EFFECTIVE LINE INTERVAL FOR SIGNAL -TO -NOISE (S/N) IMPROVEMENT IN 3D SEISMIC SURVEY.

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ABSTRACT

Detailed study of the effective line spacing for seismic data quality improvement using six 3D Seismic acquisition field data in the Niger Delta region of Nigeria was carried out in order to extract relevant seismic field design parameters from the knowledge of spatial and temporal sampling information. A 2kg charge size with source depth range between 42m and 3.5m were used. The source and receiver point interval for all surveys was 50m each. The result obtained showed variations in the nominal full fold coverage with range of 150 – 48 folds. The observed cross-line fold range was 10 – 6 folds, and Inline folds, 15 – 8. This information was used to evaluate the trend patterns exhibited by the investigated field parameter (the source and receiver line interval). The investigated parameter was observed to vary uniquely with the 3D fold. Mathematical equations showing the type of relationship observed between the source and receiver line interval and the fold were generated from parametric graphs. The parameters and their observed relationship with the Nominal fold were; $y = 0.005x^2 - 5.88x + 1638$ where y is the nominal fold and x is the source line spacing, $y = -0.302x + 200.1$ where y is the fold and x is the receiver line spacing. This information is valuable in the design of 3D seismic acquisition cross spread subset of the orthogonal geometry in the Niger Delta region of Nigeria.

INTRODUCTION

The starting point and most important stage of any survey work is the design phase. In the design phase, relevant concepts and ideas are considered, developed and adequately sieved towards providing meaningful and achievable set goals, ready for execution (Chaouch, 1990). In 3D seismic acquisition design all field parameters are carefully considered so as to maximise the potential of all relevant parameters. This is done because errors at the design stage critically affect the whole seismic operation. Seismic processing sequences and data repair processes can only be meaningful if the design and acquisition processes are adequately carried out. In planning a 3D land or marine survey, various factors come into play. These factors define, to an extent, the expectations and the general outcome of the survey. Cordsen (2000) outlined these factors; managerial attitudes, industry trends, financial issues, target horizons, sequence of events for data acquisition, environment and weather.

In designing a 3D seismic survey using the orthogonal geometry, various design parameters must be considered. They include number of active receivers number of swaths, source point interval, receiver point interval, source line interval, receiver line interval, total source spread length, receiver spread length, total receivers, bin size, total shot events, shot factor, station density, source charge size, source drilled depth, temporal and spatial frequency, maximum offset, minimum offset, largest minimum offset.

The above listed parameters make up a sensitive part of the variables considered during the design phase of any 3D seismic survey. They define the data acquisition part of the survey

(Anderson *et. al*. 2006). Vermeer, (2012) also noted that they determine the interpretability and usefulness of the survey data obtained. The designer of a 3D survey needs to be given clear and precise specifications for these parameters to effectively optimize the 3D design (Keed, 2009). This study is limited to the effects of line interval (source and receiver line) on the 3D data. As observed by Cordsen (2000) and Xiao, (2014), the signal to noise ratio is controlled by the fold. If the fold is doubled, a 41% increase in signal to noise ratio is accomplished. Doubling the ratio requires quadrupling the fold, assuming that the noise is distributed in a random Gausian fashion (Steefles and Miller 2000).

In this study, we attempt to generate a relationship between a design parameter (line interval) and the signal to noise ratio through a careful investigation of the relationship between the line interval (source line interval and receiver line interval) and the fold of coverage.

METHODOLOGY

The data used for this investigation was generated from six surveys carried out in the Niger Delta region of Nigeria. The source and receiver point interval for all surveys were 50m each, (Tables 1 and 2), 2kg charge size were used with source depth range of 42m to 3.5m. Field designs for all surveys were done so as to improve data quality. The source line azimuth and receiver line azimuth for all surveys were 90^{o} and 0^{o} respectively, clearly describing the survey geometry employed for all investigated surveys. The 3D total fold is the product of the inline fold and the cross line fold.

Table 1: Summary of source field parameters

Survey	Line interval(m)	Charge size (kg)	Point interval(m)	Line azimuth(^{o})	Number of lines	Total fold
A	400	2	50	90	67	150
B	600	2	50	90	51	66
C	600	2	50	90	28	45
D	600	2	50	90	37	54
E	500	2	50	90	62	48
F	600	2	50	90	30	48

Table 2: Summary of receiver field parameters

Survey	Line interval(m)	Station density	Point interval(m)	Line azimuth (^{o})	Number of lines	Total fold
A	200	50.7	50	0	88	150
B	600	58.6	50	0	53	66
C	600	68.6	50	0	46	45
D	600	73.3	50	0	48	54
E	500	50.0	50	0	67	48
F	600	47.0	50	0	48	48

As observed by Margrave, (1997),

$$\text{the inline fold} = \frac{\text{in\_ine patch dimension}}{2 \times \text{SLI}}$$

$$\text{the cross line fold} = \frac{\text{cross\_line patch dimension}}{2 \times \text{SLI}}$$

where SLI and RLI are the source line interval and the receiver line interval.

$$\text{the total fold} = \text{the in\_line fold} \times \text{the cross\_line fold}$$

$$\text{total fold} = \frac{\text{in line patch dimension} \times \text{cross line patch dimension}}{4 \times \text{RLI} \times \text{SLI}}$$

In all survey designs, the total fold ranged from 48 – 150 folds. The source line interval ranged from 400m to 600m and the receiver line interval ranged from 200m to 500m.

DATA ANALYSIS AND INTERPRETATION

The Source Line Interval (SLI) and the Receiver Line Interval (RLI) were independently plotted against the total 3D fold. This provided a linkage between the 3D source and receiver line interval and the 3D fold.

As supported by the parametric graph (Figure 1), a logarithmic relationship exist between the 3D fold and the source line interval, with observed relationship,

$$y = 0.005x_{sli}^2 - 5.58x_{sli} + 1638$$

Where y is the 3D fold and x_{sli} is the source line interval.

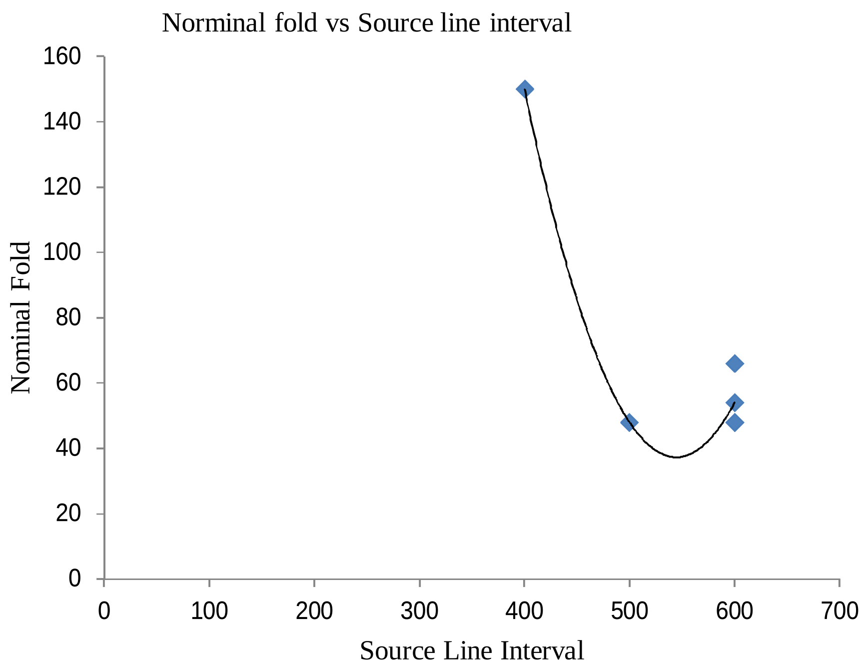

Figure 1: 3D fold vs source line interval

Figure 2 shows an increment in the source line as a result of a decrement in the total fold. The linear relationship shows an increase in the total fold only when there is a reduction in the receiver line interval. The observed mathematical relationship is

$$y = -0.302x_{rli} + 200.1$$

Where y is the 3D fold and x_{rli} is the receiver line interval.

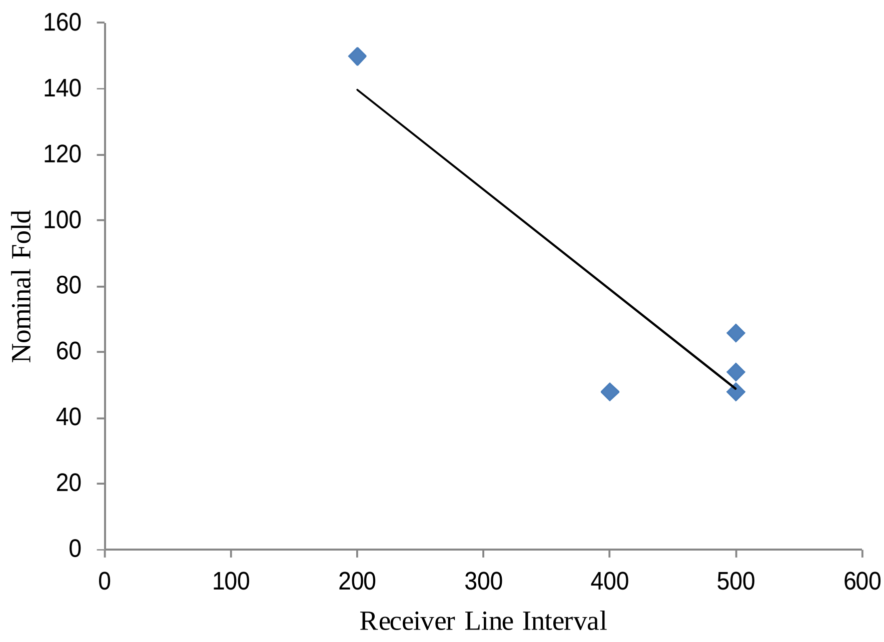

Figure 2: 3D fold vs receiver line interval

CONCLUSION

The design of high resolution seismic survey is hinged on the designer's ability to understand and efficiently manipulate the design parameters. All design parameters have unique roles and must be correctly utilised to acquire a perfect survey data. A 41% fold increment is acquired by quadrupling the 3D fold. One way of adjusting or improving the fold quality is proper design of the line intervals (source line and receiver line interval). This method demonstrates the improvement of the signal to noise ratio by fold increment through effective line spacing.

Based on the result obtained in this study, the fold has a logarithmic relationship with the source line interval and an exponential relationship with the receiver line interval.

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