# HI-FIX CHAIN AT BONNY, NIGERIA

*An operational summary compiled by the Topographical Department of the Shell-BP Petroleum Development Company of Nigeria Limited and the Decca Navigator Company Limited.*

Port Harcourt, October 1964

---

**Introduction**

In 1957 an extensive hydrographic survey was carried out off Bonny Island to study the feasibility of dredging a channel through the Bonny Bar, in order to facilitate the passage of fully laden tankers of up to 18 000 tons in the initial stage, and of still greater tonnage at a later date.

This preliminary survey was carried out using conventional methods (buoys, beacons and sextants) for position fixing. It was evident that these methods were rather unsatisfactory due to the distances from shore markers, parts of the dredged channel being up to 8 miles from land. During the dust-laden harmattan winds of the dry season and during periods of heavy rain, visibility can be very poor.

Accordingly, when the dredging of the experimental channel started in 1959, a three-station Decca Survey Chain was installed to provide the dredgers and the survey vessel with a means of accurate position fixing. These stations were operated on a 24 hours per day basis by a team of Decca engineers and provided a very satisfactory service for more than two years. Nevertheless it was felt that, due to the lane width and geometry of the chain, the fixing accuracy at the seaward end of the project was marginal from the point of view of operating large dredgers in a narrow channel.

Fortunately at this time the new Decca Hi-Fix system was becoming generally available and in the middle of 1962 a three weeks field trial was undertaken at Bonny using a complete Hi-Fix chain and one fitted ship. Many hundreds of readings and check observations were made to investigate the stability and overall performance of Hi-Fix under the difficult environmental and noise conditions prevailing in the Bonny area. Results showed that in this particular case there were many practical advantages and economies (apart from a reduction in lane width to a fifth that of Decca)

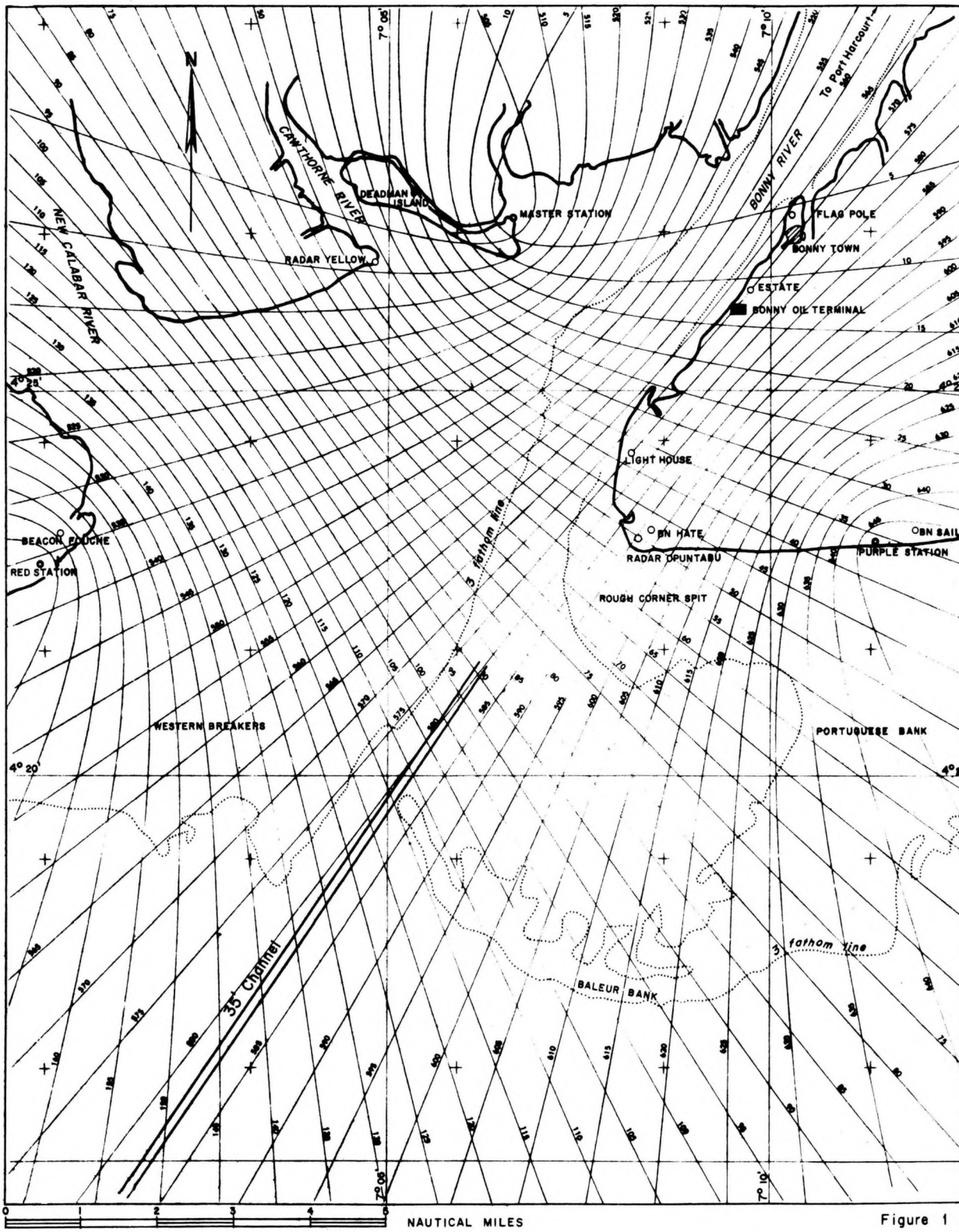
N
7° 05'
7° 10'
4° 25'
4° 20'
NEW CALABAR RIVER
CRAWTHORNE RIVER
DEADMAN ISLAND
MASTER STATION
RADAR YELLOW
BONNY RIVER
To Port Harcourt
FLAG POLE
BONNY TOWN
ESTATE
BONNY OIL TERMINAL
LIGHT HOUSE
BN HATE
RADAR OPUNTABU
BN SAIL
PURPLE STATION
BEACON POUCHE
RED STATION
3 fathom line
ROUGH CORNER SPIT
WESTERN BREAKERS
PORTUGUESE BANK
35' Channel
3 fathom line
BALEUR BANK
0
1
2
3
4
6
NAUTICAL MILES

Figure 1

and the decision was made to replace the conventional Decca chain by Hi-Fix. The actual change-over took place in October 1962 and the Hi-Fix chain has been running continuously since that date.

## The Hi-Fix System

The Hi-Fix system is similar in many respects to Decca, but operates on a much higher frequency (between 1.7 and 2.0 Mc/sec), and the transmissions consist of only one frequency which is time shared between the stations. Hi-Fix has many advantages for short range offshore work : the lane width is smaller, giving better fixing accuracy; only one frequency is required; the band width of the system is extremely small (approximately 100 cycles); the stations are compact, easily transported and quickly erected; and all equipment operates from 24-volt batteries.

The ship-borne installation is very simple consisting of one small receiver box which also contains the two pattern counters. The only external connections are to the small whip aerial which is mounted over the observing point and to the 24-volt batteries. The two counters provide hyperbolic co-ordinates which can be plotted on lattice charts similar to those used for Decca.

Also a track plotter is available on which a moving pen traces the actual movement of the vessel over a pre-drawn chart. By this means the movements of a survey vessel or dredger can be controlled to very fine limits without continuous hand plotting.

## Station Siting and Operation

Selecting favourable sites for the master and the slave stations in the Bonny area is not an easy matter as, apart from a very narrow strip of firm soil along the beaches, the whole area consists mainly of swamps. Our aim was to fulfil the following three conditions :

(*a*) The best possible fixing accuracy in the area to be dredged.
(*b*) A minimum amount of land in the transmission paths.
(*c*) One set of hyperbolae to be as nearly as possible parallel to the channel to be dredged, thus providing the most accurate fixing across the channel and avoiding having to make frequent changes of track plotter charts.

After considerable investigation the best compromise between the above desirable features, the terrain and general logistics seemed to be as shown in figure 1. The master station was erected on Deadman's Island, the red slave station at Fouche Point and the purple station along the southern shore of Bonny Island.

Hi-Fix does not require large areas of bush clearance ad a small hut $8' \times 8'$ is adequate to contain the electronic equipment. A small diesel

generating set was installed to recharge the batteries, together with an R/T set to maintain contact with the Decca H.Q. at Bonny.

Apart from the time taken in clearing sites and erecting the huts, the installation of the Hi-Fix equipment took approximately one day per station.

A team of four Nigerians look after each station, their duties consisting mainly of keeping the batteries charged and reporting any unusual changes in the equipment to the Decca H.Q. where a trained Decca engineer is always available.

Each pattern can be monitored at the opposite slave station and the exact value is recorded automatically for future reference. An additional check receiver is installed at Bonny so that the Decca engineer may make an independent check at any time.

**Survey Data**

To establish the co-ordinates of the three Hi-Fix stations a triangulation was made connecting Bonny Island, Deadman's Island and Fouche Point. The accuracy of this triangulation is of the order of 1 in 25 000. Purple station was connected to this triangulation by a traverse closing 1 in 15 000.

Co-ordinates were computed on the Transverse Mercator projection using a mean scale factor for the entire area.

The length of the red baseline is 14 133.3 metres.

The length of the purple baseline is 11 728.9 metres.

The base angle of master being 113 degrees.

From the Hi-Fix tests carried out before installation of the permanent Hi-Fix chain, the following propagation velocities were derived :

$$V_R = 299\,651 \text{ km/s}$$
$$V_P = 299\,468 \text{ km/s}$$

The frequency used for red and purple is 1 902 kc/s.

Track plotter charts on a scale of 4″ = 1 lane (approximately 1/1 500) were drawn showing the tracks to be followed by the dredgers and survey vessel.

When the chain is first switched on it is necessary to make a once for all adjustment at the slave stations to make the radiated and charted patterns agree in the operational area. This is best accomplished by a programme of careful simultaneous Hi-Fix fixes and conventional survey observations in the operational area. Once this adjustment has been made all ships will record the same readings at any point without further checks.

**Accuracy and Stability Tests**

There are two important factors to be considered in assessing the accuracy and stability of a Hi-Fix chain :

Firstly the basic stability of the transmitted patterns and the receiving equipment, which is really an indication of the repeatability of the system or the accuracy within which one can expect to return to a position where the previous Hi-Fix co-ordinates are known.

Secondly the absolute accuracy, in which one is concerned solely with the differences between the geodetic co-ordinates of a point derived from Hi-Fix observations and the geodetic co-ordinates of the same point derived from conventional survey work of accuracy.

In a tropical country such as Nigeria heavy local storms occurring from time to time can produce an intensity of static some hundreds of thousands times greater than the normal signal strength of Hi-Fix, or any other radio signals for that matter. Fortunately these major disturbances are confined in area and occur only at certain times of the year. Experience during 1963 has shown that the Hi-Fix system has been unusable for less than 1 % of the total operating hours, which is quite tolerable in an operation of this nature.

Excluding the periods mentioned above, the standard deviation of the chain monitor readings during 1963 was $\pm$ 0.017 lanes, which compares favourably with the figure of $\pm$ 0.01 normally obtained in more temperate areas. This figure means that two out of every three observations made, at say mid-channel, should be within a few metres of the mean position.

The absolute accuracy will be always somewhat less than the repeatability, since the latter does not include errors due to the incorrect assumption of the propagation speed or variations in the propagation speed.

To check a high precision system such as Hi-Fix it is really necessary to utilise theodolites for the check fixes. However, by using trained sextant observers under conditions of good visibility it is possible, with a large number of fixes, to make an accurate assessment of the absolute accuracy.

During 1963 a series of sextant fixes were taken each month throughout the entire length of the channel, using the shore beacons ' Fouche ', ' Lighthouse ' and ' Sail '. Hi-Fix readings were computed from the sextant fixes and these values compared with the observed Hi-Fix co-ordinates with the following results.

(*a*) *Purple Pattern*

Of the 150 observations made during the period November 1962 to December 1963, a maximum difference between computed and observed Hi-Fix co-ordinates was + 0.05 of a lane in the northern part of the channel, + 0.03 in the middle part, and a maximum of — 0.04 in the southern end. The mean of all observations of the purple pattern was + 0.015 lanes and the standard

deviation of the difference between the sextant fixes and the Hi-Fix observations was found to be ± 0.025 lanes.

(*b*) *Red Pattern*

Of 149 observations made of the red pattern the maximum difference between Hi-Fix and sextant fixes was + 0.08 lanes in the north, + 0.02 in the middle, and — 0.09 lanes in the south. The mean of the differences in the red pattern was — 0.04 lanes and the standard deviation ± 0.03 lanes.

The changes in the differences along the channel are, to a great extent, fixed in time and are due largely to the small variations in land paths which occur between one end of the channel and the other. Having once carried out a complete check, most of these errors could be removed by re-drawing the charts slightly in the areas concerned.

From a practical dredging and surveying point of view, the accuracy of position fixing in the direction perpendicular to the channel is much more important than the longitudinal accuracy. With a shift of + 0.05 lanes in purple and + 0.08 in red in the northern part, the lateral shift perpendicular to the alignment of the channel amounts to 12 feet. The maximum lateral shift in the middle part of the channel is 20 feet and the maximum lateral shift in the south 30 feet.

It should be noted that these figures represent maximum errors and we feel confident that the day to day variations are well within the accuracies demanded by such an offshore dredging and survey project.

## Conclusion

The Bonny Bar Hi-Fix Chain has given excellent service, enabling dredging to continue day and night independent of visibility and weather conditions.

The overall accuracy is checked at frequent intervals and results show that the required accuracies are being met.

The equipment is simple to operate, works well under tropical conditions and the system is relatively little affected by static noise. The total down time from all causes is less than 2 % of the overall operating hours.

The economic advantages in installing Hi-Fix for such a project as the Bonny Bar dredging are far reaching and we feel sure that there will be many other similar tasks which will benefit from this latest electronic aid to survey and position fixing.