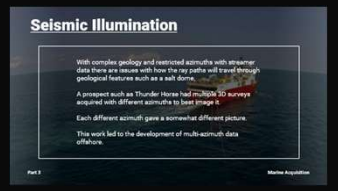
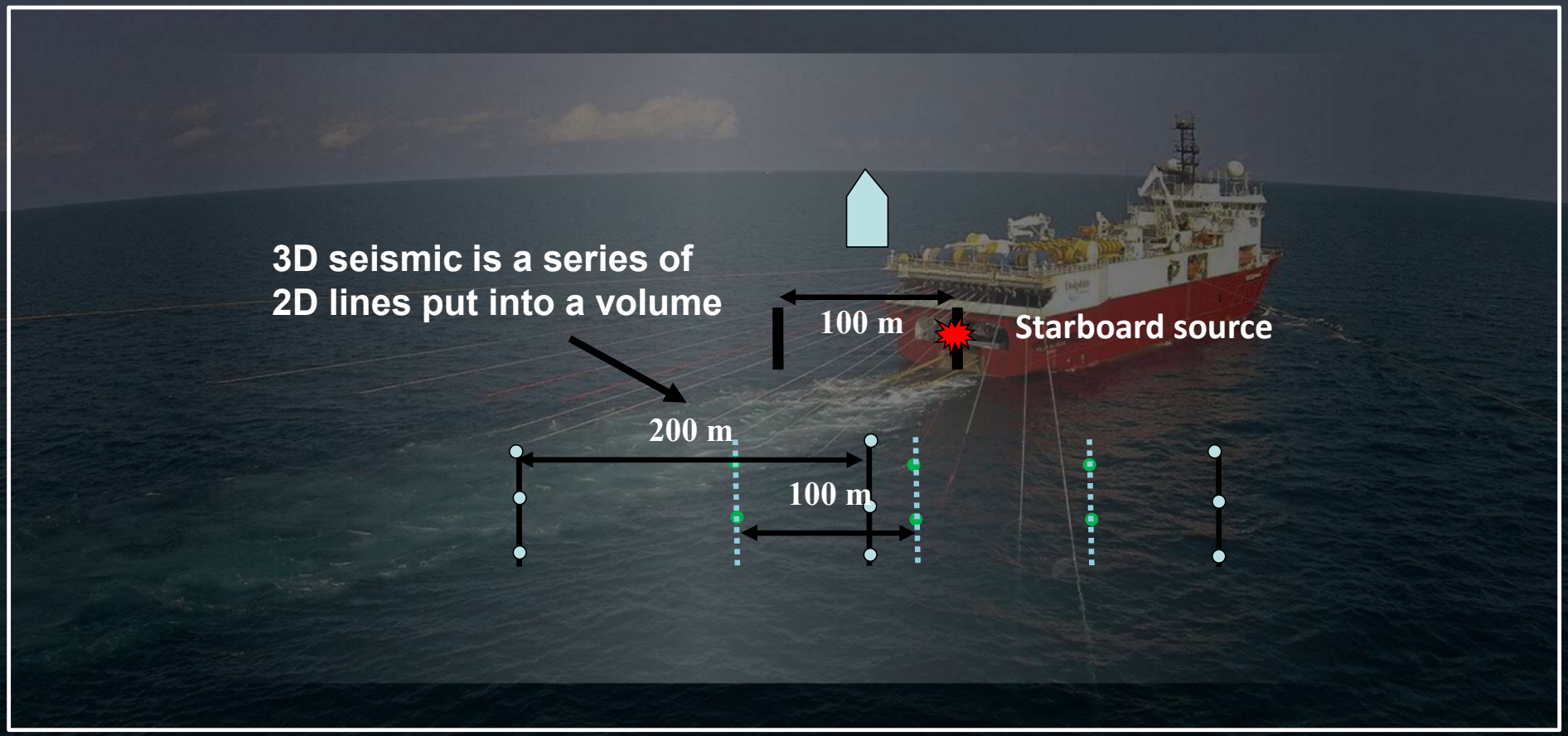
MARINE SEISMIC ACQUISITION

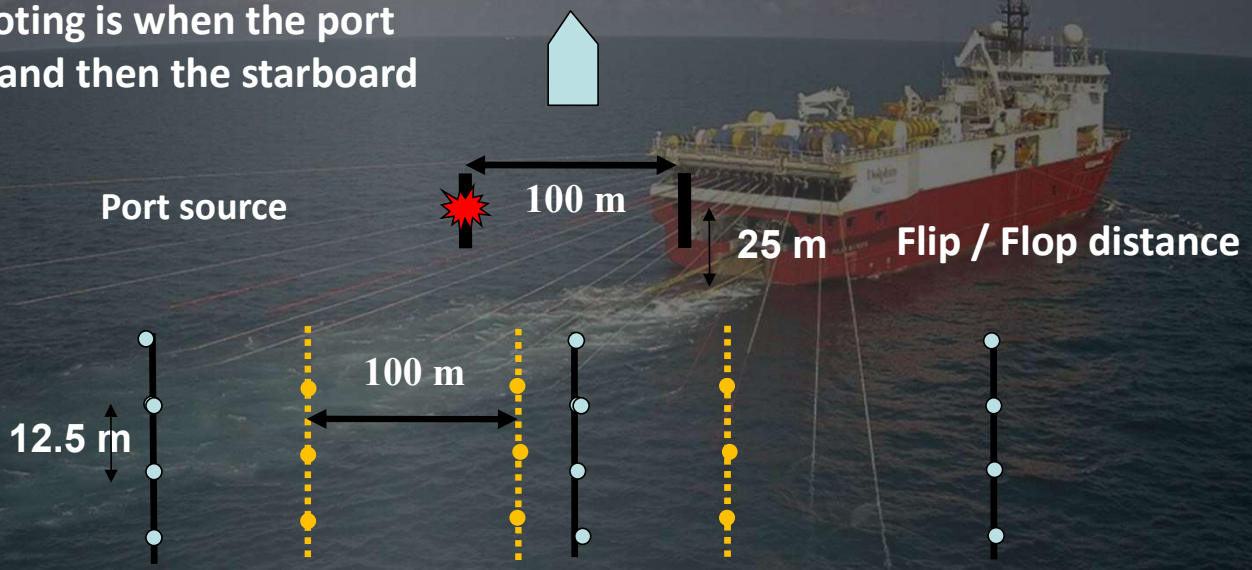


3D STREAMER

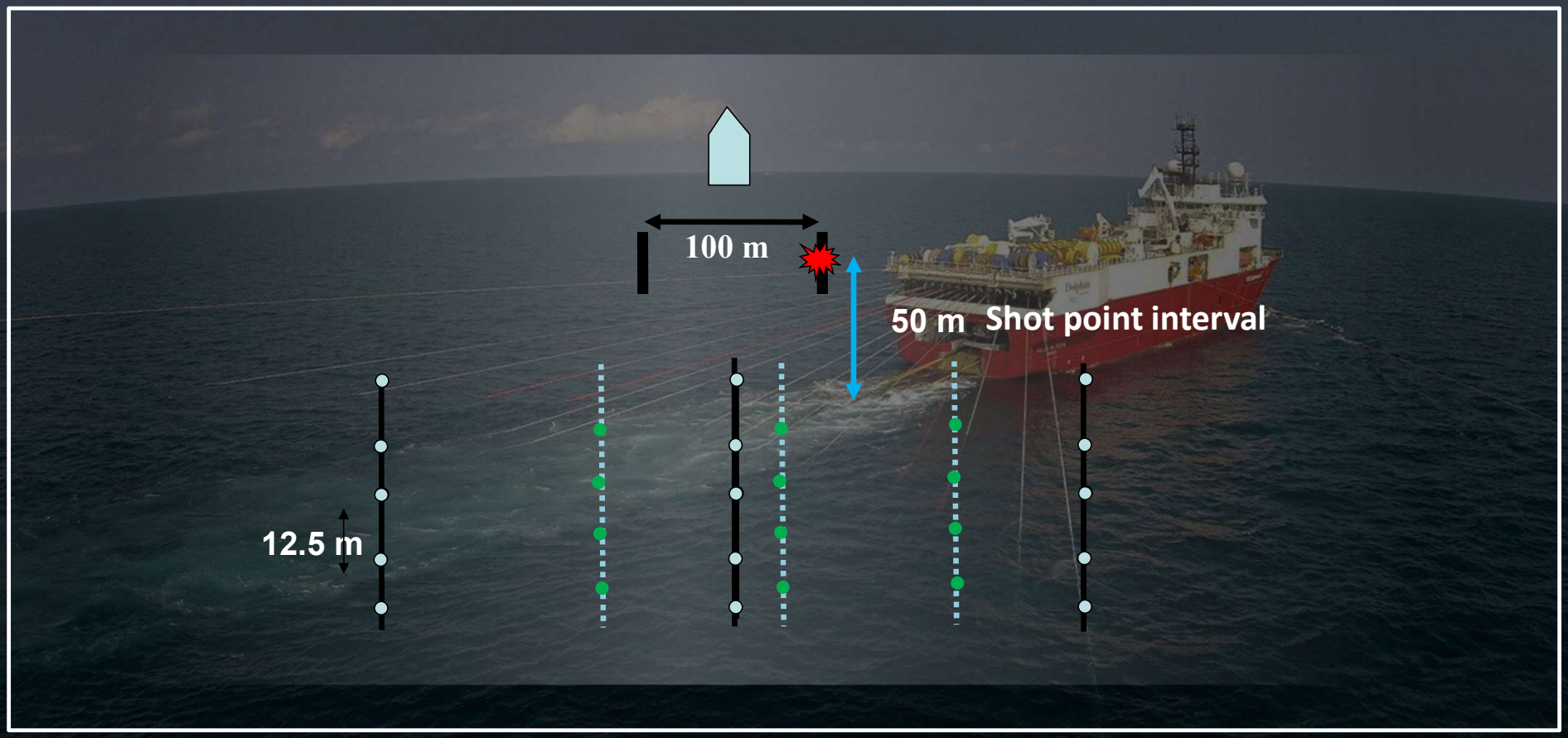

3D seismic is a series of
2D lines put into a volume
100 m
Starboard source
200 m
100 m

3D STREAMER

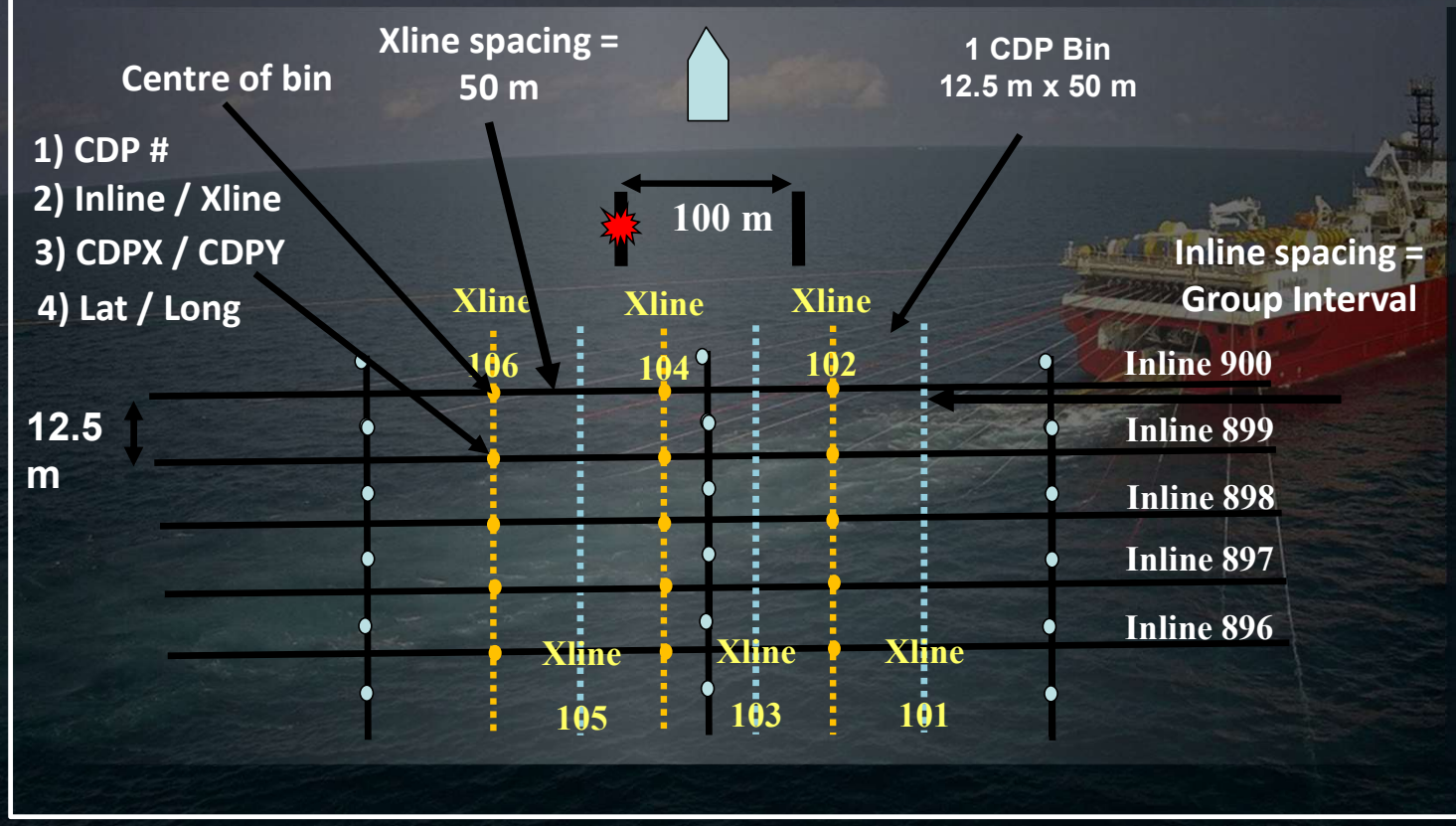
Flip Flop shooting is when the port gun goes off and then the starboard gun goes off.



3D STREAMER



3D STREAMER



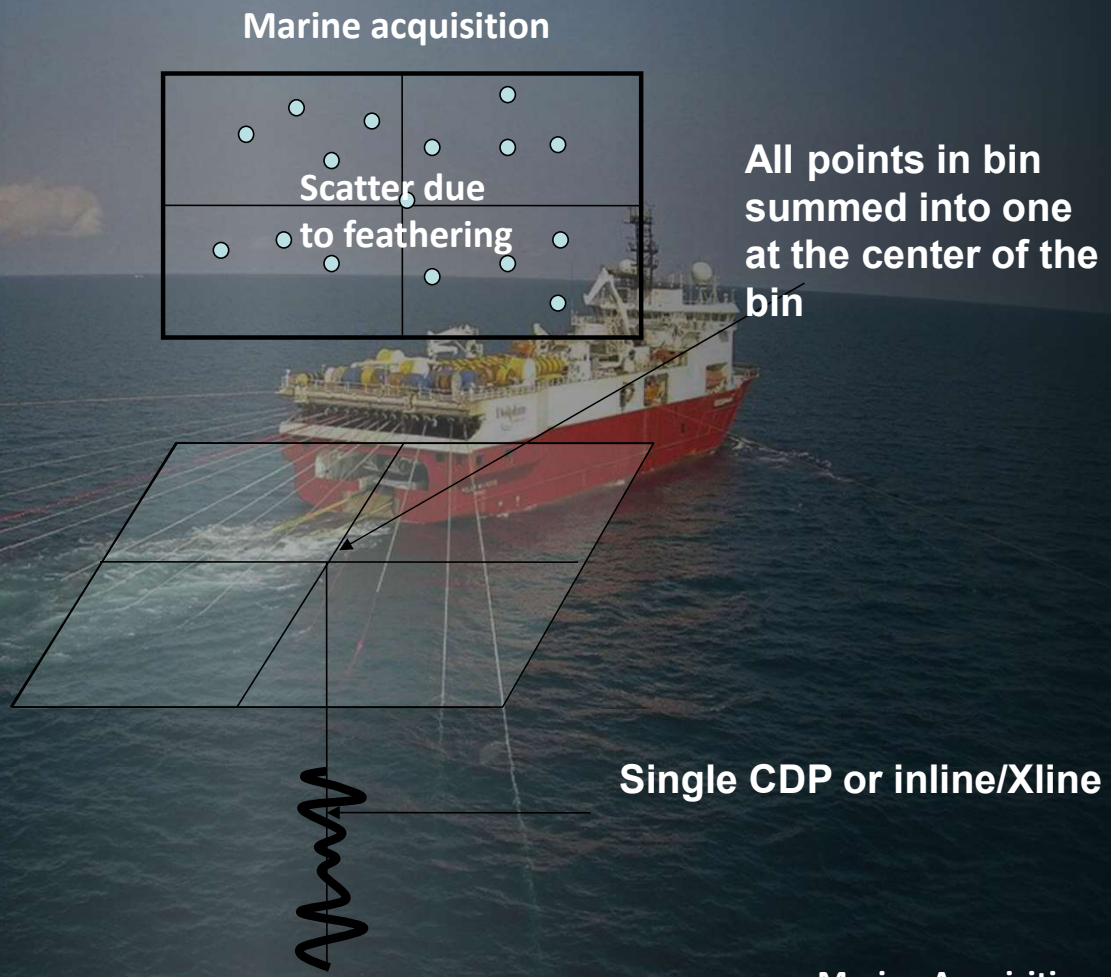
Bin – a volume where any traces that fall into small cube are stacked at the center of the cube. The center of the cube is the intersection of the xline and inline.

Inline and crosslines are determined by the marine shooting geometry and each seismic survey maybe independent of other 3D seismic surveys in an area.

CDP Bin

As shown above:

3D seismic is recorded in a grid composed of sources and streamers that create 2D CMPlines.
The CMPlines are then gridded into inlines and crosslines.
Inlines and crosslines are perpendicular to each other and where they intersect form the center of the bin.
This is the location of the stacked CDP trace.



Lat and Longs and X and Y's

Seismic is acquired in a specific survey datum and projection such as NAD 27.

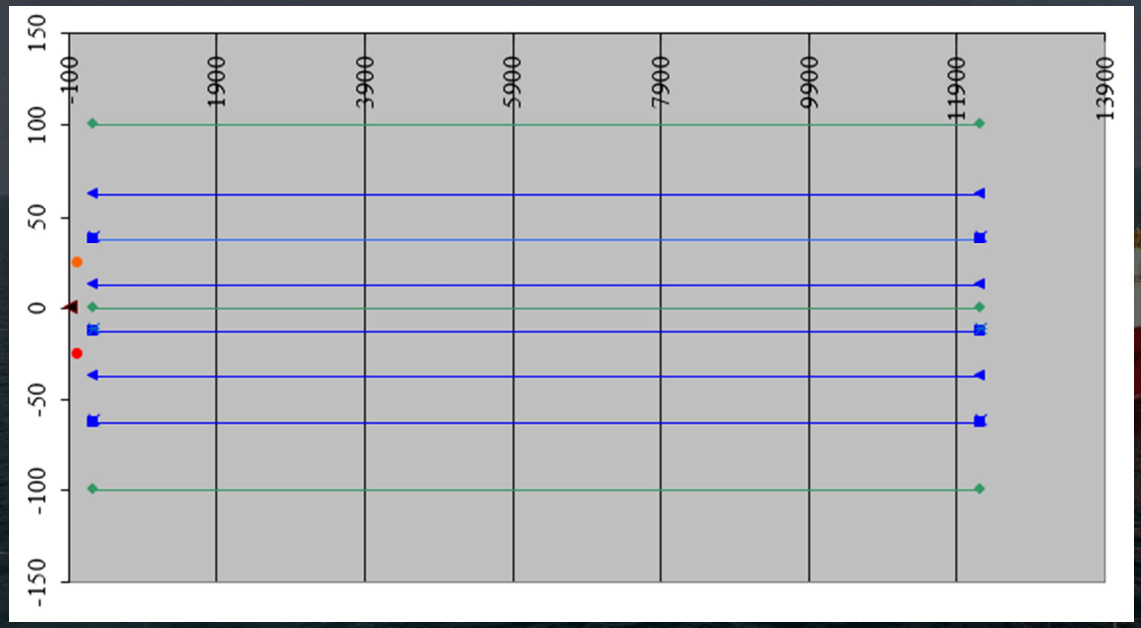
When loading the seismic data we need to ensure the seismic acquisition datum and projection match the datum and projection of the interpretation project.

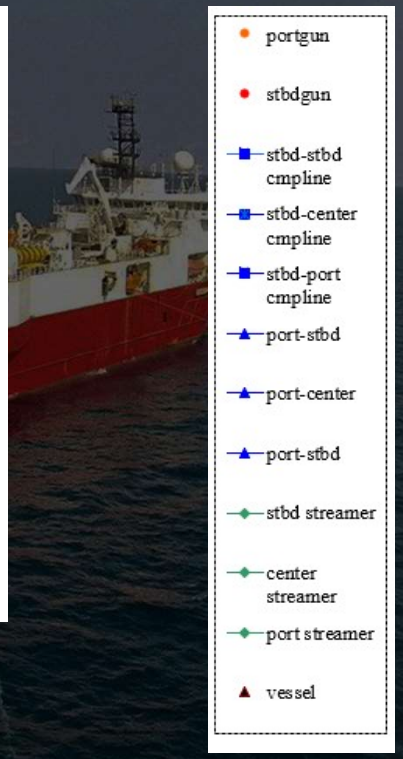
The well logs also need to have the latitude and longitude converted to the interpretation datum and projection.

We can address any point within a seismic survey by its:

1. X and Y coordinates
2. Inline and Xline
3. CDP – (some fix the CDP so it is (#inline*10000) + #xline)

Azimuth of streamer survey





Azimuth of survey
Tan θ = 125/12188
θ = 1

Azimuths very limited.

Seismic Illumination

With complex geology and restricted azimuths with streamer data there are issues with how the ray paths will travel through geological features such as a salt dome.

A prospect such as Thunder Horse had multiple 3D surveys acquired with different azimuths to best image it.

Each different azimuth gave a somewhat different picture.

This work led to the development of multi-azimuth data offshore.

Seismic Illumination

- To understand the illumination where there is complex geology well data and 2D lines or a previous 3D survey need to be utilized to do an illumination study.
- Illumination studies help us understand how ray paths will travel through salt or complex geology so the best parameters can be determined to acquire the seismic data including bin sizes.
- This involves migrating synthetic data created from the well logs and seismic records.

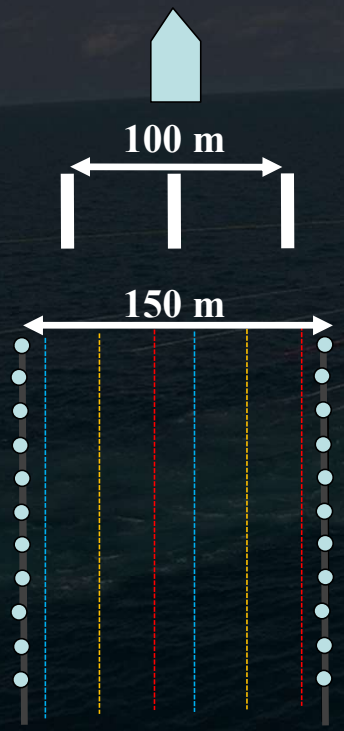
Future of Marine Seismic Acquisition

Part 3

Marine Acquisition

3D Streamer Triple source

Flip-flop-flap acquisition



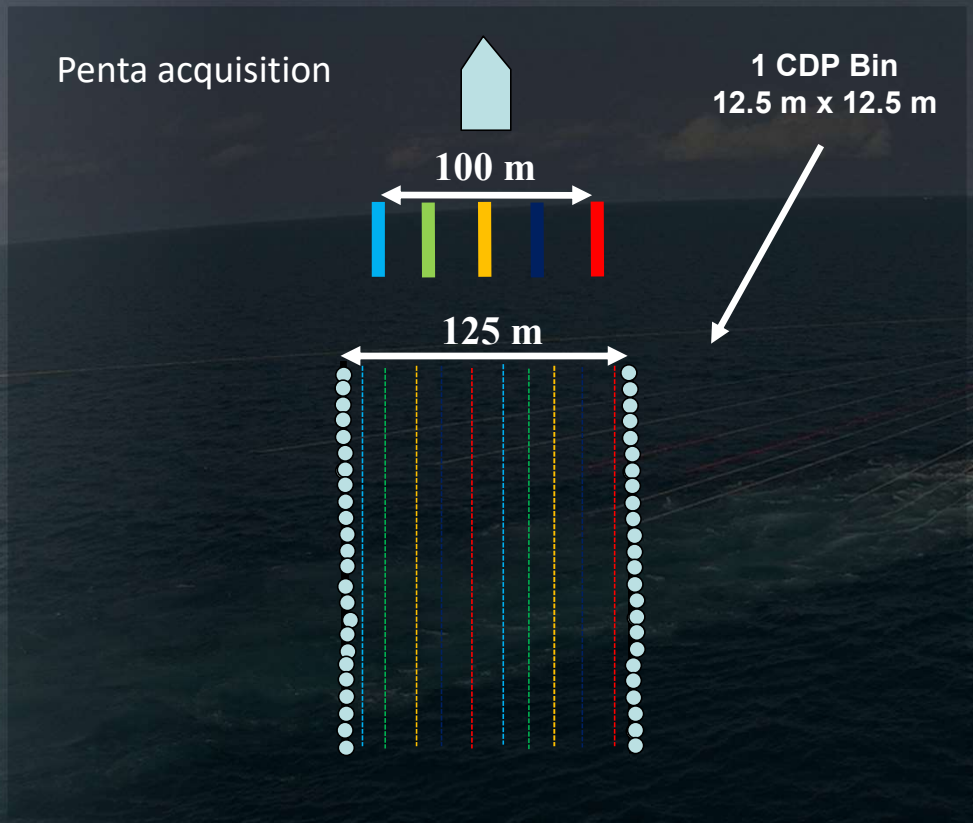
Bin size dual source 3 streamers
12.5 m x 50 m

Bin size triple source 2 streamers
12.5 m x 25 m

Crossline spacing is tighter by having 3 sources and 2 streamers. Number of CMP lines is still 6. This will produce a denser survey.

To achieve the same in-line common mid-point (CMP) fold for triple compared to dual source acquisition, shot interval must be decreased by 33%. This means a part of each shot record may include energy from the next shot which can be removed in processing.

3D Streamer Penta source



Crossline spacing is tighter by having 5 sources and 2 streamers. Number of CMP lines is now 10. This will produce a denser survey. By changing number of sources and their spacing able to change the crossline bin size.

To achieve the same in-line common mid-point (CMP) fold for penta compared to dual source acquisition, shot interval must be decreased by 80%. This means a part of each shot record may include energy from the next shot which can be removed in processing.

Steerable seismic streamers

With streamer data, the streamers are affected by ocean currents, or rivers entering the ocean which cause streamers to feather and form irregular shapes that leads to infill.

As number and length of streamers increase the necessity to maintain tight, uniform positioning increases to maintain the fold.

Steerable streamers increase productivity and reduce costs by reducing the amount of infill.

For a typical 3D seismic survey, infill shooting may account for as much as 25% or more of the total cost of prime line seismic acquisition.

With steerable streamers now using the size of Fresnel Zone, which is a function of offset, angle of incidence, frequency content and depth to set the steering tolerances for streamers during acquisition. This further minimizes amount of infill required in a marine streamer survey.

Multiple Azimuths with streamer data

Wide azimuths means we are sampling the structure in the earth in 360 degrees which allows us to illuminate structures better.

There are 2 ways to do it with streamer data

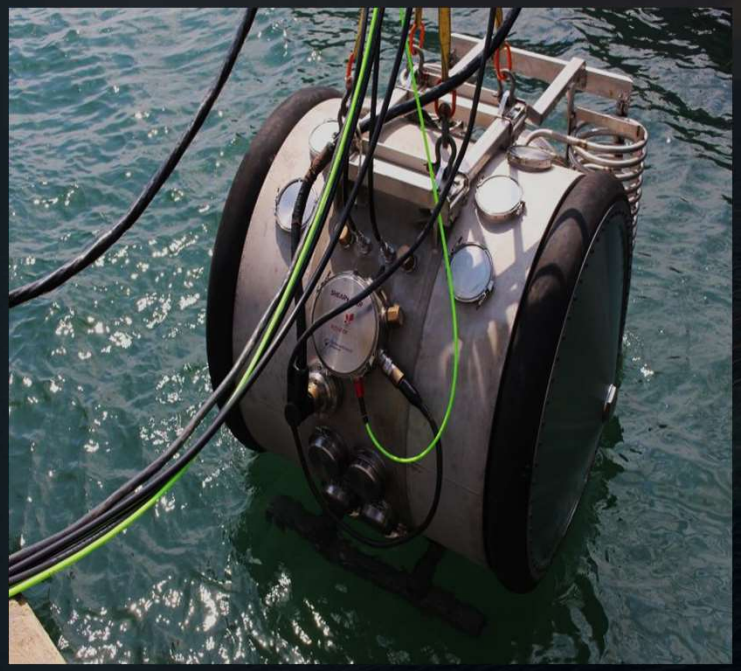
- Acquire multiple streamer data over an area
- Multi-boat acquisition

MARINE VIBRATOR

Marine vibrator was first tested in recording seismic data in North America, on a Geco-Prakla Schlumberger transitional zone test line back in 1992.

The problem was penetration of signal into the ground. The signal was very good in the shallow section but was attenuated in the deeper section due to the fact we had only one Marine Vibrator.

MARINE VIBRATOR



- Less environmental impact.
- Interest in marine vibrators because of the ultra-low frequency potential in the 2-6 Hz frequency range: Beneficial for FWI, elastic impedance inversion, and deep signal penetration.
- To achieve low frequencies marine vibrators will have to operate at large depths (60-120 m) for the source ghost effect to be optimized for ultra-low frequency generation.
- Marine vibrator system can potentially reduce the acquisition time and the overall survey cost especially in utilizing deblending in seismic processing.

DEBLENDING

Part 3

Marine Acquisition

DEBLENDING

Simultaneous-source acquisition is an efficient method to save costs in marine acquisition by allowing multiple sources to operate simultaneously. However, it introduces challenges due to crosstalk interference in the recorded seismic data.
Please talk with your processor on how they do it.

There are different techniques to do this such as:

01 Iterative Deblending with Coherency-Pass Shaping Operator.

02 Structure-Oriented Space Deblending

03 Filtering and Sparse Inversion Methods.

04 Robust Deblending with Signal Preservation.

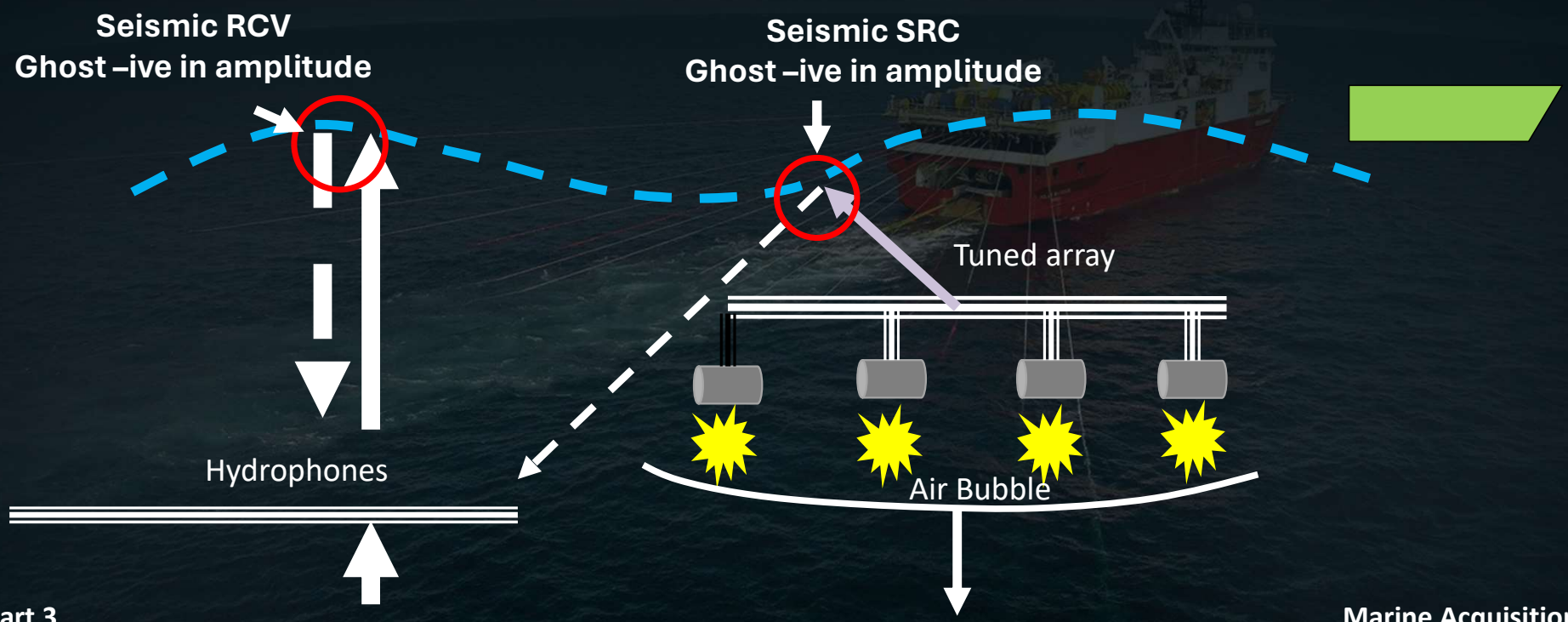
Ghosting in Marine Acquisition

Part 3

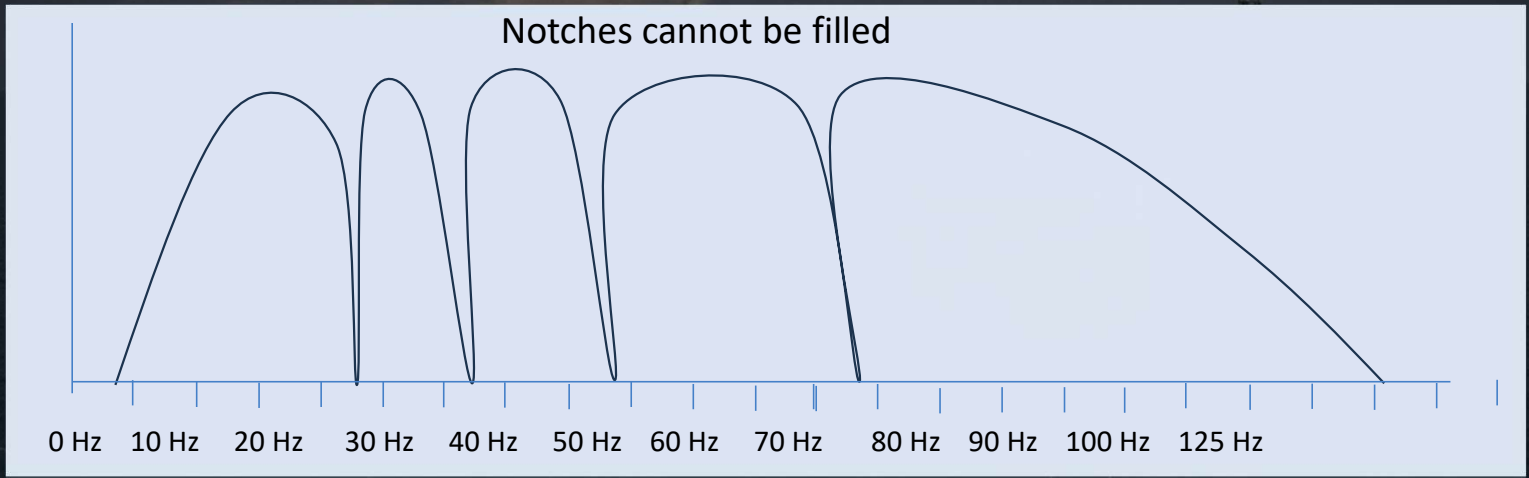
Marine Acquisition

GHOSTS

Ghosts have a slight delay due to being reflections off the surface with the resulting interference can be either constructive or destructive for different wavelengths creating notches in the frequency spectrum which reduces the resolution.



Effect of source ghost are frequency notches



Source depth (z) is 6 m
The speed of sound (v) in sea water is about 1500 m/s
The notches occur at f=Vw/2D
Source ghost notches occur at 125 Hz, 63 Hz, 43 Hz, 31 Hz, 21 Hz….

Depth of the air gun arrays determine frequency content (Broad band source)

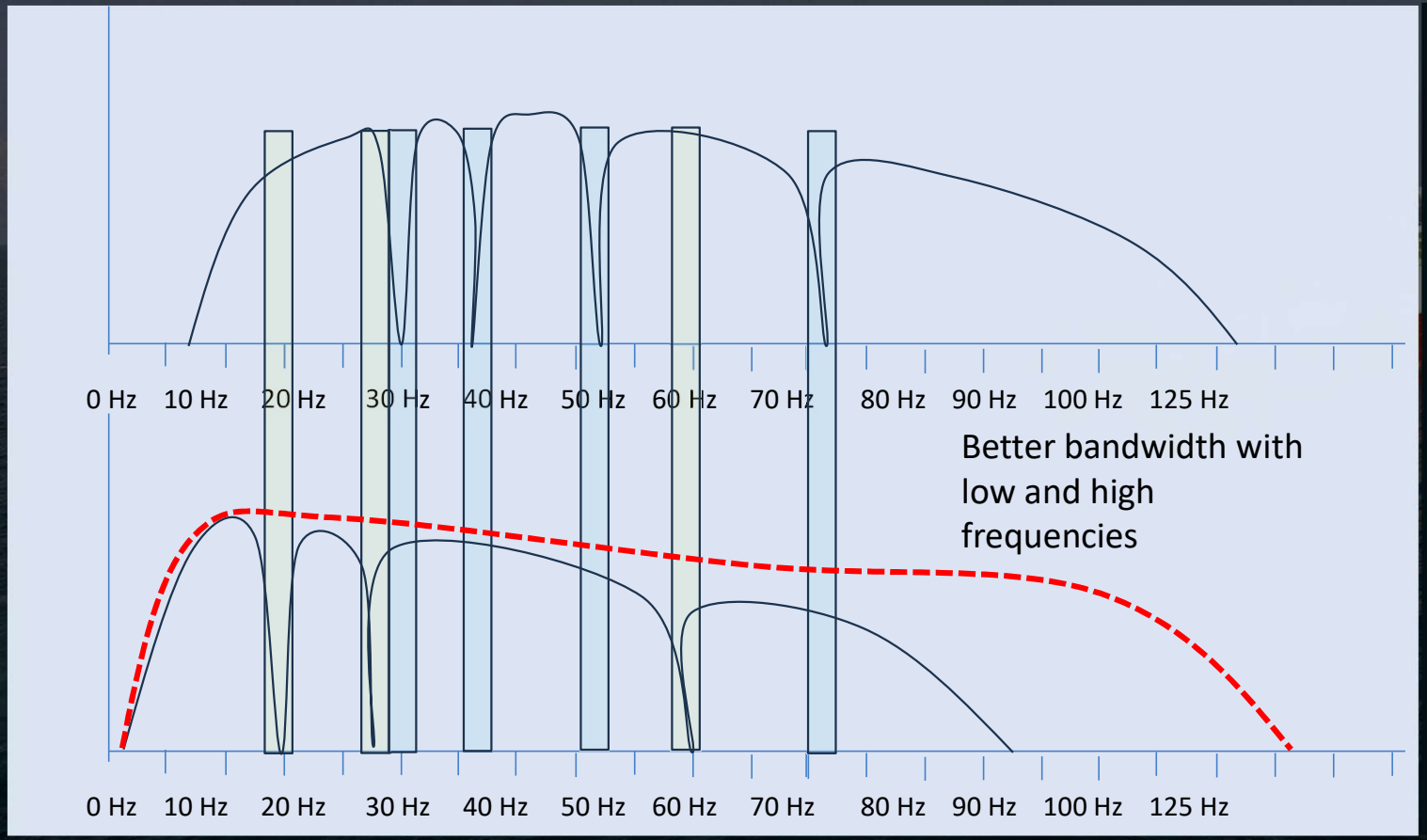
Source depth influences the frequency band of seismic data.

Shallow source provides improved high frequency content at the cost of degraded low frequency content due to the ghosting effect.

Due to the source ghost effect, it is advantageous to deploy the sources deep to enhance the low frequency content of seismic data, but deep sources reduce the seismic bandwidth.

Solution to the challenge of extending the bandwidth both on the low and high frequency side is to deploy over/under sources, where sources are towed at two depths.

What happens when 2 sources are used



When 2 sources are summed together it fills the notches providing continuous frequencies without notches with the shallower source has higher frequencies and deeper source lower frequencies.

Effect of receiver ghosts are frequency notches

Receiver depth (z) = 8m
The speed of sound (v) in sea water = 1500m/s
The notches occur at
f = Vw/2D

Receiver ghost notches occur at 94 Hz, 47 Hz, 31 Hz, 23 Hz….

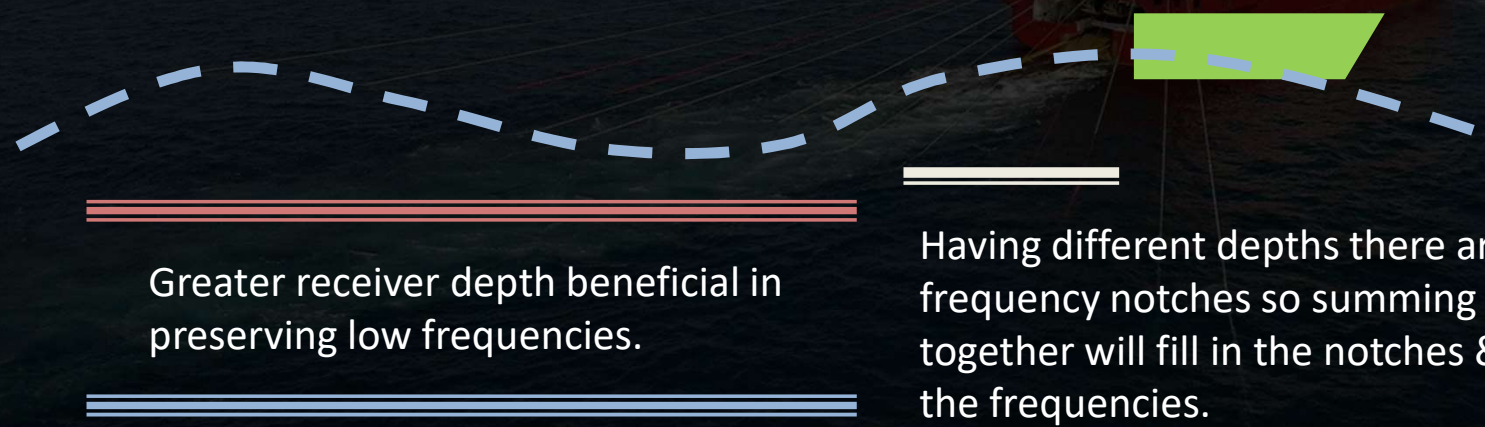
In conventional acquisition, the streamer was towed close to the sea surface, so the first ghost notch occurs beyond the desired high frequency range, but this results in attenuation of lower frequencies

With streamer depth there is a trade-off between low and high frequencies.

DEGHOSTING

Result of source and receiver ghosts are reduction in bandwidth and therefore reduction in the vertical and horizontal resolution.

There are acquisition techniques such as over/under streamer where there can be separation between the up going wave and the down going wave and allow deghosting of the data in processing.



Greater receiver depth beneficial in preserving low frequencies.

Having different depths there are different frequency notches so summing the two together will fill in the notches & broaden the frequencies.

Goal of Marine Seismic Acquisition

Lower the cost by reducing the time it takes to acquire the data.

Obtain data without any frequency notches present.

Acquire long offsets for AVO and seismic inversion. Class 1 and 2 AVOs better illuminated wit long offsets.

Have better bandwidth in the data with low frequencies especially important for Full Waveform Inversion (FWI) and to reduce sidelobes that tend to hide thin beds.

Acquire azimuthal data to improve imaging and to look at azimuthal attributes.

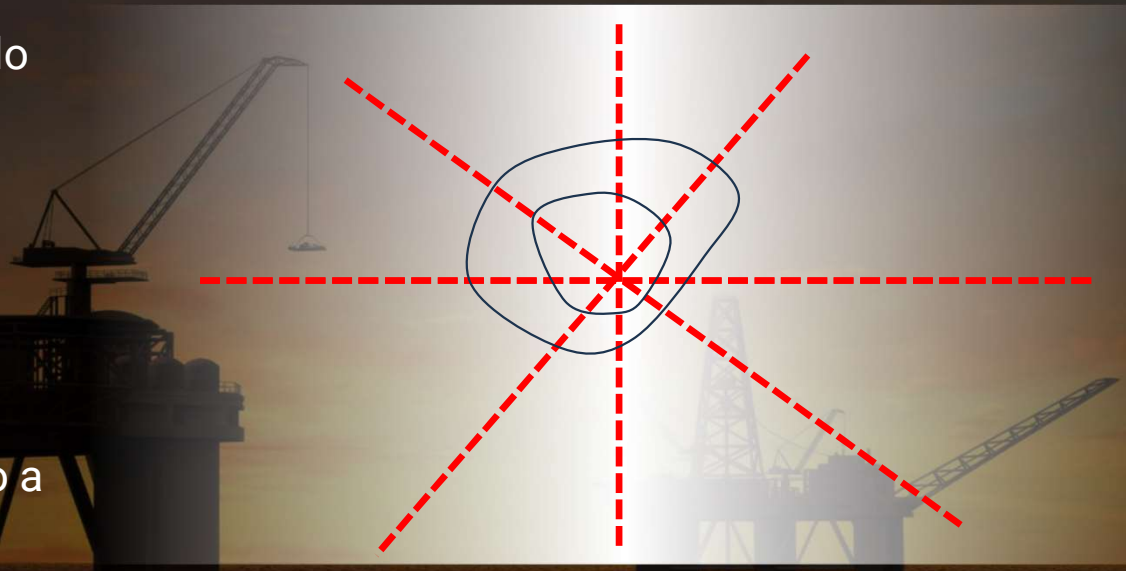
Offshore Carbon Capture Sequester

Part 3

Marine Acquisition

Offshore Carbon Capture Sequester

With OCCS they are looking at repurposing GoM platforms. To do this it will involve collaboration from members of industry, government agencies and regulatory bodies, academic institutions, and technology companies and specialists.
Like onshore CCS, DAS, and the marine vibrator can be used to do a Walk-away VSPs to monitor the CO_2 plumes growth at the injection wells; and b) to demonstrate containment and conformance as per project expectations.



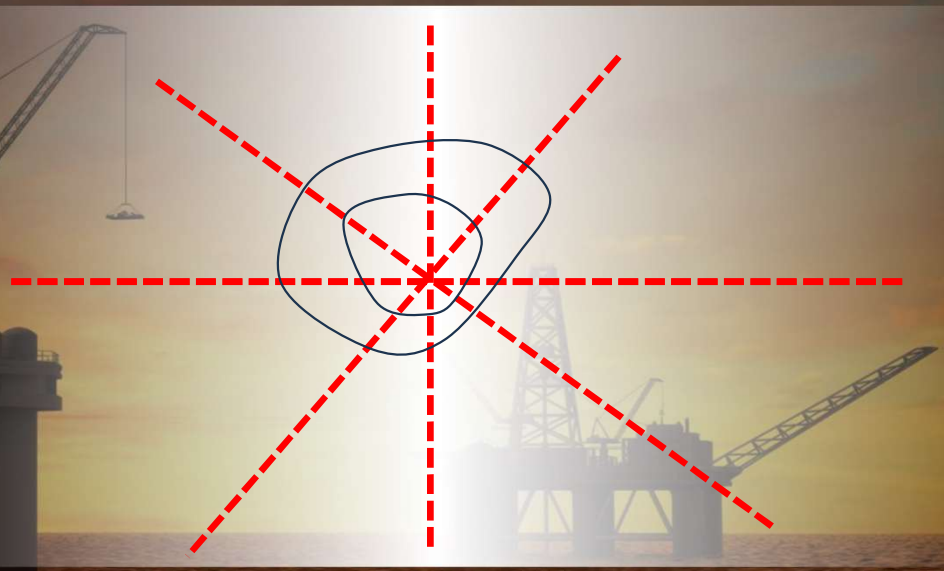
VSPs are expected to be an effective monitoring tool some 5 years into the project, up to plume sizes of about 500m radius

Why VSPs for OCCS

Fluid flow tends not to be visible on surface seismic data and the VSP helps to understand compartmentalization and fluid continuity within the aquifer.

It is important to do pre-survey modelling to achieve the VSP objectives.

An acoustic rock model can demonstrate the time-lapse seismic response to CO2 injection into a saline aquifer.



PART 4
WILL BE ON

- OBC acquisition, shear wave and geomodelling, reservoir simulation and 4D seismic.
- It will show the relationship between geomodelling, reservoir simulations and 4D seismic.


THANK-YOU!!!