Reconciliation of DTI and Industry 'Yet to Find' estimates with updated DTI reserves and prospectivity analysis of the North Sea post 21st Round (rev1)

Key Messages

- New data from revised DTI YTF figures and 21st Round applications support the view that some 5 bboe of technically recoverable YTF reserves exist in the main North Sea area. This is towards the higher of industry's two average predictions in the PILOT exercise. Further upside potential may exist as new plays and leads are de-risked.

- Large prospects have been identified in the Round, a significant proportion of which are 'stratigraphic' in nature. The key to de-risking these to a drillable level is the need to acquire and interpret high quality seismic data.

- Considerable uncertainty still remains regarding West of Shetland YTF potential but recent downward revisions in DTI volumes show better agreement with industry estimates.

Introduction

1. UKOOA reported estimates of 'Yet to Find' (YTF) reserves as part of its submission to the current stimulating exploration exercise led by the Treasury. This submission was based on a PILOT survey, administered by UKOOA, which collected data from Industry and DTI at the end of 2002. One of the main conclusions of the report, supported at the first meeting of the Exploration Steering Group, was that further work was needed to understand better the differences between DTI and industry estimates. This report aims to address these concerns and provide some updated insight into 'North Sea' volumes and prospectivity by presenting:

- Recently updated DTI Monte Carlo YTF figures for the UKCS (published in July 2003), discussing how new 'central estimates' for the West of Shetland compare with DTI and industry volumes presented in the PILOT exercise.

- New estimates of 'North Sea' technical YTF reserves based on techniques not presented by the DTI before – 'Creaming Curve' and 'Field Size Distribution' (FSD) methods.

- A preliminary analysis of North Sea prospectivity derived from submissions to the DTI for acreage in the 21st Licensing Round. This is used to help understand:

    a. differences between industry and DTI prospect numbers and Gross Recoverable Volume estimates

    b. comparisons of DTI and industry Technically Risked Reserve estimates

    c. and provides timely insight into perceptions of remaining prospectivity within the main North Sea area.

Updated DTI YTF figures – Revised 'West of Shetland' volumes

DTI Methodology

2. The DTI holds estimates of UKCS YTF reserves calculated via Monte Carlo analysis of real leads mapped by the BGS over the last 20 years. The input data set is largely derived from work carried out by the BGS in association with Licence Rounds and is not from a systematic mapping exercise aimed purely at assessing UKCS YTF potential. Many areas, including some long held acreage and frontier regions, have not been mapped at all. The perceived strengths of the system lie in the fact that it uses mapped leads and prospects but its weakness is that it is based on mapping of various vintages that does not cover the whole of the UKCS.

3. Recent upgrades have included revised and improved geo-technical assessment and risking, ongoing detailed filtering of the leads and prospects by DTI specialists and, most recently (but not incorporated in DTI Monte Carlo figures presented in this report), an improved ability to add industry prospects to the database. Confidential industry advice has recently confirmed the validity of the methodology.

4. DTI contributed to the PILOT exercise in Q4 2002 by providing extracts from its YTF database of size distributions of prospects and leads as 'Gross Recoverable Volumes' with associated geo-technical 'Chance of Success' (COS) factors. This enabled calculation of 'Technically Risked Reserves' (TRR) for both licensed and unlicensed acreage to be made in accordance with the survey questionnaire. GRV are calculated P50 recoverable lead or prospect volumes (expressed at surface conditions) with no geo-technical risk applied. TRR are calculated by

multiplying GRV by COS factors for individual leads or prospects. Whilst not discussed in this report, industry provided another layer of 'Commercial' risk, which reflects softer issues such as perceived technical challenge or internal competition for funds. Published DTI YTF figures are quoted on a TRR basis.

Revised DTI 'West of Shetland' YTF figures

5. Since the PILOT exercise, DTI has revised its prospect database as described above and performed new calculations of reserves using the Monte Carlo method. Traditionally DTI presented only ranges of reserves but this year, for the first time, 'central' estimates have been included. Many leads and prospects to the West of Shetland have been removed from the database as they are no longer considered technically valid and this, combined with re-assessment and re-risking, helps explain why there are now much smaller central volumes being calculated by DTI for the West of Shetland. The revised central estimates of technically risked YTF reserves are more in line with industry perceptions, which are themselves very broad and uncertain. Table 1 shows the most recent DTI central estimates (published at the end of July) set against DTI and industry estimates as calculated from the PILOT exercise at the end of last year:

Table 1 – DTI Monte Carlo[2] and industry 'Technically Risked Reserve' (TRR) YTF estimates

	Central estimate of technically risked reserves (million boe). No commercial overlay		'Bottom up' [3] industry TRR estimates (partly 'derived' [4] from DTI values)	'Top Down' [5] range of industry TRR estimates
Area	Current DTI YTF estimates by Monte Carlo	DTI estimates calculated for PILOT		
NNS, CNS incl MF	4161	4310	4200	500-1500-4600
SNS, Irish and Celtic sea	1348	1308	2000	100-700-2000
West of Shetland[1]	1531	3861	800	300-1000-3800
Total	7040	9479	7000	900-3200-10400

1. Industry figures include estimates for larger 'West of Scotland' area.
2. Source of latest DTI YTF estimates: DTI website http://www.og.dti.gov.uk/information/bb_updates/chapters/Table4_6.htm
3. 'Bottom up' estimates are calculated by summing operators' YTF estimates from their own licensed areas with 'derived' (see 4 below) estimates for unlicensed acreage.
4. Industry estimates for unlicensed acreage are believed to have been 'derived' by factoring DTI GRV estimates from unlicensed acreage by the ratio of observed industry and DTI estimates seen in licensed acreage. Average regional industry COS has then been applied to 'derive' TRR.
5. 'Top Down' - less rigorous industry estimates from basin analysis or gut feel. Range shows average and full spread of estimates provided

6. It should be noted that DTI YTF estimates for the more frontier areas West of Scotland (outside the West of Shetland area) are largely derived from DTI internal specialist views, operator dialogue and what limited seismic and well information exists. These unmapped areas do not form part of the prospect database and as such did not feature in the DTI submission to the PILOT exercise. Current belief is that this frontier area might have technical reserves in the region of 1 billion boe.

7. Overall DTI believes its estimates of YTF for the West of Scotland have moved closer to the volumes presented by industry in the PILOT exercise but these estimates remain very uncertain and are likely to change further due to the immaturity of exploration in the basin and evolution in thinking. DTI is also of the view that any residual differences between industry and DTI estimates for West of Shetland are not due to any special play understanding which the DTI might have gained through its privileged data access position but are more likely due to the fact that DTI has probably done more extensive mapping to identify leads than many operators.

Other YTF Estimates – Main 'North Sea' area

8. Differences between DTI and industry estimates for technically risked reserves in the main North Sea area were less marked than for the West of Shetland and recently updated volumes derived by the DTI Monte Carlo (and other) methods give similar estimates to DTI values calculated for the PILOT exercise (see tables 1 & 2).

9. Over recent months DTI has looked at two other ways of assessing YTF potential using 'Creaming Curve' and 'Field Size Distribution' (FSD) methods. These are based on the DTI's extensive field and discovery database and should therefore provide useful comparison to the standard Monte Carlo prospect approach. Preliminary results for the main North Sea region have recently been compiled and are presented in figures 1-6. It must be stressed that both methods are highly subjective in their ability to predict accurate estimates of YTF reserves and the results are dependent on curve fitting techniques, which if varied slightly can give very different estimates. The main limitation of these and other methods is that they do not identify upside that may come from potential new plays or techniques not yet known about or applied. As such they tend to predict minimum volumes.

10. The 'Field Size Distribution' (FSD) method (figures 1-5), as used by the USGS in its worldwide resource calculations, shows a frequency

distribution plot of discoveries grouped into different size classes. A curve is then fitted and the difference between the curve envelope and the plot of histogram of discoveries gives an estimate of likely remaining YTF potential. The method is underpinned by the belief that geological size distributions are generally lognormal in nature. Statistically this works best for 'in place' volumes (e.g. fig 1) in mature basins. It can be used in a 'reserve' mode but this is considered less accurate because man-made non-lognormal recovery factors are introduced. Curves have been fitted which show reasonable agreement within the ranges of DTI and industry YTF estimates. Even though it can be argued that some 'steering' has been made, they do provide estimates of remaining field size distributions and assurance of volumes.

11. Another traditional method of assessing remaining basin YTF potential is via the use of 'Creaming Curves'. An adaptation of this is the 'Inverse Time Discovery' method (fig 6), which plots time on an inverse scale against cumulative discovered 'in place' volumes (or reserves) for a basin. This allows an extrapolation of creaming curve data to make an estimate of ultimate 'in place' resources or reserves. This method, as well as giving YTF estimates, has the ability to provide some insight on how and when new plays or technology advances have impacted during basin evolution.

12. 'Field Size Distribution' and 'Inverse Time' creaming curve plots are presented for the entire North Sea and for the three major sub-basins (figs 1-6) and estimates of technically risked reserves from the various DTI and Industry methods are presented in Table 2 below.

Table 2 – North Sea FSD, Creaming curve, DTI Monte Carlo, DTI and Industry 'Technically Risked Reserve' estimates

North Sea Basin	DTI 'Field Size Distribution' method (some 'steering').		DTI Inverse time creaming tech. res. (bboe)	DTI PILOT tech. res. (bboe)	Latest DTI MC central estimate tech. res. (bboe)	'Bottom Up' Industry tech. res. (bboe)	'Top Down' Industry tech. res. [(1)] (bboe)
	Tech res. 4 mmb cutoff (bboe)	Tech res. 8 mmb cutoff (bboe)					
NNS	1.1	0.9		0.7	4.2	0.7	0.2-0.4-1.6
CNS&MF	4.3	3.3		3.5		3.5	0.3-1.1-3.0
SNS	1.6	1.1		1.0	1.0	1.0	0.1-0.6-1.8
North Sea	5.4-7.0	3.8-5.3	0.7 – 4.5	5.2	5.2	5.2	0.6-2.1-6.4

1. Range shows average and full spread of estimates provided

13. Predictions of technically risked reserves from the FSD and creaming curve methods fit within the range of PILOT estimates and revised DTI Monte Carlo figures. As would be expected the FSD method predicts that the majority of future opportunities will be for smaller fields but there still remain many significant leads in the North Sea and this is supported by analysis of applications made in the 21st Round (see later section).

14. The 'Inverse time' predictions (fig 6) show interesting breaks in the straight line gradients which can be interpreted as the 'kick in' of new plays or technology exploitation e.g. Jurassic/Triassic and Alba plays in the CNS (1984-87), the use of 3D seismic and the move to smaller and more subtle fields in various plays (1987-2000) and the impact of Buzzard in 2000. Some would argue that the exploitation of this and similar stratigraphic plays would strongly influence ultimate North Sea recovery.

Comparison of lead and prospect volumes applied for in the 21st Round with DTI and industry PILOT submissions

15. A key feature of licence applications is the presentation of ideas and analysis on leads and prospects seen on acreage applied for. Such analysis ranges from general play concepts through mapped leads to fully worked-up prospect evaluation. Future licence work programmes largely focus on the need to 'de-risk' plays and leads into drillable prospects (normally via further seismic acquisition and analysis). In many ways the mapped leads and prospects presented by industry in the Round are comparable in calculation methodology (volumes and risking) to those held by DTI in its prospect database.

16. Acreage available in the 21st Round covered most of the unlicensed mature North Sea areas (except for parts of the Inner Moray Firth) and,on the assumption that a large proportion of the remaining known leads and prospects were applied for, then it should be possible to compare PILOT estimates for unlicensed acreage with aggregate Round volumes as a further crosscheck of YTF estimates. The two key uncertainties that make this comparison difficult and potentially misleading are a) the assumption that most remaining North Sea prospects in unlicensed acreage were applied for in the 21st Round - if you follow this logic then one would not have expected many applications in this Round as largely the same area was available in the 20th Round! And b) many plays, leads and prospects

identified in the Round have not yet been mapped by industry and have had no volumes calculated. In any case one would expect aggregate volumes presented in the Round to be less than total unlicensed PILOT estimates, which cover all unlicensed acreage including large parts of the Inner Moray Firth.

17. DTI's analysis of Round applications is based on P50 GRVs and associated Chance of Success (COS) values presented by industry for geologically separate mapped leads and prospects. Some leads are very loosely mapped estimates based on scant data and in general these figures should be viewed in the context of a competitive Round application and may as such be somewhat optimistic and will need considerable de-risking before any drilling can happen. Many additional plays and leads were presented in the Round but, as no volumetrics were calculated, they do not form part of this analysis. Some of the mapped leads do 'spill-over' on to adjacent licensed acreage and this means that GRV volumes for unlicensed acreage may be slightly high (5-15%?). However this does not, in DTI's view, seriously affect any conclusions drawn.

Gross Recoverable Volume (GRV) comparison

18. Table 3 compares DTI and industry GRV estimates for the mature North Sea. Alongside the DTI PILOT estimates for unlicensed acreage three different industry estimates are presented:

1) Industry 'Bottom Up' PILOT estimates of GRV for unlicensed acreage – these are understood to have been largely 'derived' through factoring DTI unlicensed estimates by the ratio of industry and DTI estimates seen in licensed acreage.

2) Industry 'Top Down' PILOT estimates for combined licensed and unlicensed acreage. These are presented because they are the only truly independent industry estimates addressing unlicensed acreage.

3) Aggregate GRV numbers and volumes from mapped leads and prospects presented by industry in the 21st Round.

Table 3 – Comparison of GRV estimates for the 'North Sea' from Industry presentations in 21st Round and PILOT submissions

Basin	Gross Recoverable Volumes presented in PILOT exercise (unlicensed areas only)			Industry GRV presented in 21st Round (1)		'Top Down' Industry PILOT GRV estimates **(licensed + unlicensed)**
	DTI		Industry GRV (derived)			
	Number of leads	GRV		Number of leads	GRV	
NNS	122	2.5	1.9	32	2.1	0.3-1.5-4.0
CNS	314	20.6	6.4	73 (1)	7.4 (1)	1.3-3.7-10.0
SNS	317	6.3	1.3	51	2.3	0.2-1.4-3.6
North Sea	753	29.4	9.6	156	11.8	1.8-6.6-17.6

1. Parts of the Inner Moray Firth were not on offer in the Round

19. Some interesting observations and conclusions can be drawn from this GRV comparison:

- Central values from the 'Top Down' industry estimates (which includes both licensed and unlicensed acreage) are considerably less than the mapped volumes applied for in the Round. This suggests industry PILOT submissions were either overly pessimistic or there was considerable prior risking of leads and prospects.

- Industry 'Bottom Up' derived estimates for unlicensed acreage are closer but still less than volumes applied for in the Round. Bearing in mind these figures are partly derived from DTI and industry perceptions of licensed acreage, it is difficult to comment further other than to say this again supports the view held in the UKOOA report that industry may have been conservative and/or had applied some geo-technical risking prior to submitting its GRV numbers.

- The number of mapped leads applied for by industry in the Round is only about a fifth of the number held in the DTI database. Possible explanations for this, some of which were alluded to before, include:

  a. much acreage on offer was not applied for but will be applied for in future Rounds? – time will tell,

  b. many leads seen in 21st licence applications have yet to be mapped (particularly large numbers of high risk and many smaller leads),

c. parts of the Inner Moray Firth were not offered in the Round – DTI has mapped prospects in this area,

d. DTI database needs continued updating and further verification work i.e. are the leads presented by Industry in the Round the same as those held in the DTI database? - A high percentage of industry Round leads were 'stratigraphic' whereas many of the DTI's leads are 'structural'. These are areas that DTI will need to evaluate further when updating its database over the next year. Clearly there will be improvements gained by careful integration of DTI and industry leads.

Technically Risked Reserves (TRR) Comparison

20. DTI has made preliminary 'Technically Risked Reserve' (TRR) estimates from 21st Round applications by multiplying P50 GRVs by a 'Chance of Success' (COS). Industry provided estimates of COS for about a third of the mapped leads and DTI has estimated COS for the remainder. Comparison of Industry and DTI technically risked reserves is a more consistent comparison than that done on a GRV basis because differing perceptions of risk have been introduced and one is now really comparing like with like.

21. Interestingly, many companies, when queried during Round interviews about the 'chance of success' (COS) associated with the lead and prospect GRVs, often said that it was very difficult to be specific on COS values in cases of less than 10% COS as there was often limited information available or very little in-depth interpretation had been made. The average COS for leads when given by industry in the Round was about 15%. This again supports the view that industry submissions for the PILOT exercise would be generally be limited to leads and prospects with COS greater than 10%.

22. Table 4 shows GRV, COS and calculated TRR from 21st Round applications alongside industry 'Top Down' (TD) estimates for licensed and unlicensed acreage and DTI PILOT TRR estimates for unlicensed acreage. UKOOA reports 'Bottom Up' (BU) estimates for licensed acreage as being more accurate but it must be re-iterated that some doubt exists over industry BU estimates for unlicensed acreage, as these have largely been 'derived' by factoring DTI unlicensed volumes – see previous discussion and Table 4 - footnote 4. As noted for GRV calculations, TD industry estimates are presented for comparison because

they are the only truly independent industry estimates addressing unlicensed acreage.

Table 4 – Technically Risked Reserves of mapped leads and prospects in acreage applied for in the 21st Round alongside Industry and DTI PILOT estimates

Basin	21sr Round Applications (Unlicensed acreage)			Industry PILOT 'Top Down' Technical Reserves - all North Sea **incl. licensed and unlicensed** (bboe)	DTI PILOT Technically Risked Reserves Unlicensed Acreage (bboe)
	'Gross Recoverable Volume' (GRV) (bboe)	'Chance of Success' (COS) estimates - part Industry, part DTI	'Technically Risked Reserves' (TRR) (bboe)		
Northern North Sea	2.1	6.5%	0.14	0.2 - 0.4 - 1.6	0.3
Central North Sea	7.4 (1)	8.6%	0.64 (1)	0.3 - 1.1 - 3.0	1.4
Southern North Sea	2.3	11.3%	0.26	0.1 - 0.6 - 1.8	0.3
Total North Sea	11.8 (1)		1.03 (1)	0.6 - 2.1 - 6.4	2.0

1. Parts of the Inner Moray Firth were not on offer in the Round

23. Similar observations and conclusions can be made when comparing Technically Risked Reserves as were seen when comparing Gross Recoverable Volumes ie:

- Central values from the 'Top Down' industry estimates (which included both licensed and unlicensed acreage) are not that much greater than the risked volumes applied for in the Round. Using the Central North Sea as an example, it would appear somewhat pessimistic and unlikely that industry can only expect to find 1.1 bboe, in both licensed and unlicensed acreage, when it identified 0.64 bboe of risked YTF reserves in unlicensed acreage applied for in the Round.

- DTI technically risked reserve estimates from the PILOT exercise are about twice those applied for in the Round (direct comparison possible as both figures are for unlicensed acreage alone). This would appear to be reasonable bearing in mind

  a) the likelihood that more acreage will be applied for in future Rounds,

  b) not all industry leads in 21st Round applications have been mapped and

c) parts of the Inner Moray Firth were not on offer.

- As with the GRV analysis, the DTI database needs continued updating and further verification work i.e. are the leads presented by industry in the Round the same as those held in the DTI database? - A high percentage of industry Round leads were 'stratigraphic' whereas many of the DTI's leads are 'structural'. These are areas that DTI will need to evaluate further when updating its database over the coming year. Clearly there will be improvements gained by careful integration of DTI and industry leads.

Overall Prospectivity of 'North Sea' area

24. Another objective of the analysis of Round applications was to get a better feel for the general level of prospectivity seen by the industry and a clearer understanding of the size of prospects being looked at by industry. The area on offer in the 21st Round broadly covered the mature North Sea, except for parts of the Inner Moray Firth, and Figure 7 shows a size distribution of leads and prospects identified. These are presented on an un-risked Gross Recoverable basis because this better shows the true potential size of leads and prospects should they be drilled. As stated before these are often very loosely mapped and could be optimistic, but it does show that there are many significant leads and prospects which industry is prepared to invest in over the next few years in order to de-risk to drillable levels.

25. Regarding the nature of future prospects, some 60% of the mapped leads applied for in the Central and Northern North Sea had a large stratigraphic component. This means that good access to high quality seismic data will be vital if successful de-risking (enabling drilling) is going to happen. This supports the ongoing PILOT drive to ensure access to seismic data is improved.

Conclusions:

a. DTI has recently upgraded its West of Shetland YTF volumes from those presented to the UKOOA survey. New figures of 1.5 billion boe fit well within the 0.3 to 3.8 bboe industry range.

b. Revised DTI 'Monte Carlo', 'Field Size Distribution' and 'Creaming Curve' YTF estimates for the North Sea area (NNS,

CNS and SNS) fit reasonably with industry predictions. The range of industry and DTI central estimates for technical reserves in the North Sea are between 2 and 6 bboe. DTI best estimates are in the region of 5 bboe.

c. Future field sizes as predicted by the 'Field Size Distribution' method confirm the trend towards smaller fields but the likelihood of discovering significant fields remains, as evidenced by submissions in the 21st Round.

d. Analysis of the 21st Round submissions confirm the belief that industry 'Gross Recoverable Volume' submissions to the PILOT exercise had been filtered by some risking before submission. This helps account for the apparent discrepancy with DTI GRV numbers, where very little geological risk had been applied.

e. Provisional analysis of acreage applied for in the 21st Round shows potential technically recoverable reserves of greater than 1 billion barrels in mapped leads and prospects. Upside potential exists through de-risking of plays and leads with (as yet) no mapped volumes.

f. Industry 'Top Down' estimates of technically recoverable reserves provided in the PILOT exercise (2.1 bboe) seem somewhat conservative when compared to volumes associated with applications in the 21st Round. This further supports the DTI and industry 'Bottom Up' view that a value of around 5 bboe is the best estimate of technically recoverable reserves for the mature North Sea region.

g. Preliminary analysis of leads and prospects identified in the 21st Round show that significant North Sea prospectivity remains in some potentially large geological traps.

h. A significant proportion of 21st Round applications were for 'stratigraphic' leads and a key to the successful de-risking of these will be the provision of high quality seismic.

Peter Haile
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Fig 1 – Field Size Distribution - North Sea ‘In Place’ volumes

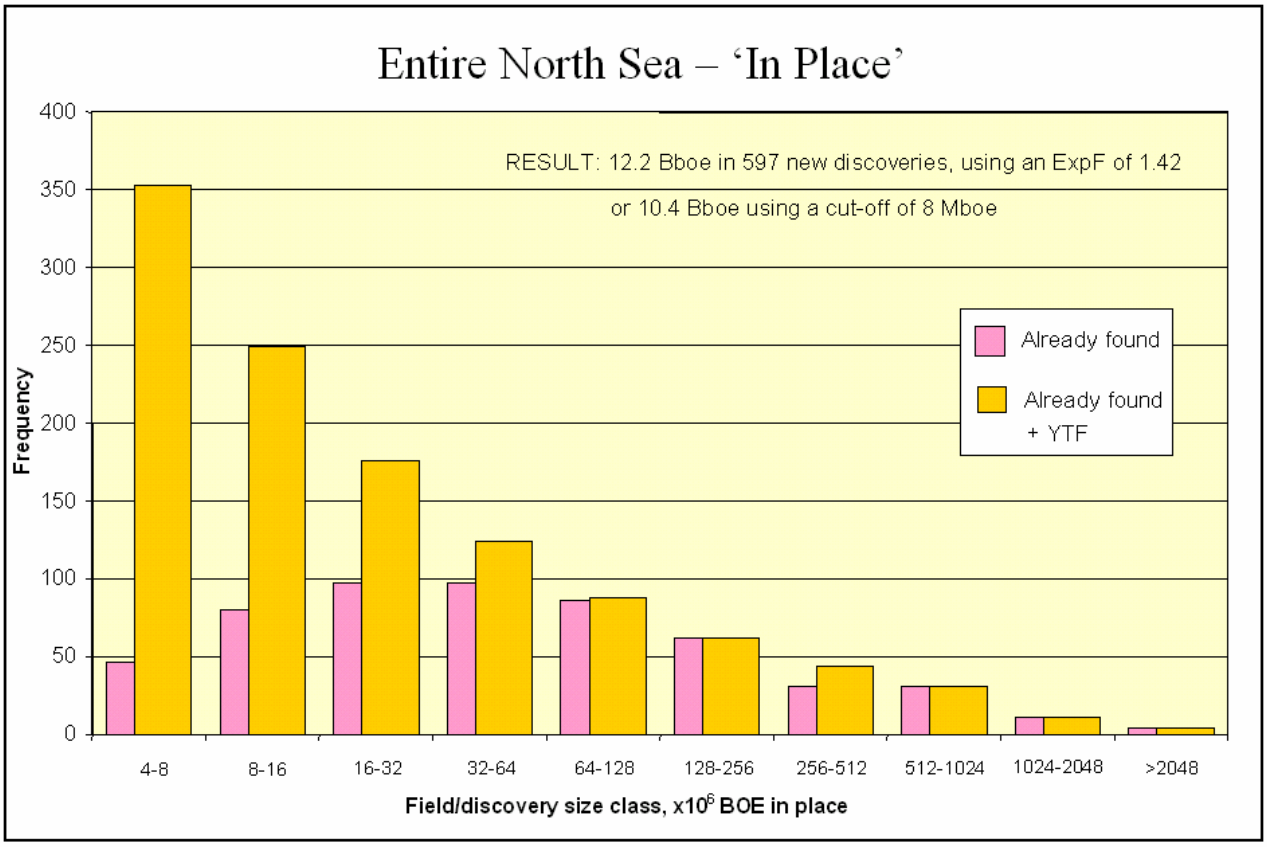

Fig 2 – Field Size Distribution – North Sea – ‘Recoverable’ volumes

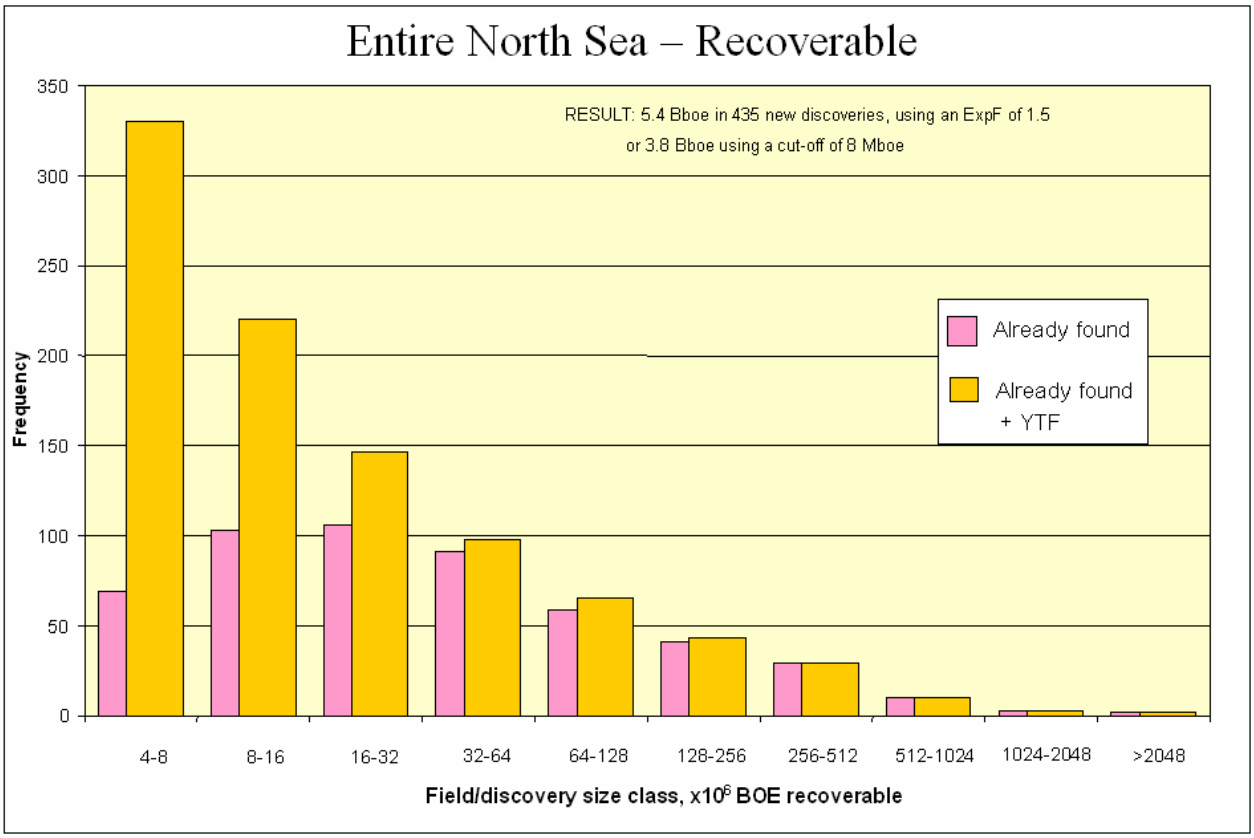

Fig 3 FSD – Northern North Sea - ‘Recoverable’ volumes

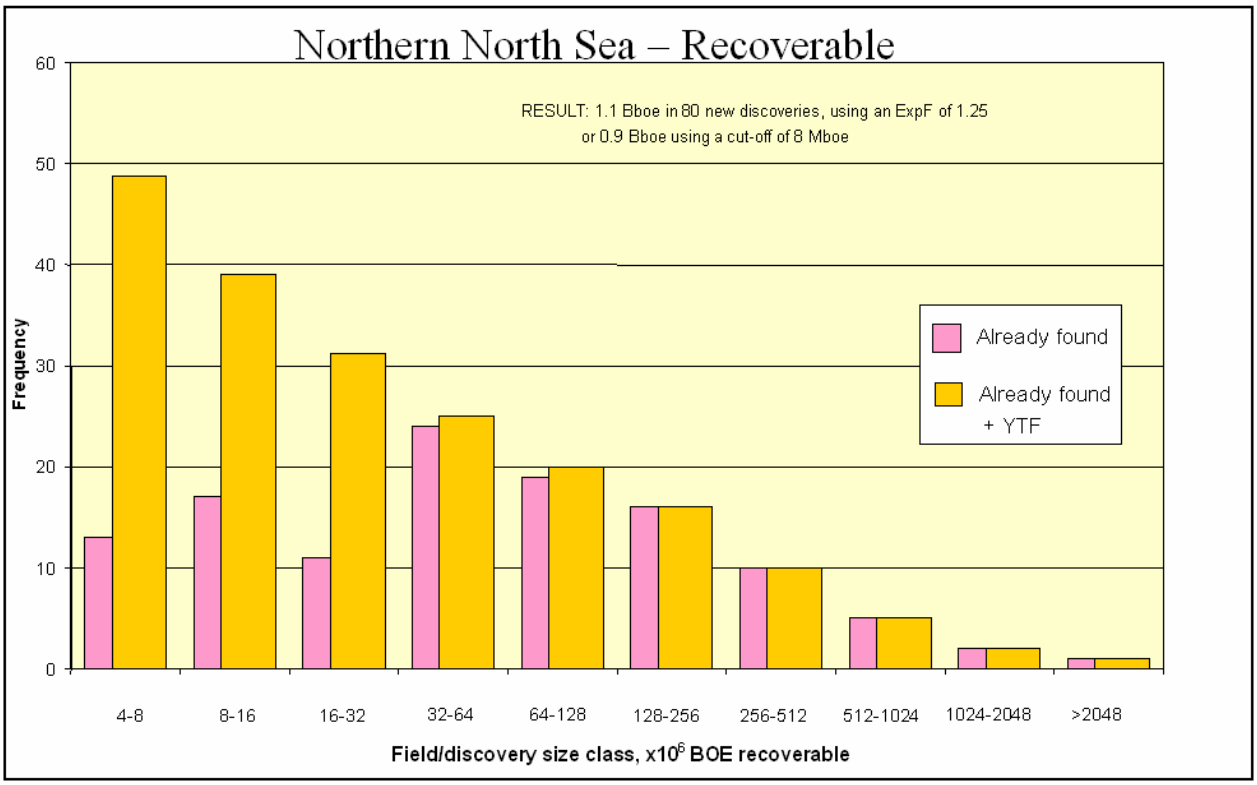

Fig 4 FSD – Central North Sea - ‘Recoverable’ volumes

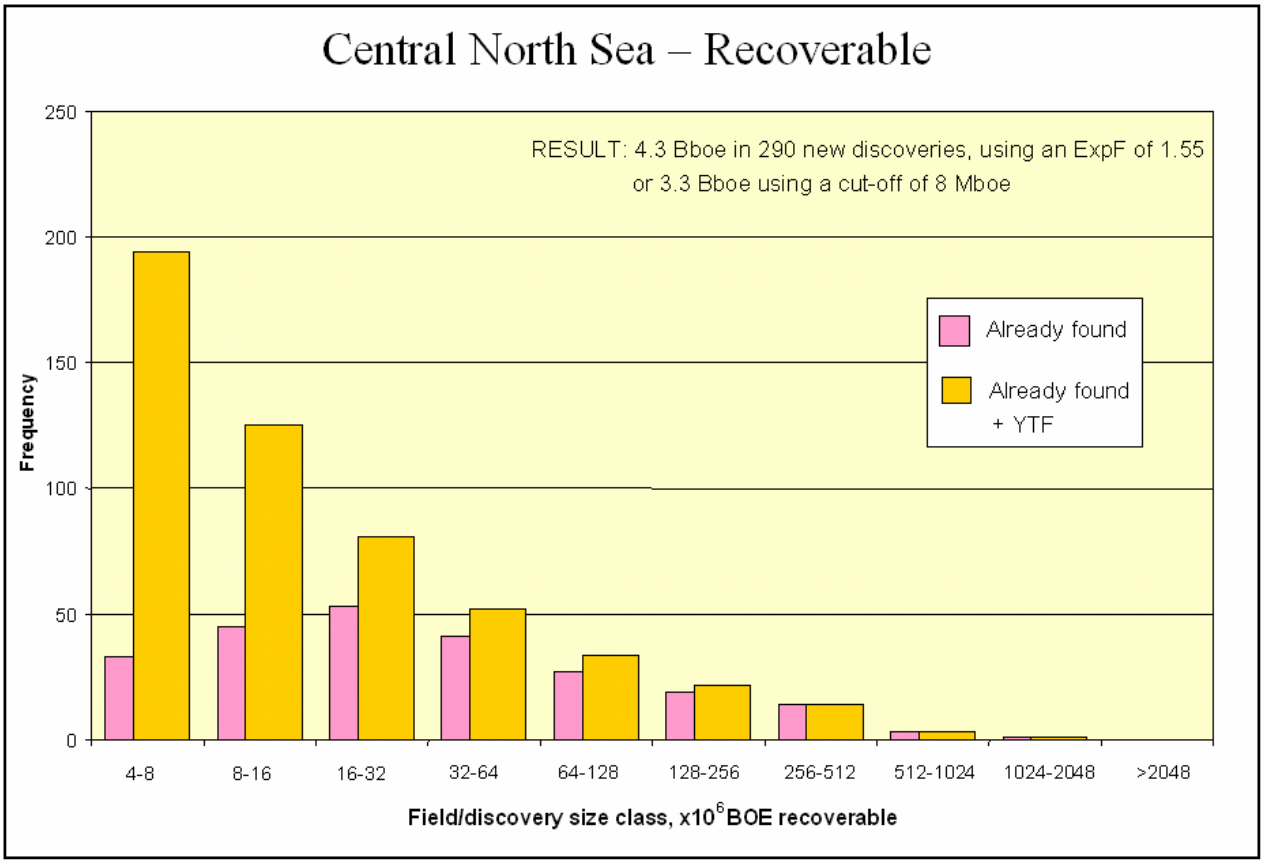

Fig 5 FSD - Southern North Sea - ‘Recoverable’ volumes

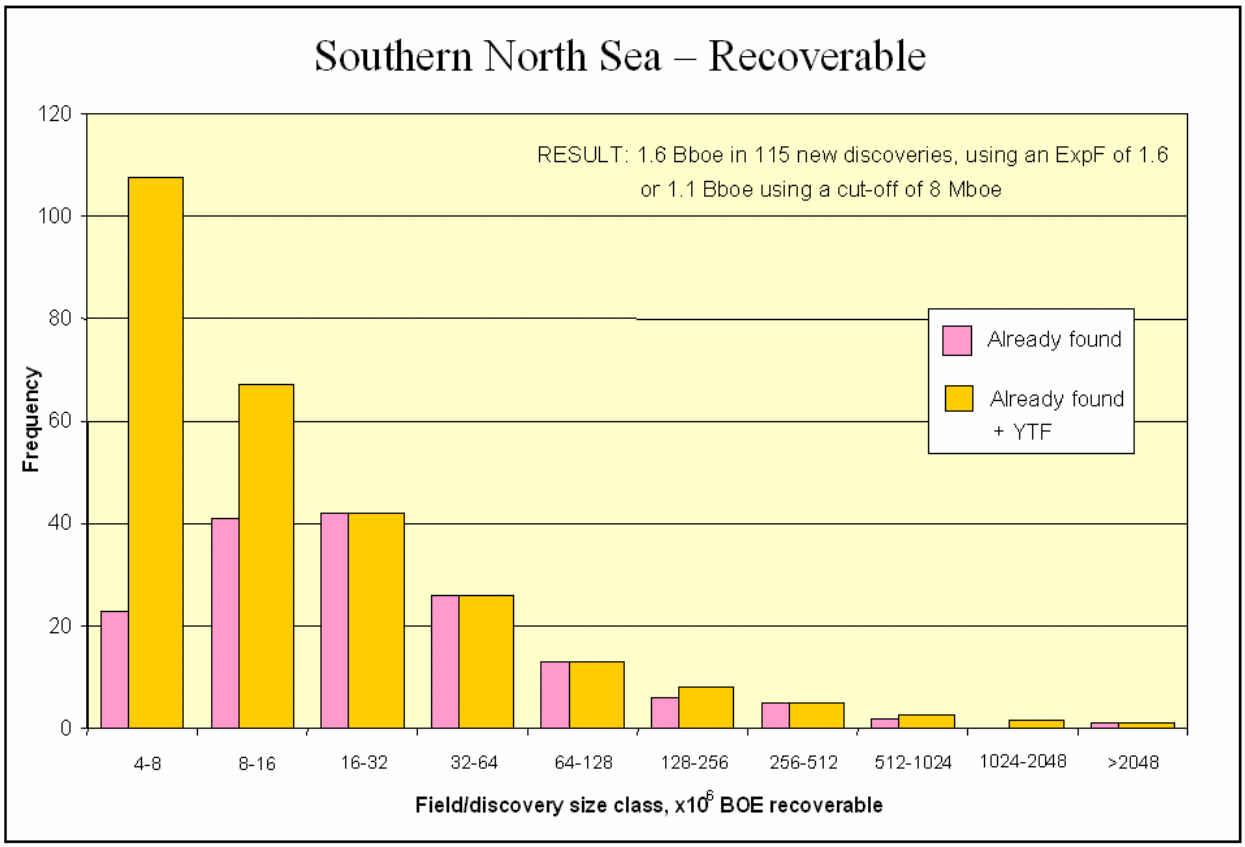

Fig 6 – Discovery Curve for entire North Sea - ‘Recoverable’ volumes

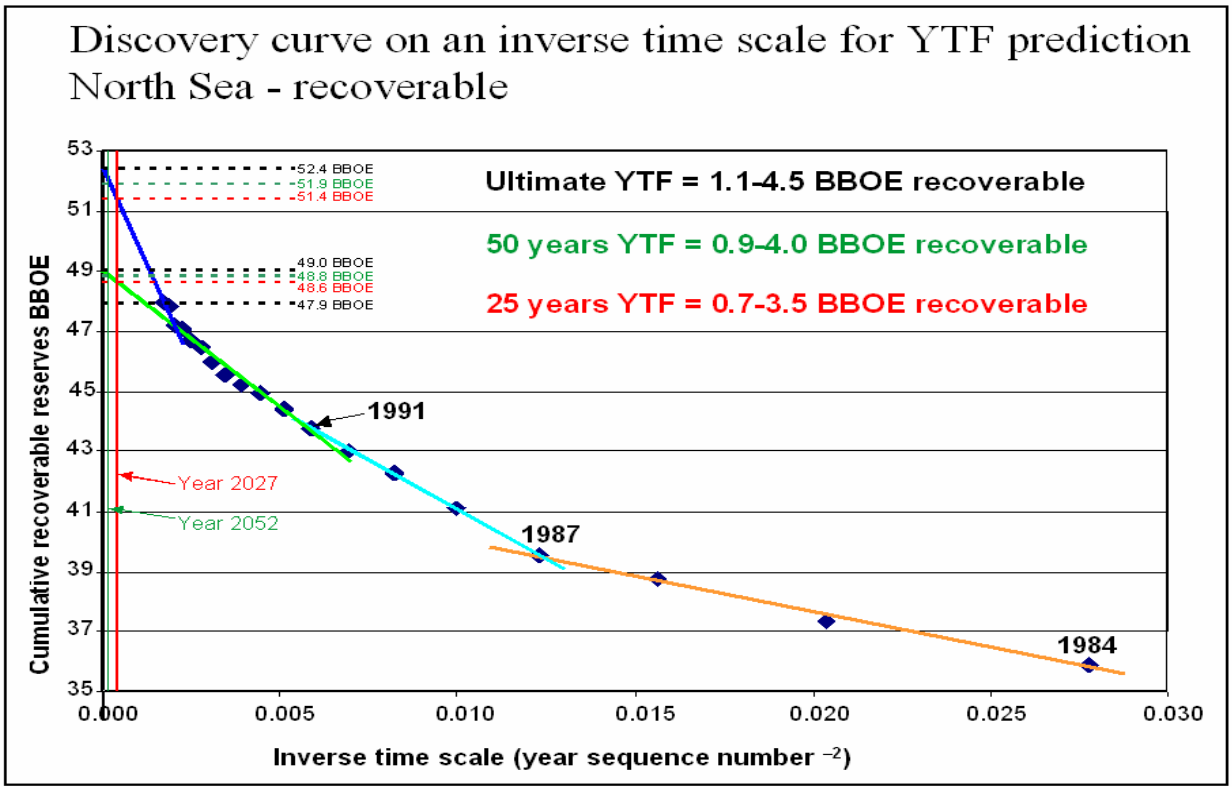

Fig 7 – Mapped Lead and Prospect analysis from 21st Round applications