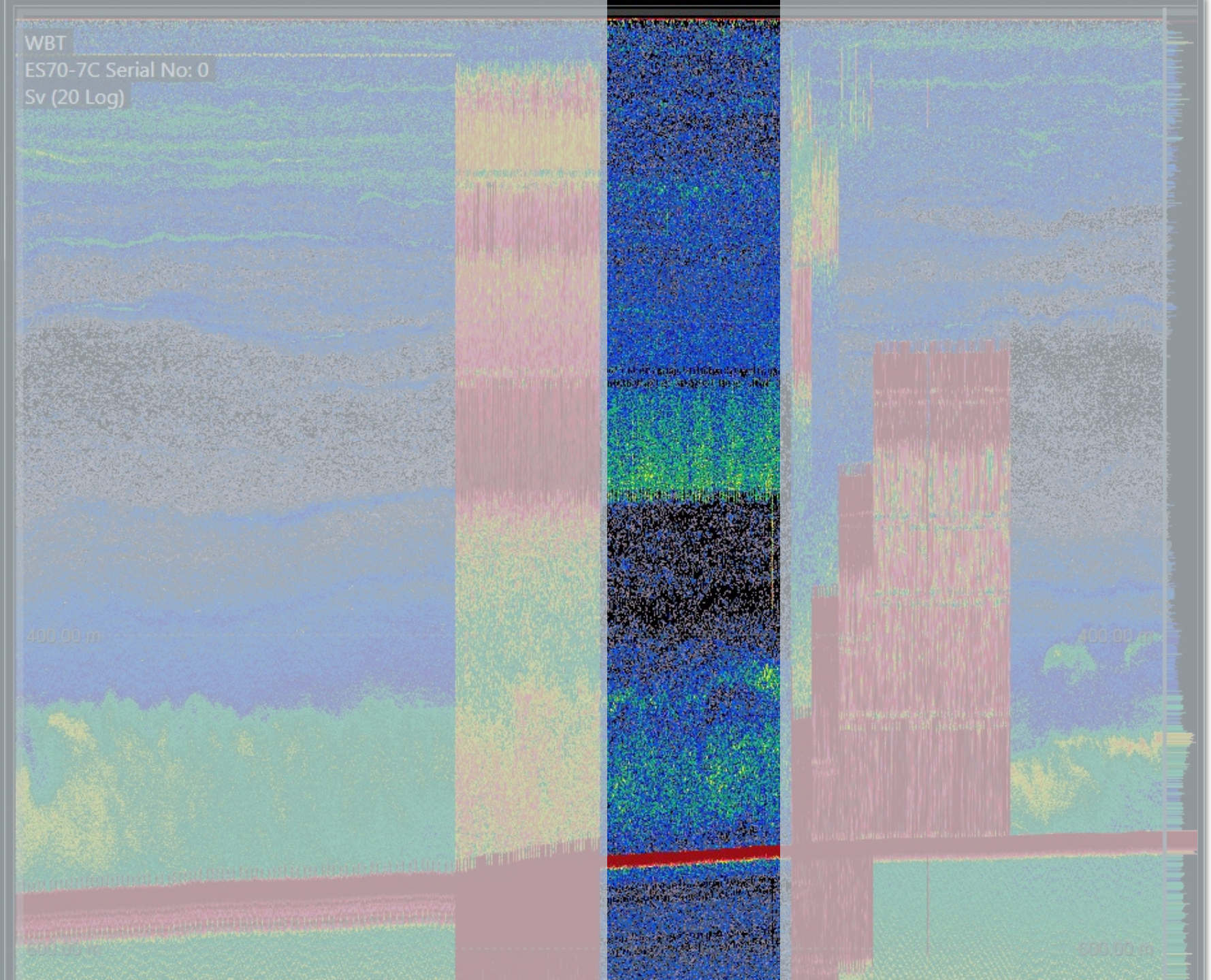
CONS

- Completely destroys EK80 70kHz upper water column
- High data storage for partly usable record

Useful Scenarios:

Could be used if only interested in gathering FM EK data in deeper parts of the WC, beyond the region of interference.

Keep Synced



Operation: *Turn EK80 70 kHz from FM to CW mode.*

PROS

- Does not interfere with EM302. Preserves ping density.
- Provides full depth range water column data in CW

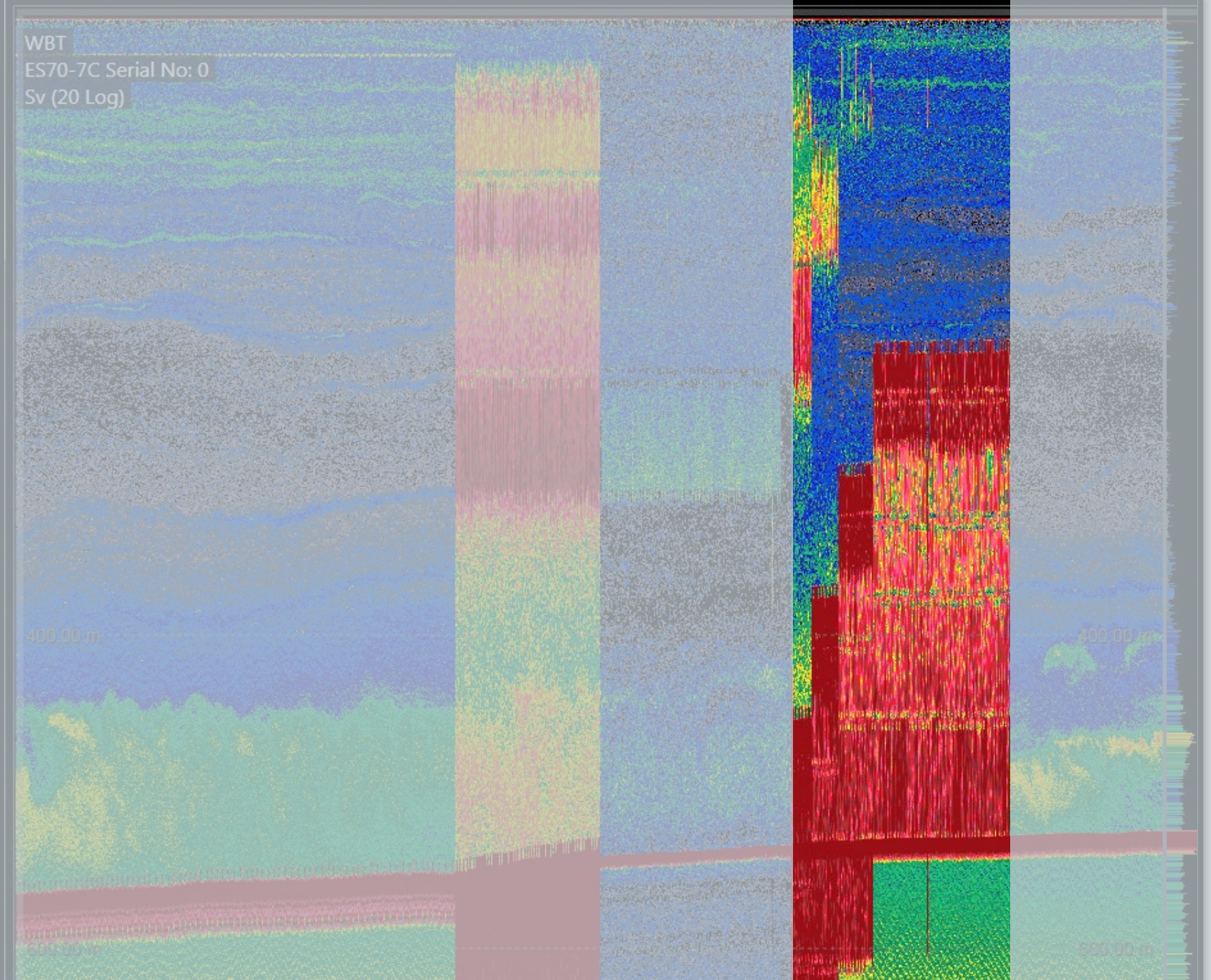
CONS

- Unable to utilize benefits of FM for EK 70 kHz

Useful Scenarios:

Could be useful for normal operations as it provides useful water column data and does not degrade sounding density.

EK CW Mode



Operation: *Set a delay from EM trigger in EK software. Keep EK in FM mode.*

PROS

- Moves interference into noncritical part of the water column.
- Preserves FM record in area of interest and data density.

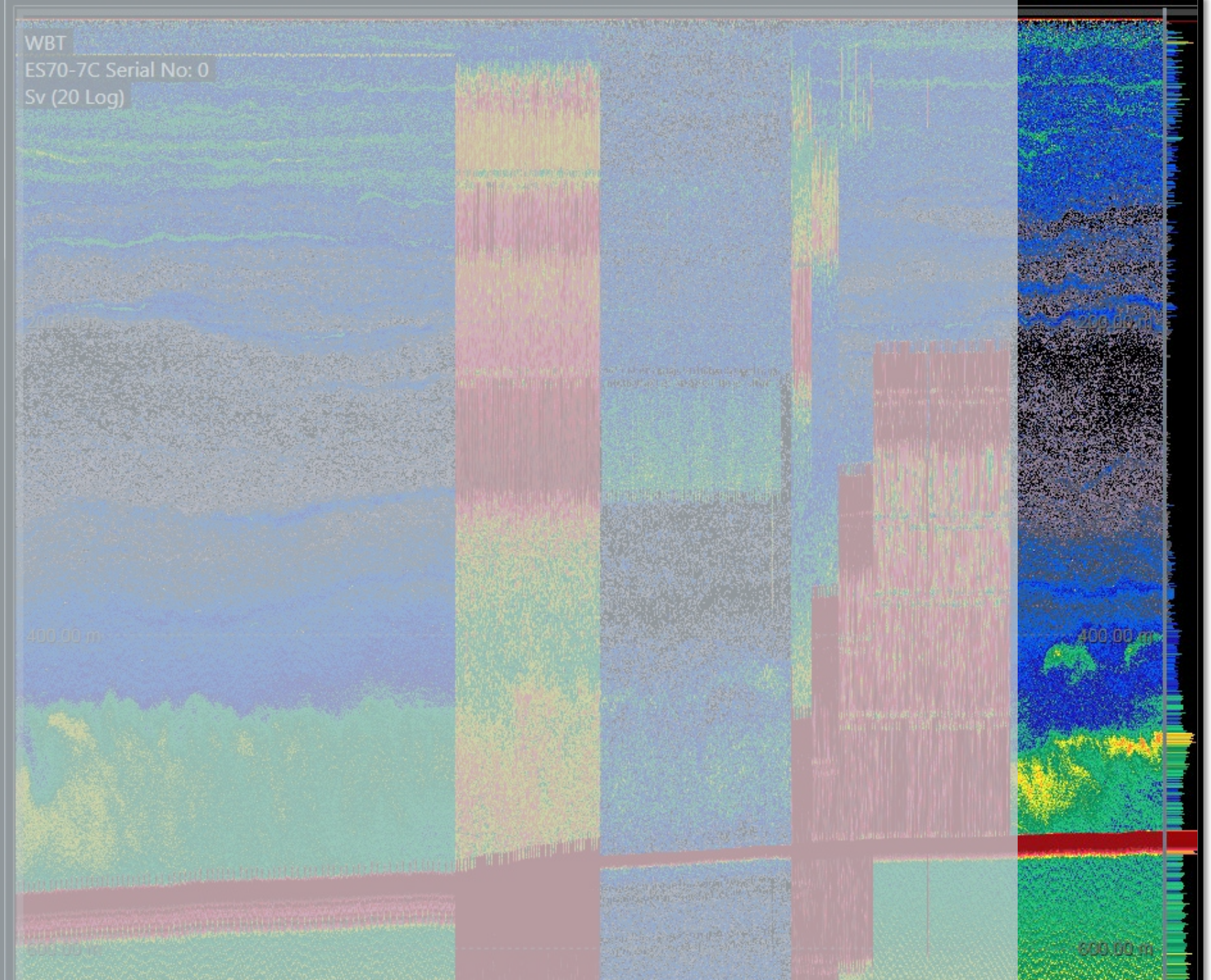
CONS

- Still degrades some part of the EK record.
- Operationally intensive as it will be site, depth, and purpose specific.
- High data storage for partly usable record

Useful Scenarios:

Useful for specific operations, such as only interested in upper water column.

Delay in EK



Operation: *Trigger EM and EK in separate groups using Ksync.*

PROS

- No interference in both the EM and EK

CONS

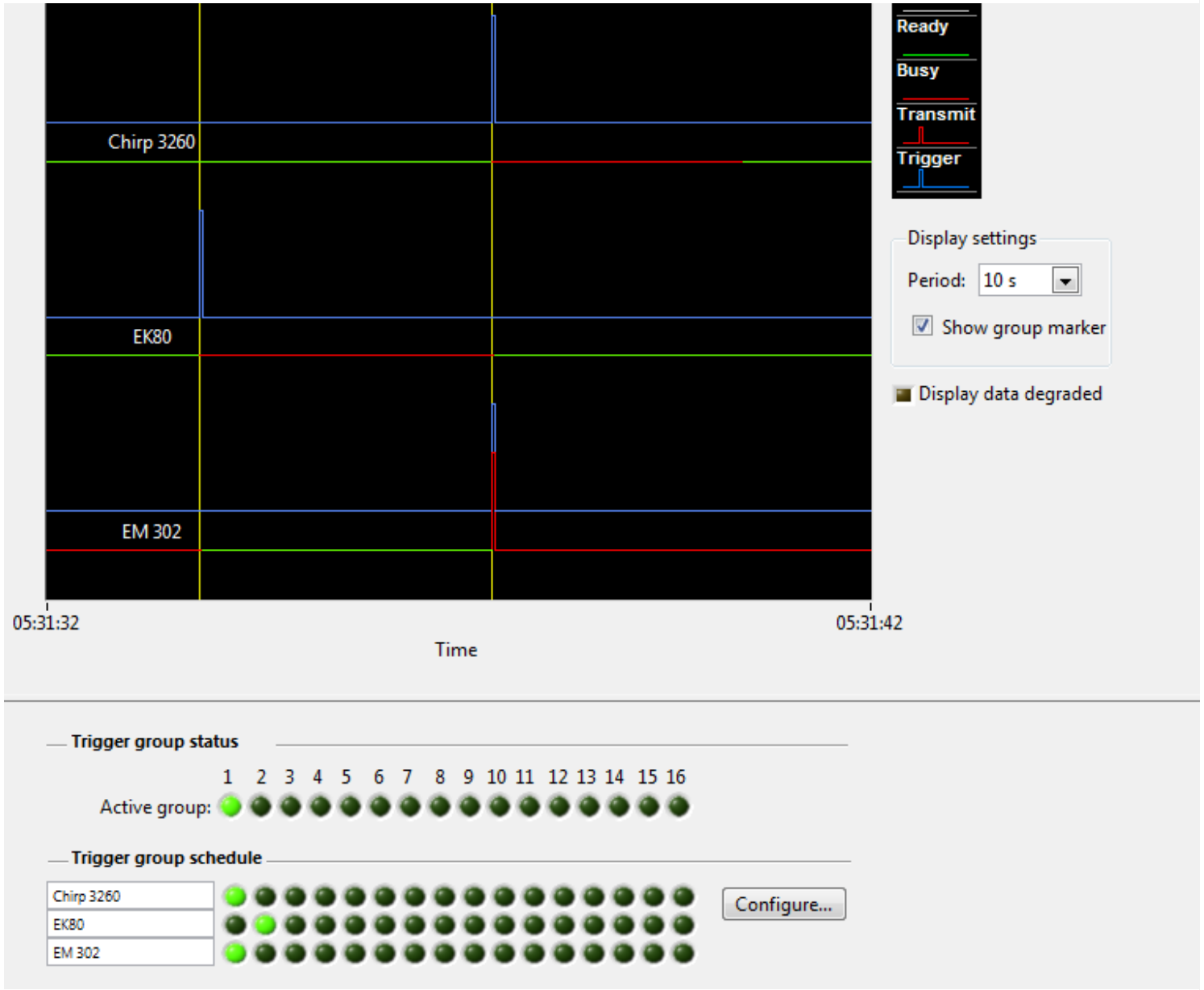
- Decreases ping frequency of the EM and the EK. (See next slide)

Useful Scenarios:

If you are willing to decrease bathy sounding density for full FM water column record.

Group (Ksync)

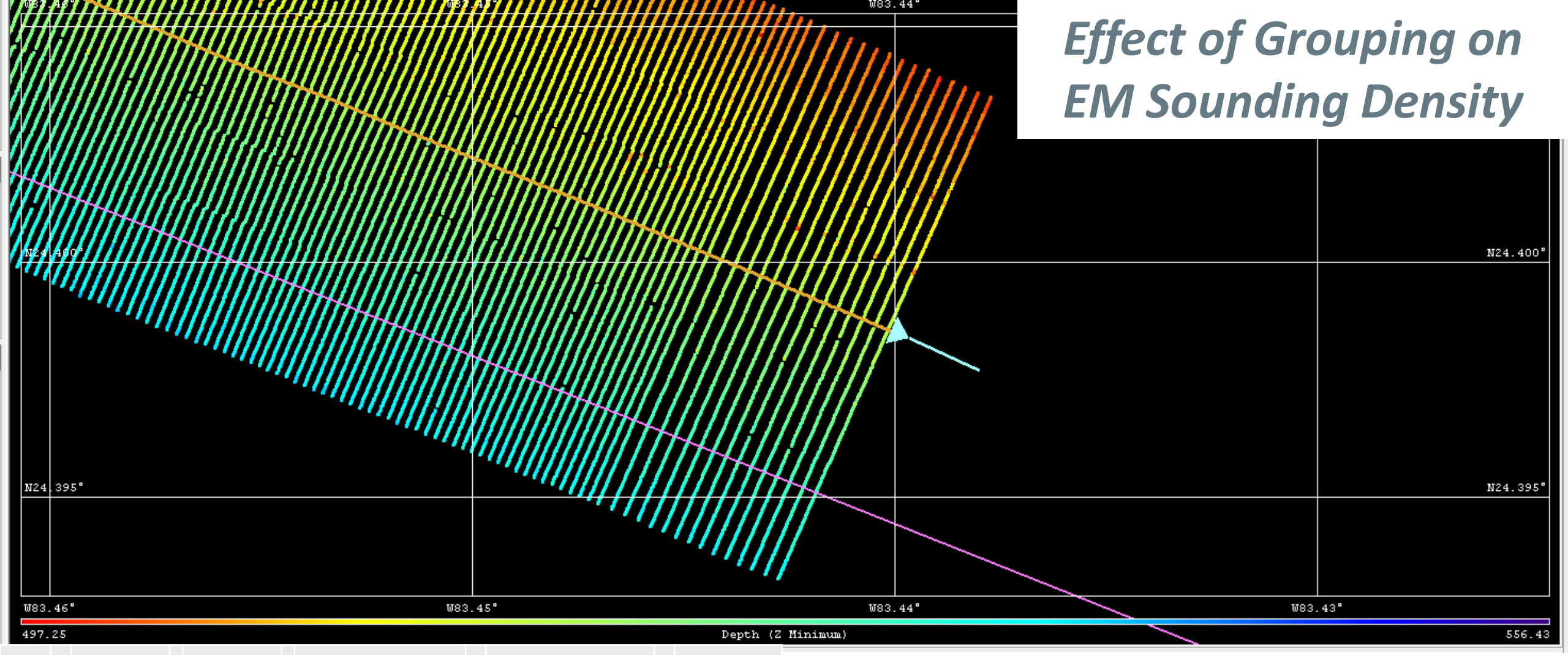
2 Groups



Profile: Deep >1000 (FM mode) 2 Groups

Group (Ksync)

Effect of Grouping on EM Sounding Density



Depth	Ping Rate (1)	Ping Rate (2)	Alongtrack Spacing (1)	Alongtrack Spacing (2)	% Increase
500 m	3.417 s	5.445 s	14 m	22 m	59
1500 m	6.342 s	8.849 s	26 m	36 m	40
2000 m	7.888 s	10.598 s	32 m	44 m	34
2500 m	8.552 s	12.101 s	35 m	50 m	41
3000 m	9.636 s	13.189 s	40 m	54 m	37

Change in alongtrack spacing with 2 groups vs 1 (estimating as single swath at 8 kts)

Group (Ksync)

Okeanos Explorer Sonar Synchronization (05.2019)

Sonars EK Suite – 18 kHz (CW), 38 kHz (CW), 70 kHz (CW/FM), 120 kHz (CW), and 200 kHz (CW)
Multibeam – EM302 (30 kHz)
Subbottom – Knudsen 3260 (3.5 kHz)

SHALLOW *(CW MODE)*

EM Modes: (V) Shallow, Medium, Deep
Depth Range: 0 – 1000 meters

OPERATIONS

All sonars should be synced to trigger at the same time, with the EM302 set as the master. This will maximize ping density and minimize interference for all sonars.

DEEP *(FM MODE)*

EM Modes: Deep', Very Deep, Extra Deep
Depth Range: 1000+ meters

OPERATIONS

Tradeoff based on operational priority.

Normal Operation: EK80 70 kHz in CW mode.

Operation Specific: Separate Groups for EM and EKs, Delay EKs, or Disable FM/Turn off EM 302

Factors that unnecessarily increase ping rate:

- Minimum Ping Rate on EKs (due to duty cycle?)
  18 kHz (8 ms) = 1.64 seconds
  18 kHz (.864 ms) = 1.64 seconds

- A frequency not able to detect the seafloor (with bottom detect ON)

- Too large of a Window Range

- Too large of a Record Range

Ocean Exploration and Research

THANKS!

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