The Impact of Declining Major North Sea Oil Fields Upon Norwegian and United Kingdom Oil Production

Roger D. Blanchard
Department of Chemistry
Northern Kentucky University
Highland Heights, KY 41099-1905
Phone: (606) 572-6552
FAX: (606) 572-5162
e-mail: blanchard@nku.edu

There has been a growing debate concerning the direction of future global oil production. Several prominent international petroleum geologists have written numerous papers expressing the view that world oil production will peak in the not too distant future, possibly before 2010.[1,2,3] They base their assessment on a 1956 model developed by the petroleum geoscientist M. King Hubbert. The Hubbert model assumes that if oil production is unrestrained in a very large producing region, it will follow a bell-shaped curve with peak production occurring when approximately 1/2 of the ultimately recoverable amount of oil is extracted. Figure 1 is a graph of oil production versus time for the U.S. lower 48 states. For this paper, oil is considered crude oil plus condensate. Historical oil production in the U.S. lower 48 states approximates a bell-shaped curve with peak production occurring in 1971 and a decline after the peak of approximately 4.5 million barrels/day (mb/d) by 1999 (~ 48%).

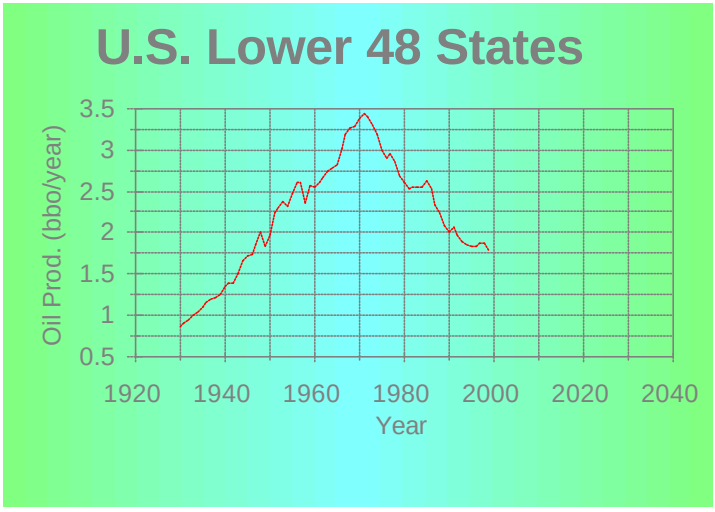


Figure 1: Historical Oil Production
For the U.S. Lower 48 States

The opposing view that oil production will increase far into the future is expressed by organizations such as the U.S. Department of Energy/Energy Information Administration (U.S. DOE/EIA) and the American Petroleum Institute (API).[4,5,6] These organizations project a significant expansion of world oil production in the future due to the application of advanced oil production technology. Matthew Simmons, in a February

1999 *World Oil* article, introduced another factor to the debate.[7] He discussed the problem of declining oil fields in many producing basins around the world and the impact of these declining fields on global oil production. He wondered what the average depletion rate may be for declining oil fields and how that will influence long-term supply. This paper provides data for net depletion rates, after efforts to enhance production, in one important oil production region of the world.

The North Sea has been a major oil production province since its first significant production in the middle 1970s. In 1998, North Sea oil production represented nearly 9% of world oil production.[8] North Sea fields were selected for this analysis because high quality data are available for individual oil fields, because the North Sea has been a key factor in increasing non-OPEC oil production over the last 20 years, and because the best available technology is used in the North Sea. Norway and the United Kingdom (U.K.) are the main oil producing countries in the North Sea and major oil fields within these two countries will be analyzed. In this paper, a major field is considered one with an estimated ultimate recovery (EUR) of greater than 100 million barrels oil (mbo). There are approximately 35 major Norwegian oil fields and 55 major U.K. oil fields in the North Sea. Masters et al. (1994) assessed the total EUR (all fields) for Norway at approximately 30 billion barrels oil (bbo) and the U. K. at approximately 36 bbo.[9] U.K. field data from 1976 through 1997 were obtained from *Oil & Gas Journal*. Field data for Norway from 1978 through 1997 are from *Oil & Gas Journal* and 1998 field data from the Norwegian Petroleum Directorate (NPD).

Seven major Norwegian fields peaked prior to 1995 and 29 major U.K. fields peaked prior to 1994. Table 1 provides data for the Norwegian major oil fields in decline.

Table 1
Norwegian Major Oil Fields in Decline with Maximum Production Levels Prior to 1995

Fields	Estimated Ultimate Recovery (mbo)[a]	Maximum Production Year	Maximum Production (b/d)[10]	1998 Production (b/d)[11]	Decline from Maximum Prod. to 1998 Prod. (b/d)	% Decline from Maximum Prod. to 1998 Prod.
Tor	>130	1979	80,361	5,981[b]	74,380[b]	92.6[b]
Eldfisk	>450	1980	118,166	40,570[b]	77,596[b]	65.7[b]
Statfjord	4,500	1991	741,532[c]	315,145[d]	426,387	57.5
Ula	420	1992	133,000	29,256	103,744	78.0
Gyda	230	1992	68,000	32,198	35,802	52.6
Gullfaks	2,500	1994	530,000	338,846	191,154	36.1
Oseberg	2,800	1994	502,644	415,467	87,177	17.3

[a] Values were determined by plotting annual production versus cumulative production and extrapolating to the x-axis for data after the maximum production level

[b] Using 1997 production figures from Oil & Gas Journal. The Norwegian Petroleum Directorate does not have individual field data for Tor and Eldfisk in 1998

[c] Sum for Norway plus the U.K. Norway has an 85.5% share and the U.K. a 14.5% share of Statfjord

[d] U.K. 1998 production for Statfjord was obtained from Statoil

Table 2 provides data for the U.K.'s major oil fields in decline.

Table 2
U.K. Major Oil Fields in Decline with Maximum Production Levels Prior to 1994[10]

Fields	Estimated Ultimate Recovery (mbo)[a]	Maximum Production Year	Maximum Production (b/d)	1997 Production (b/d)	Decline from Maximum Prod. to 1997 Prod. (b/d)	% Decline from Maximum Prod. to 1997 Prod.
Auk	>120	1977	58,690	13,301	45,389	77.3
Piper	1,100	1979	276,758	49,334	227,424	82.2
Forties	2,700	1980	523,000	85,660	437,340	83.6
Thistle	420	1982	129,662	8,868	120,794	93.2
Ninian	1,200	1982	304,806	48,323	256,483	84.1
Heather	110	1982	37,767	4,948	32,819	86.9
Maureen	230	1984	85,374	9,044	76,330	89.4
Claymore	650	1984	103,600	40,529	63,071	60.9
Murchison[b]	390	1984	109,145	22,753	86,488	79.2
Brent	2,400	1985	439,843	132,751	307,092	69.8
Beatrice A&B	>160	1985	57,649	9,334	48,315	83.8
Buchan	>120	1985	39,000	9,123	29,877	76.6
South Brae	270	1986	97,879	8,962	88,917	90.8
Fulmar	550	1986	156,962	11,474	145,488	92.7
North Cormorant	>250	1986	100,998	30,170	70,828	70.1
N.W. Hutton	140	1986	52,785	6,318	46,467	88.0
Dunlin	390	1987	103,273	16,315	86,958	84.2
Tartan	140	1987	35,110	6,775	28,335	80.7
Clyde	140	1988	51,443	14,337	37,106	72.1
Hutton	210	1988	63,012	15,959	47,053	74.7
S & C Cormorant	300	1988	122,400	20,775	101,625	83.0
Eider	120	1990	40,548	13,381	27,167	67.0
North Brae	145	1990	80,400	7,690	72,710	90.4
North Alwyn	250	1991	92,058	18,304	73,754	80.1
Balmoral	120	1992	28,050	9,756	18,294	65.2
Arbroath	280	1992	35,478	23,600	11,878	33.5
Scapa	140	1992	28,128	18,247	9,881	35.1
Magnus	800	1992	155,400	64,644	90,756	58.4
Beryl	1,100	1993	110,849	77,260	33,589	30.2

[a] Values were determined by plotting annual production versus cumulative production and extrapolating to the x-axis for data after the maximum production level

[b] Production figures for Murchison are the sum of production for the U.K. plus Norway. The U.K. has a 77.8% share and Norway has a 22.2% share of Murchison

The 7 major oil fields in Table 1 constitute approximately 37% of Norway's total EUR and the 29 major oil fields in Table 2 constitute approximately 42% of the U.K.'s total EUR based upon Masters' EUR values. Several aspects of the data in Tables 1 and 2 are worth noting. First, the application of modern technology in the extraction of oil has

not prevented rapid production declines in major North Sea oil fields. It actually contributes to the high rates of decline by accelerating the rates of extraction and the subsequent rates of decline. Second, not all oil fields decline at the same rate due to a variety of factors, but all fields in Tables 1 and 2 that have been in decline for at least 6 years have total declines of more than 50% from their maximum production levels.

Figures 2-7 are graphs of field production versus year for the 3 Norwegian and 3 U.K. oil fields that achieved the highest production rates. For the 3 Norwegian fields, the last data point is the average production rate for the first 9 months of 1999. The substantial drop off in production for the Ninian field in 1984 and Brent field in 1990 are indicative of technical difficulties that occasionally led to extended shutdowns and reduced production rates in oil fields.

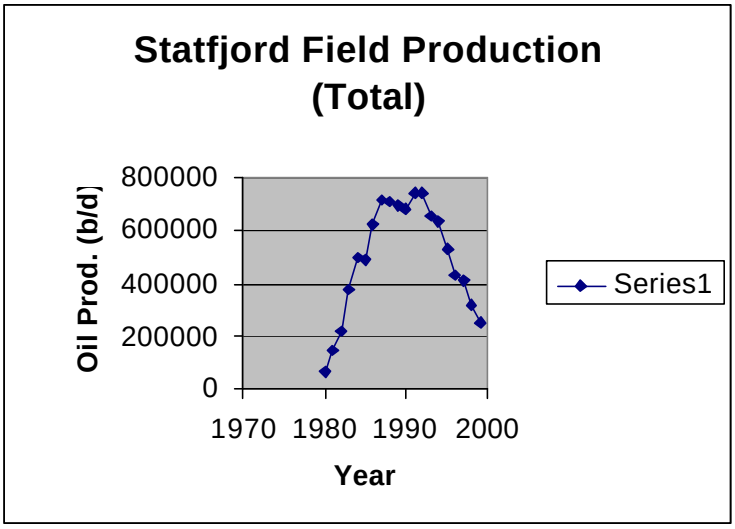
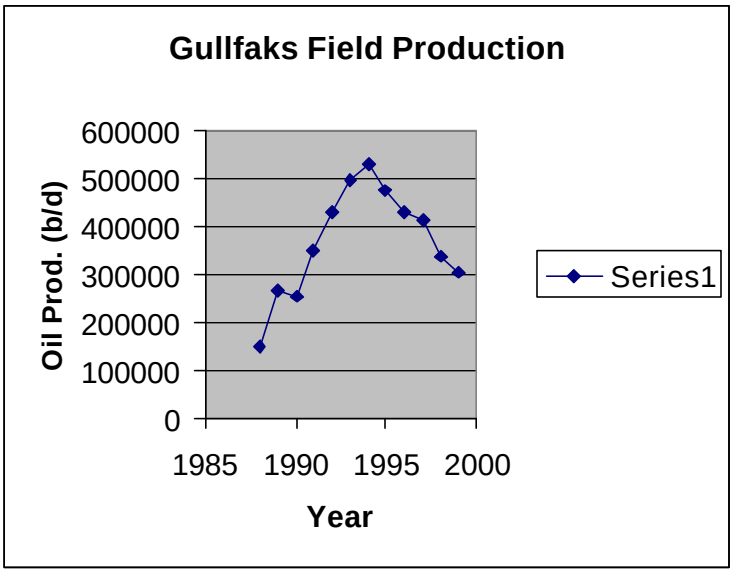


Figure 2



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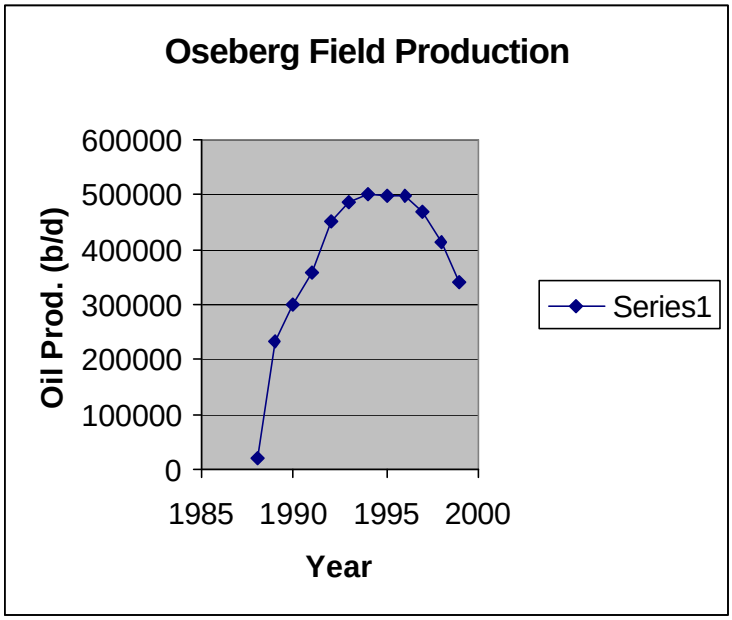


Figure 4

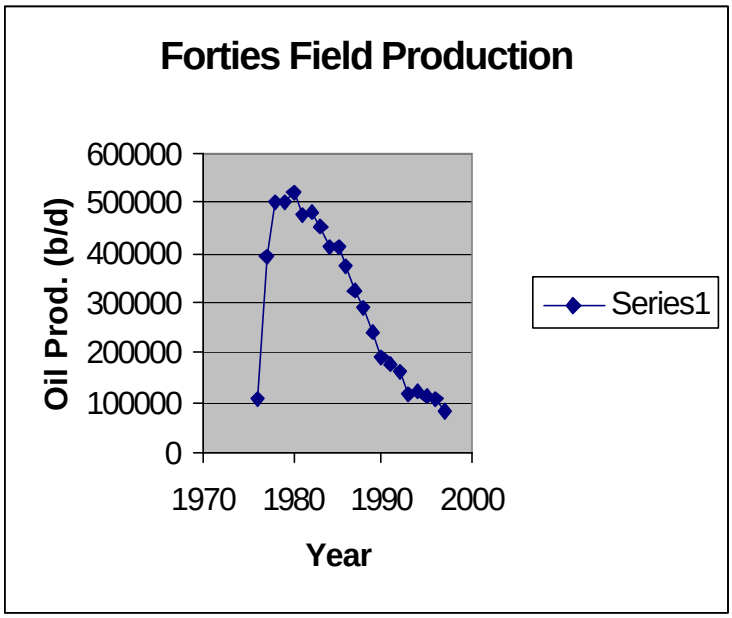
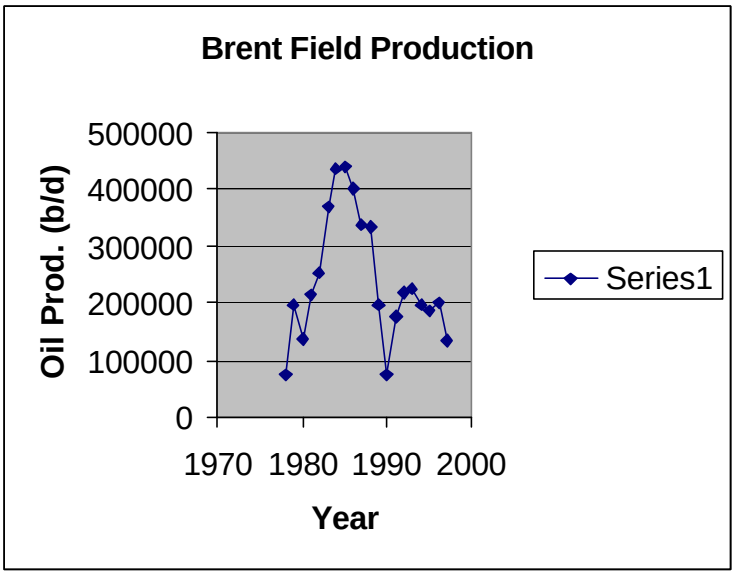


Figure 5



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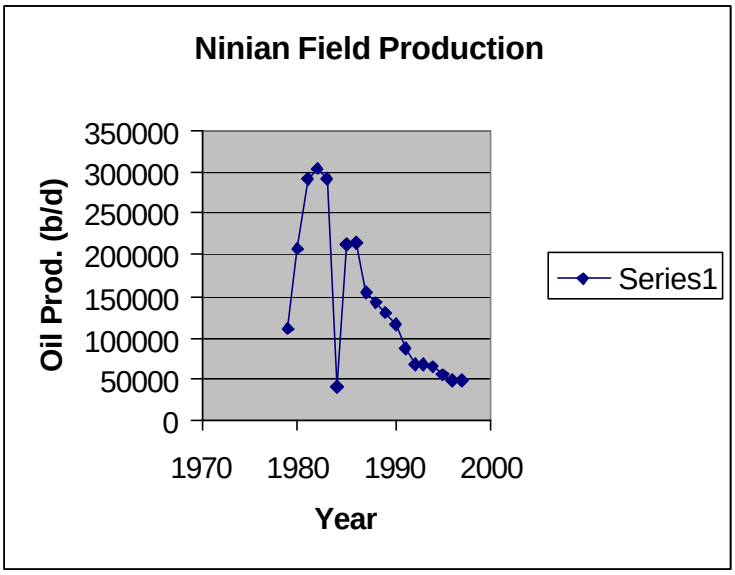

Figure 7

Figure 8 shows the summed oil production versus time for Norwegian oil fields in Table 1. The decline in summed oil production for these fields has been 675,492 b/d (36.1%) since 1994.

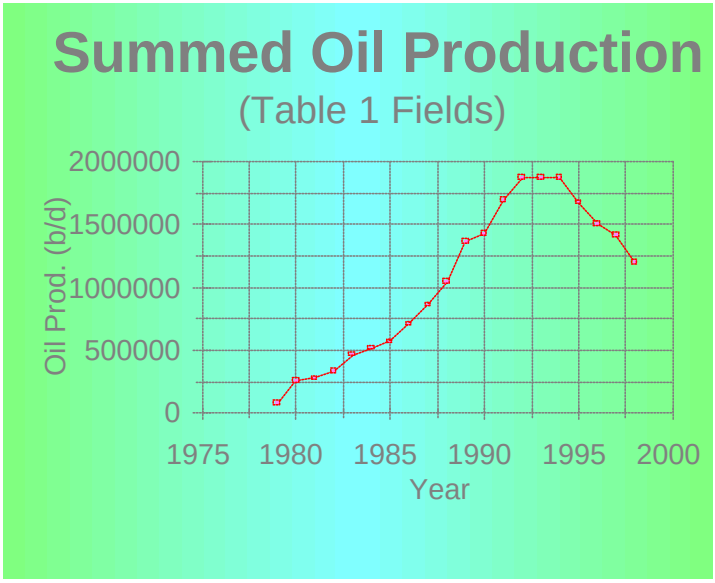

Figure 8: Summed Production for Norwegian Oil Fields
In Table 1

Figure 9 shows the summed oil production versus time for U.K. oil fields in Table 2. The decline in summed oil production for these fields has been 1,482,064 b/d (65.0 %) since 1988.

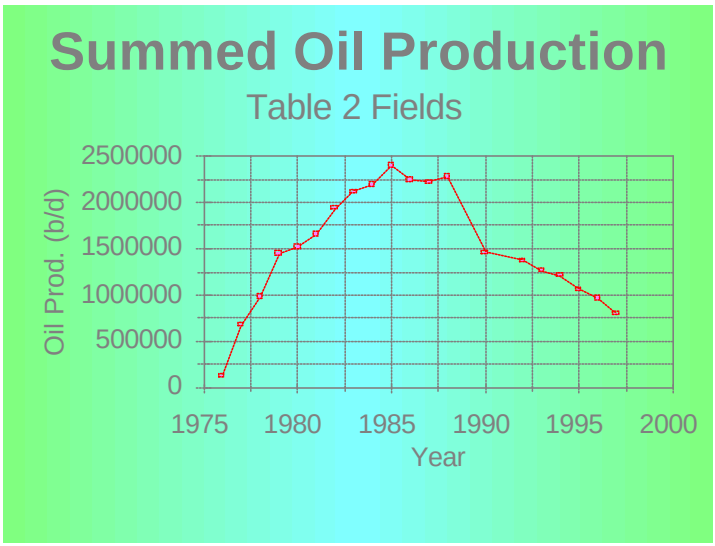

Figure 9: Summed Production for U.K. Oil Fields
In Table 2

Many of the major fields in the North Sea are now in decline. To counteract the rapid decline of mature fields, new but smaller fields are being brought on-line at an accelerated rate. As an example, in Norway 23 out of 34 fields (67 %) listed in the Sept. 1999 Field Data Press Release by the NPD have start-up dates after January 1, 1993. In the U.K. sector of the North Sea, the 200th oil and gas field was recently brought on-line.[12] It took 25 years for the first 100 fields to be brought on-line but only 6 years to bring the second 100 fields on-line. According to the U.S. DOE/EIA, the average EUR

of new U.K. oil fields is approximately 50 million barrels.[13] That is small compared to the large early U.K. fields (see Table 2). The fields that are now being brought on-line in both the U.K. and Norway are coming on-line at or near maximum production and many will have lifetimes of 10 years or less. In an extreme example, the Durward and Dauntless fields were brought on-line in August 1997 and were terminated in April 1999.

As an oil province becomes more extensively explored, there are fewer places to search for new fields. The North Sea has been extensively explored and consequently the oil discovery rate has been declining. This is illustrated in Figures 10 and 11. Figure 10 is a graph of cumulative oil discovery versus the cumulative number of wildcat oil wells for Norway.

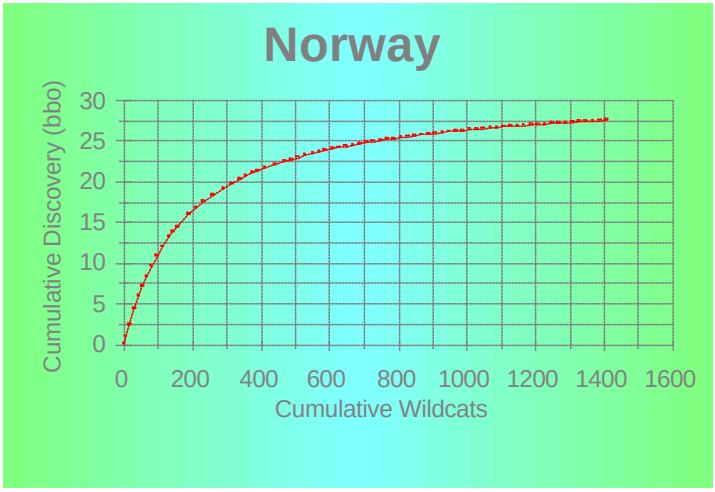

Figure 10: Cumulative Discovery versus Cumulative Wildcats for Norway

Figure 11 is a graph of cumulative oil discovery versus the cumulative number of wildcat oil wells for the U.K. sector of the North Sea.

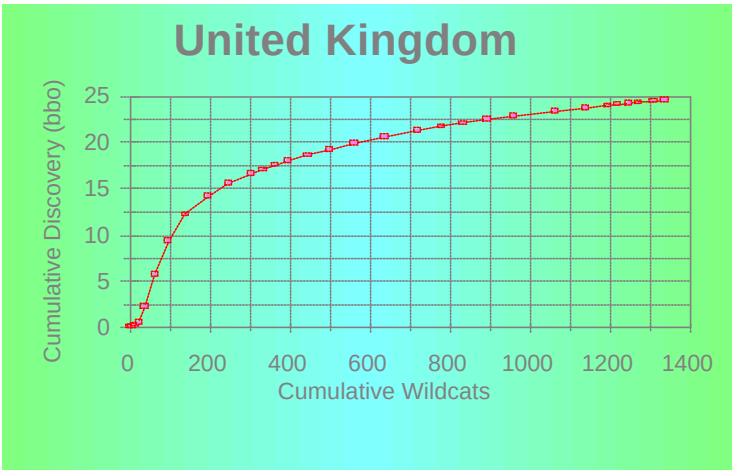

Figure 11: Cumulative discovery versus cumulative wildcats for the U.K. sector of the North Sea

The curves in Figures 10 and 11 suggest that the EUR values for Norway and the U.K., estimated by Masters et al., are not unrealistic. Virtually all of Norway's oil is located in the North Sea but the U.K. has oil in areas other than the North Sea.

At the end of 1998, 11.7 bbo had been produced in Norway and 16.8 bbo had been produced in the U.K. Based upon Hubbert's model, the current rates of oil production, and the EUR values from Masters et al., Norway's total oil production, for all fields, would peak in approximately 2001 and the U.K.'s total oil production, for all fields, would peak in approximately 1999. Figure 12 is a plausible oil production curve for Norway based upon Masters' EUR value for Norway. Oil production through 1998 represents historical data and production after 1998 represents projected production. The total area under the curve represents 30 bbo and the decline rate after the peak is 7.2 %/year.

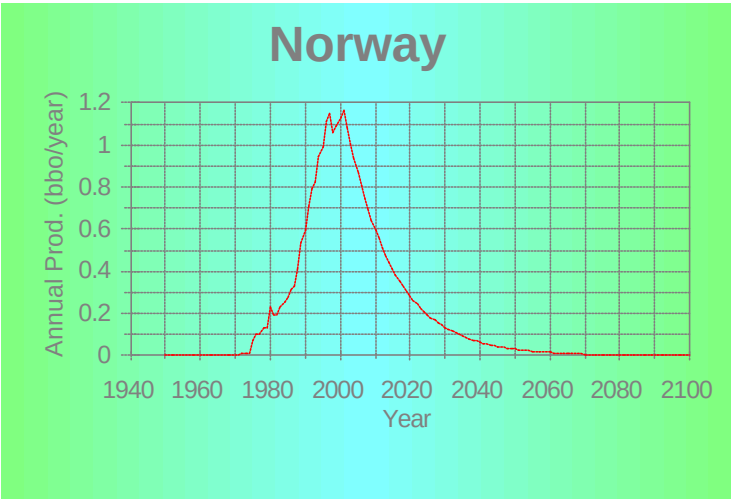

Figure 12: Historical and Projected Production for Norway

Figure 13 is a plausible oil production curve for the U.K. based upon Masters' EUR value for the U.K. Oil production through 1998 represents historical data and production after 1998 represents projected production. The total area under the curve represents 36 bbo and the decline rate after the peak is 5.0 %/year. A 1995 report by the U.K. Offshore Operator's Association projected a similar 5%/year decline rate after peak production to 2020 for U.K. offshore production.[14]

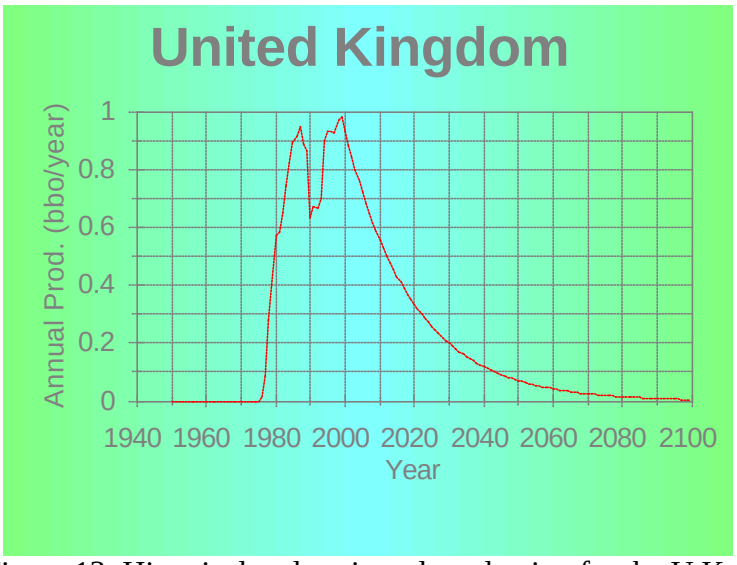

Figure 13: Historical and projected production for the U.K.

The U.S. DOE/EIA has been very optimistic concerning the impact of technology on future oil production. In their 1999 International Energy Outlook, they project that oil production from the North Sea, mainly the U.K. and Norway, will increase significantly in coming years from 6.2 mb/d in 1998 to a peak in 2006 above 8 mb/d (includes natural gas liquids, NGL's, and processor gain).[4] They also project a decline rate of about 2% per year, after the peak, to 2020. Table 5 shows a comparison of the author's projections of Norwegian and U.K. oil production versus the U.S. DOE/EIA's projections.

Table 5
Author's and U.S. DOE/EIA's
Projections of Norwegian and U.K. Oil Production to 2020

Author's Projections	Peak Year	Peak Oil Production (mb/d)	2010 Oil Production (mb/d)	2020 Oil Production (mb/d)
Norway	2001	3.2	1.6	0.77
U.K.	1999	2.7	1.5	0.92
U.S. DOE/EIA's Projections[4]				
Norway	2005	3.9[a]	-	3.2[a]
U.K.	~2006	3.3[a]	-	2.2[a]

[a] Excludes NGL's and processor gain. From 1995 through 1998 crude + condensate made up 90% of U.K.'s total oil production and 96% of Norway's total oil production. It's assumed that these percentages won't change in the future.

Based upon the U.S. DOE/EIA's projections, both Norway and the U.K. would have cumulative oil production values of approximately 40 bbo by 2020 (excluding NGL's and processor gain). This would by approximately 10 bbo more than the EUR for Norway and 4 bbo more than the EUR for the U.K. based upon the estimates by Masters et al. There would also be considerable production in both countries after 2020 to add to those cumulative production values because oil production wouldn't end abruptly at 2020. Figure 14 is a graph of historical and projected oil production for Norway based upon the U.S. DOE/EIA's projections (excluding NGL's and processor gain).

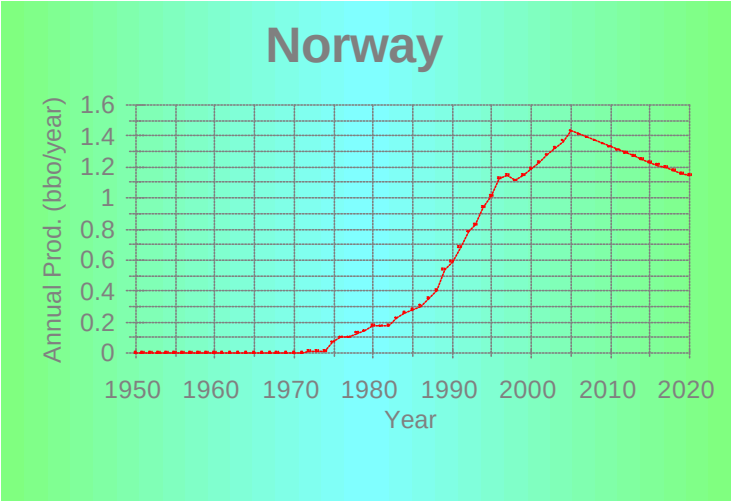

Figure 14: Historical and Projected Production for Norway based upon U.S. DOE/EIA's projection for Norway

The area under the curve to 2020, in Figure 14, represents a cumulative production of approximately 40 bbo. Figure 15 is a graph of the U.K.'s historical and projected oil production based upon the U.S. DOE/EIA's projections (excluding NGL's and processor gain).

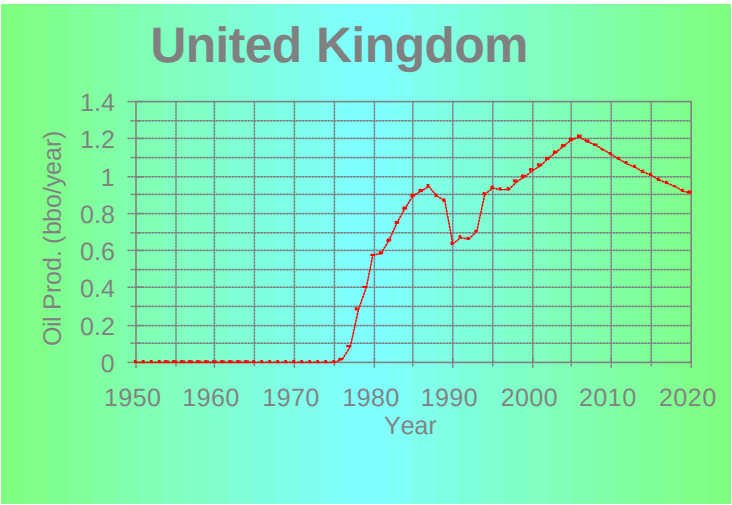

Figure 15: Historical and Projected Production for the U.K. based upon U.S. DOE/EIA's projection for the U.K.

The area under the curve to 2020, in Figure 15, represents a cumulative production of approximately 40 bbo.

It doesn't appear that the U.S. DOE/EIA is considering the high decline rates of major North Sea oil fields or the EUR values from the U.S. Geological Survey[9] when making projections of future production in the U.K. and Norway, or for that matter, in their global assessment. The rapid decline of major fields appears to exist in many producing basins around the world and must be considered in long-term supply forecasts. If this situation isn't recognized by national and international organizations that make projections of long-term supply, the future may present some unpleasant surprises.

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