# 2D Seismic Acquisition Undershoot : 2D Seismic OBN PHE WMO Case Study

**Yukha Ariadmana[1], Agung Ardiyanto[2] , Ferdy[3] , Husein Asy'ari[4], Rizqi Wahyu Nurcahyo[5]**
[1,2,3] *PT. Pertamina Hulu Energi WMO,* [4,5] *PT Elnusa Tbk*
a) yukha.ariadmana@pertamina.com b) agung.ardiyanto@pertamina.com c) ferdy.phe@pertamina.com
d) husein@elnusa.co.id e) rizqi.wahyu@elnusa.co.id

**Abstract**

In mapping the subsurface structure of the earth, is a challenge in seismic survey operations. One of the challenges in the transition area in the 2D seismic survey PHE WMO is silting up to a depth of 1 meter on the northwest side of the survey area.

Bathymetric data shows that in the northwest area of the survey, the depth of the seabed is shallow up to 1 meter in the transition zone so that the vibration source using only gun boat cannot pass that depth because the draft of the ship is only able to pass a depth of 3 meters. While the receiver used is nodal with a very flexible ability to the environment, both land and sea.

In order to maintain data in the prospect zone area on the northwest side of the survey, the source line on the northwest side is offset or shifted to a depth of more than 3 meters where the seismic source (air gun) on the gun boat can still pass through. This method is known as undershoot, which is doing 2D seismic data acquisition where the source line and receiver line are not in the same line, resulting in a CDP that is not right under the acquisition line. The effectiveness of this method is quite capable of maintaining full fold coverage and describes a good layer to be interpreted starting from the shallowest depth of about 700 miliseconds.

**Keywords**: *Seismic data acquisition, silting, undershoot*

## 1. Introduction

To support exploration activities in finding oil and gas reserves, the right techniques and methods are needed in the exploration process. 2D seismic data acquisition of Pertamina Hulu Energi West Madura Offshore OBN is one of the exploration activities in searching for seismic data to map the subsurface of the earth in transition areas with vibration sources using only an air gun with a Z100 nodal receiver. Acquisition conditions in the transition area have their own challenges in terms of operational aspects. In addition to conditions from the surface aspect, such as fishing activities, muoring buoys, and platforms, there are also conditions from the subsurface that must be watched out for, such as silting areas, pipelines, and old wells.

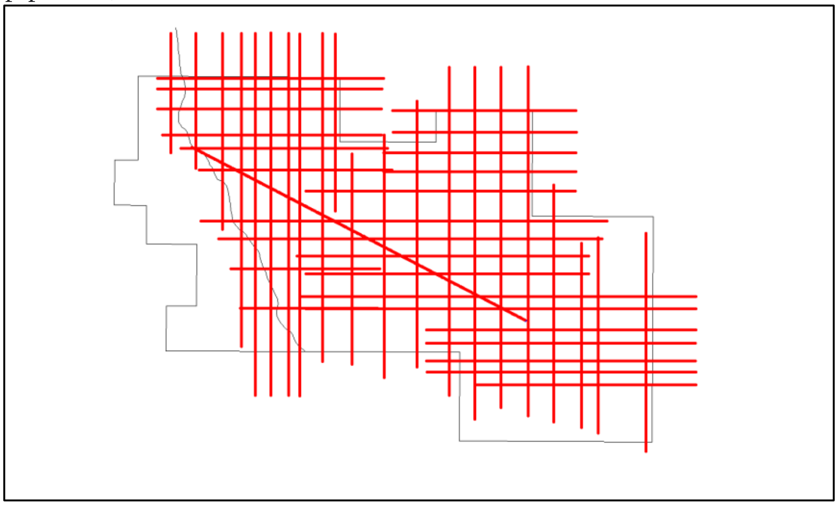


**Figure 1.** 2D Seismic design acquisition PHE WMO

The total 2D line in this 2D seismic data acquisition PHE WMO are 46 lines, with a total of 21 vertical lines, 24 horizontal lines, and 1 diagonal line (Figure 1). Before to carrying out data acquisition operations, a bathymetric survey was conducted to map the subsurface conditions of the survey area throughout the track and obtained a depth variation of 1 m to 46 m spread over the boundaries of the survey area. On the northwest side, the bathymetry data was found to be shallow, causing the potential for data recording to be impossible, due to the limited draft of the gun boat.

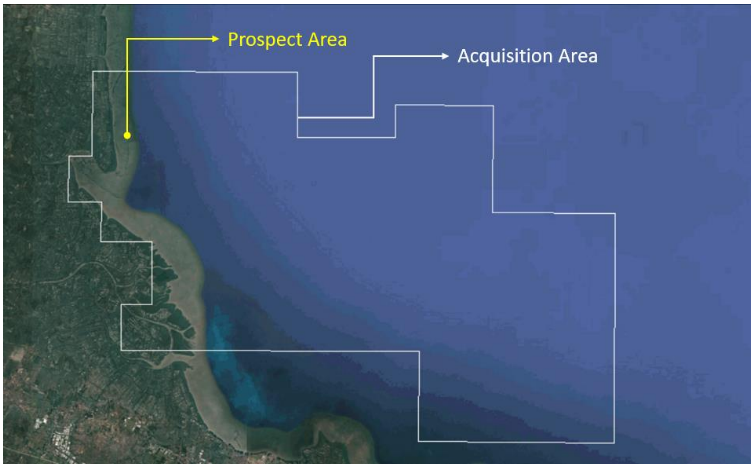



**Figure 2.** Prospect Area 2D seismic acquisition PHE WMO

One of the main prospects in this area is on the northwest side of the boundary (Figure 2) with a plio-pleistocence target where on the surface is a seismic line with a north-south direction to describe it. In this line, the receiver layout can still be positioned in the original position, while for the shot point layout it is not possible because the area is shallow so that it is shifted away from the silting area so that the gun boat can operate. The acquisition method in this way is called the undershooting geometry method, which is a method for obtaining seismic data with the shot point layout and receiver not being in one inline due to an obstacle (OGP, 2011). If this is not done, then important data that is in the main lead area will not be able to be obtained.

## 2. Data and Methodology

### *2.1. Bathymetric Result*

From the bathymetric results, it is found that in the northwest area of the boundary there is a depth that silting up to a depth of 1 meter as shown in Figure 3 with a white border. At this depth there is one vertical acqusition line, namely line 01 which cannot be acquired, because the draft of the gun boat can only reach a depth of 3 meters.

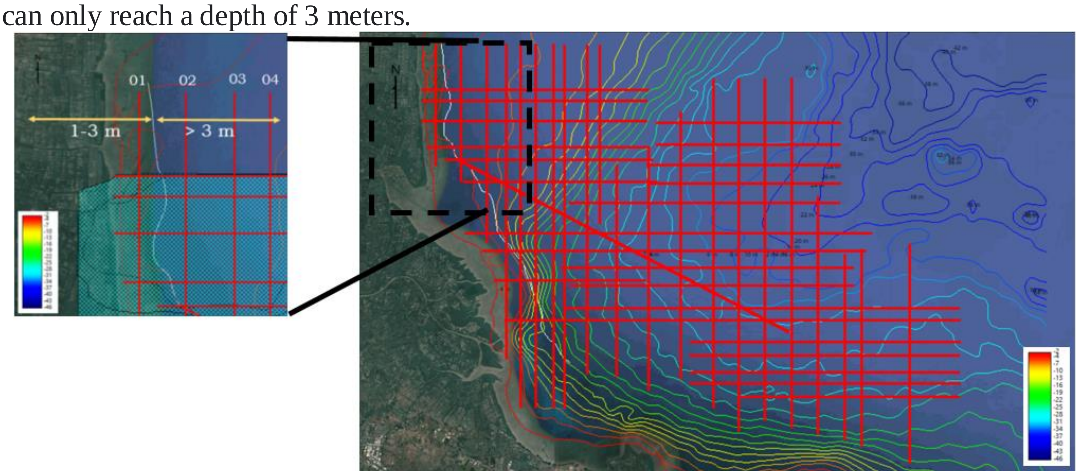



**Figure 3.** Bathymetric data

Figure 3 (left) shows that the acquisition line is at a depth of 1 to 3 meters which is having siltation. The position of the receiver will not be a problem because of the flexibility of the nodal system to the land, sea or in-between environment. As for the shot point position, at a depth of 1 to 3 meters the gun boat will not be able to pass it apart from the draft of the ship, the gun depth position is around 2.5 meters from the water surface.

### *2.2. Undershooting method*

The undershooting method is a seismic acquisition technique used to describe the subsurface caused by obstruction (OGP, 2011). In this method, the receiver position is in a shallow area while the shot point position is offset by 1.1 km from the normal line position towards the sea. The position of the receiver line and the position of the source line are not in the same line, while the normal 2D seismic data acquisition, the position of the source line and the receiver line are in the same line.

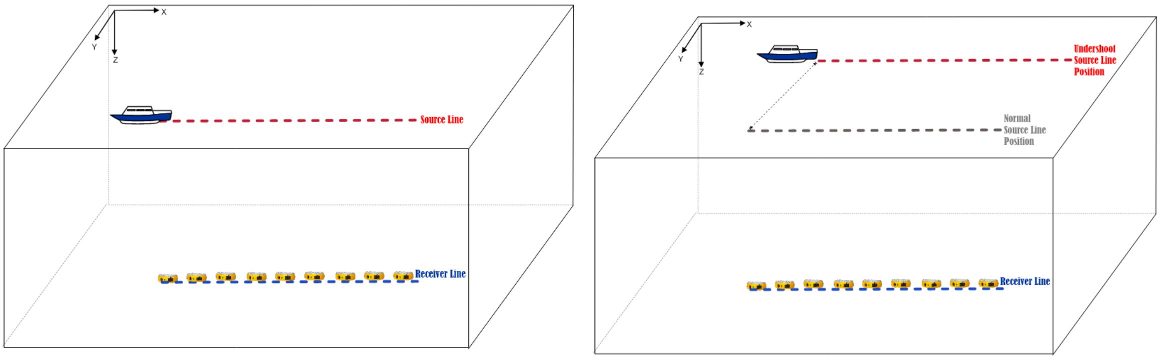



**Figure 4.** Normal seismic data acquisition method (left) and Undershoot seismic data acquisition method (right)

Figure 4 shows a schematic of the normal 2D seismic data acquisition geometry versus the acquisition geometry using the undershooting method. In principle, this method can facilitate acquisition so that data in shallow areas does not data loss because all shot points can be recorded, but the side effect of this undershooting method will be a little data loss at near offset (shallow targets) (Sano et al, 2020).

The fold simulation with the undershooting method is maintained by showing a value of 200. While the CDP position is not right on the original line acquisition, but shifted and is still in the subsurface target zone in the Plio-Pleistocene (Figure 5).

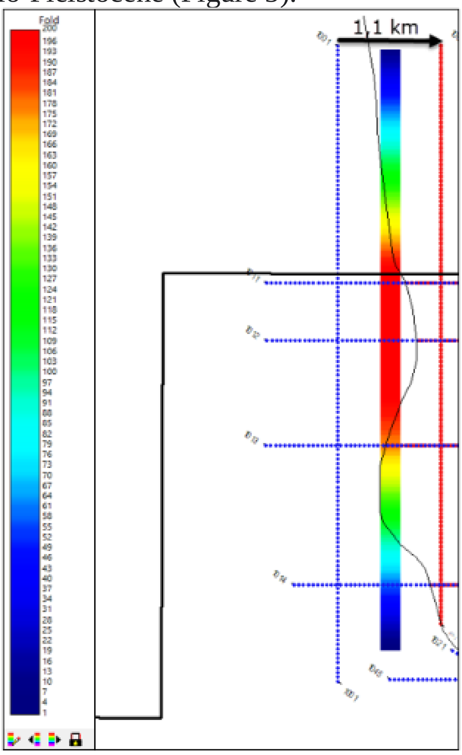



**Figure 5.** Fold coverage simulation undershoot method with mesa software

### *2.3. 2D Seismic Operation*

Small draft vessels are still required to position the nodal receiver. while for the shot point, a shift of 1.1 km is made from the normal position of the line which is already out of the depth area that is having silting. So that the acquisition operation in this case uses a sea truck ship for nodal deployment and a gun boat ship to record data. In table 01 below are the acquisition parameters for 2D seismic PHE WMO.

**Table 1.** Seismic data acquisition parameters

| | |
|---|---|
| Type of source | Air Gun |
| Shot point interval | 25 meter |
| Gun depth | 2,5 meter & 6 meter |
| Volume air gun | 960 cuin & 2730 cuin |
| Type of receiver | Far field Nodal Z100 |
| Receiver interval | 50 meter |
| Total length full fold | 461 km |
| CDP | 25 m |
| Active channels | 200 channels |
| Pola bentangan | Symetrical split spread |
| Low/High cut filter | Out 1/250 Hz |
| Record length | 9 second |
| Tape format | SEGY receiver gather |
| Sampling rate | 2 milisecond |
| Polarity | Normal (SEG standard) |

The volume of 960 cuin is used for the water depth area of less than 15 meters and the volume of 2730 cuin for the rest using two different gun boats. Then for the operation of the receiver node using AHTS type vessels for depths of more than 10 meters and sea trucks for shallower depths.

The gun boat scheme can be seen in Figure 6 where the air gun is towed under the water surface to a depth of 2.5 meters from the surface. This is not safe if data is recorded in a shallow area because the position of the air gun will touch the seabed in a shallow area.

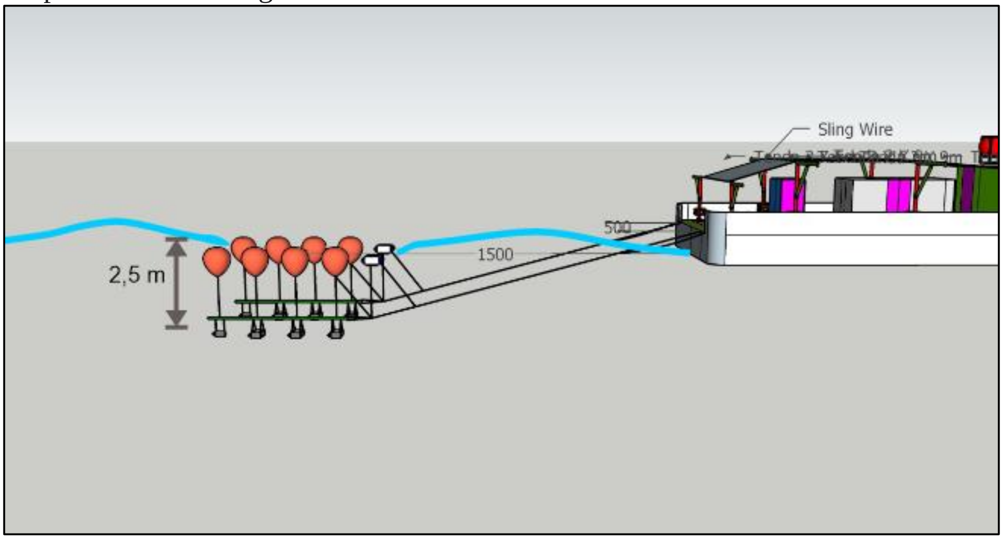



**Figure 6.** Air gun array schematic on gun boat

Operational constraints other than silting are massive fishing activities, so it is necessary to escort gun boats while operating. Figure 7 is the shooting direction when using the undershoot method. From the picture, the position of line 01 is the last line sequence and it can be seen that the maneuver of the ship when it will enter the line 01 area is very close to the silting area so that it turns slightly away from the silting area.

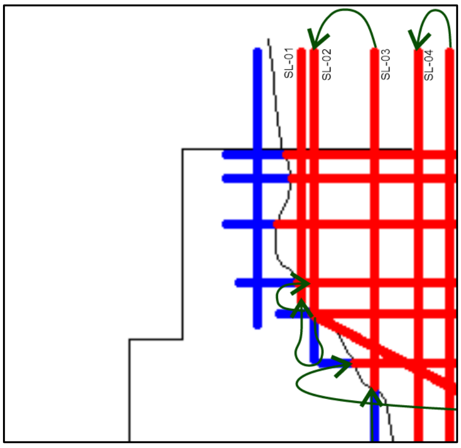



**Figure 7.** Shooting direction line 01

When the position of the ship will approach the line destination, the ship will position the gun position at the coordinates that have been shifted. With such conditions, the position of the shot point that is closed to the shallow area can still be recorded according to the theoretical point of the seismic data acquisition design from the parameters that have been set. Figure 8 below is the shooting direction and sequence of all lines of seismic data acquisition in the PHE WMO area.

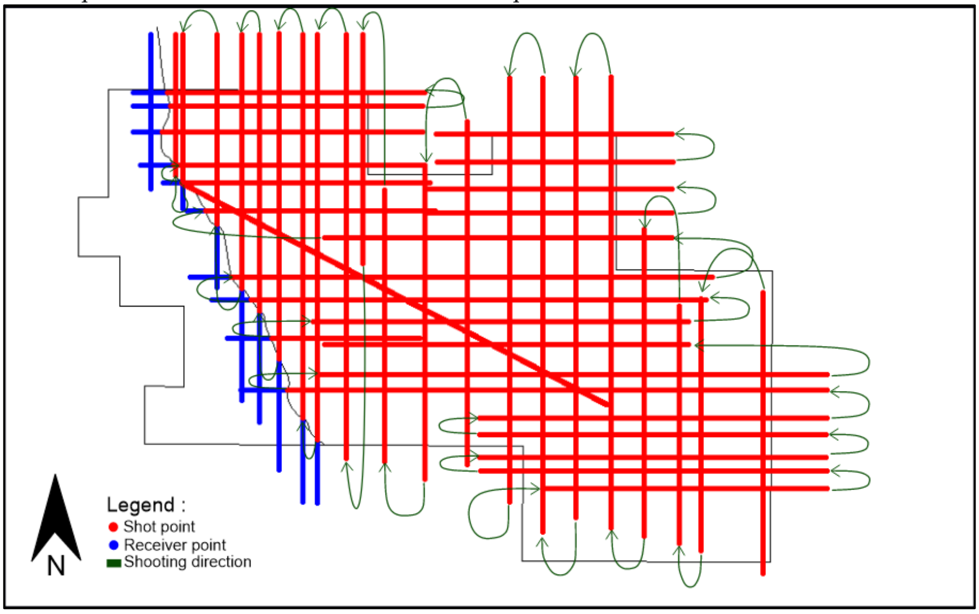



**Figure 8.** Shooting direction all line acquisition

Differences in seismic data acquisition operations with normal acquisition and undershoot methods are shown in Figure 9 and Figure 10. For the normal method of acquisition, the source line and receiver line layouts are in one inline shown in Figure 9, while for the undershoot method, the source line and receiver line layouts are not in one inline as shown in Figure 10.

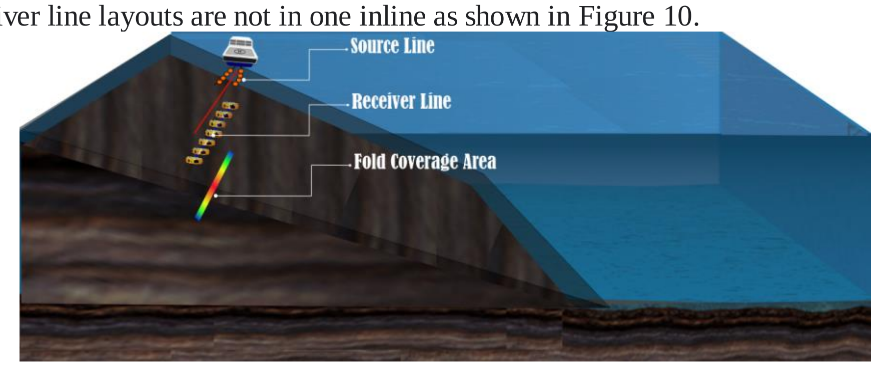



**Figure 9.** Seismic data acquisition with normal acquisition method

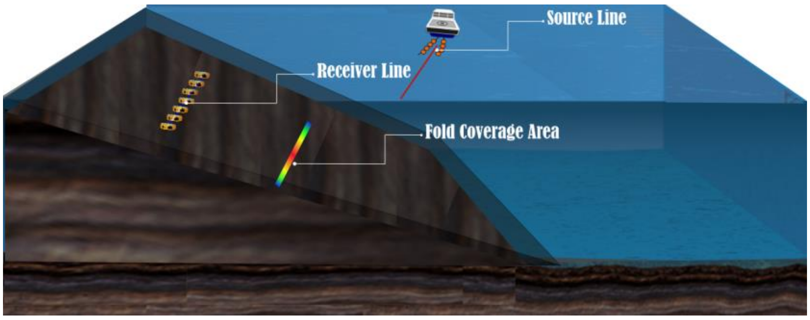



**Figure 10.** Seismic data acquisition with undershoot method

The Figure shows that the receiver line layout is still in a shallow position, while the shot point layout is shifted away from the shallow area. This operation can be said to be more effective when dealing with seismic data acquisition in the transition area if it experiences siltation than using other methods, for example using a seismic catamaran can be seen in Figure 11. If use the seismic catamaran, then from the operation side there will be additional costs, such as the cost of using the vibration source becomes explosive and the cost of catamaran crew and the cost of the catamaran equipment.

**Figure 11.** Seismic drilling with catamaran equipment in transition zone

## 3. Results and Discussion

The results of the fold coverage simulation before and after the shot point shift on line 01 in the silting area can be seen in Figure 12. The fold coverage before the shift is obtained just below the acquisition line position, while the fold coverage data after the shot point is shifted 1.1 km away from the normal line is at a distance of 5.5 km from the normal line. This is because the CDP generated from this undershoot geometry is not in the same shot point and receiver line.

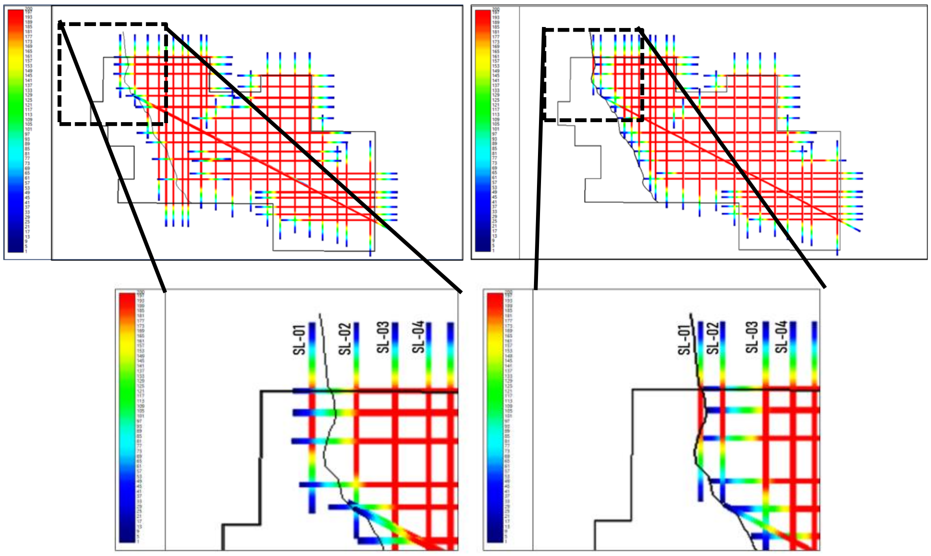
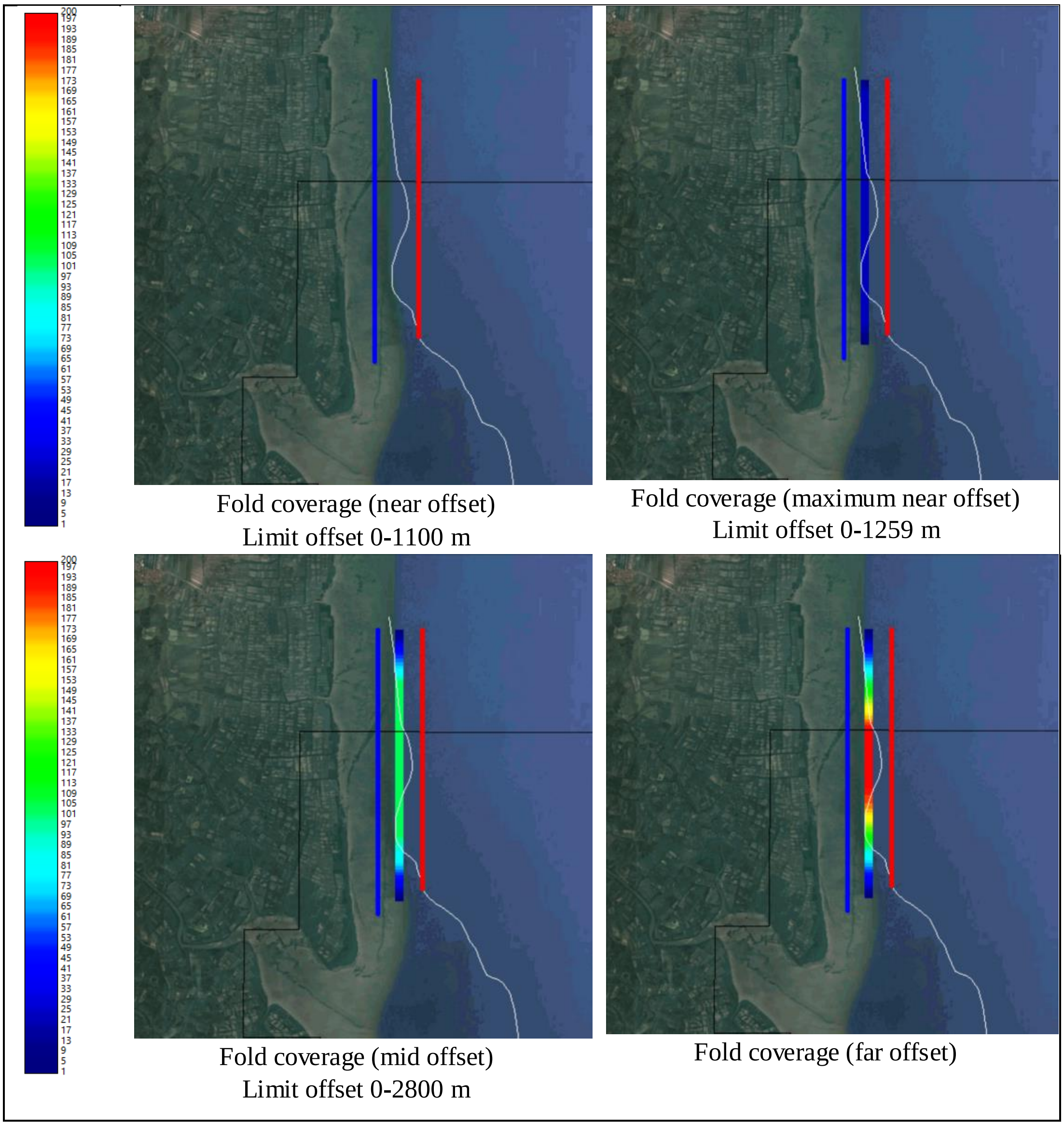



**Figure 12.** Comparation of fold coverage before and after shifting line 01

In the simulation results of fold coverage using mesa design software, it is found that the value of full fold coverage is 200 fold with binning dimensions of 25 cm. This fold coverage is still on target from the acquisition parameters so that in the prospect zone there is no loss of fold coverage data. If don't use this undershoot method, then line 01 cannot be acquired and could potentially lose data in the prospect zone.



Fold coverage (near offset)
Limit offset 0-1100 m

Fold coverage (maximum near offset)
Limit offset 0-1259 m

Fold coverage (mid offset)
Limit offset 0-2800 m

Fold coverage (far offset)

**Figure 13.** Fold coverage simulation (near, mid, and far offset)

The simulation of fold coverage data on line 01 at the near offset, mid offset, and far offset limits is shown in Figure 13 above. In the simulation of fold coverage near offset (0-1100) meter indicates that there is data loss. This can be seen in Figure 14 which shows the results of the processing data migration stack that there is data loss in 0 to 0.7 second. In the Figure, it can be seen that the results of the acquisition using the undershoot method at near offset (shallow targets) cannot be optimally obtained, but the results for mid and far offsets can still be described well.

## 4. Conclusions

Seismic data acquisition method using the undershoot method can be used as a solution for acquisition in areas where silting occurs, but it can also be applied to other obstacles. However, it should be noted that when shifting shot points in the silting area, it is necessary to simulate fold coverage data in order to obtain optimal fold coverage data in the prospect area. This undershoot method has advantages, namely that all shot points can be recorded during data acquisition, but it has disadvantages is that there is a loss of fold coverage data at near offset (shallow targets).

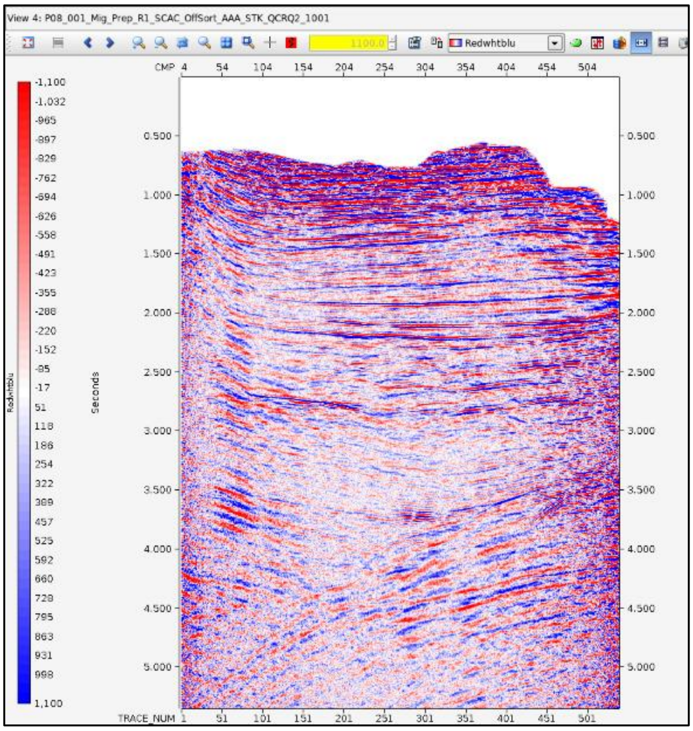



**Figure 14.** Migration stack line 01

The results of the acquisition method with undershoot in this 2D seismic survey OBN PHE WMO, obtained seismic data can be described well, this can be seen from the migration stack results in Figure 14. From this data, there is data loss at near offset, but at the target at far offset reflector continuity is obtained clearly so that it can be used for further data interpretation in the prospect area.

## Acknowledgments

We would like to gratefully thank PT. Pertamina Hulu Energi West Madura Offshore for allowing us to publish these acquisition data and thanks also to the Elnusa seismic crew for their cooperation while on board in the field.

## References

[1] OGP, 2011: An Overview of Marine Seismic Operations: Report 448, OGP Publications, 50p

[2] Sano, Seiya, et al. (2020). High resolution 3D seismic undershooting acquisition over platforms and seismic processing challenges in a gas producing field. *Journal of the Japanese Association for Petroleum Technology*, Vol. 85, (1), 44−53