



ROSE

ROCK SEISMIC research project

Norwegian Institute of Science and Technology



Broadband seismic – Increasing the chance of success. Understanding limitations and possibilities with broadband seismic data.

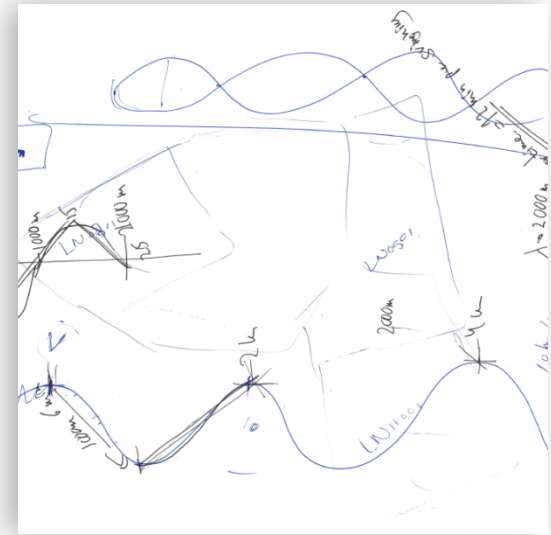
Presented by Per Eivind Dhelie, Lundin Norway AS



*ROSE – meeting 5-8th May 2014
Trondheim, Norway*

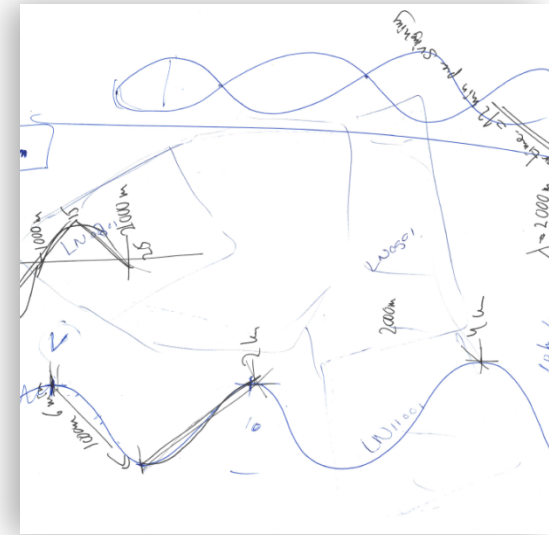
Outline

- Background & motivation
- Modeling & design
- The field experiment
- Data examples
- Conclusions, discussions and the road ahead

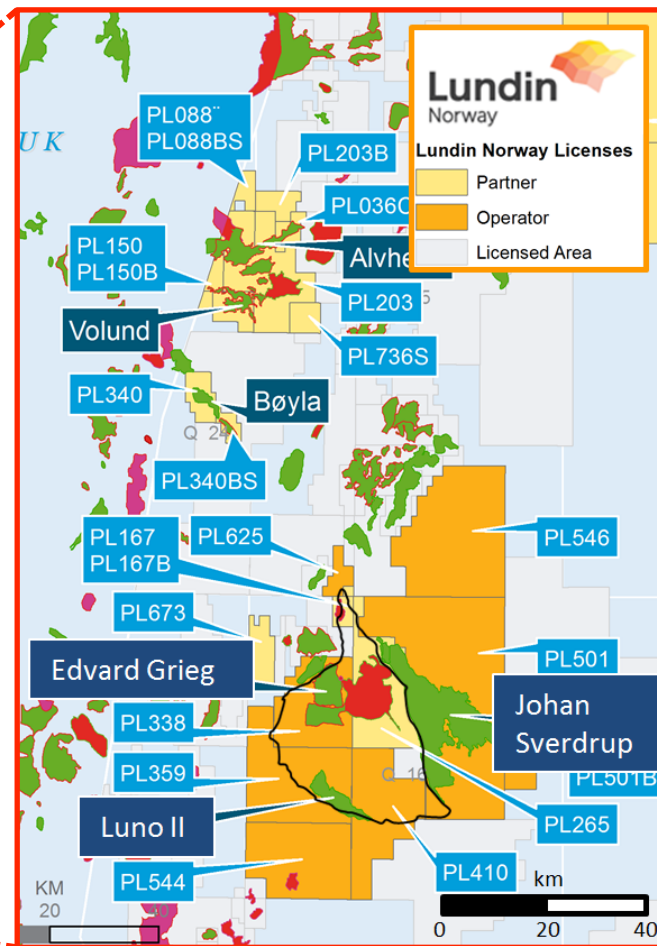
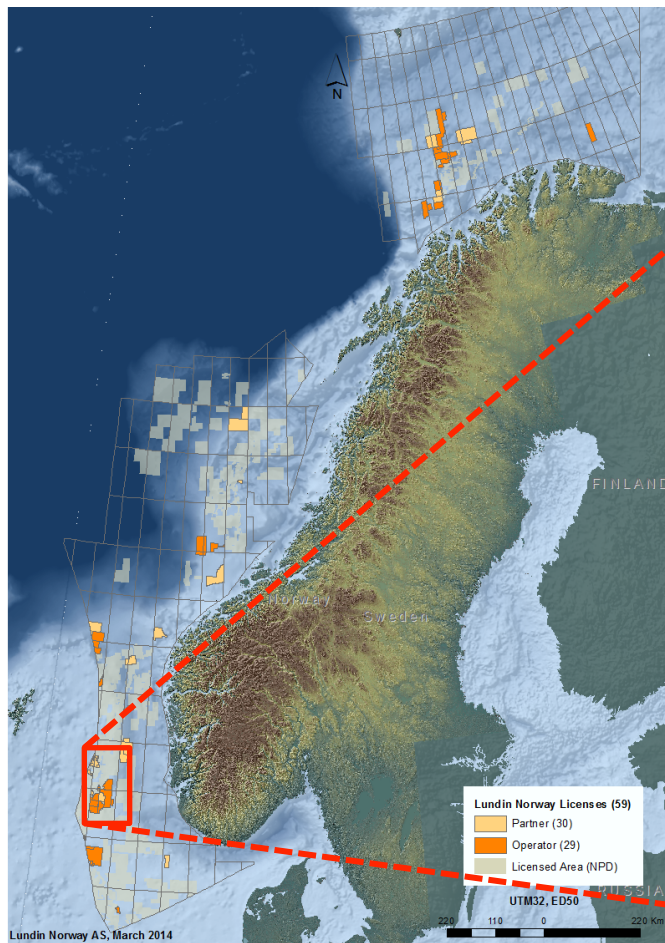


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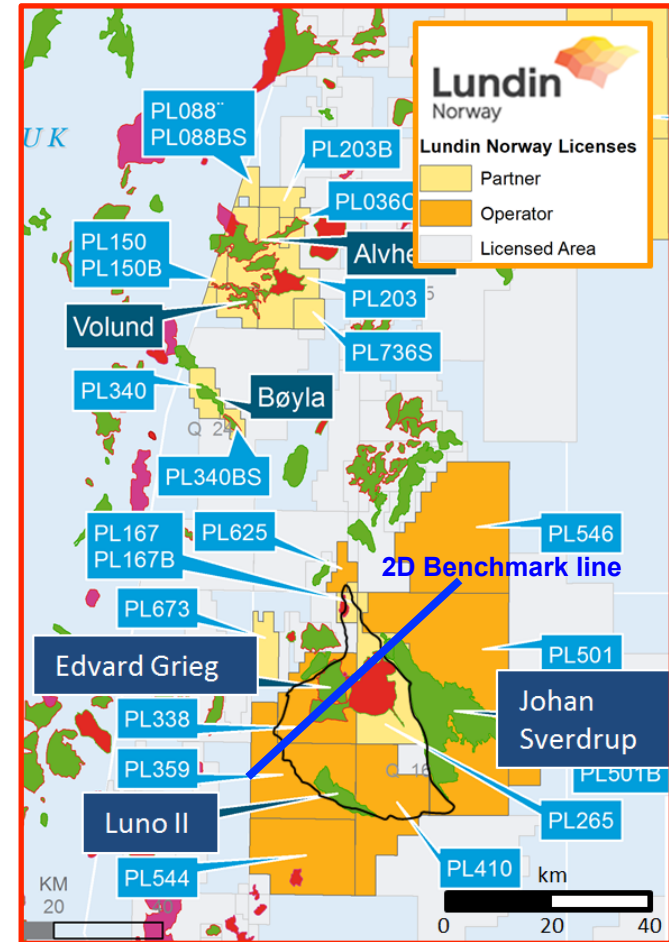
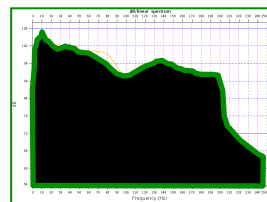
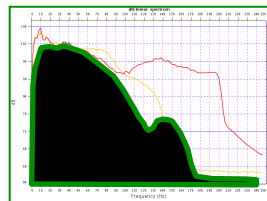
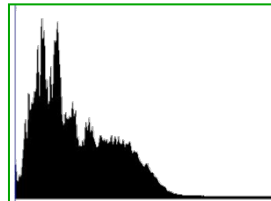
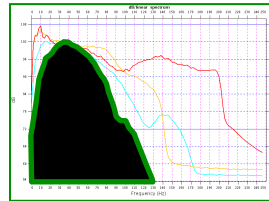


Background & motivation I



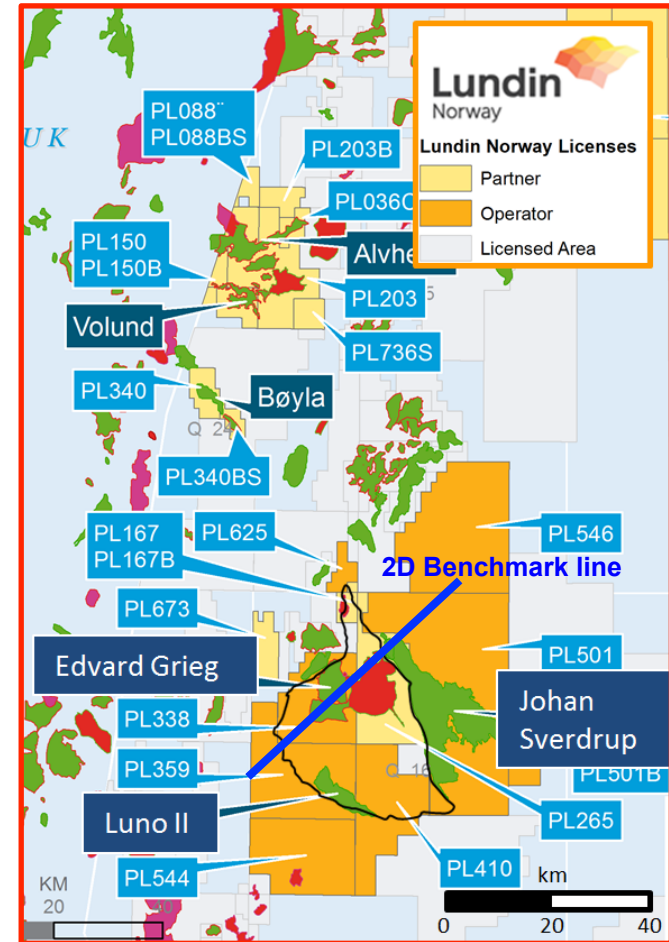
Background & motivation II

- Discovered LUNU (now Edvard Grieg) in 2007 using old legacy poor seismic data quality.
- Acquired Luno OBC data (40sqkm) in 2008 / 2009. Showed much better data (LF) - delineation
- 2009 – GeoStreamer > Johan Sverdrup discovery
- 2010/11 – Broadseis, broadsource, fwi,
- 2012 Large 3D Broadseis/ Broadsource
- 2014 - IsoMetrix



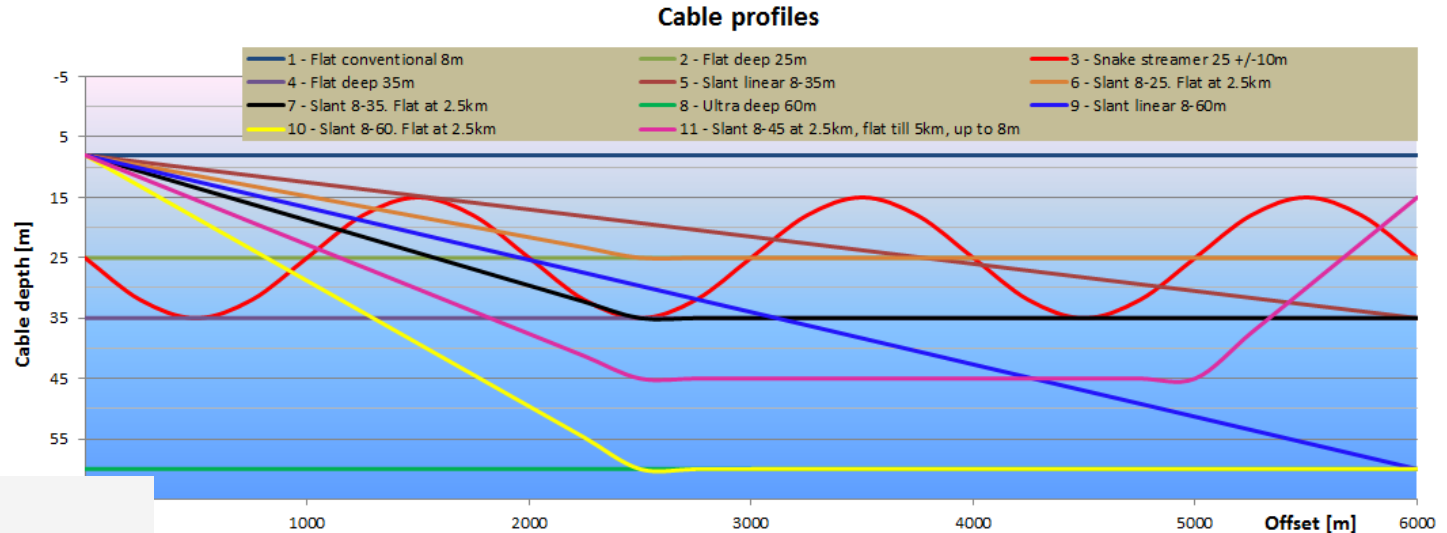
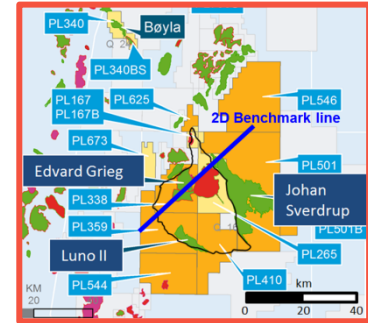
Background & motivation III

- Slant cable – curved or straight? Development into a linear straight slant in the ghosted domain
- New ideas followed – straight slant – 8-35m, mild slant 18-22m
- Notch diversity through variable sea-state acquisition – larger swell is better – notch is not too deep
- How deep is deep? – is 30m deep, is 50m deep, or even more
- More slant over shorter offsets



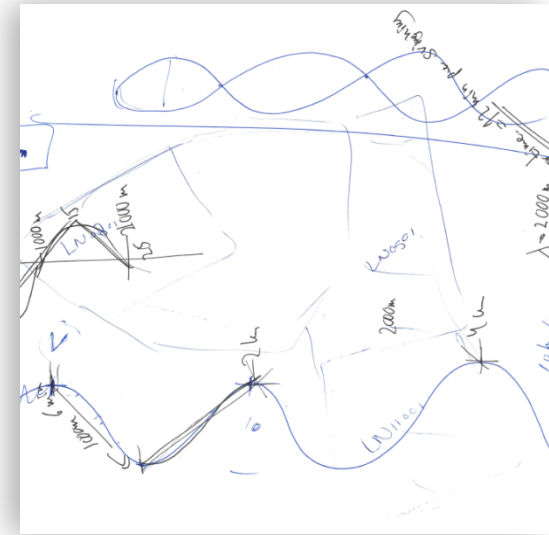
Variable cable depth profiles – Luno Benchmark Line

- Ghost notch diversity test – conventional hydrophone only
- Developing processing based deghosting solution
- Sea-state variability imitation test



Outline

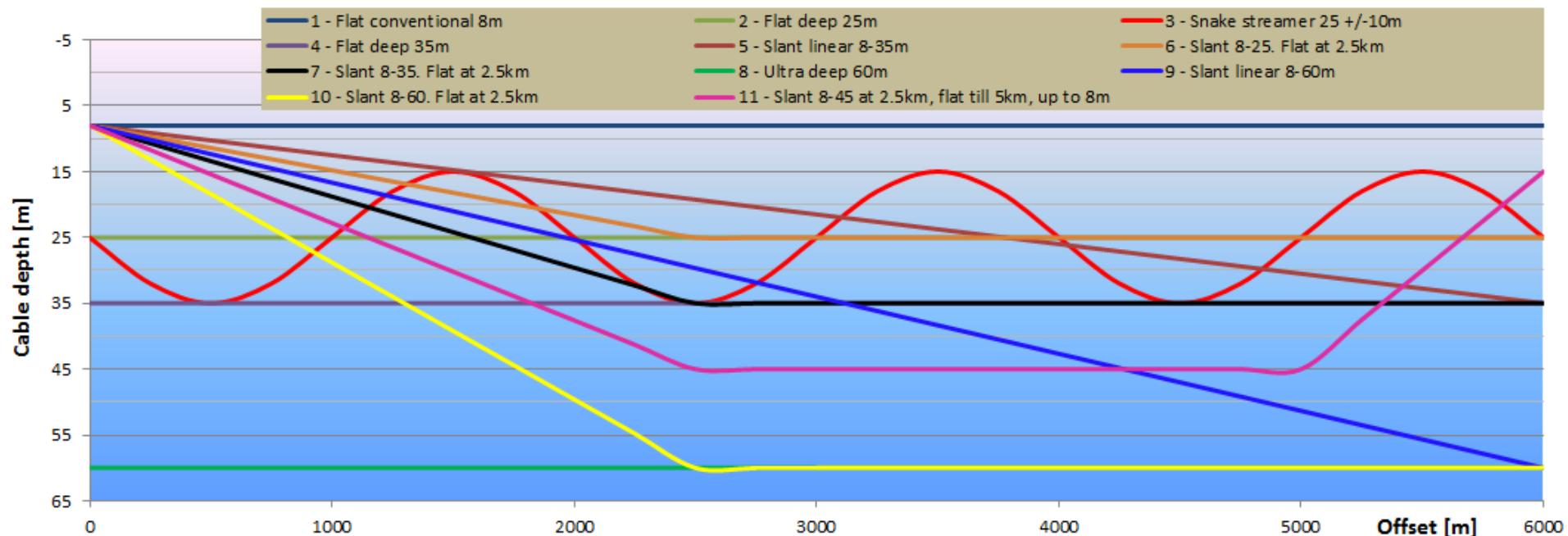
- Background & motivation
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Streamer profiles – from basic to novel

- Flat: 8m, 25m, 35m & 60m
- Slants, straight: 8-35, 8-60
- Slants, non linear: 8-25-25, 8-35-35, 8-45-15, 8-60-60
- Snake: 25 +/- 10m

Cable profiles



Snake streamer design

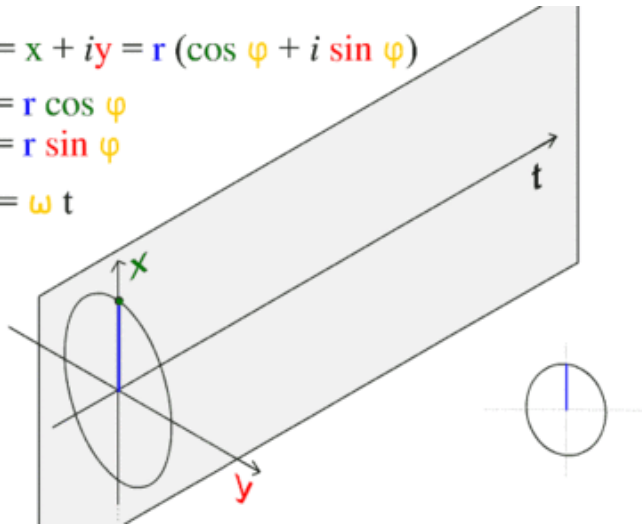
- Mean average depth – 25m
- Periodicity, wavelength – 2000m
- Height of snake – +/- 10m (15-35m)

$$z = x + iy = r (\cos \varphi + i \sin \varphi)$$

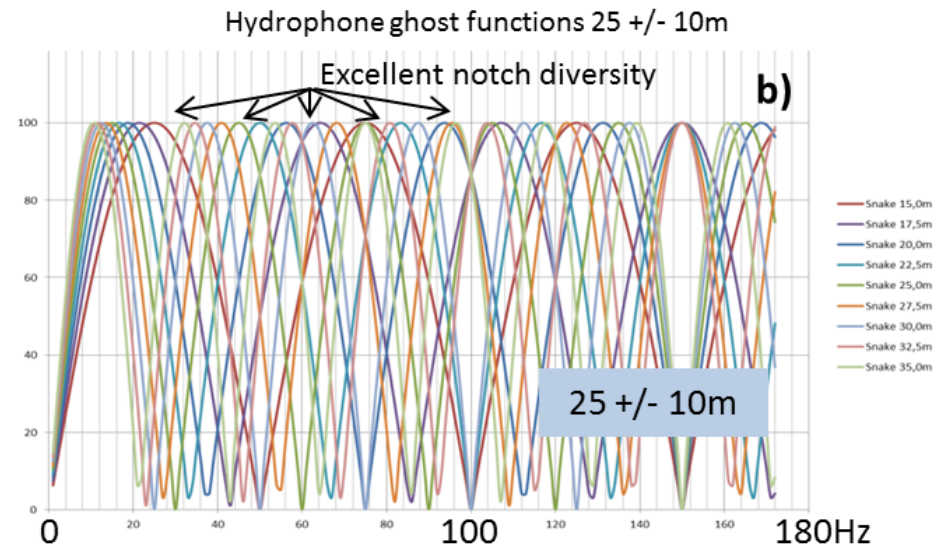
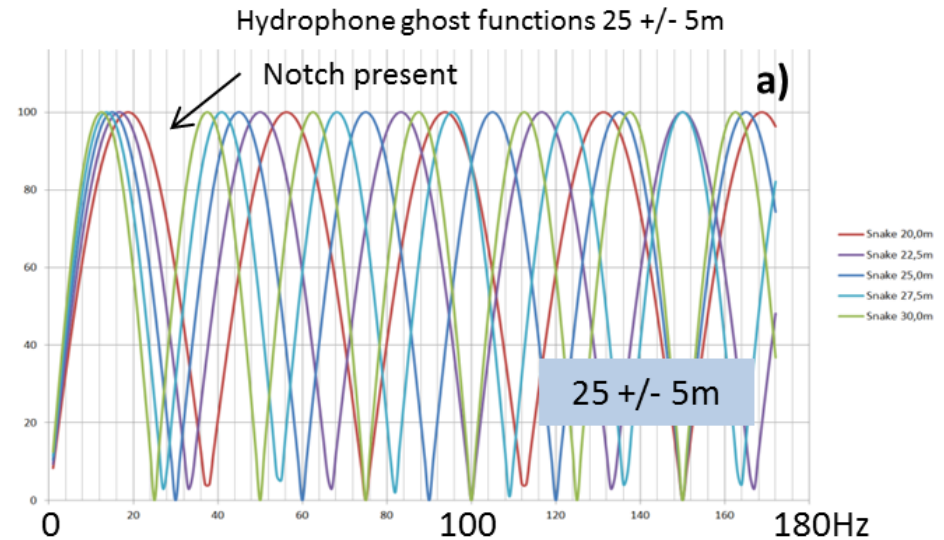
$$x = r \cos \varphi$$

$$y = r \sin \varphi$$

$$\varphi = \omega t$$

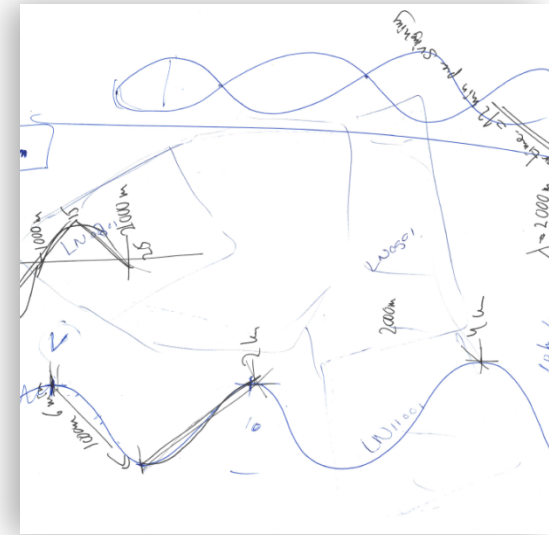


5knots, 10km/h, 1000m/6min
Sinusoid with 12min duration



Outline

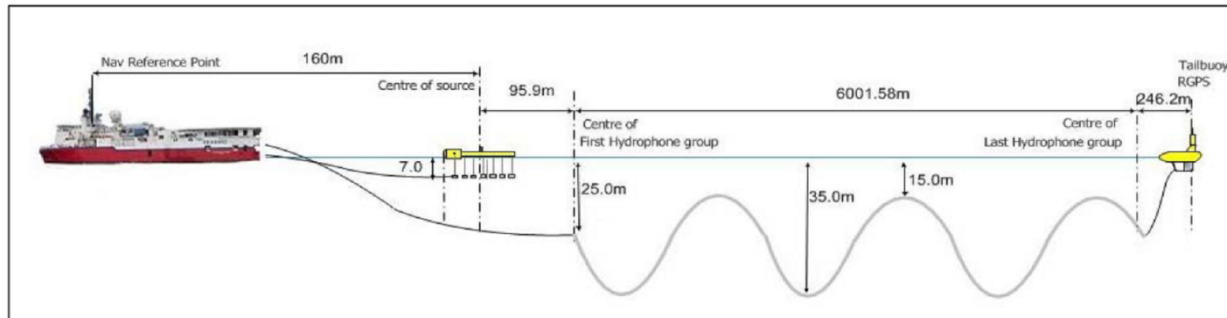
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Harrier Explorer

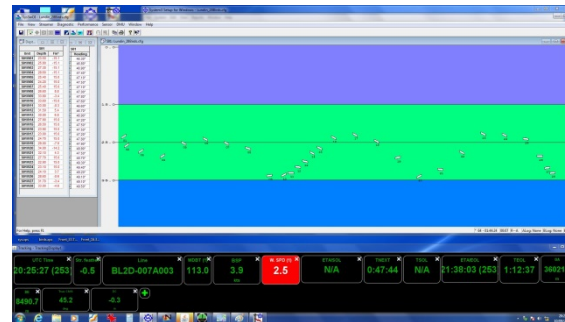
- 2D single streamer
- 6000m offset
- Depth birds roughly every 300m
- 2D single source at 7m depth

- SEQ001 - 001A001 - Constant flat depth 8m
- SEQ002 - 002A002 - Constant flat depth 25m
- SEQ003 - 007A003 - Snake streamer +/-10 25+-10m
- SEQ004 - 003A004 - Constant flat depth (max) 35m
- SEQ005 - 004A005 - Linear slant – front to tail 8-35m
- SEQ006 - 005A006 - 2.5km slant – then flat 8-25m
- SEQ007 - 006A007 - 2.5km slant – then flat 8-35m
- SEQ008 – 008B/C009/010 – Constant flat depth 60m
- SEQ011 – 009A011 – Linear slant – front to tail 8-60m
- SEQ012 – 010A012 – 2.5km slant – then flat 8-60m
- SEQ013 – 011A013 – 2.5km slant 8-45m, up at last 1km,45-8

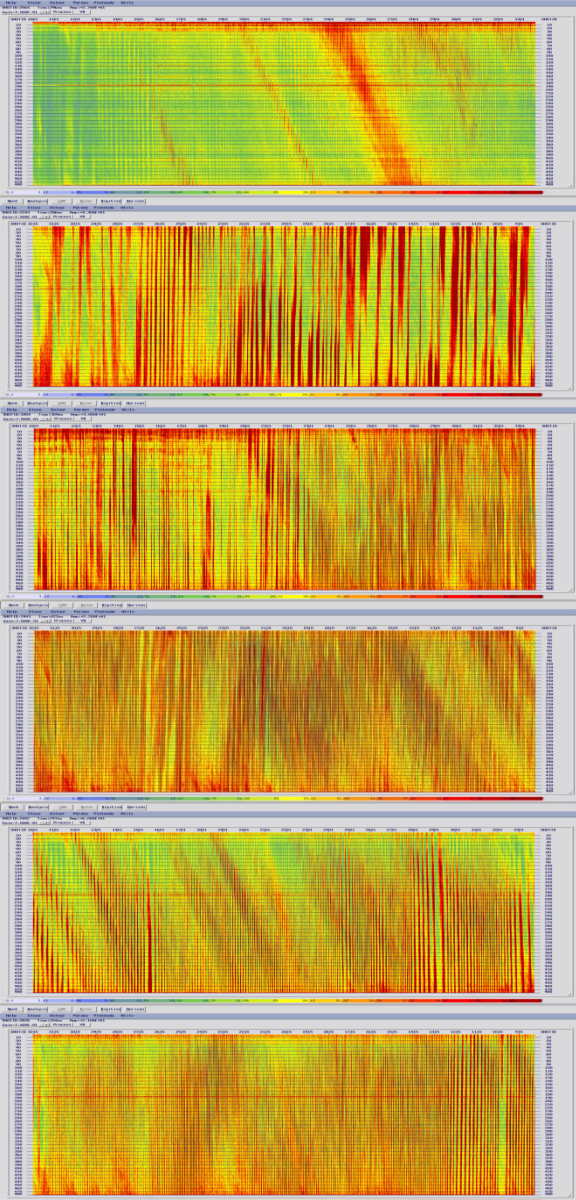


Streamer control

- Controlling the depth of the single streamer is easy for a fixed layout, but for a moving snake the birds has to all be adjusted constantly and according to the speed of the vessel above ground.
- With modern streamer controlling devices this is an easy automated task – but with manual depth control this becomes a very challenging task



	Bird Distance
Bird 1	Flex
Bird 2	0.0
Bird 3	274.6
Bird 4	524.6
Bird 5	824.2
Bird 6	1124.2
Bird 7	1423.8
Bird 8	1723.8
Bird 9	2023.4
Bird 10	2223.3
Bird 11	2323.4
Bird 12	2423.1
Bird 13	2523.3
Bird 14	2623.0
Bird 15	2723.2
Bird 16	2923.1
Bird 17	3222.6
Bird 18	3522.7
Bird 19	3822.2
Bird 20	4122.3
Bird 21	4421.8
Bird 22	4721.9
Bird 23	5021.4
Bird 24	5321.5
Bird 25	5621.1
Bird 26	5820.9
Bird 27	5921.1
Bird 28	5997.9



RMS DEEP NOISE

SEQ 001
8m tow depth

SEQ 002
25m flat constant tow depth

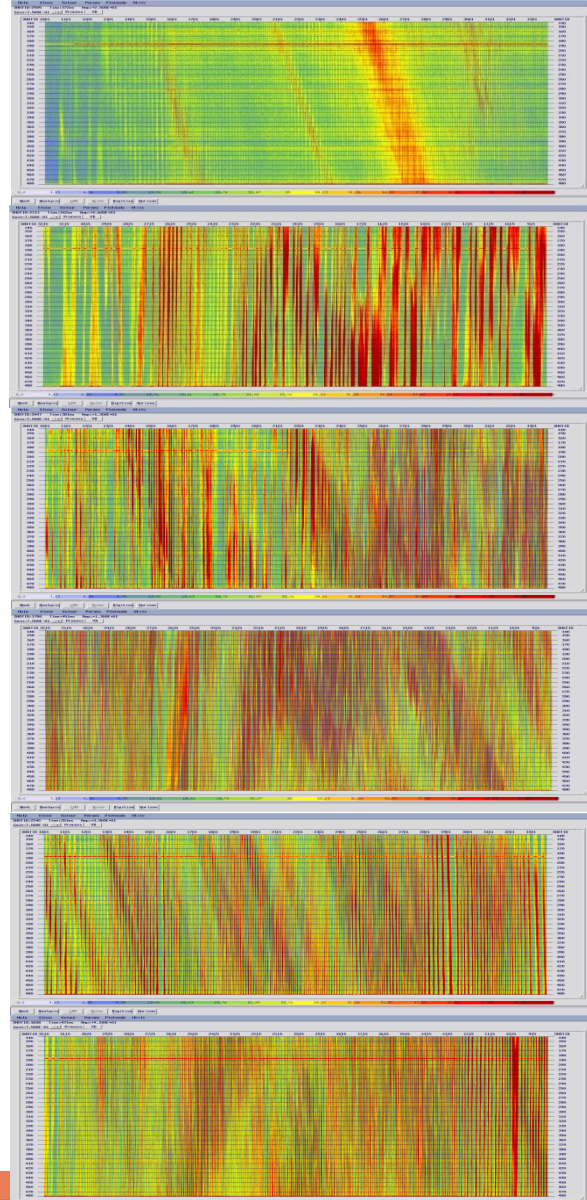
SEQ 003
25m +/- 10 variable tow depth

SEQ 004
35m flat constant tow depth

SEQ 005
Linear slant 8m – 35m

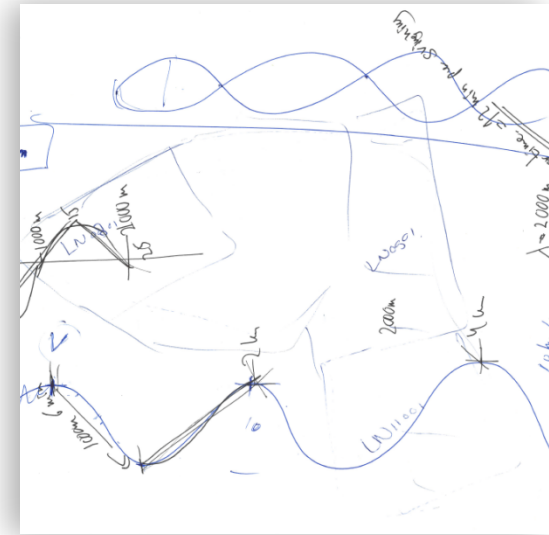
SEQ 006
2.5km slant 8m – 25m,
then flat at 25m

RMS SHALLOW NOISE

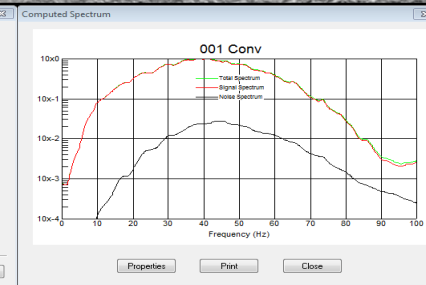
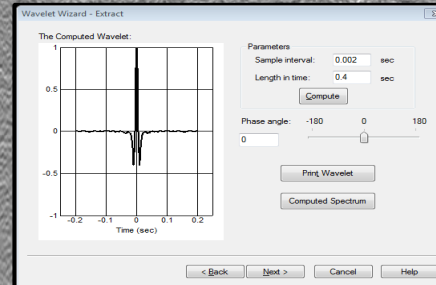
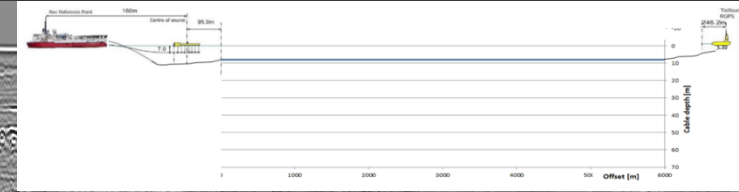
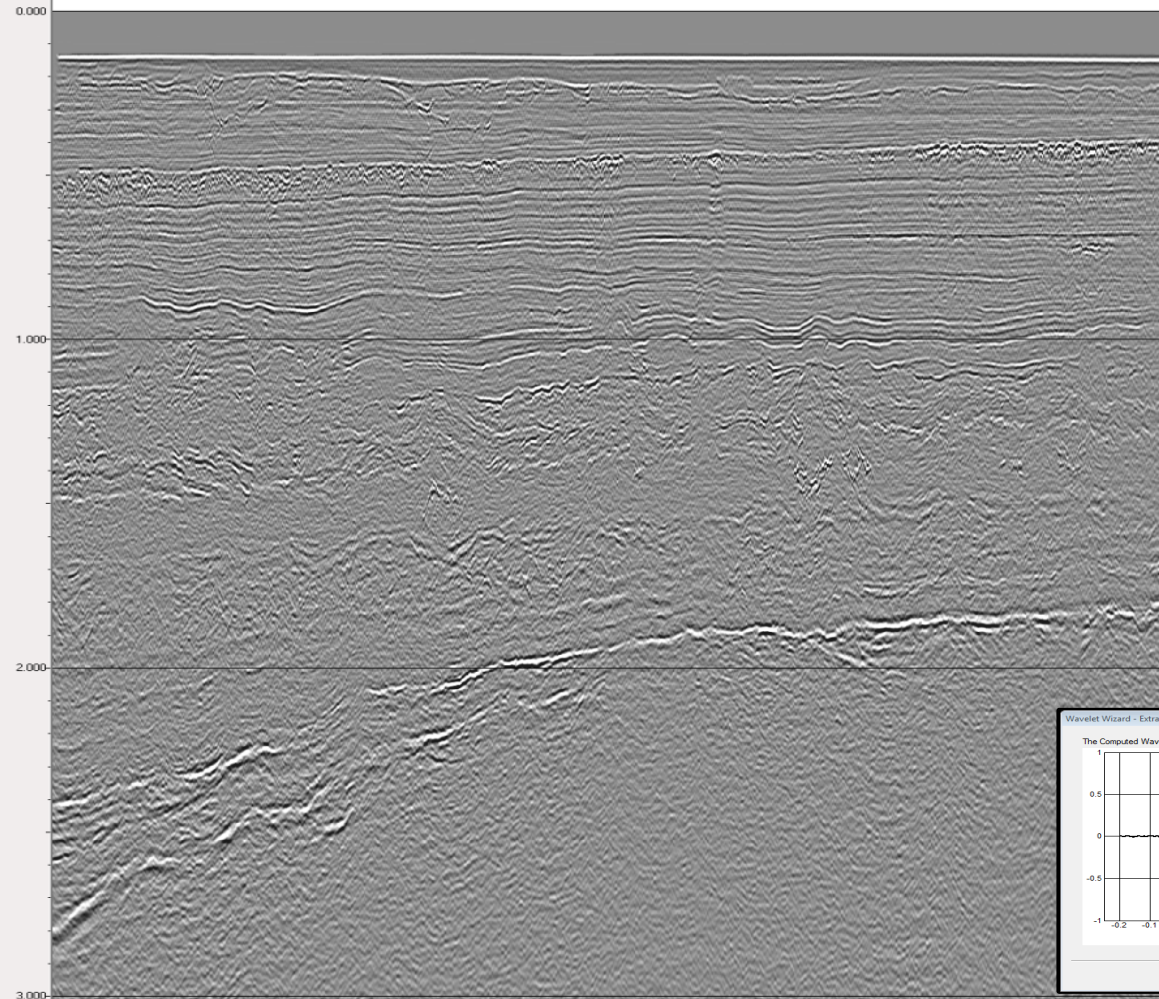


Outline

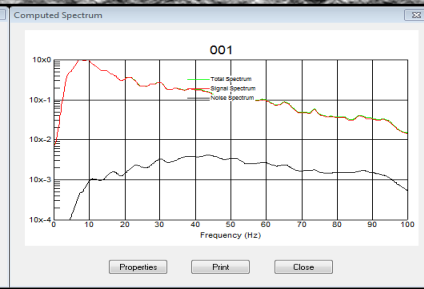
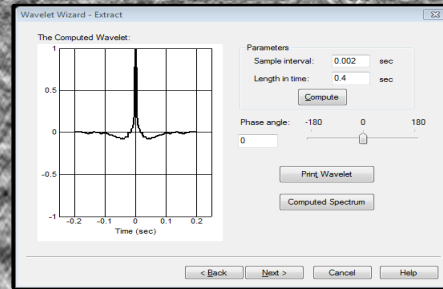
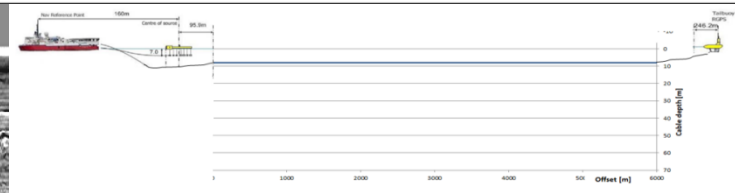
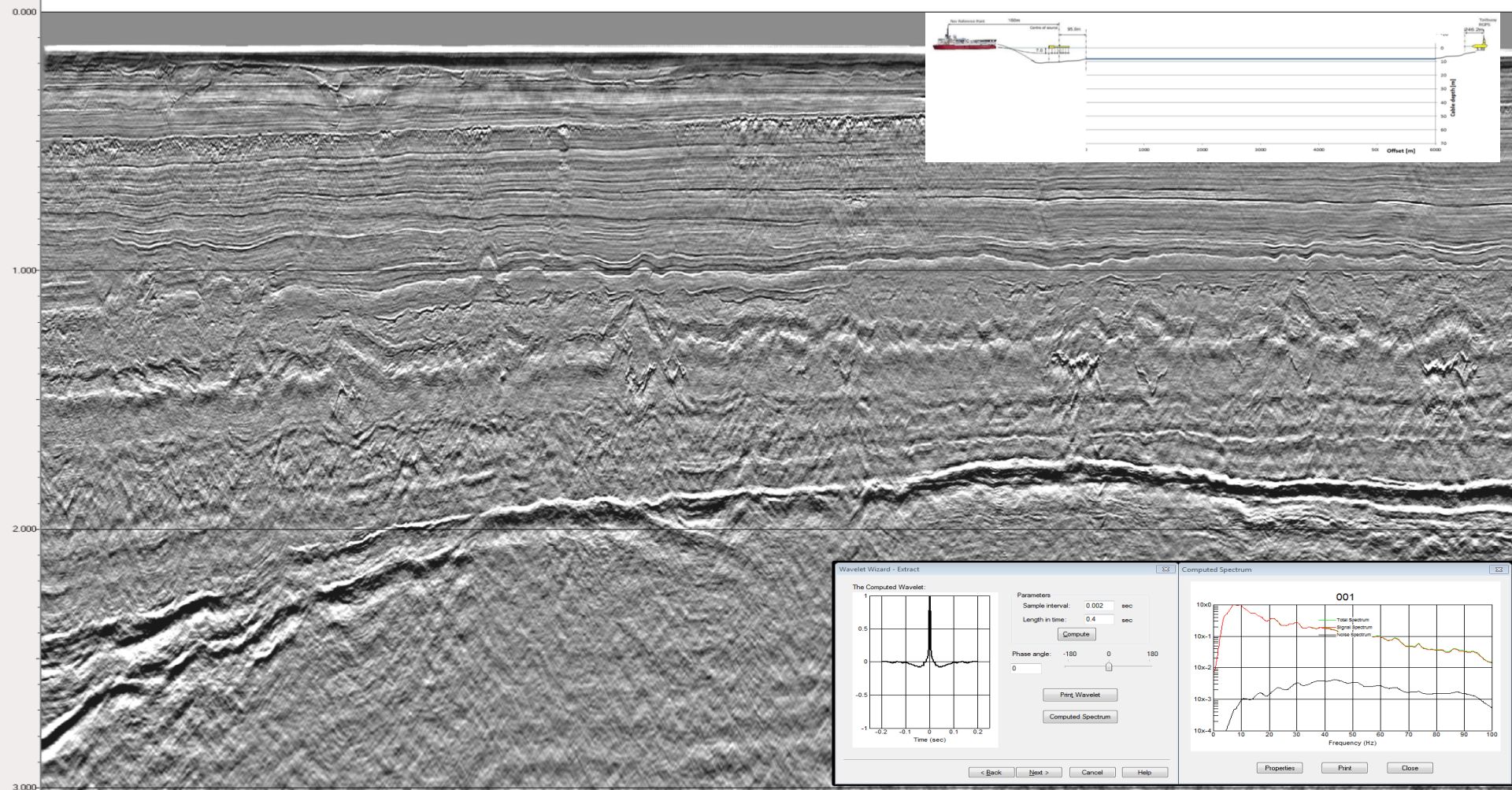
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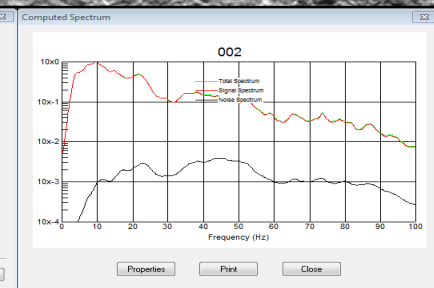
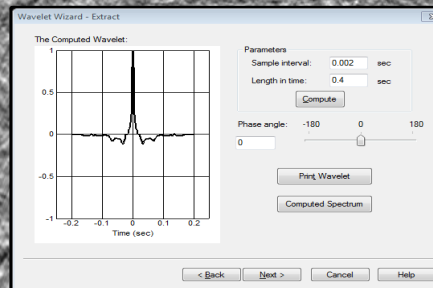
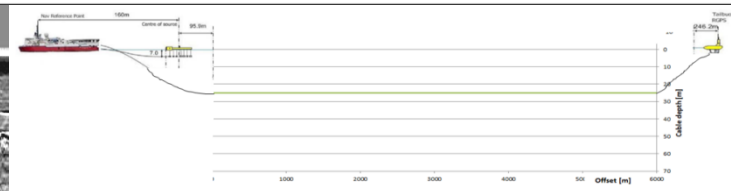
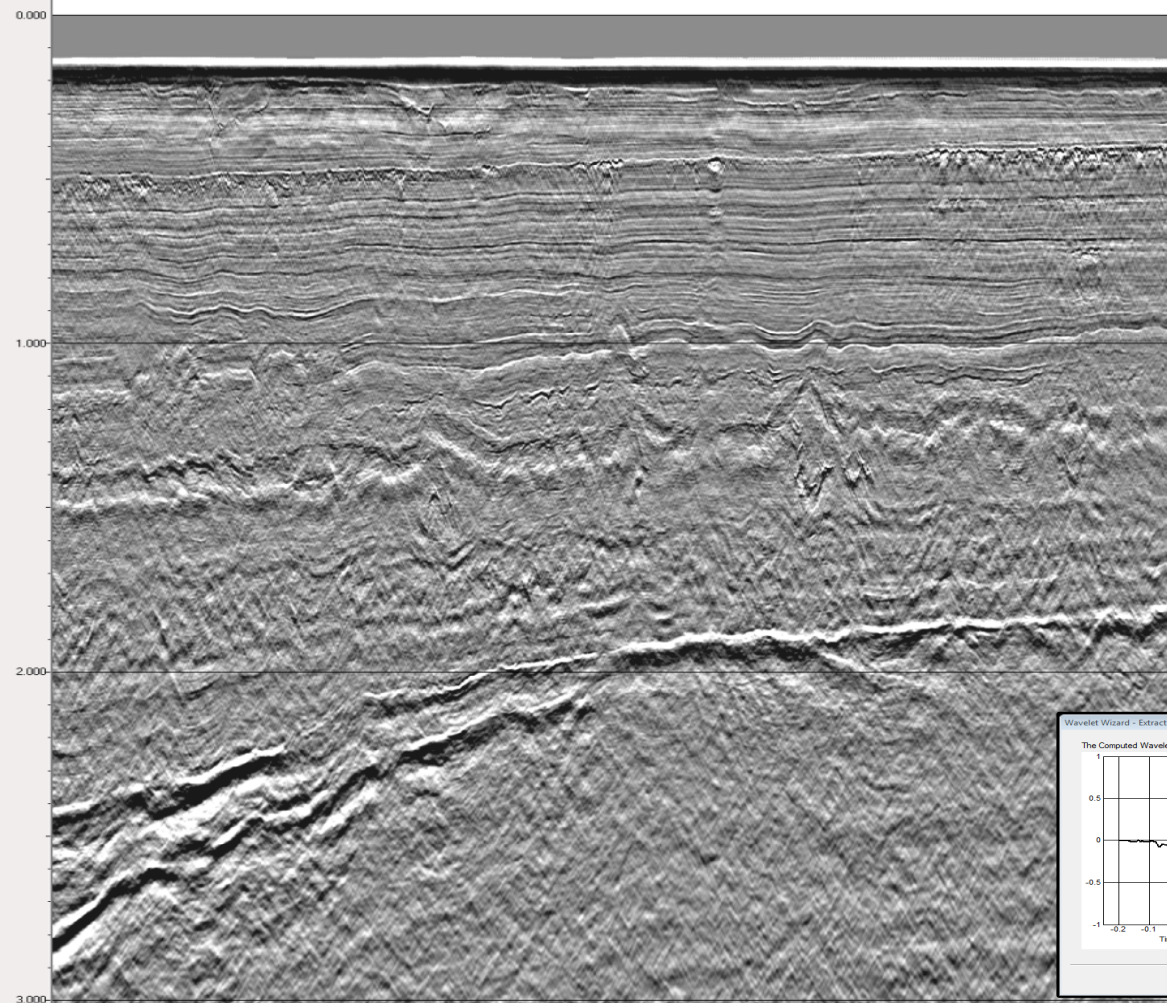
001 - 08-08-08 Conv



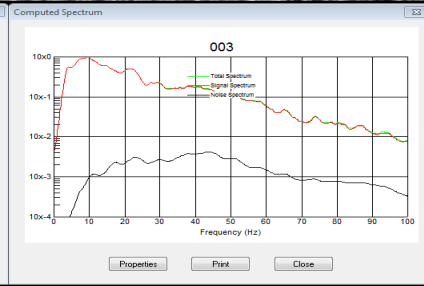
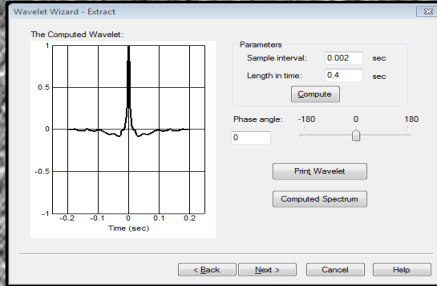
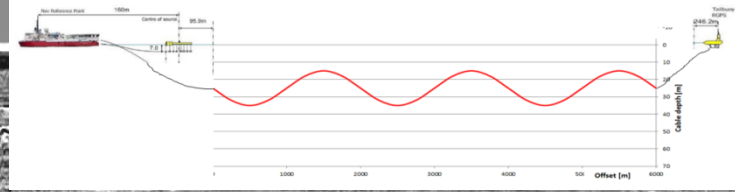
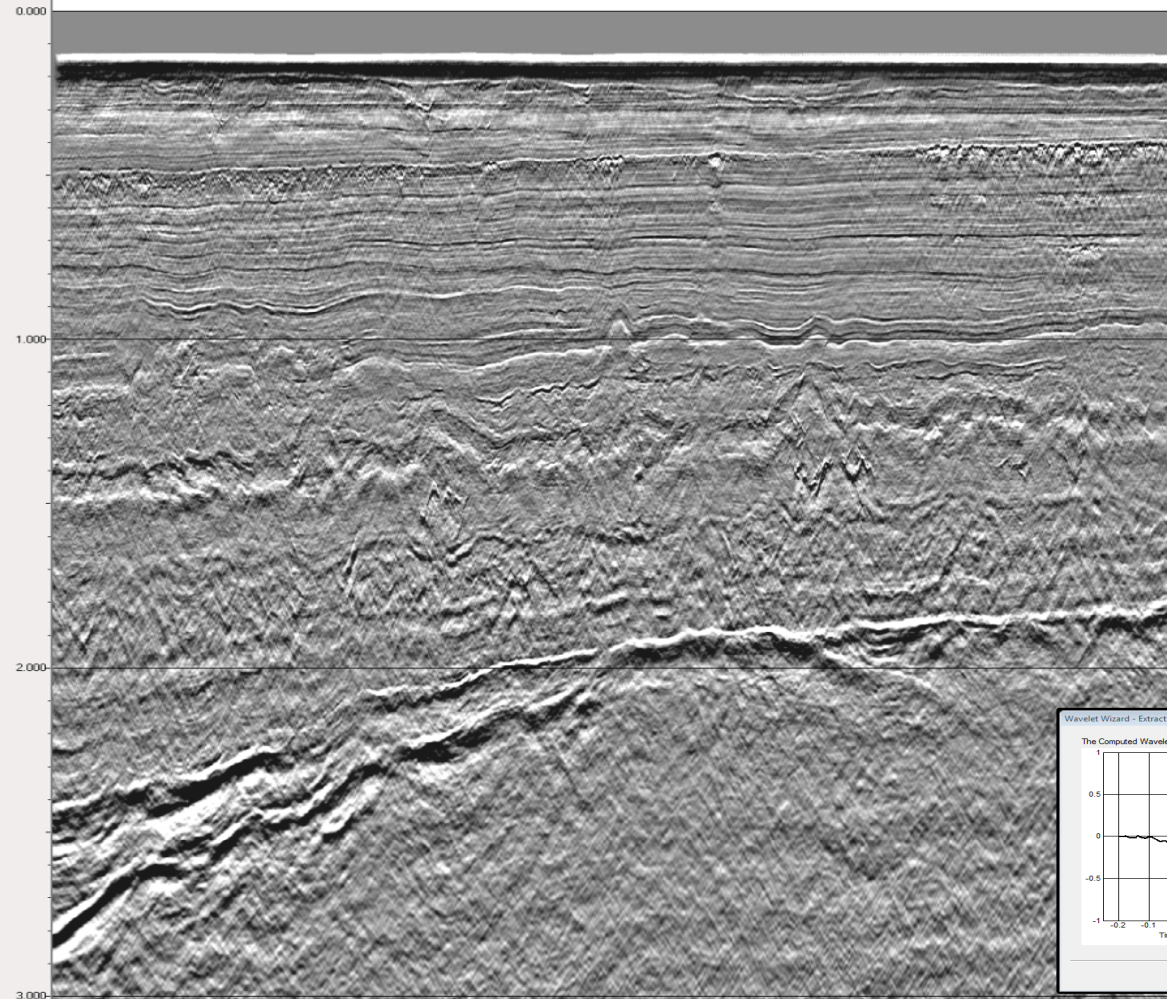
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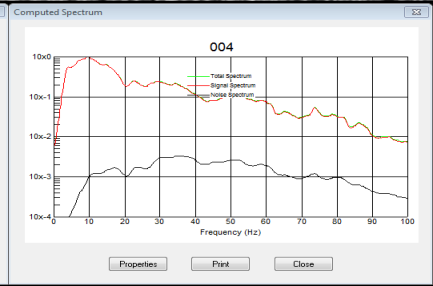
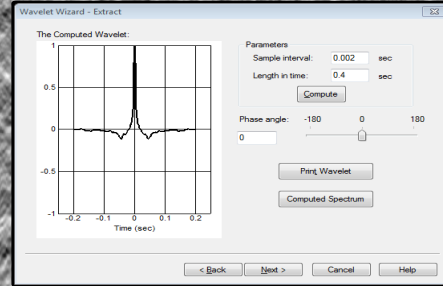
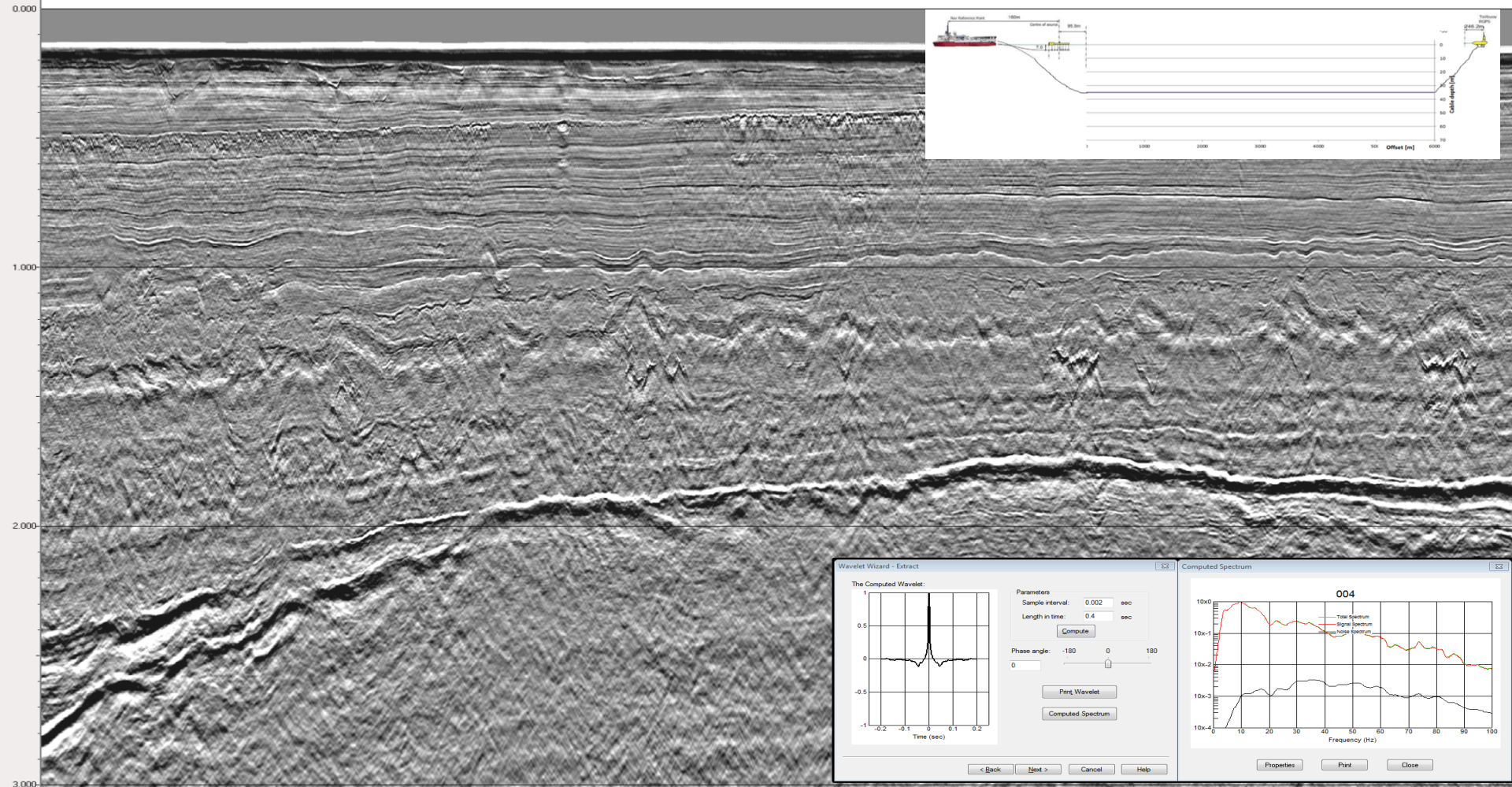
002 - 25-25-25



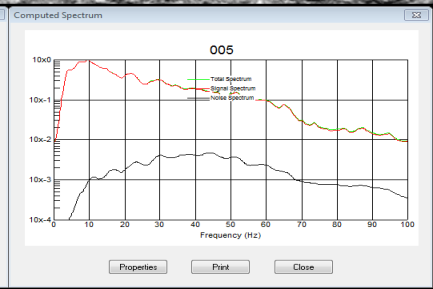
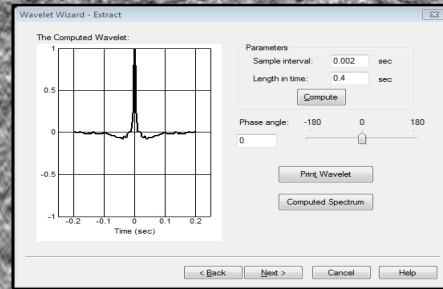
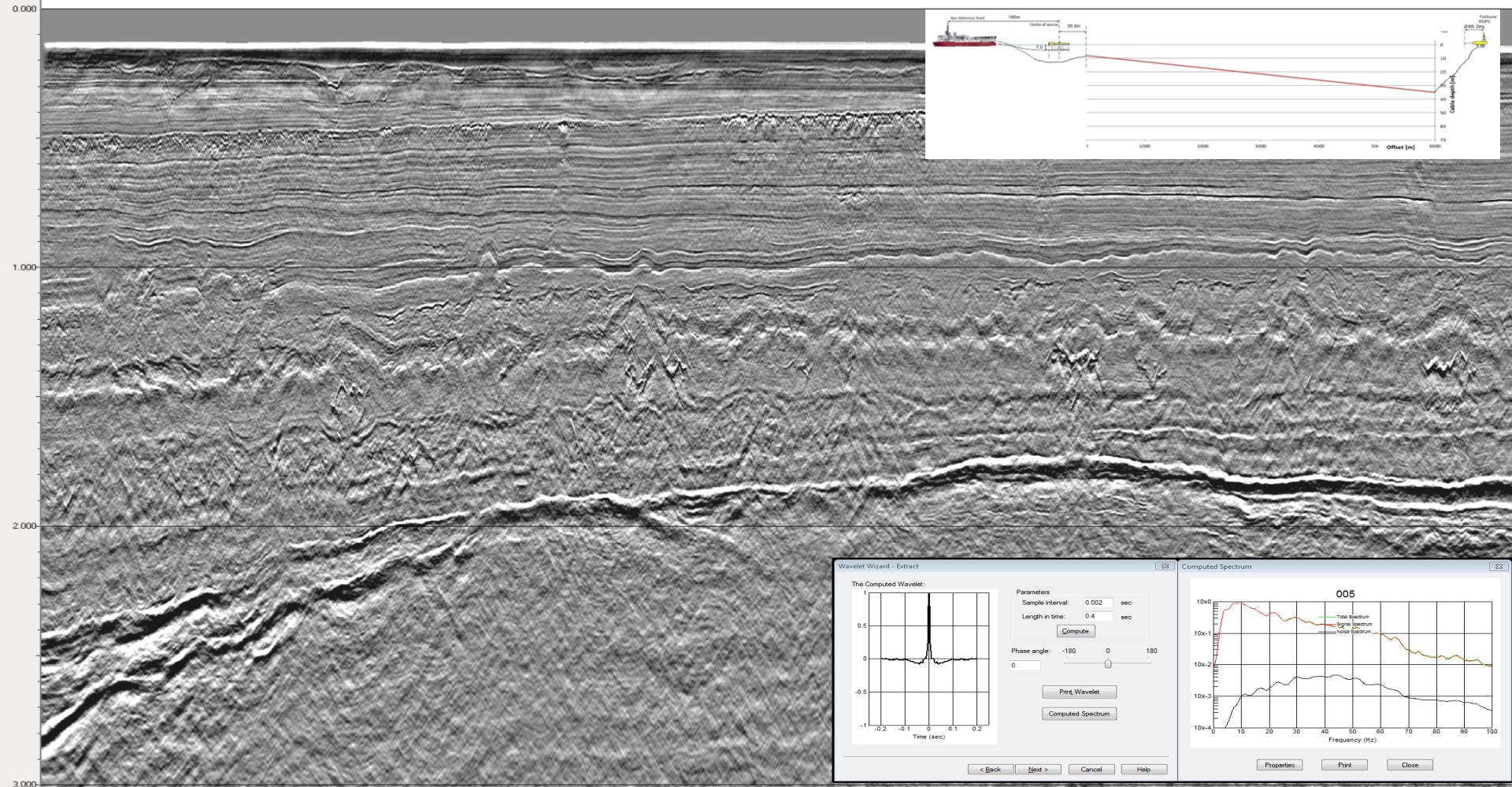
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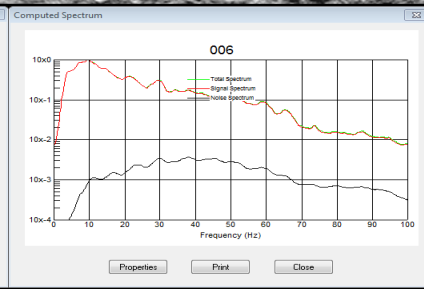
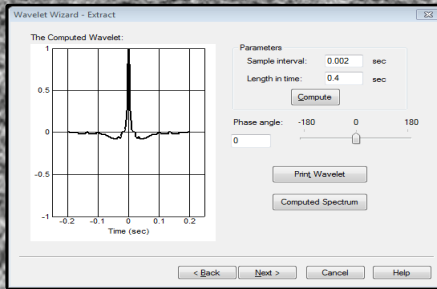
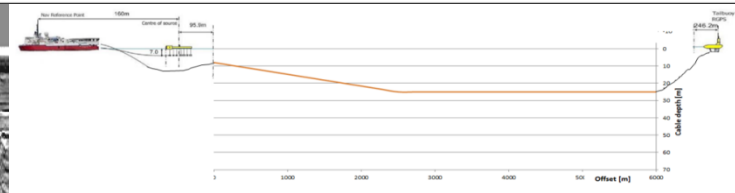
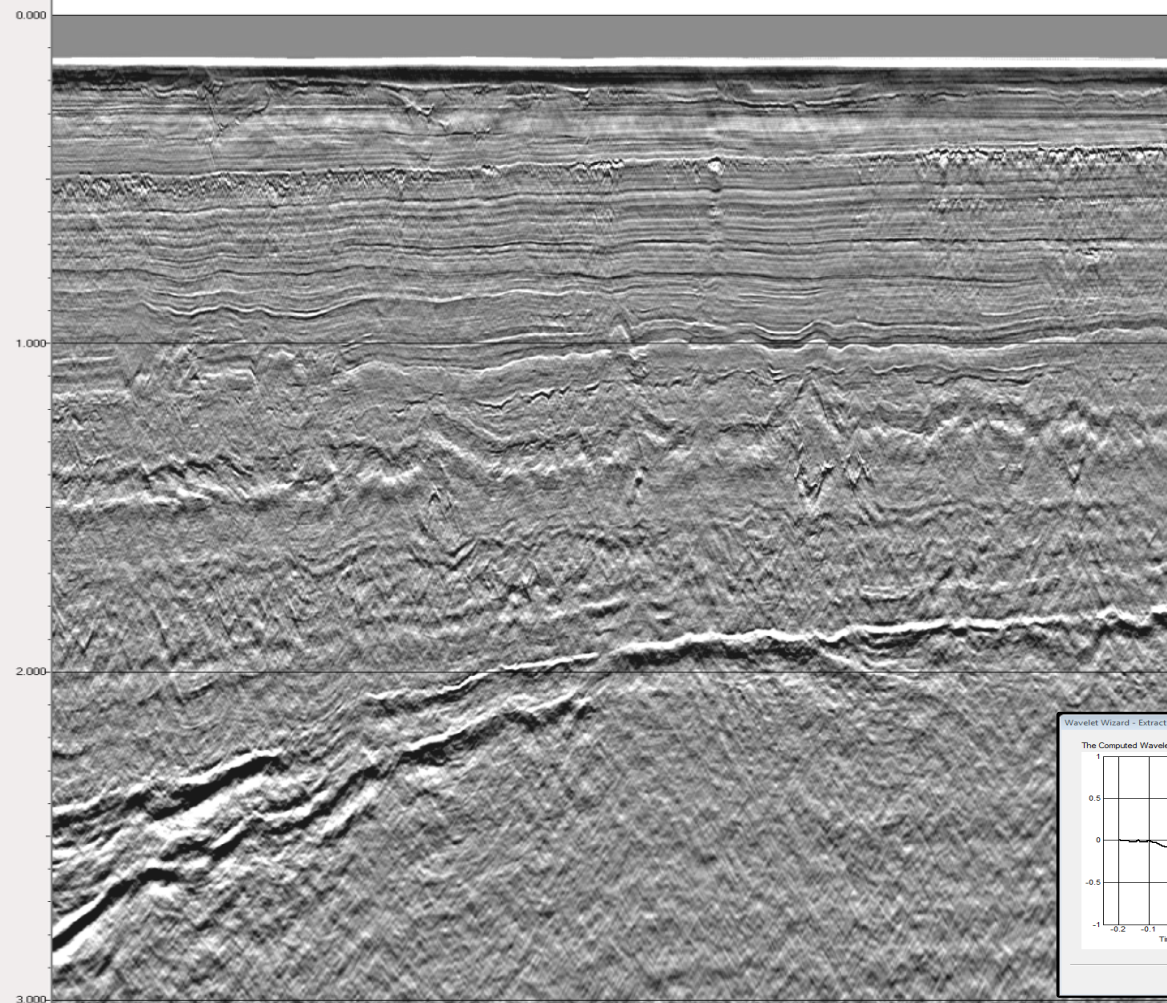
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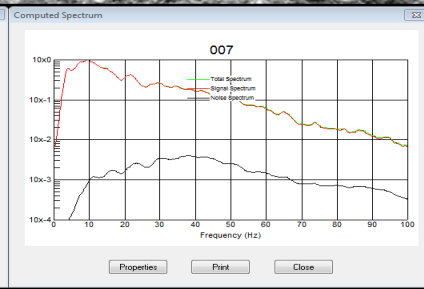
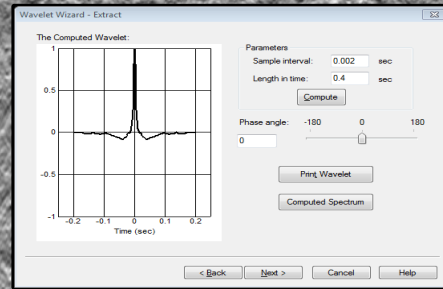
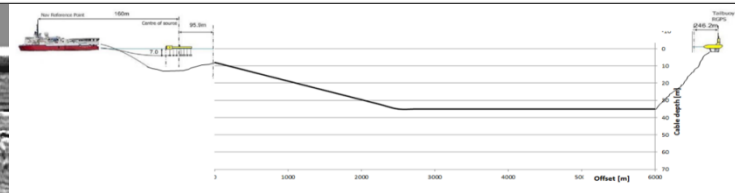
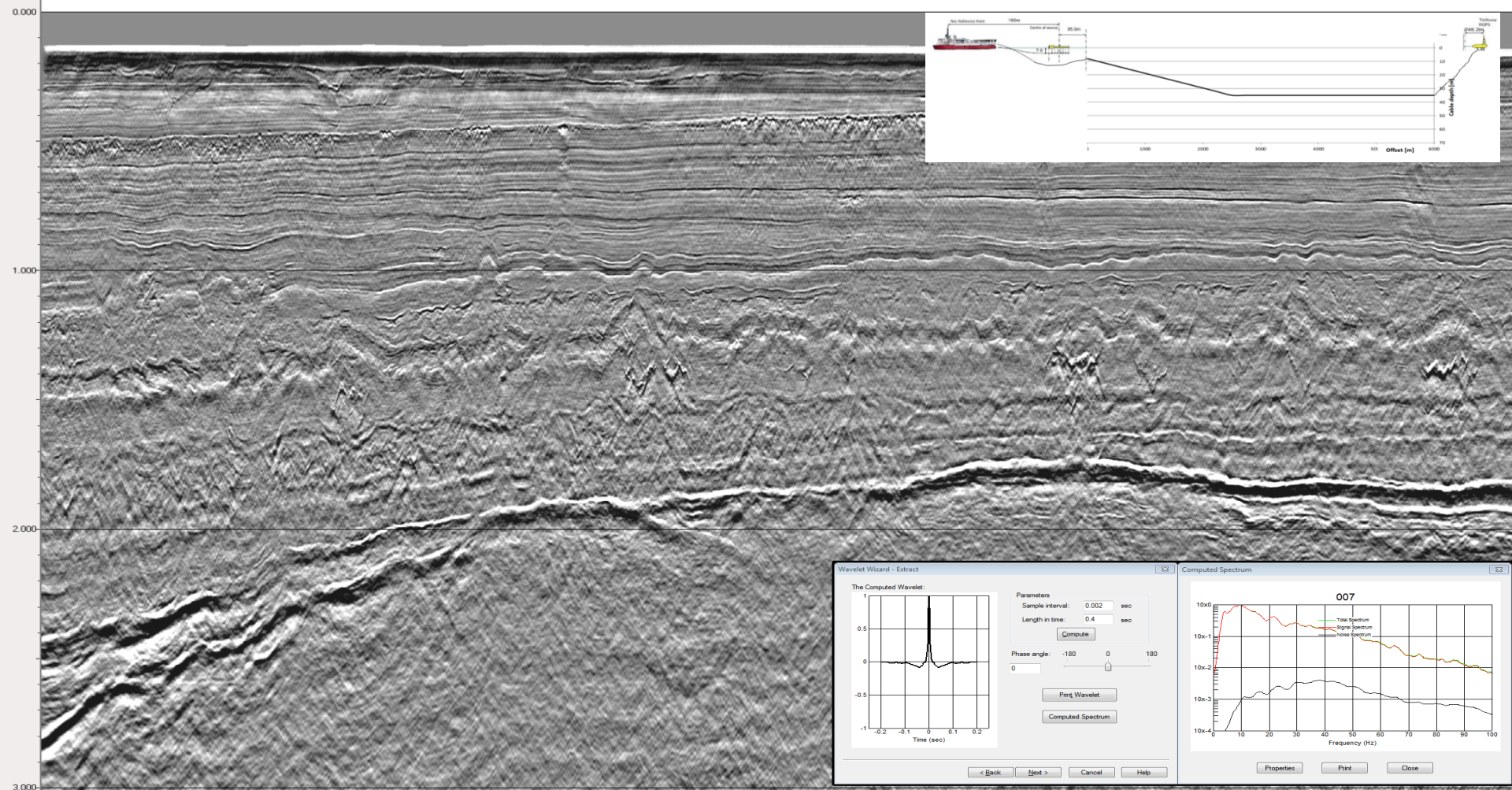
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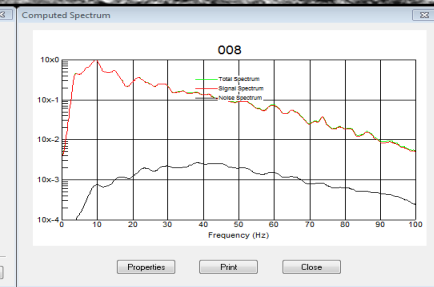
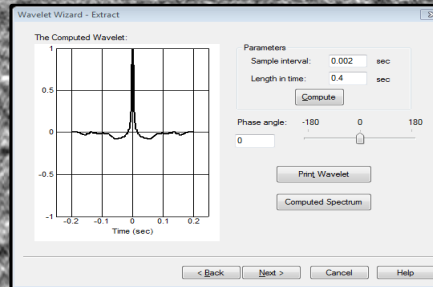
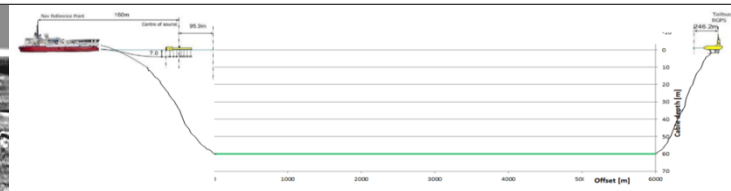
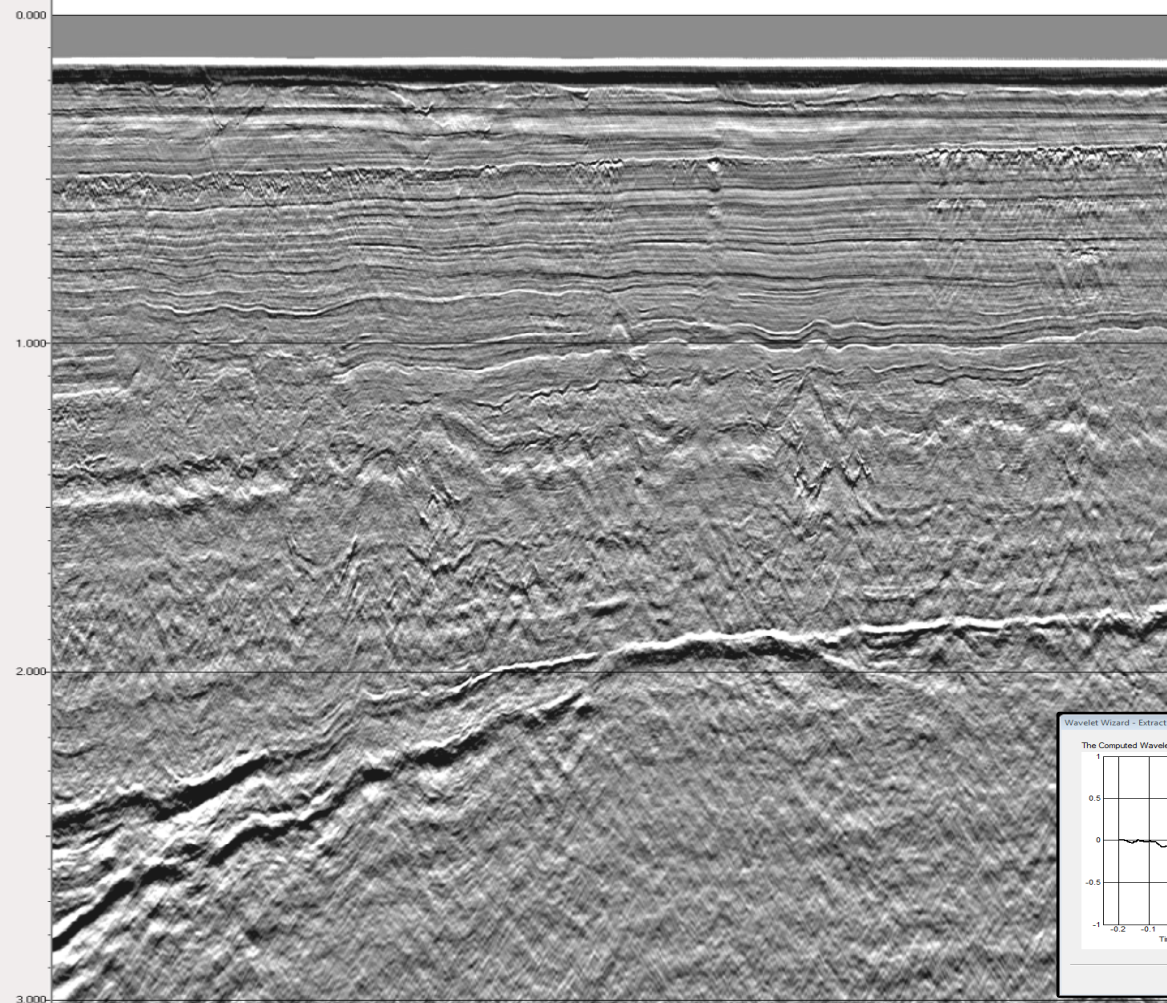
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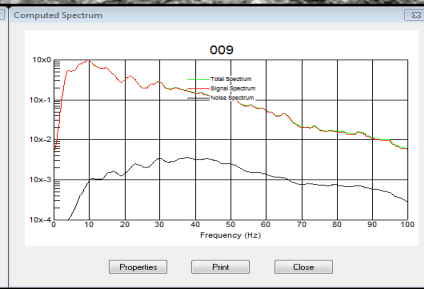
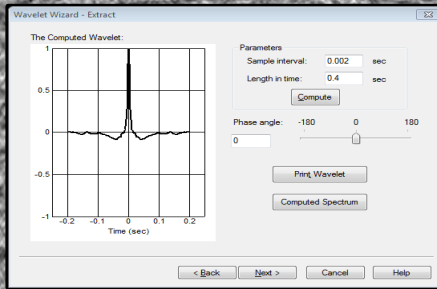
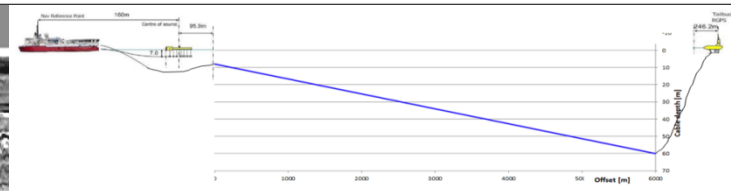
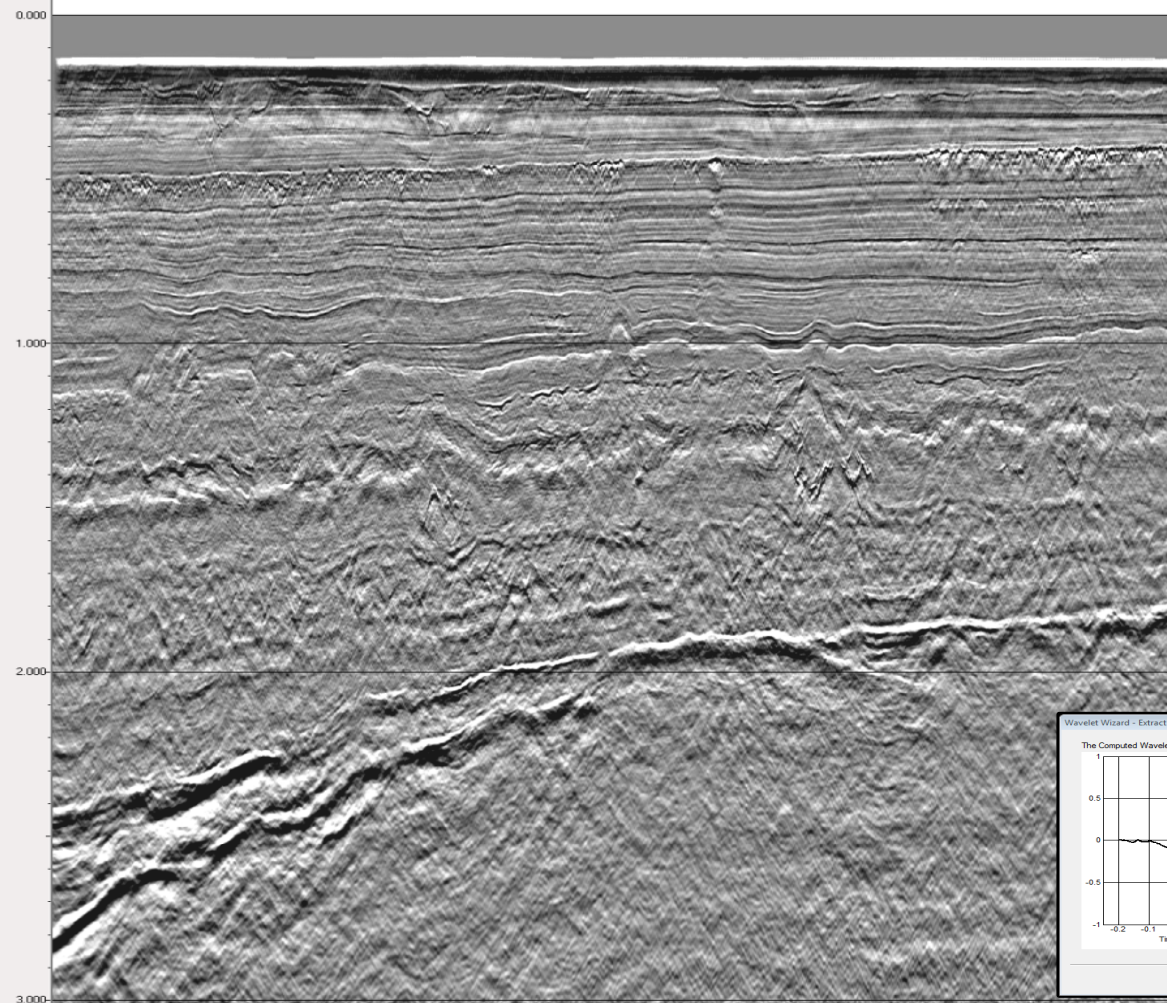
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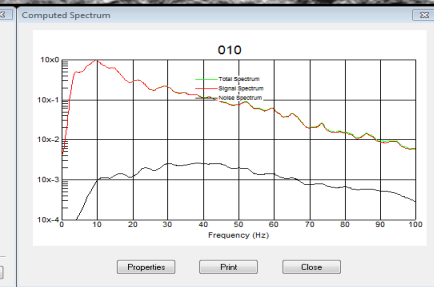
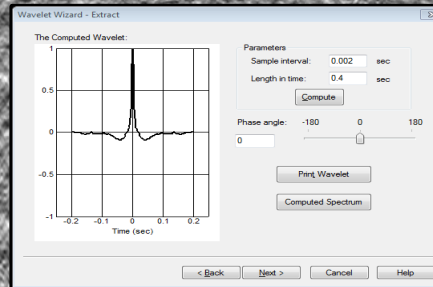
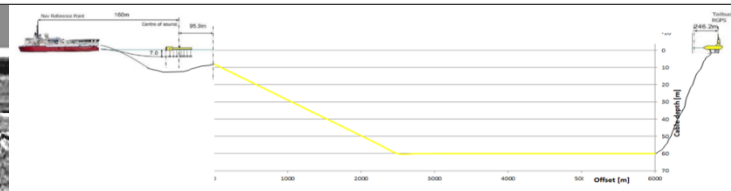
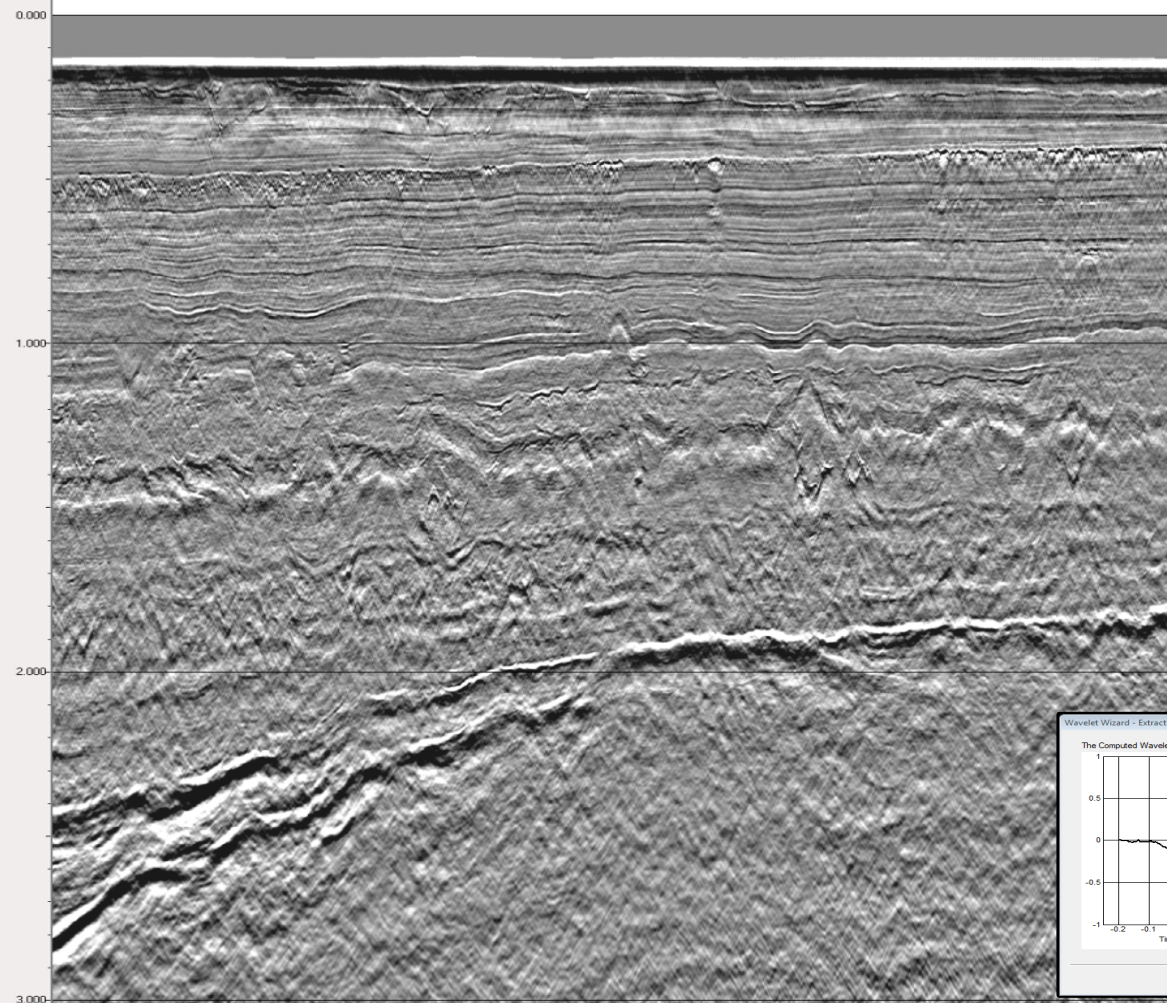
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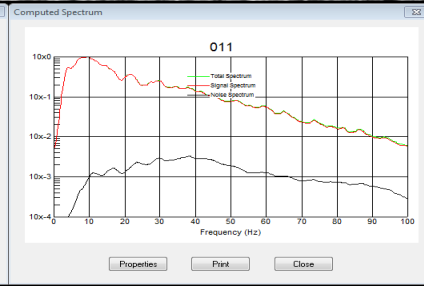
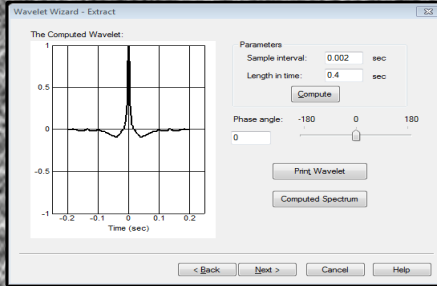
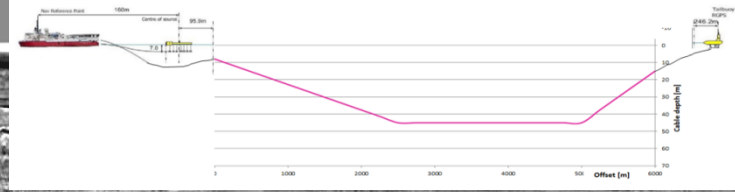
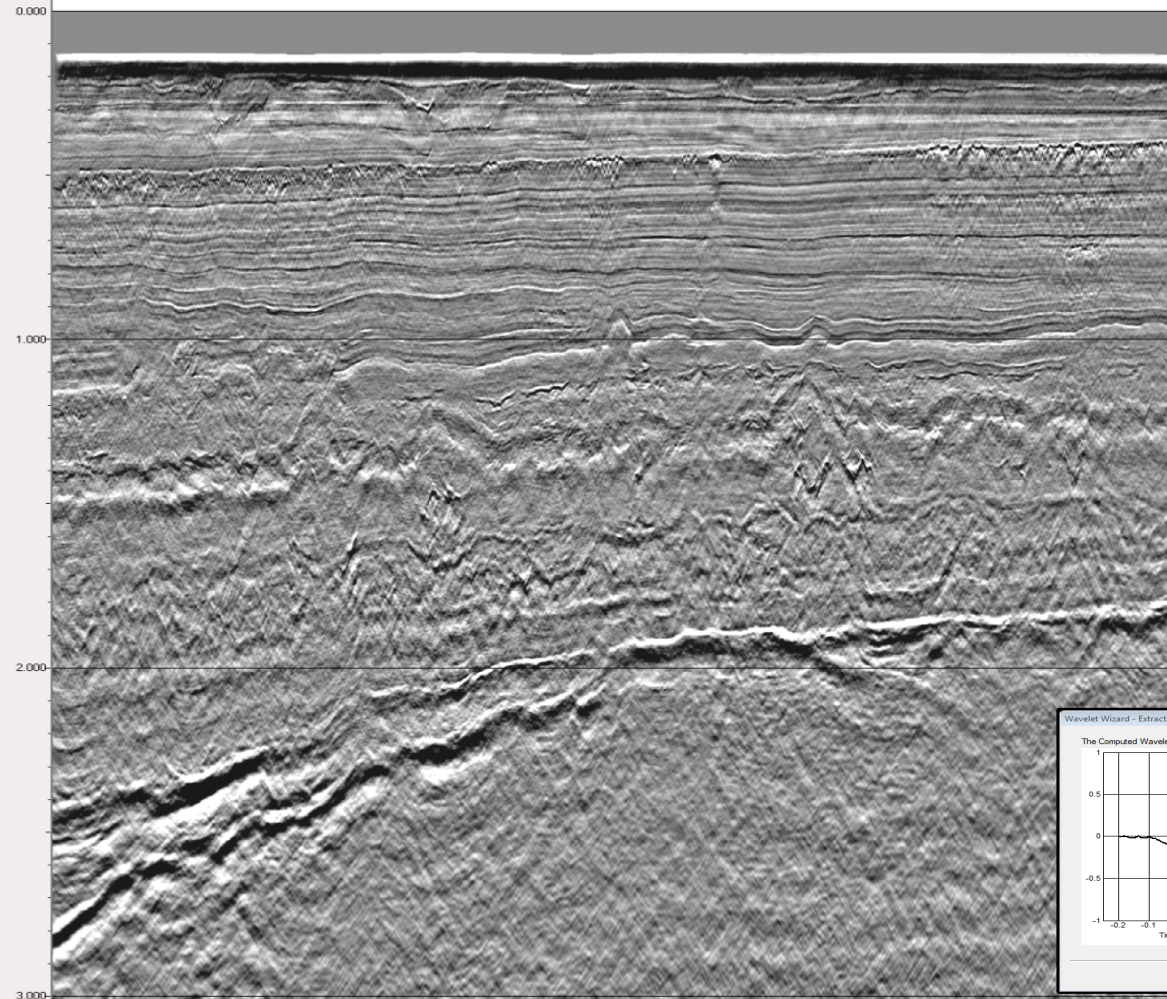
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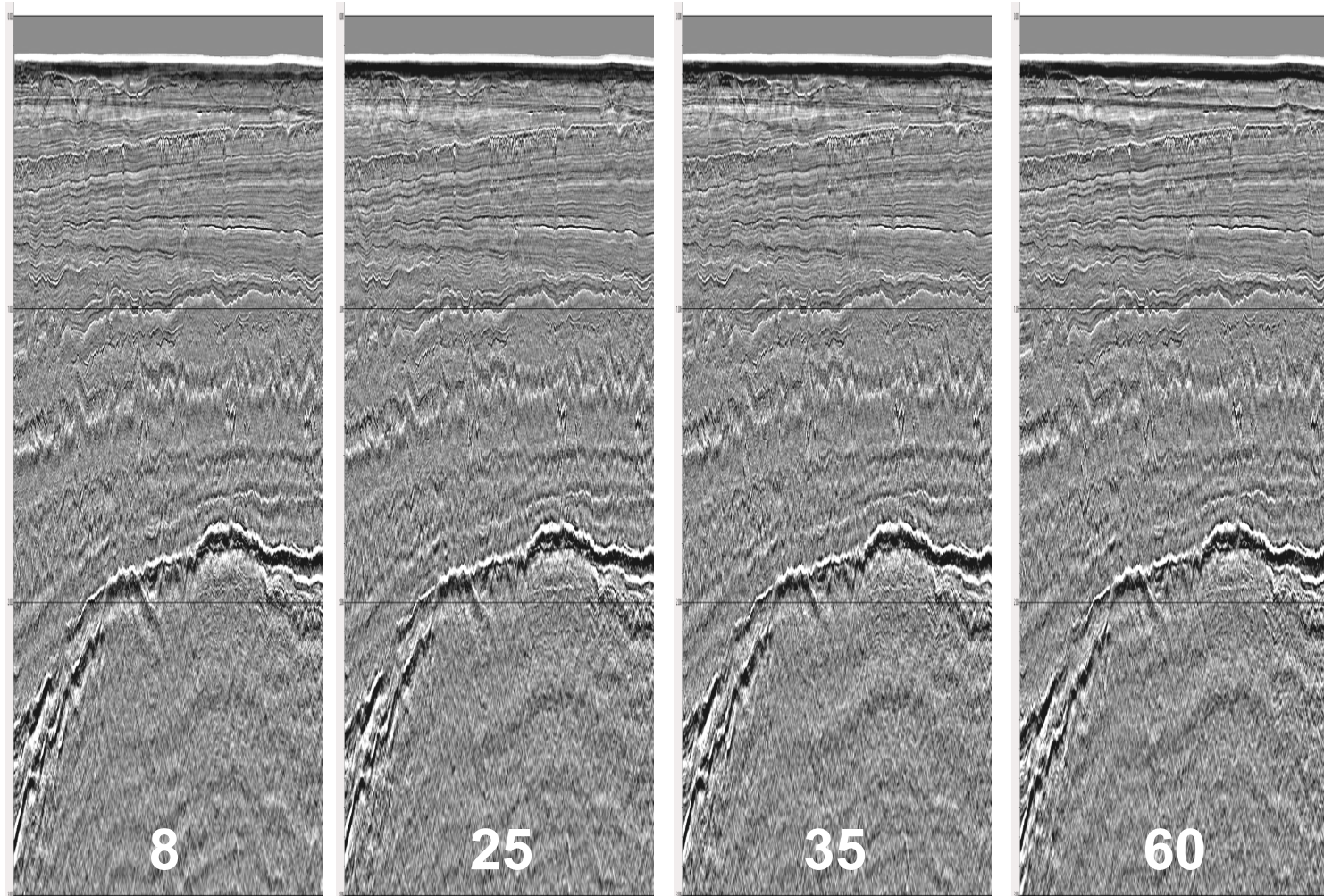
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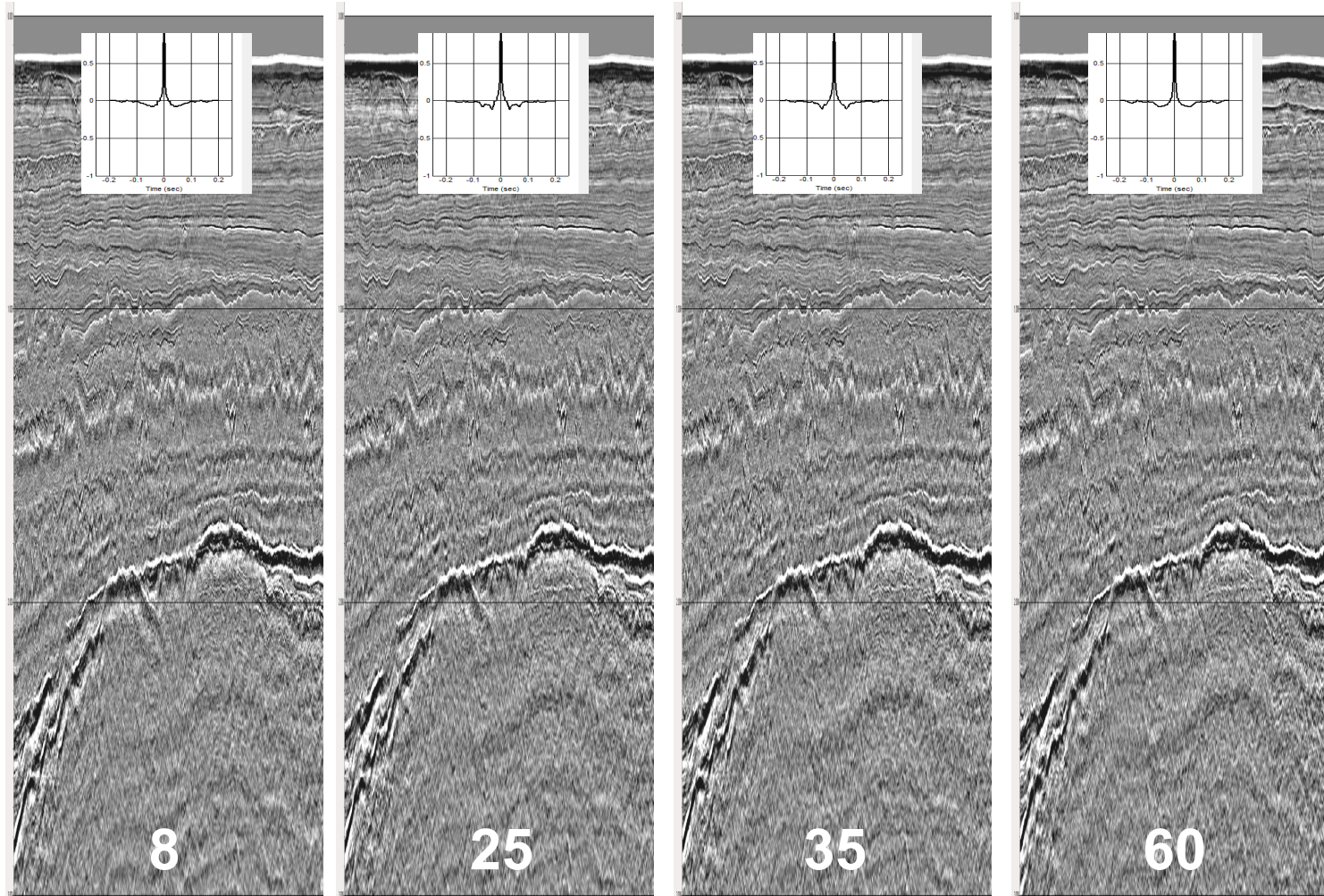
011 - 08-45-15



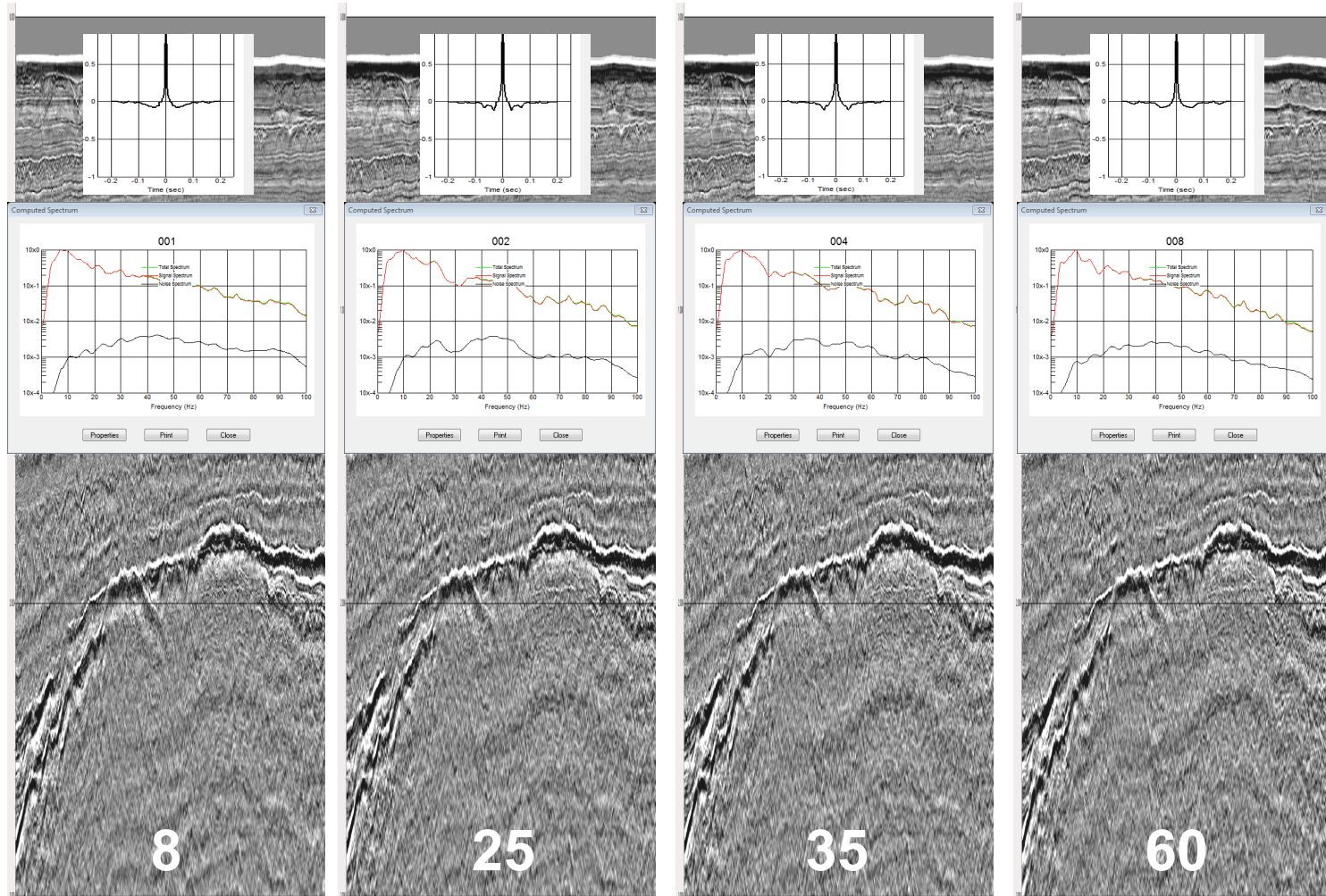
Constant Flat Depth Comparisons



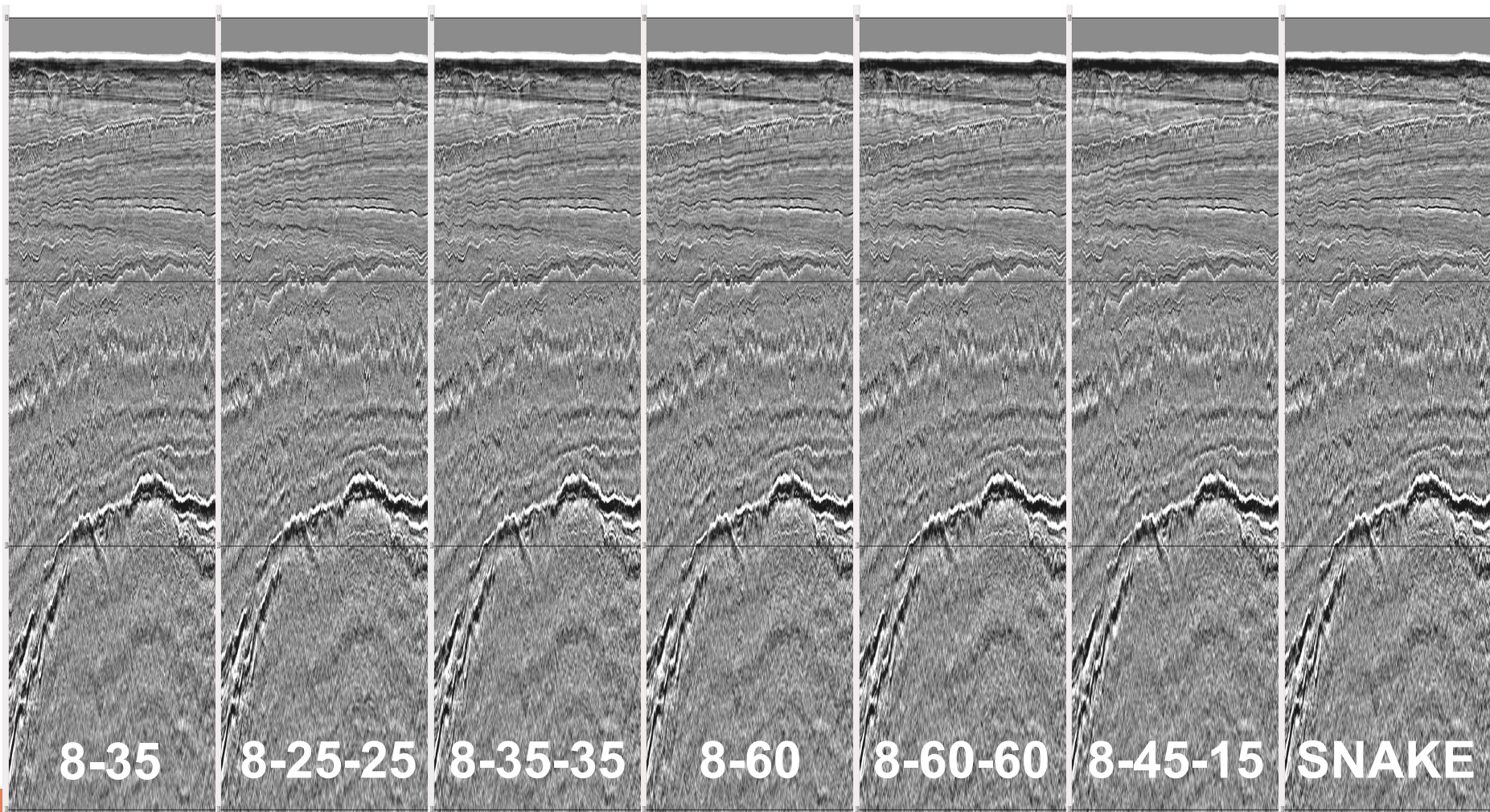
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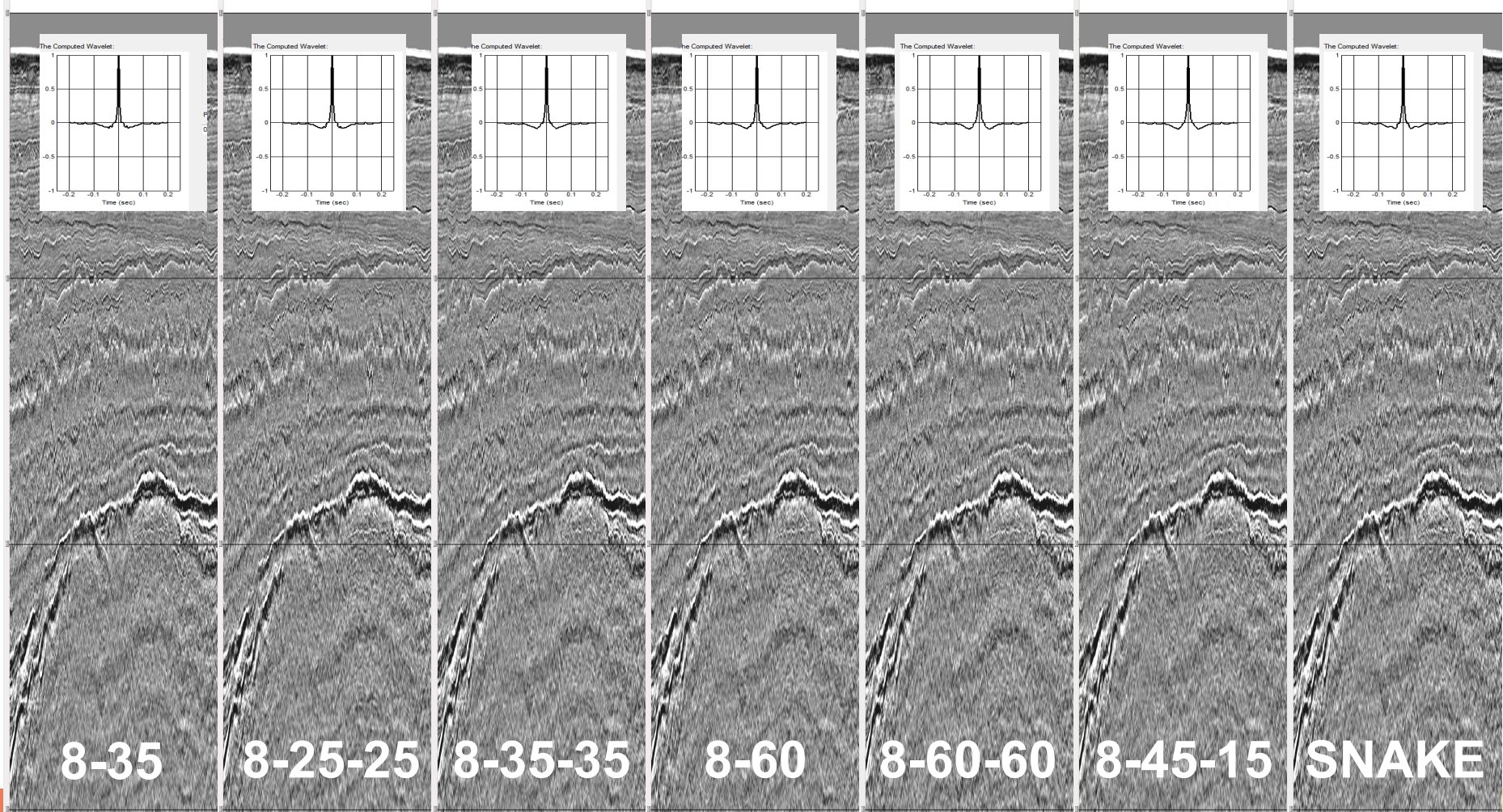
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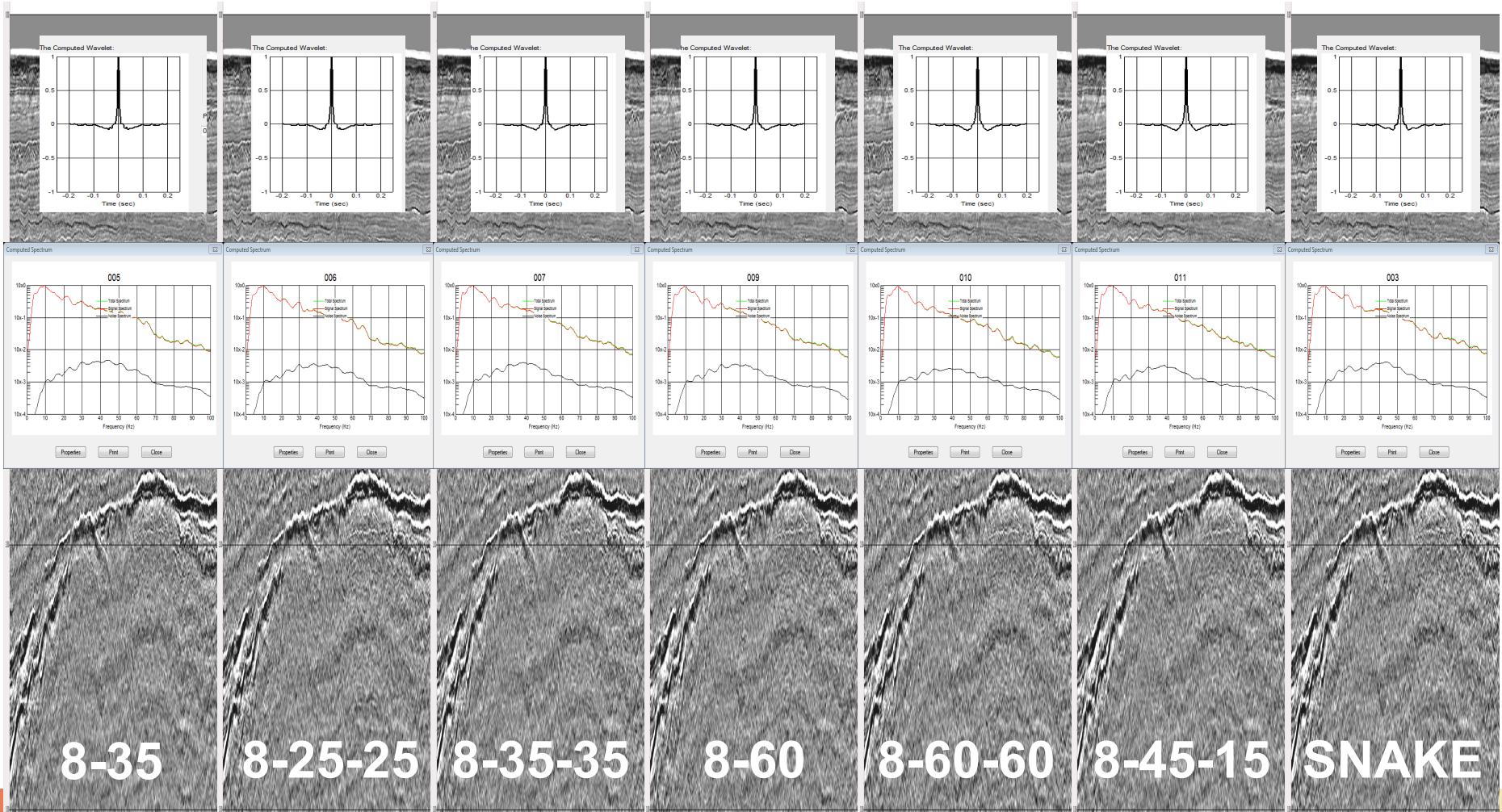
Slanted Comparisons



Slanted Comparisons

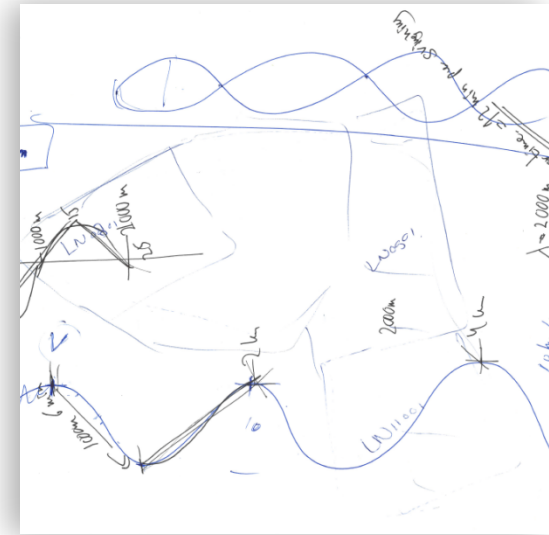


Slanted Comparisons

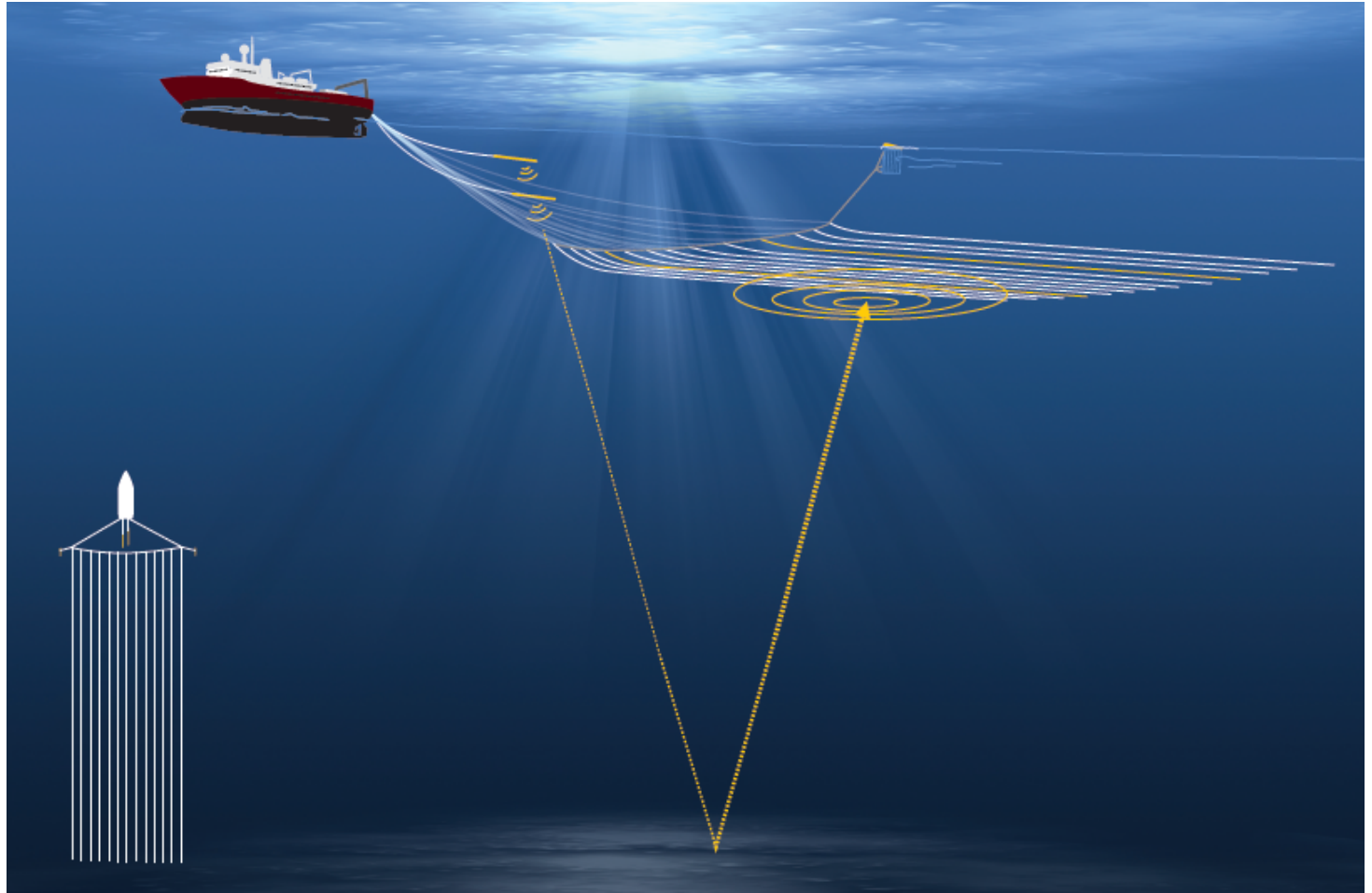


Outline

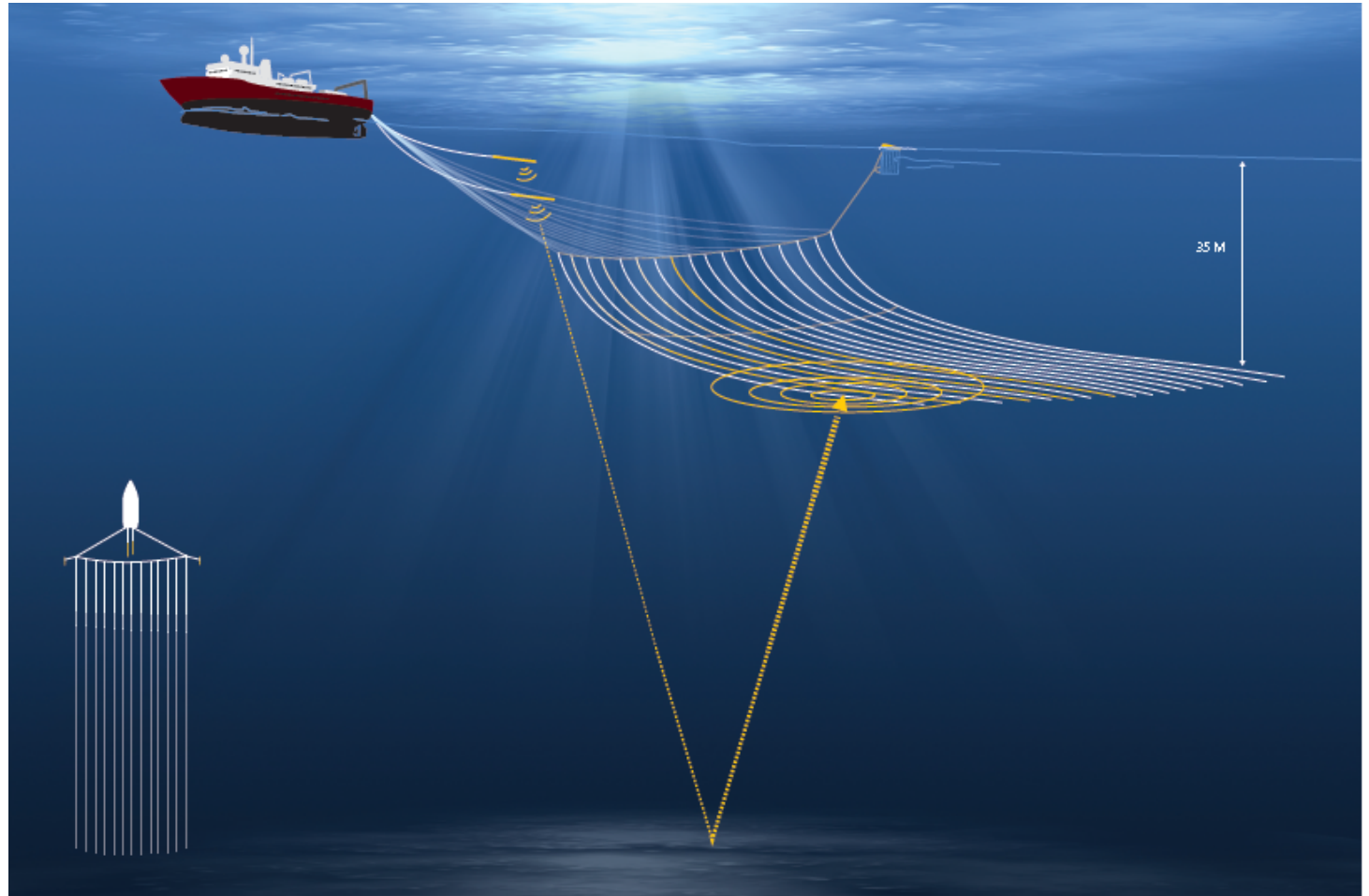
- Background & motivation
- Modeling & design
- The field experiment
- Data examples
- Conclusions, discussions and the road ahead



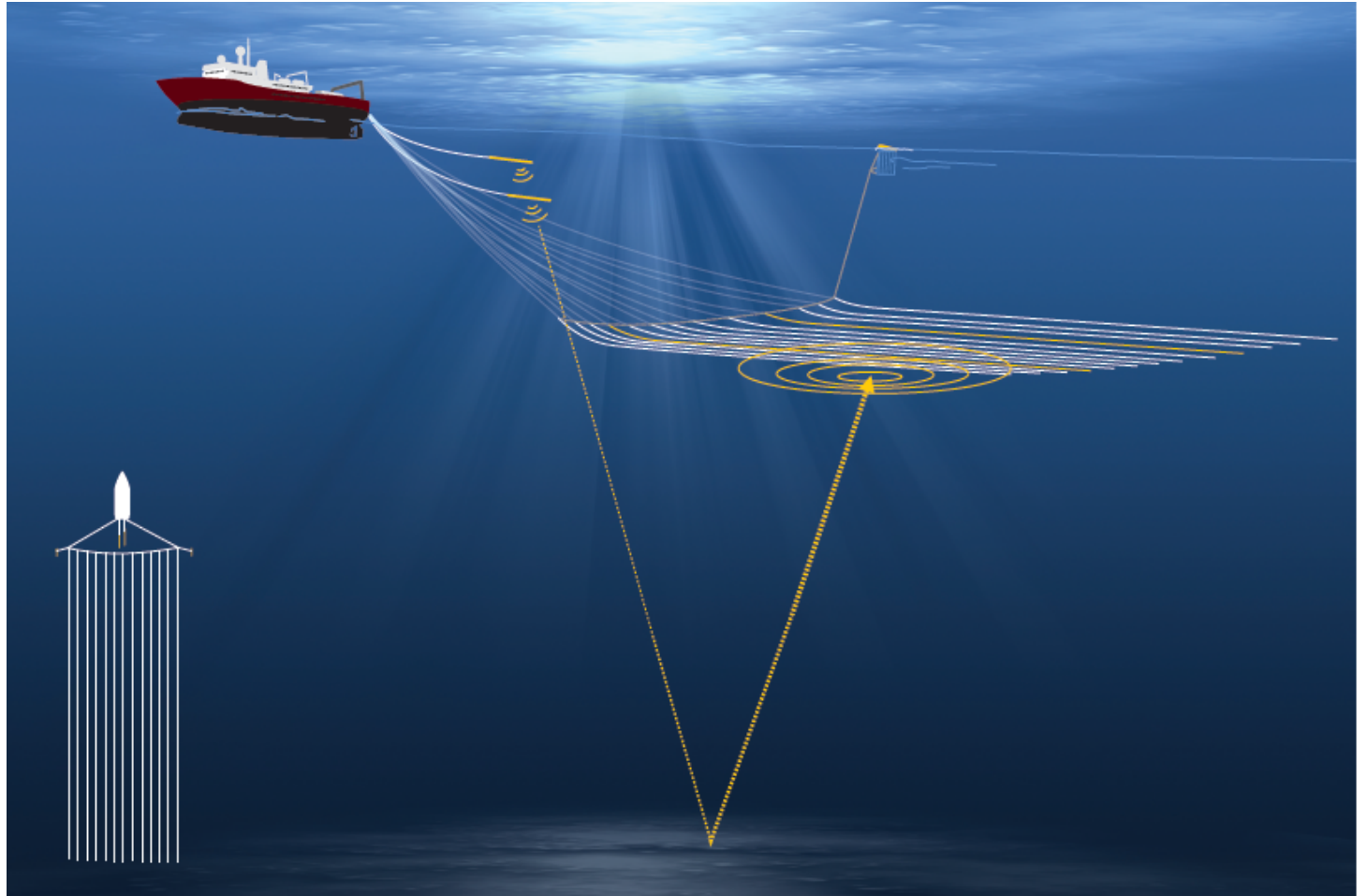
The old days



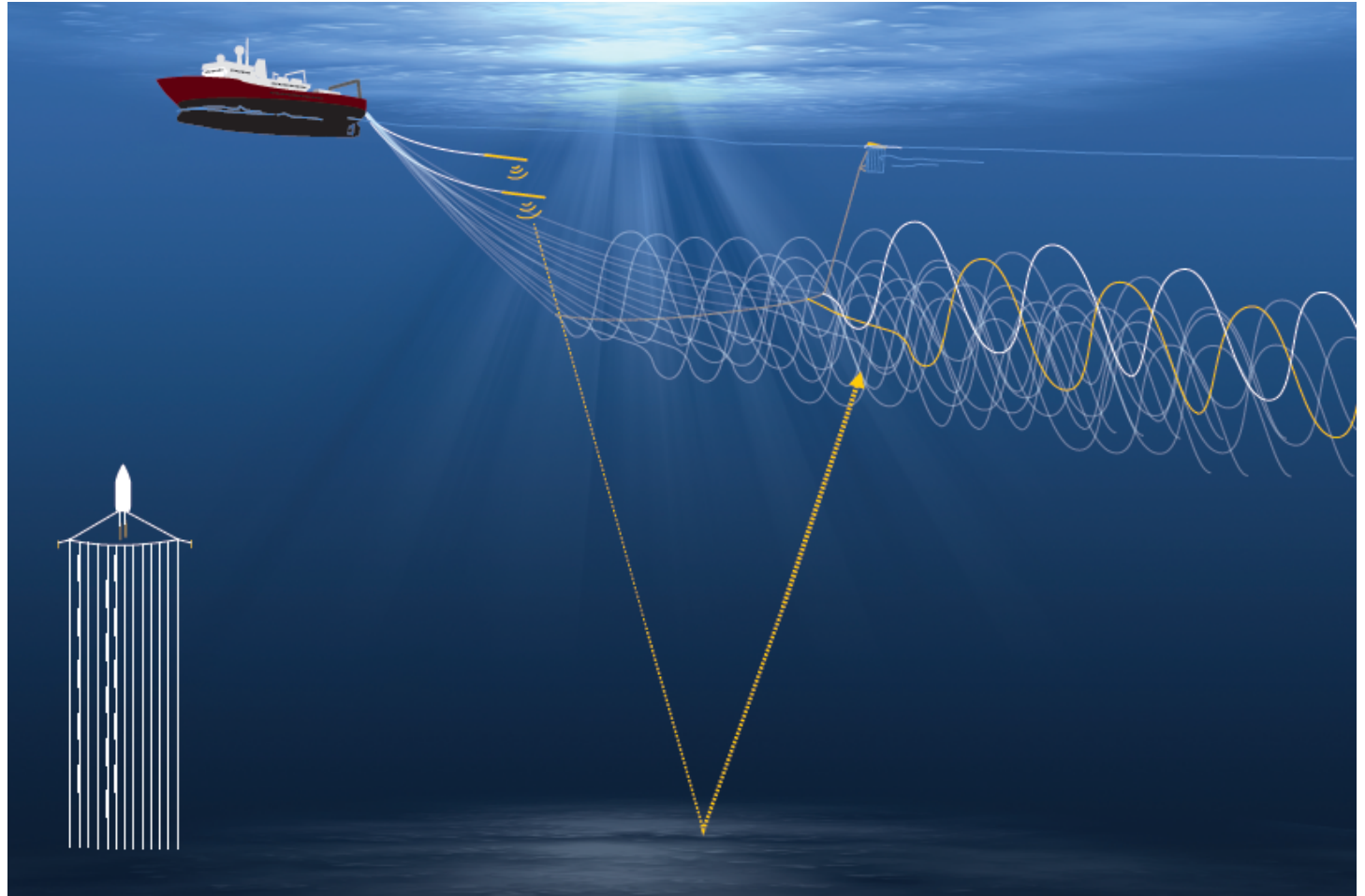
A few years ago



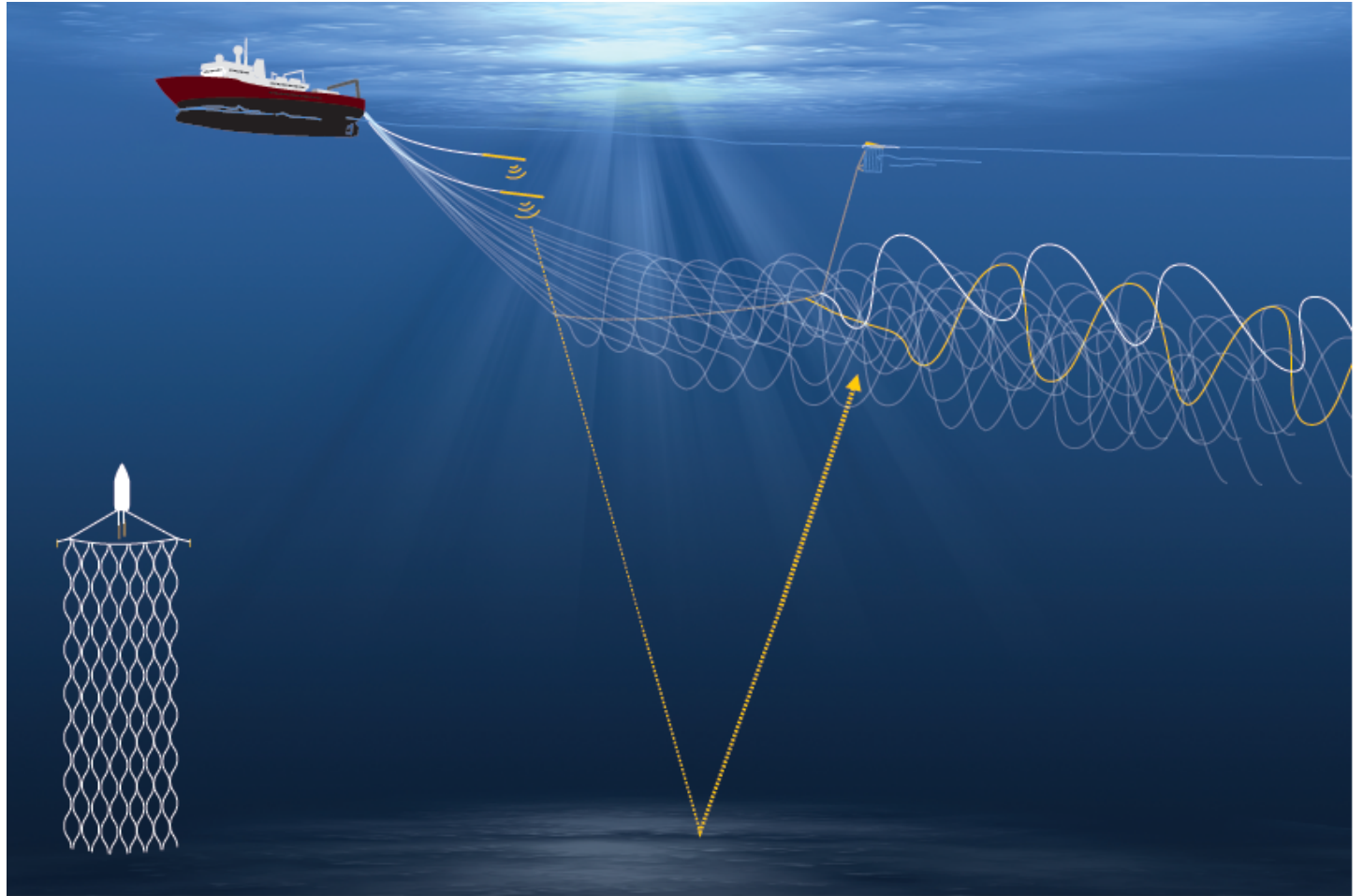
A few years ago – moving deeper and deeper



For those of us with innovative ideas

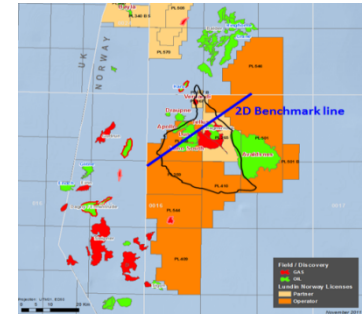



For those of us with innovative ideas – and big ...



Variable cable depth profiles – Luno Benchmark line

- Processing based deghosting works well on all configurations
- Deeper is better (for low frequencies)
- Increasing the notch diversity has merit (more is better)
- Further conclusions – to be presented at EAGE




Amsterdam '14
 Broadband for everyone – Increasing notch diversity using variable streamer profiles
Per Eivind Dheilie, Jan Erik Lie, Vidar Danielsen (Lundin) and Aslak Myklebostad (Seabird)*

