

Resource report 2016



NORWEGIAN PETROLEUM
DIRECTORATE

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PREFACE



The Norwegian Petroleum Directorate (NPD) presents updated estimates of undiscovered resources on the Norwegian continental shelf (NCS) at regular intervals. These also occupy an important place in this year's report. Our previous review of undiscovered resources on the NCS is three years old. Fifty-seven discoveries have been made since the resource report in 2013. At the same time,

changes to our overall estimate of undiscovered resources are insignificant. A slight decline in the North and Norwegian Seas is outweighed by a higher estimate for the Barents Sea. That largely reflects the geological information provided by exploration results in recent years.

Fifty years have passed since the first exploration well was spudded on the NCS. Since then, roughly 100 fields have been brought on stream, jobs have been generated and value creation for society has been huge. Forty-seven per cent of the total expected resources have so far been produced, and undiscovered resources amount to 20 per cent. This means that much remains to be found, and that the basis exists for continued production over many decades.

Most of the discoveries made since the 2013 resource report are located close to existing infrastructure, and can be developed simply and cost-effectively through tie-backs to such facilities as platforms and transport networks. That applies particularly to the discoveries in the North Sea and mature parts of the Norwegian Sea, and underlines the importance of exploring in these areas. That discoveries are still being made after 50 years of exploration activity underpins the continuing attractiveness of NCS as a petroleum province. Each exploration well provides more knowledge about and a basis for enhanced understanding of the geology and resource potential of the continental shelf.

To make discoveries, wells must be drilled. The level of activity has been high over the past decade, with an annual average of 40 exploration wells. No less than 56 were spudded in 2015, and about 30 are expected in 2016.

We have conducted an analysis of the full-cycle profitability of exploration in 2000-14, which shows that this activity paid off in socio-economic terms in every part of the NCS during the period. Our calculations indicate that the greatest value creation has clearly taken place in the North Sea, since the levels of exploration activity and investment have been highest there. Access to infrastructure, as in the North Sea, also boosts profitability. Exploration creates great value for society in the Norwegian and Barents Seas, too. In the longer term, new discoveries which contribute to infrastructure development in these regions will lay the basis for a level of value creation similar to that in the North Sea.

Fifty-three companies were involved on the NCS at 31 December 2015. That represents a doubling since 2000. Most of these companies are active in the exploration phase. New players mean greater diversity, which means in turn that more and innovative ideas get tried out. This contributes overall to further discoveries and enhanced value.

An important part of our work is to map unopened areas of the NCS in order to increase understanding of and knowledge about the geology of these areas. Our commitment in recent years has primarily been directed at data acquisition from Barents Sea North and Barents Sea North-East, towards the boundary with Russia. During the summer of 2015, for example, shallow wells were drilled east and north of Kvitøya. Results from these will be important for understanding the geology and resource potential in Barents Sea North, including the area adjacent to the boundary with Russia. Work is now under way to interpret the data we have acquired in recent years.

Exploration is learning, and it takes time to learn. We are now in a period where the industry faces major challenges. Maintaining a long-term perspective is important at such times. The purpose of this report is to provide greater understanding of the resource base on the NCS, and thereby contribute to good choices of direction for future value creation.

A handwritten signature in black ink, which appears to read 'Sissel Eriksen'.

Sissel Eriksen
Exploration director



A bronze model of the Ekofisk field forms part of the decoration in the Norwegian Petroleum Directorate's offices at Ullandhaug in Stavanger.

INTRODUCTION

The purpose of the 2016 resource report is to detail the status of, facts about and analyses concerning exploration developments on the NCS, and to present an updated estimate for undiscovered resources.

The 2016 resource report has three main messages:

- Exploration activity has been high over the past decade, and a number of large discoveries have been made. Resource growth from exploration represents substantial value for Norwegian society.
- The level of exploration activity must remain high if undiscovered resources are to help maintain production from around 2025 and create value both for the industry and for society in a long-term perspective.
- The total remaining resources can provide a basis for oil and gas production over many decades to come. That view is supported by the updated estimate for undiscovered resources.



The first NCS map, 1965.

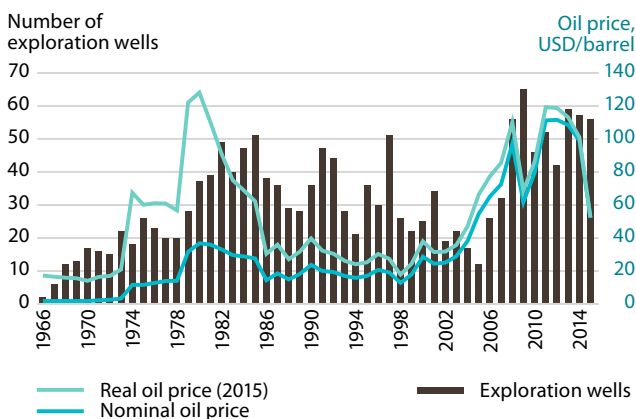


Figure 1.1 Exploration wells spudded and oil prices, historical. Sources: BP, Thomson Reuters and EIA

This year marks the 50th anniversary of the first wildcat spudded on the NCS. The first commercial petroleum deposit, Ekofisk, was discovered in late 1969. Once the size of that field had been grasped, it became very attractive for the oil companies to explore the NCS and a number of major discoveries were made over the following decade.

In the course of the 50 years since the first wells were drilled, oil prices have fluctuated considerably. That has also affected the level of activity in the industry (figure 1.1).

Targeted measures

Exploration activity declined in the wake of relatively low oil prices during the late 1990s, and the low point was reached in 2005 with 12 wells spudded. Long-term projects such as

exploration and technology development were postponed, and many employees made redundant. Companies merged and their diversity was reduced.

The low level of exploration activity prompted the government to adopt targeted measures to encourage competition and increase diversity on the NCS. Three adjustments to operating parameters were particularly important – the prequalification of new companies, annual licensing rounds with awards in predefined areas (the APA scheme), and refunding the tax value of exploration expenses. Combined with rising oil prices, these steps led to a sharp increase in exploration activity. New companies became involved, and a number of profitable discoveries were made.

Cost reductions

Partly because the level of activity was high, costs eventually rose steeply. Measures were therefore adopted to reduce them and limit capital spending. A big fall in oil prices from the late autumn of 2014 made that even more necessary. Drilling rigs are now being laid up, investment is being postponed and workforces are being downsized. A substantial decline in the number of exploration wells is expected in 2016.

Lower prices give the whole industry a strong incentive to work more efficiently and to be innovative. That will be significant for the competitiveness of the NCS and for achieving good resource management. However, it is important that cost-cutting efforts do not lead to the loss of resources and value, but aim at long-term measures which enhance industry efficiency.

Solid resource base

Total expected recoverable resources were estimated at 31 December 2015 to be 14.2 billion standard cubic metres of oil equivalent (scm oe) (figure 1.6 and table 1.1). Of this amount, 6.6 billion scm oe has been produced. After 45 years of petroleum production, more than half the estimated resources remain to be recovered.

Oil production has historically been larger than gas output (figure 1.2). This position has been reversed over the past five years. Gas revenues outstripped income from oil for the first time in 2015.

Forty-one per cent of the remaining estimated resources are classified as reserves and 38 per cent as undiscovered (figure 1.3). Contingent resources in fields and discoveries account for the remainder. Gas represents more than half the remaining resources.

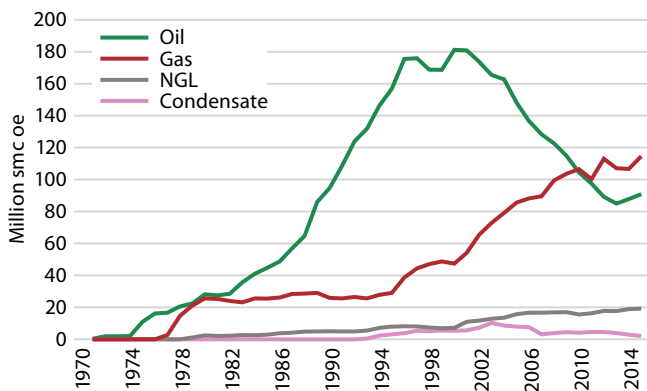


Figure 1.2 Production from the NCS, historical.

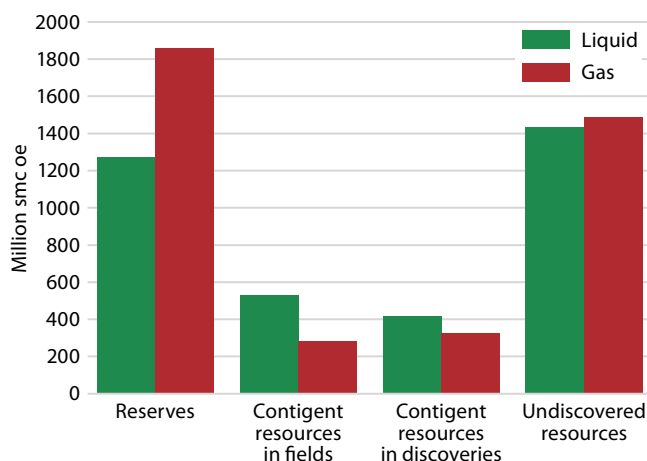


Figure 1.3 Estimated remaining petroleum resources at 31 December 2015.

Prices – very significant for exploration and recovery

The future development of oil and gas prices will be very significant for exploration activities, the development of discoveries and how much of the resources will be commercial. These trends are governed by conditions external to Norway. What the players – both companies and government – can do something about is to contribute actively to optimising the efficiency of exploration and recovery on the NCS. Improved productivity and lower unit costs could help to sustain activity, production and value creation for a long time to come.

Long-term perspective

The NPD takes the view that the total remaining resources provide a basis for continued Norwegian oil and gas production over many decades to come (figure 1.4).

Undiscovered resources will represent an increasing share of annual output from 2025. Substantial undiscovered resources remain to be found.

If these are to help sustain production, a high level of exploration activity must be maintained. Many years can pass before a discovery comes on stream. Exploration activity over the next few years will therefore be important for reducing the decline in production.

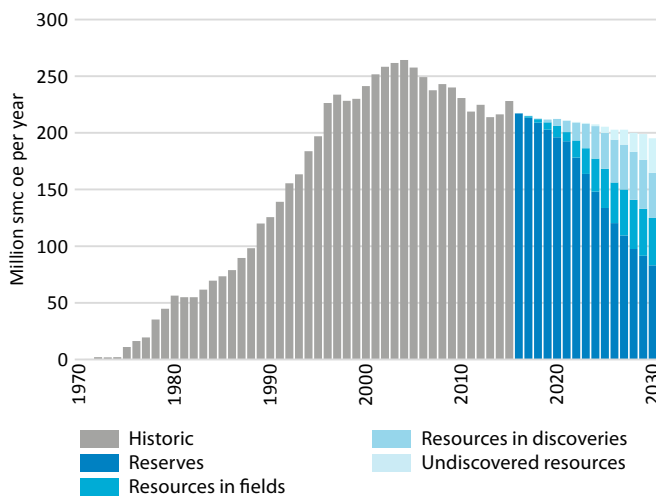


Figure 1.4 Historical and expected production from the NCS.

Chapter 2: Exploration on the NCS

Exploration activity is essential if undiscovered resources are to contribute to production and create value both for the industry and for society. Through its exploration policy, the government gives companies access to exploration acreage in both mature and frontier areas. A high level of exploration activity on the NCS since 2005 has resulted in a number of profitable discoveries.

Chapter 3: Undiscovered resources

The updated estimate for undiscovered resources confirms that total remaining resources provide the basis for oil and gas production over many decades to come. It is roughly the same as the previous estimate in 2013. Total undiscovered resources are put at 2 920 million scm oe. About half of this amount lies in the Barents Sea, where the biggest change has occurred in the estimate. It has increased by about 125 million scm oe for this area.

Chapter 4: Full-cycle profitability of exploration

Exploration contributed substantial value to society between 2000 and 2014, according to the NPD's analysis of its profitability during this period.

Overall net cash flow from discoveries made in these years is estimated at roughly NOK 2 000 billion after deducting exploration costs.

The analysis shows that exploration made a positive contribution to value creation in all parts of the NCS. Both activity and resource growth have clearly been greatest in the North Sea, with Johan Sverdrup as the biggest contributor to value creation. Exploration in the Norwegian and Barents Seas has also generated substantial value.

Chapter 5: Player picture

A player picture which reflects the challenges facing the industry in both mature and less mature areas is important for realising the resource and value potential.

Companies involved in the exploration phase today display considerable diversity. The result has been a high level of activity, increased competition and a greater variety of ideas, which have yielded many discoveries and created substantial value for society.

It is important that the companies participate actively in the exploration phase and contribute expertise and capital. The NPD's analysis of the part played by the various company constellations shows that they have all made a positive contribution to exploration, resource growth and value creation.

Getting more companies involved in the exploration phase has also increased the number of operators for discoveries and fields. While eight companies were operators for producing fields in 2000, this had risen to 15 in 2015.

Chapter 6: Geological mapping

Geological mapping by the NPD in unopened and frontier areas of the NCS helps to enhance understanding of their geology and to expand data coverage. Funds for this work are provided over the government budget.

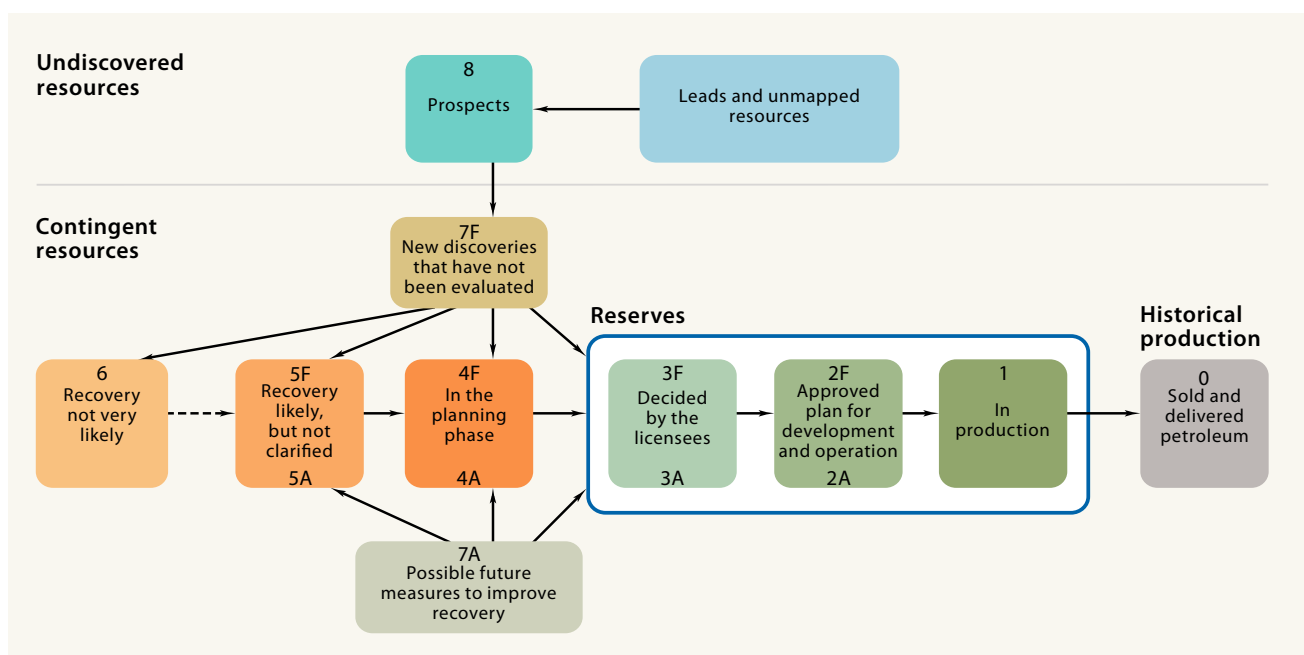


Figure 1.5 Classification of resources by the NPD.

Resource accounts at 31 December 2015

The NPD's resource accounts provide an overview of total expected recoverable petroleum resources, including those remaining to be discovered, and form the basis for the production forecast in figure 1.4. They incorporate resources from the whole NCS, with the exception of the new Barents North-East area defined by the boundary treaty between Norway and Russia.

These accounts build on data reported by the operators as well as the NPD's own assessments of fields and discoveries and its estimate of undiscovered resources. They are based on the NPD's resource classification. All petroleum quantities can be related to a project, and the classification reflects the maturity of each project. The various resource classes are presented in figure 1.5, with arrows showing how the projects can be matured. Further details can be found at www.npd.no.

At 31 December 2015, total recoverable resources were estimated to lie within an uncertainty range (P10 and P90) from 12.2 to 17.2 billion scm oe, with 14.2 billion scm oe

representing the expected value (figure 1.6). The amount sold and delivered totals 6.6 billion scm oe (47 per cent). Roughly 54 per cent of total recoverable resources have been produced so far if the lower part of the uncertainty range is applied, but only 38 per cent with the upper part.

Remaining resources are estimated to be 7.6 billion scm oe, including 3.1 billion scm oe (41 per cent) as reserves (table 1.1). Contingent resources in fields and discoveries, including possible future measures for improving recovery, represent 20 per cent of expected remaining resources.

The undiscovered portion represents about 20 per cent of expected total resources on the NCS, and 38 per cent of expected remaining resources.

Total recoverable resources

Project category	Oil mill scm	Gas bn scm	NGL mill tonnes	Condensate mill scm	Total mill scm oe
Sold and delivered	4075	2100	179	114	6630
Reserves	1023	1856	116	28	3128
Contingent resources in fields	328	222	22	2	594
Contingent resources in discoveries	375	323	15	13	739
Possible future measures to improve recovery	155	60			215
Undiscovered resources	1315	1484		120	2920
Total resources	7272	6047	333	277	14227
Total remaining resources	3196	3746	153	163	7597

Table 1.1 Resources accounts at 31 December 2015.

RESOURCE ACCOUNTS

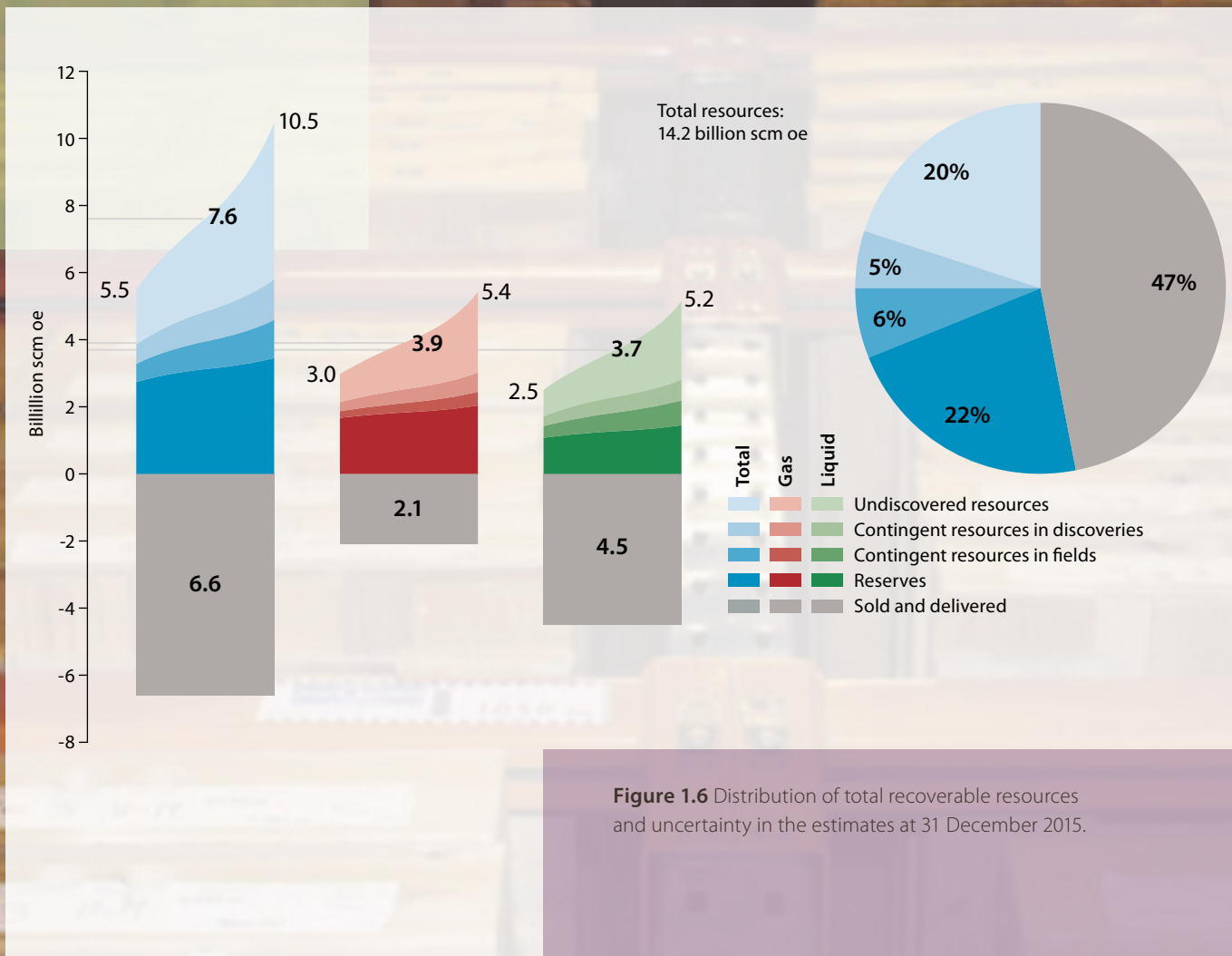


Figure 1.6 Distribution of total recoverable resources and uncertainty in the estimates at 31 December 2015.

The NPD's core store contains rock samples from virtually all the wells on the NCS.



Somewhat younger versions of two NPD geologists, Bernt Egeland (left) and Harald Brekke (centre). Svein Johnsen, on the right, is no longer with the NPD.

Exploration on the NCS

Exploration activity is essential if undiscovered resources are to contribute to production and create value both for the industry and for society.

Through its exploration policy, the government gives companies access to exploration acreage in both mature and frontier areas. A high level of exploration activity on the NCS since 2005 has resulted in a number of profitable discoveries.

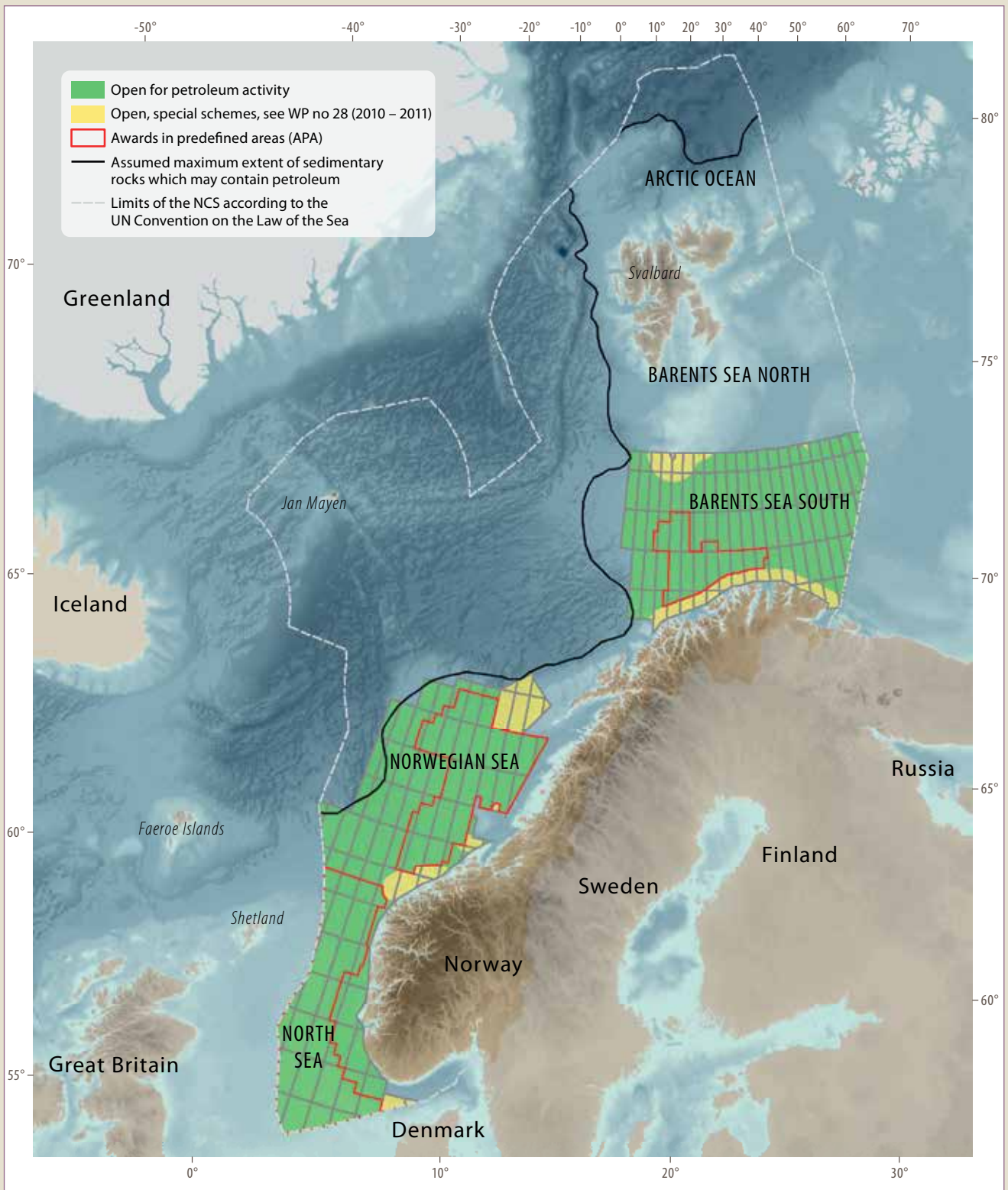


Figure 2.1 Status of NCS.

The NCS covers about 2 040 000 square kilometres and is six times larger than mainland Norway. Two-thirds of this area could contain sedimentary rocks with a potential for petroleum.

The areas currently opened for exploration amount to 570 000 sq.km, with some 130 000 sq.km awarded as production licences – in other words, six per cent of the whole NCS and 10 per cent of the area with sedimentary rocks (figures 2.1 and 2.2).

With certain exceptions, the North and Norwegian Seas and Barents Sea South have been opened for petroleum activities. The unopened sections are parts of Skagerrak and areas off Trøndelag, Nordland, Lofoten, Vesterålen, Senja and Jan Mayen, as well as Barents Sea North and the Arctic Ocean.

The NCS has been opened for petroleum activities gradually. Oil companies were invited to apply for a total of 278 North Sea blocks in the first offshore licensing round during 1965. Seventy-eight blocks were licensed, the largest single set of awards on the NCS (figure 2.3).

Information about and knowledge of geological conditions in the North Sea were used when awarding the first blocks in the Norwegian and Barents Seas during 1980. Between 1981 and 1989, more areas in these two regions were made available for petroleum operations through step-by-step announcements and awards.

Deepwater areas in the Norwegian Sea and parts of the Nordland VI area off Lofoten were opened for petroleum activities in 1994. Two decades then passed before Barents Sea South-East was opened in 2013.

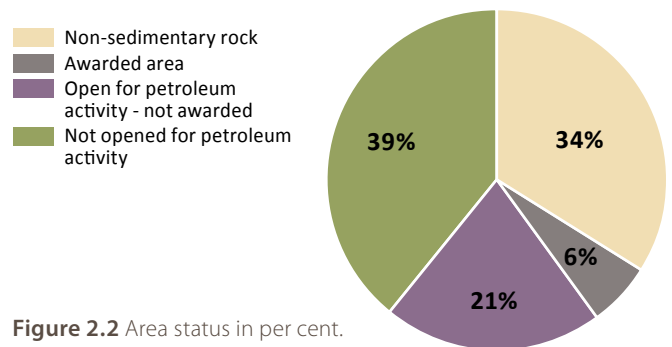


Figure 2.2 Area status in per cent.

In the areas opened to the petroleum industry, oil companies can gain access to acreage either by applying for production licences in licensing rounds or by buying or swapping interests in such licences.

An extensive set of policy instruments has been developed on the NCS to take account of other industries and the environment in all phases, from the opening of new areas, through awards, exploration, development and production, to decommissioning.

Licensing rounds

Two types of licensing round with equal status are conducted on the NCS. Awards in predefined areas (APA) cover mature areas, while numbered rounds concentrate on frontier areas. Mature areas are characterised by known geology and well-developed or planned infrastructure. They usually offer a greater probability of making discoveries than frontier areas, where geological knowledge is more limited and infrastructure lacking. Frontier areas are likelier to yield large discoveries than mature ones.

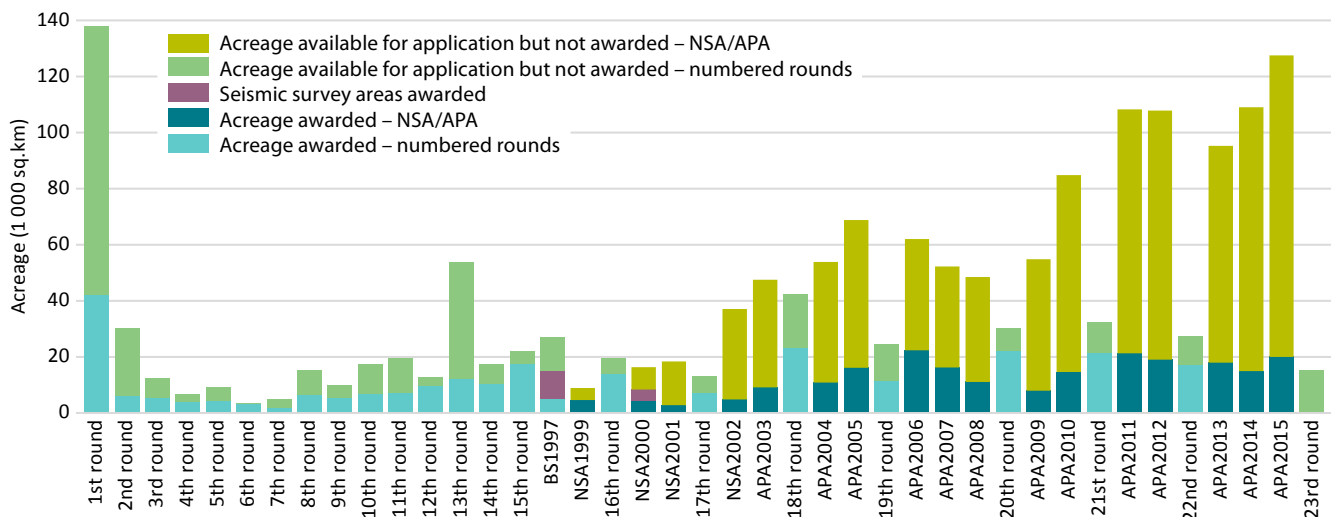


Figure 2.3 NCS acreage put on offer and awarded at 1 March 2016.

Increased availability of acreage has led to more licence awards (figure 2.4). Over the past 15 years, the government has strengthened the predictability of the allocation system by holding APA rounds annually, while the numbered rounds generally take place every other year. In addition, the companies know in advance which principles govern the kind of acreage included and the general work commitments for production licences in the APA rounds compared with the numbered ones.

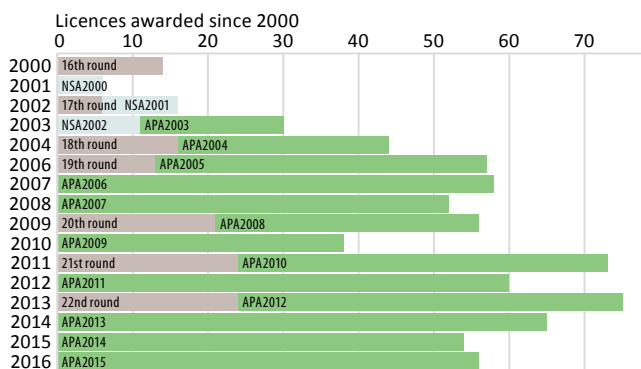


Figure 2.4 Awards since 2000 by licensing round. North Sea awards (NSA) were introduced in 1999 as a predecessor of the APA.

As figure 2.4 shows, the largest number of awards has been made in the APA rounds. Since these cover areas with known geology and well-developed infrastructure, they generate more applications than the numbered rounds. Opportunities to develop smaller discoveries through tie-ins to existing infrastructure have made the APA rounds especially attractive to new players on the NCS, particularly the smaller companies.

Frontier areas are investigated gradually through sequential exploration. New licence awards in the numbered rounds are generally limited to a small number of key blocks.

Many applications have been received and a lot of licences awarded since 2000. The APA 2013 round generated the greatest number of awards during this period, with 65 production licences allocated, closely followed by the APA 2011 and 2006 rounds with 60 and 58 awards respectively (figure 2.4).

APA rounds

The APA scheme is intended to secure efficient exploration of mature areas and to prove time-critical resources close to existing and planned infrastructure. It is also important that known areas are re-examined with fresh eyes and that new ideas are tested. The Johan Sverdrup discovery in a previously well-explored area provides an example of this. Most of the discoveries in mature areas are otherwise expected to be small. To make them worth developing, they will usually need to be tied back to an existing field. Infrastructure has a limited lifespan, which makes it important to prove nearby resources in good time before existing fields shut down.

Acreage covered by the APA has been extended every year since the scheme began in 2003 (figure 2.5).

The area put on offer in the APA rounds is still attractive to the oil companies. That was demonstrated by the 2014 and 2015 rounds, when applications were received from 47 and 43 companies respectively.

Numbered rounds

Numbered rounds are generally announced every other year. A sequential approach forms an important part of the exploration strategy for licensing rounds in frontier areas. This means that the results obtained from wells in one locality should be evaluated before further drilling is conducted in the same area. That ensures available information is applied in further exploration.

The number of awards has varied since 2000, from six in the 17th round to 24 in the 22nd (figure 2.4).

Parts of Barents Sea South-East, which was opened for exploration in 2013, are included in the 23rd round. The latter covers 57 full or part blocks, including 34 in Barents Sea South-East, 20 in the rest of the Barents Sea and three in the Norwegian Sea. At the deadline of 2 December 2015, applications had been received from 26 companies. The government aims to award new production licences before the summer of 2016.

Total resource growth from discoveries in numbered and annual APA rounds has been roughly the same since 2000 (figure 2.6).

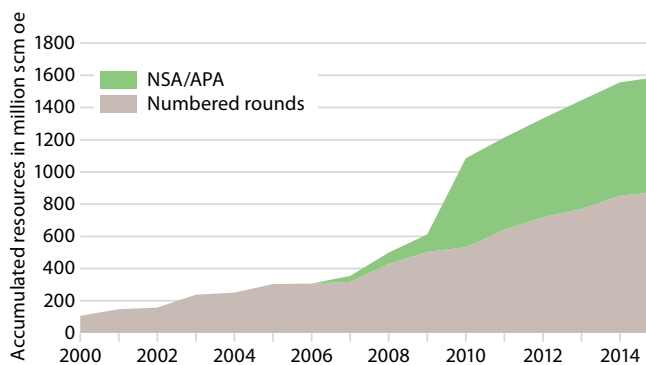


Figure 2.6 Accumulated resource growth by licensing rounds (2000-15).

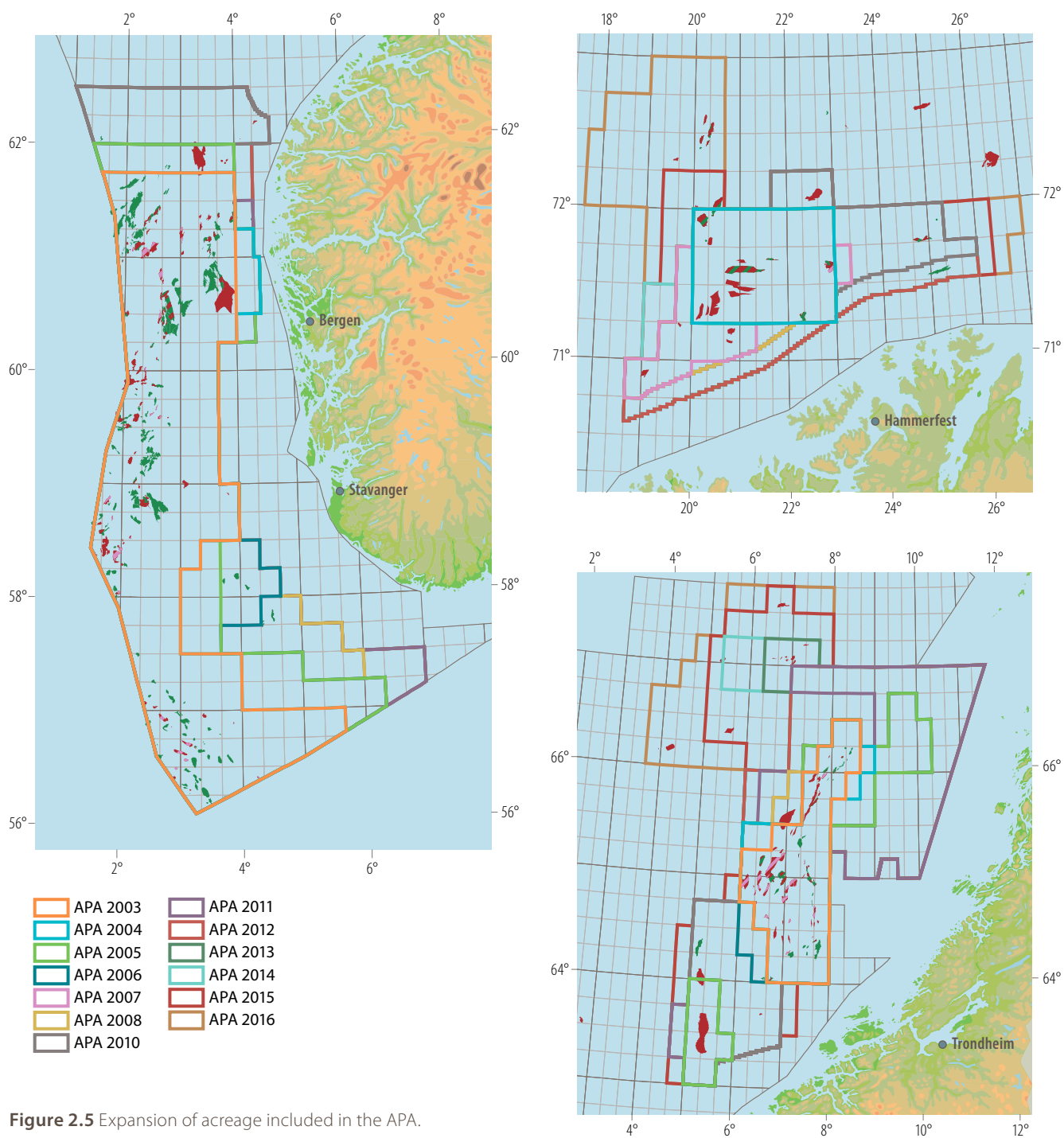


Figure 2.5 Expansion of acreage included in the APA.

Exploration activity

Exploration wells

The level of exploration activity measured by the number of wells drilled has varied considerably since 1966 (figure 2.7). It was high in the 1980s, with up to 50 wells per year, while only 12 were drilled in 2005. But activity recovered from 2006 and reached a record 65 wells spudded in 2009. The level has been high since then, with more than 40 wells drilled per annum in 2009-15. Fifty-seven and 56 wells were spudded in 2014 and 2015 respectively. Exploration activity has always been highest in the North Sea (figure 2.8). About 30 wells are planned across the NCS in 2016, partly reflecting the decline in oil prices.

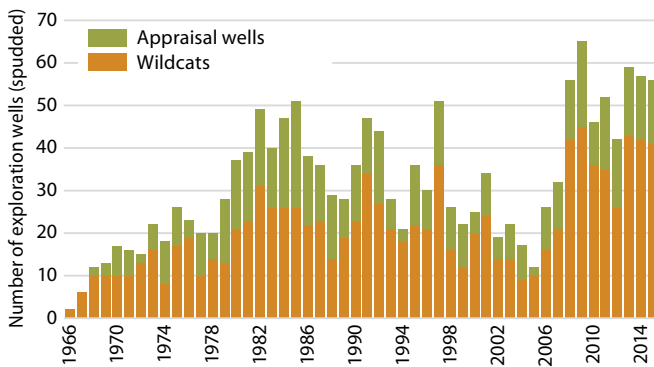


Figure 2.7 Exploration wells spudded per year (1966-2015).

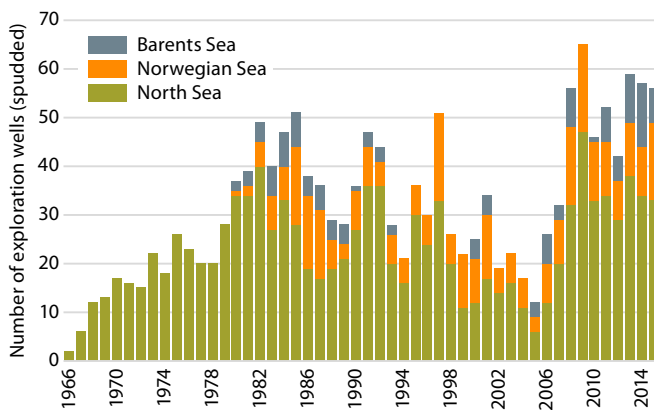


Figure 2.8 Exploration wells spudded per year by NCS region (1966-2015).

Discoveries

The high level of exploration activity has yielded many discoveries. Viewed overall, the greatest proportion of these are in the North Sea. For the first time, however, the Barents Sea accounted for the largest number of finds and the biggest resources proven in 2014. Nine discoveries were made that year in this region, eight in the North Sea and five in the Norwegian Sea. Nothing was found in the Barents Sea during 2015, but 10 discoveries were made in the North Sea and six in the Norwegian Sea (figure 2.9).

Various definitions

Exploration well is the collective term for wildcats and appraisal wells.

Wildcat is the first well drilled on a new, clearly defined geological structure (prospect).

Appraisal well is a well drilled to determine the extent and size of a discovery.

Discovery. One or more deposits identified collectively in the same well which, through testing, sampling or logging, are established as likely to contain mobile petroleum. This definition covers both commercial and technical deposits. A discovery acquires the status of a field or becomes incorporated in an existing field when a plan for development and operation (PDO) is approved by the government.

Technical finding rate. The relationship between technical discoveries made and wildcats drilled.

Commercial finding rate. The relationship between discoveries currently under development or declared commercial and wildcats drilled.

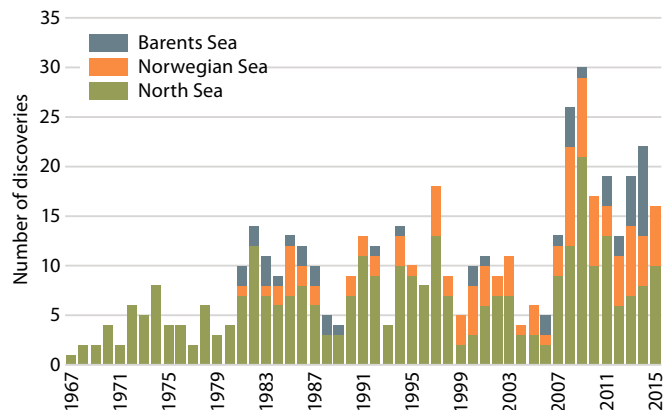


Figure 2.9 Discoveries per year by NCS region (1967-2015).

With few exceptions, the largest discoveries were made early in the exploration of the NCS (figure 2.10). A substantial one was again made in 2010, when Johan Sverdrup ranked among the world's biggest finds that year. Two considerable oil discoveries were made during 2011 and 2012 in an area north-west of Snøhvit in the Barents Sea. Designated 7220/8-1 (Skrugard) and 7220/7-1 (Havis), these now form part of Johan Castberg.

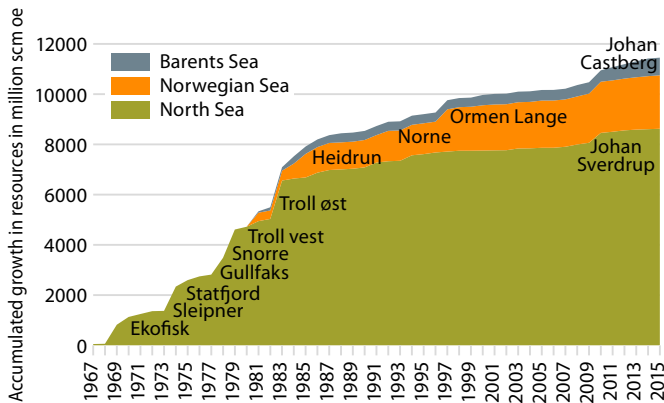


Figure 2.10 Accumulated resource growth by NCS region (1967-2015).

North Sea

Exploration since 2000

Norway’s North Sea sector is the best-explored part of the NCS, and the largest proportion of its resources have been proven there. After more than 50 years of activity and over 1 140 completed exploration wells at 31 December 2015, many discoveries are still being made.

Proving resources close to existing and planned infrastructure represents one of the main challenges in the North Sea. Finding additional resources while the big facilities are still on stream is important. Even very small discoveries can be profitable if existing infrastructure can be utilised effectively. Phasing discoveries into fields on stream also helps to extend the producing life of the latter, and thereby maintains their profitable production and improves recovery from them.

Relatively few wells were drilled in the North Sea from 2000 to 2005 (figure 2.11). However, their number rose substantially from 2005 and peaked in 2009 at 47. Exploration activity has remained high since 2010, with an annual average of 34 wells.

A total of 127 discoveries have been made since 2000 (figure 2.12).

The finding rate in the North Sea has been relatively high over the same period, averaging 0.2-0.7 per annum (figure 2.13).

Resource growth since 2000 has been highest in the North Sea, but most of the discoveries are small (figure 2.14). It peaked in 2008-11 at about 600 million scm oe, largely thanks to the discovery of Johan Sverdrup.

Exploration for the past three years

Since the NPD’s previous resource report in 2013, 114 exploration wells have been spudded and 25 discoveries made. All the latter are small and close to fields, and many of these are commercial.

Exploration activity in 2013 was at its highest around the southern end of the Utsira High. Most of the wells were drilled

to delineate Johan Sverdrup. An oil discovery – 16/4/6 S (Luno II) – was also made in this area.

Four discoveries were made about 25 kilometres south-west of Oseberg South in 2013 and 2014 – 30/11-8 A, 30/11-10 (Krafla North), 30/11-9 S (Askja) and 30/11-9 A (Askja East). During 2011, 30/11-8 S (Krafla) was found in the same area. Collectively, these discoveries proved over 30 million scm oe, and further prospects are due to be drilled in the area during 2016. Results so far show that the well-explored section of the North Sea continues to provide good opportunities for value creation.

The biggest discovery on the NCS in 2015 was made by well 2/4-23 S (Julius), where about seven million scm oe of gas and condensate were proven. This well also delineated the 2/4-21 (King Lear) gas and condensate discovery made in 2012.

Plans call for 15-20 exploration wells in the North Sea during 2016. About 170 production licences were awarded in the APA rounds during 2013-15. That could help to maintain exploration activity in the years to come.

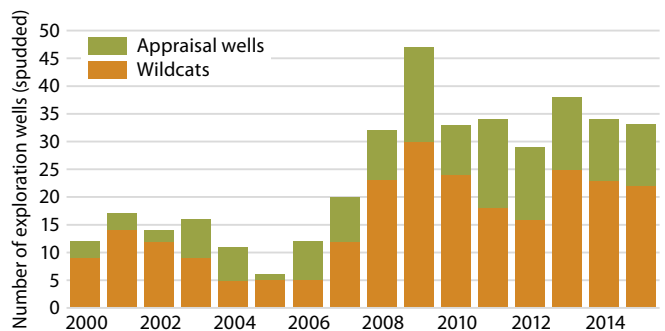


Figure 2.11 Exploration wells spudded per year in the North Sea (2000-15).

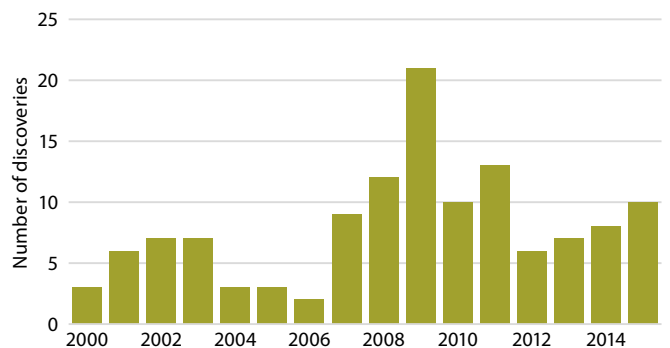


Figure 2.12 Discoveries per year in the North Sea (2000-15).

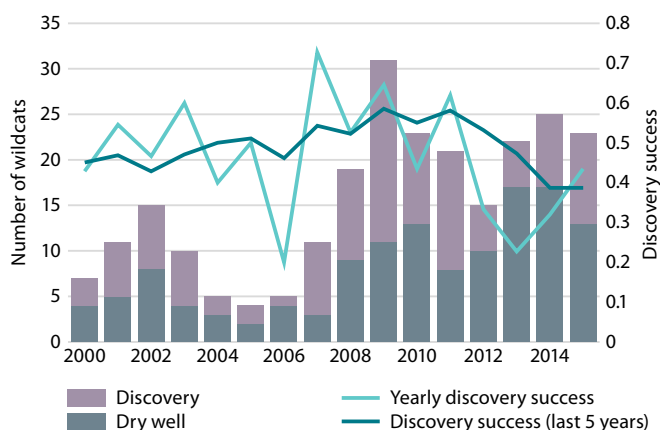


Figure 2.13 Completed wildcats and finding rate in the North Sea (2000-15).

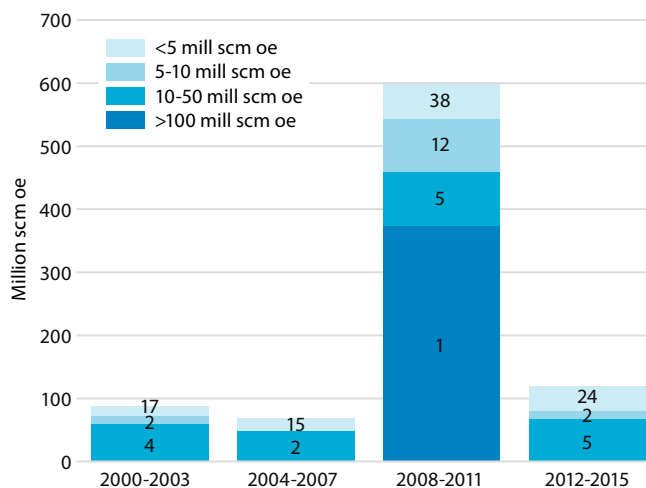


Figure 2.14 Resources in discoveries by discovery size in four-year periods, North Sea (2000-15). Number of finds specified in the columns.

Norwegian Sea

Exploration since 2000

The level of exploration activity has varied a great deal since 2000 (figure 2.15). It was relatively high during the first two years of this period, with nine and 13 wells respectively, and low for the next four. Only three wells were drilled in 2005. But activity rose from 2006 and set a record in 2009 with 18 spudded wells. It then slowed, averaging 10 wells a year. Exploration was high again in 2015, with 16 wildcats spudded – the largest number since 2000. Most wells are drilled in the mature areas on the Halten and Dønn Terrace. Priority has been given to drilling prospects close to existing infrastructure.

Seventy-four discoveries have been made since 2000 (figure 2.16). As in the North Sea, the finding rate in the Norwegian Sea has been high over the past 15 years, with an annual rate

of 0.25-1.00 (figure 2.17). Resource growth in this region has varied (figure 2.18), and was greatest in 2008-11 at roughly 160 million scm oe. That increase related primarily to Maria and the 6506/9-2 S (Fogelberg), 6507/7-14 S (Zidane) and 6705/10-1 (Asterix) discoveries.

Exploration for the past three years

Since the NPD's previous resource report in 2013, 42 exploration wells have been spudded and 18 discoveries made. The most interesting lies south-west of Njord, where oil and gas were proven by well 6406/12-3 S (Pil) in the Jurassic Rogn and Melke formations.

Exploration activity in deep water has been low over the past three-four years, with all the wells drilled in the Vøring Basin. Three wildcats were completed in 2015 close to the Aasta Hansteen field to prove more gas. Gas and a four-metre oil column were proven in 6706/12-2 (Snefrid North), while 6706/12-3 (Roald Rygg) and 6706/11-2 (Gymir) yielded small gas discoveries. These finds are being assessed for tie-back to Aasta Hansteen, together with others in the area. Further discoveries in the Norwegian Sea during this period are small, with a number of them close to fields.

One-two exploration wells are planned in the Norwegian Sea during 2016.

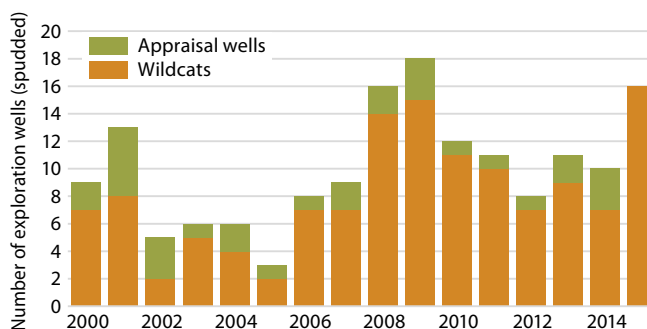


Figure 2.15 Exploration wells spudded per year in the Norwegian Sea (2000-15).

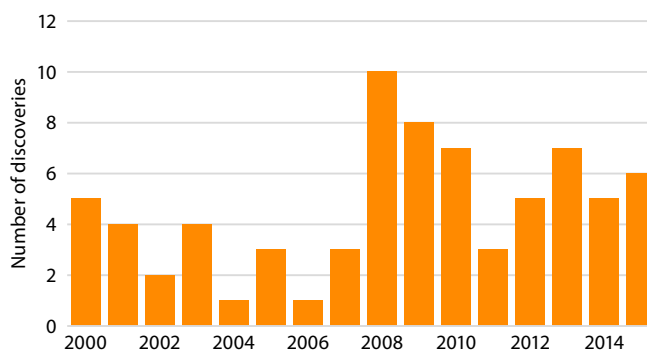


Figure 2.16 Discoveries per year in the Norwegian Sea (2000-15).

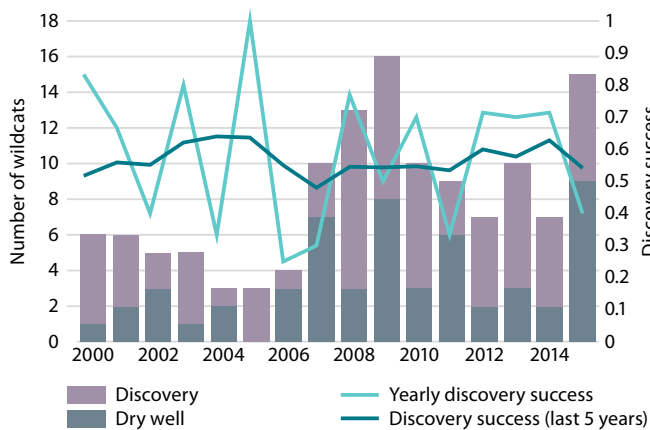


Figure 2.17 Completed wildcats and finding rate in the Norwegian Sea (2000-15).

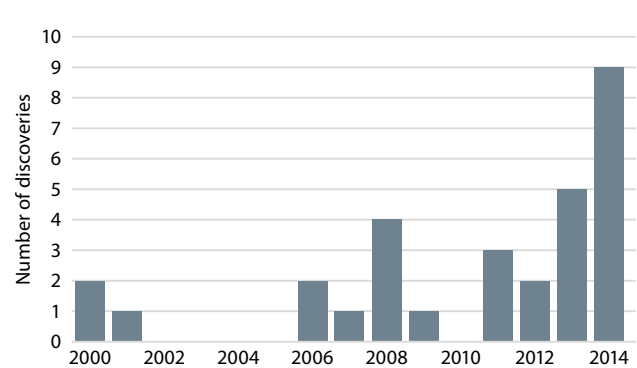


Figure 2.20 Discoveries per year in the Barents Sea (2000-15).

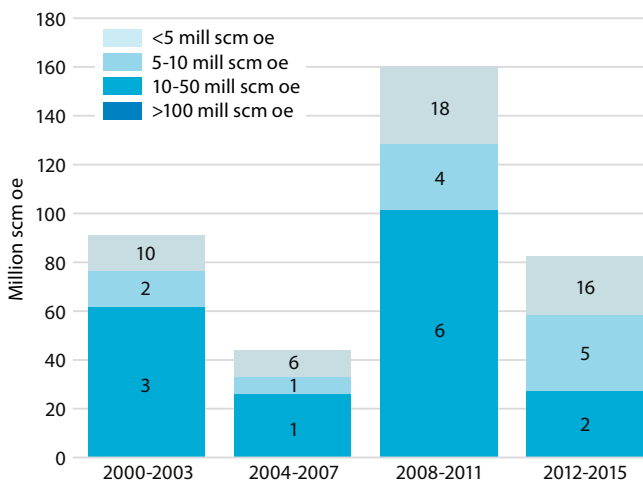


Figure 2.18 Resources in discoveries by discovery size in four-year periods, Norwegian Sea (2000-15). Number of finds specified in the columns.

Barents Sea

Exploration since 2000

A total of 71 exploration wells have been spudded since 2000, including 55 wildcats, with 30 discoveries made (figures 2.19 and 2.20).

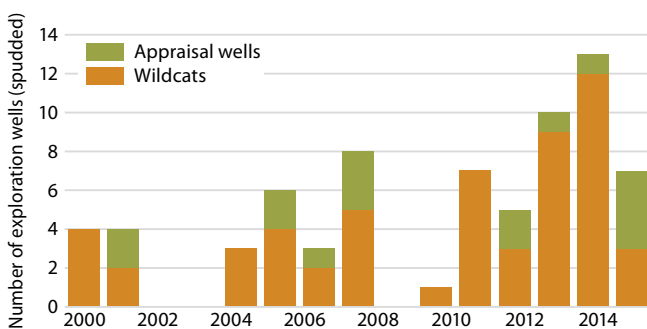


Figure 2.19 Exploration wells spudded per year in the Barents Sea (2000-15).

Although petroleum operations have been pursued in the Barents Sea for more than 30 years, only two fields are on stream – the Snøhvit gas development from 2007 and the Goliat oil field since March 2016.

Both oil and gas were found during 2000 in 7122/7-1 (Goliat), which lies in the boundary zone between the Hammerfest Basin and the Finnmark Platform. The government suspended petroleum activities in the Barents Sea in 2001 to await the impact assessment for year-round petroleum activities off Lofoten and in the Barents Sea. In December 2003, the government resolved to continue petroleum operations in those parts of the Barents Sea already opened for such activities. Following this resumption, oil was proven in the Triassic by 7122/7-3 (Goliat) and interest in the Barents Sea increased. Before this discovery, the Upper Jurassic (Hekkingen formation) was the only confirmed source rock in the Barents Sea. The Goliat well also revealed that Lower and Middle Triassic organic shales are effective source rocks, which opens opportunities for making further commercial discoveries.

The 7220/8-1 (Skrugard) and 7220/7-1 (Havis) discoveries were made in 2011-12. The first of these proved oil and gas in Middle and Lower Jurassic reservoir rocks and represented the biggest discovery in the Barents Sea since Goliat in 2000. Also proving oil and gas, the 7220/7-1 (Havis) well was drilled about seven kilometres to the south-west of 7220/8-1 (Skrugard) and 100 kilometres north of Snøhvit. Now included in Johan Castberg, these two discoveries opened a new oil province in the Barents Sea. The success continued with 7324/8-1 (Wisting) in the Hoop area on the Bjarmeland Platform to the north-west, which proved oil in a very shallow Jurassic reservoir only 250-300 metres beneath the seabed.

Wells drilled during 2013-14 in previously explored areas on the Loppa High led to the 7120/1-3 (Gohta) and 7220/11-1 (Alta) discoveries.

Resource growth has increased substantially since 2008, with the biggest rise in 2012-15 (figure 2.21). During this four-year period, the 7120/1-3 (Gohta), 7220/11-1 (Alta), 7220/7-1 Johan

Castberg and 7324/8-1 (Wisting) discoveries made the biggest contributions to resource growth.

The finding rate has varied over the past 15 years (figure 2.22). It has been relatively high for the past five years.

Exploration for the past three years

Since the NPD’s previous resource report in 2013, 30 exploration wells have been spudded and 14 discoveries made. Drilled in 2013, the 7120/1-3 (Gohta) well proved oil in Permian carbonate rocks. Mobile oil had not previously been found in such rocks in Norway’s Barents Sea sector. The find was delineated in 2014, and further appraisal is planned.

The 7220/11-1 (Alta) discovery (figure 2.23) was the largest on the NCS in 2014, and one of the biggest in the world that year. It lies north of the Snøhvit area and contains oil in rocks which include carbonates in the Permian Gipsdalen group. Formation tests show a reservoir with good flow properties. Estimated to contain roughly 36 million scm oe, the discovery was appraised by four wells in 2015. Results from these are important for further exploration.

Six wildcats have been drilled in the Hoop area, yielding four discoveries. The first well, 7324/8-1 (Wisting), proved an oil column 50-60 metres thick in 2013 at a very shallow reservoir level in the Jurassic Realgrunnen sub-group. Well 7324/7-2 (Hanssen) was drilled in 2014 just north of “Wisting” and proved oil in the Jurassic Stø formation.

Made in 2014, the northernmost discovery on the NCS is 7325/1-1 (Atlantis). This small gas deposit in Upper Triassic rocks lies about 360 kilometres north of Hammerfest. Northwest of the Johan Castberg area, 7319/12-1 (Pingvin) proved gas in a 15-metre column in the Palaeocene Torsk formation. The discovery was made in a less explored area in a previously unconfirmed play.

The good drilling results in recent years have boosted interest in Barents Sea exploration. Ten and 13 wells were drilled in 2013 and 2014 respectively – the largest numbers on an annual basis in this region. The figure for 2015 was seven, with four of these being appraisal wells on the “Alta” discovery.

Eight to 10 exploration wells are planned in the Barents Sea during 2016.

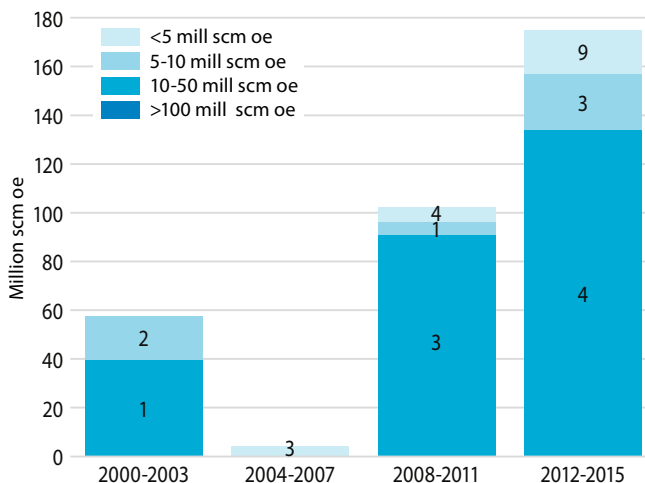


Figure 2.21 Resources in discoveries by discovery size in four-year periods, Barents Sea (2000-15). Number of finds specified in the columns.

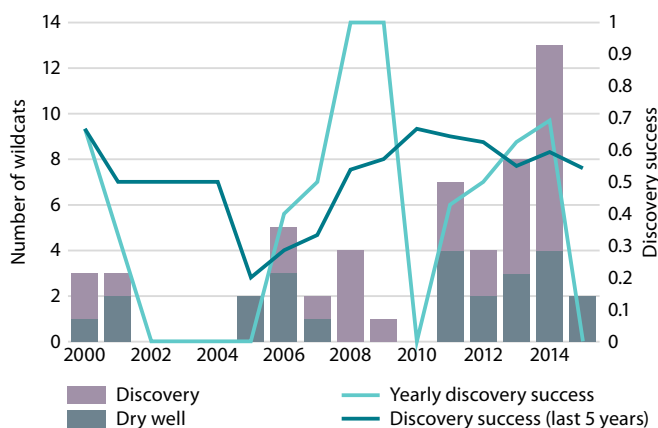


Figure 2.22 Completed wildcats and finding rate in the Barents Sea (2000-15).

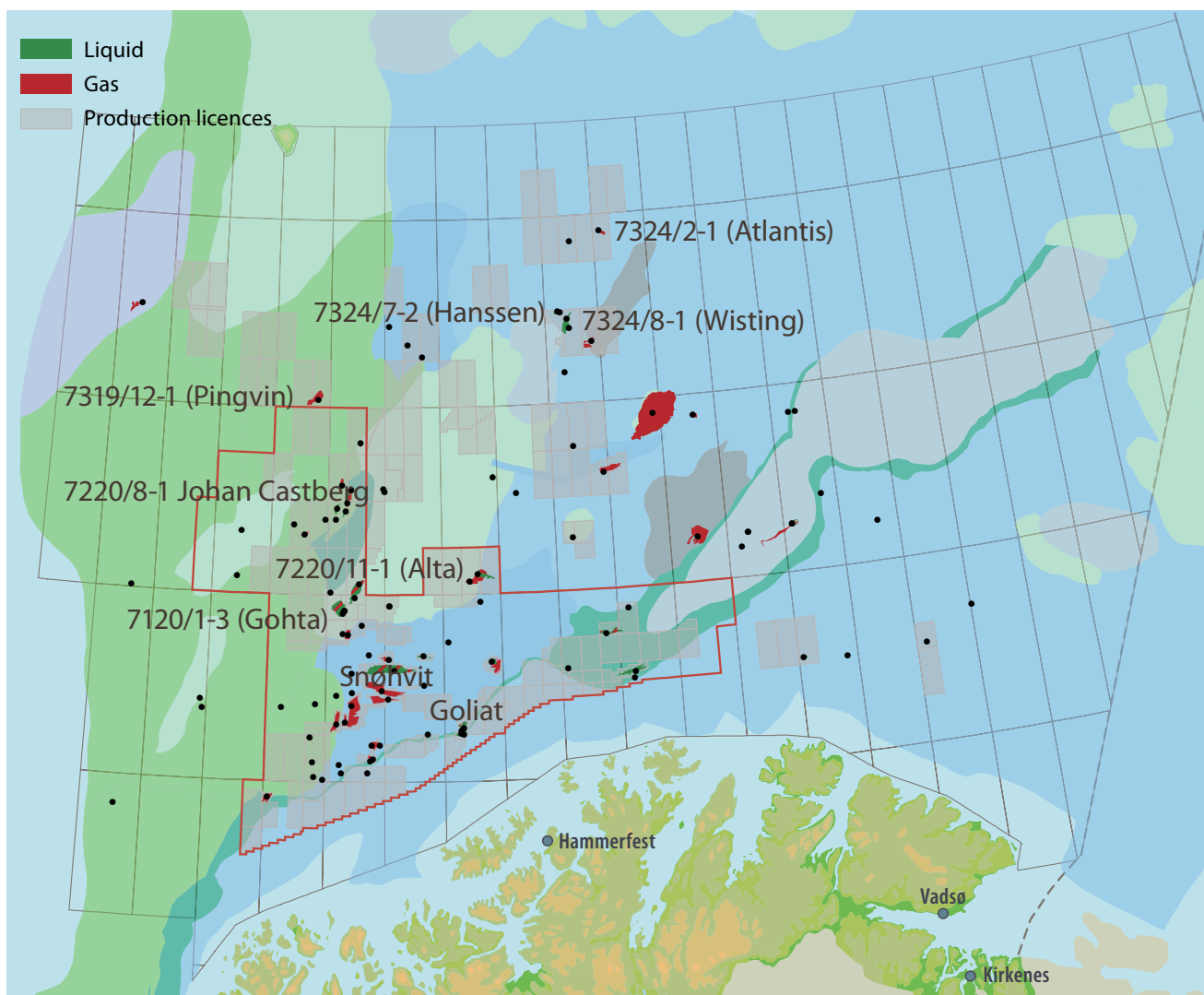


Figure 2.23 Discoveries in the Barents Sea.

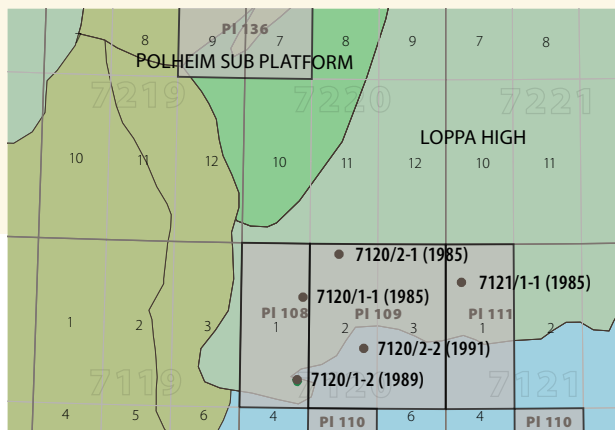
Those who seek, find

Areas around "Alta" and "Gohta"

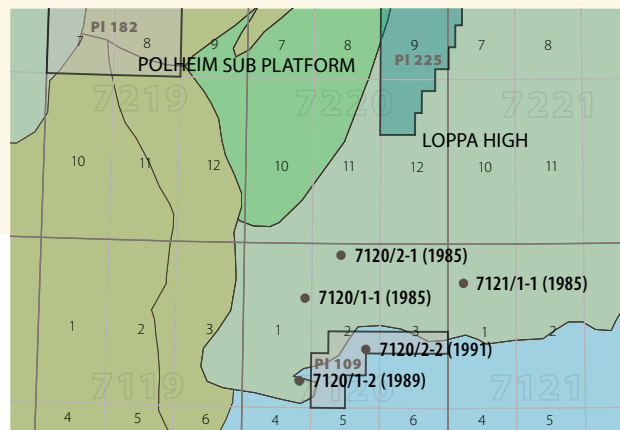
Many of the areas where exploration is being conducted today have been awarded and relinquished several times. New technology, new and better seismic surveys and innovative thinking and ideas among the oil companies mean that substantial petroleum resources are being proven in acreage explored several times. A series of examples include Johan Sverdrup, 35/9-7 (Skarfjell), 6406/12-3 S (Pil), the Johan Castberg discoveries, 7220/11-1 (Alta) and 7120/1-3 (Gohta).

Exploration of the "Alta" and "Gohta" area (south-western part of the Loppa High) began in 1985, when three production licences were awarded in the ninth licensing round. Drilled in 1985, the first two wells – 7120/1-1 and 7120/2-1 – encountered positive traces of oil in Upper Permian carbonate rocks. These have subsequently proved to lie in the rim zone of the "Alta" and "Gohta" discoveries. Five wells in all were drilled in these licences. While 7120/1-2 proved a small oil discovery, the others encountered only traces of hydrocarbons. The licences were later relinquished.

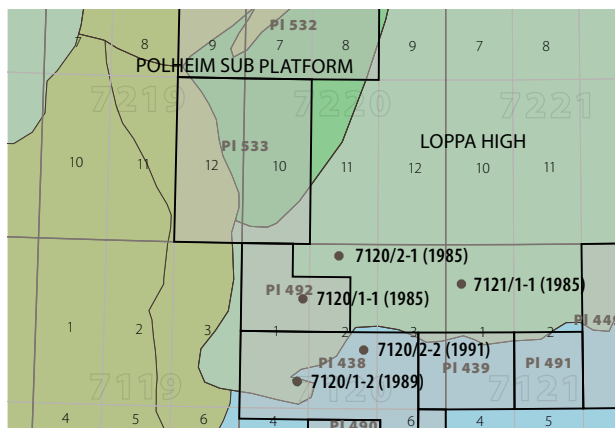
More than 20 years after the initial awards in the area, three new licences were allocated in the 2006 and 2007 APA rounds. Discoveries were made in production licences (PLs) 438 and 492 – the small 7120/2-3 S (Skalle) gas deposit and the 7120/1-3 (Gohta) oil and gas find respectively. The latter contains gross oil and columns of about 75 and 25 metres respectively in carbonate rocks of the Røye formation. Several new licences were awarded in the area through the 20th and 21st rounds in 2009 and 2011 respectively. Well 7220/10-1 in PL 533 proved a small gas discovery in Cretaceous and Jurassic rocks. Drilled in 2014 in PL 609, the 7220/11-1 (Alta) well encountered a total oil column of about 45 metres and a 10-metre gas cap in carbonate rocks with good reservoir properties. Four appraisal wells were drilled on the "Alta" discovery in 2015, all showing traces of petroleum. The age of the reservoir rock is uncertain, but is assumed to be Triassic and/or Permian.



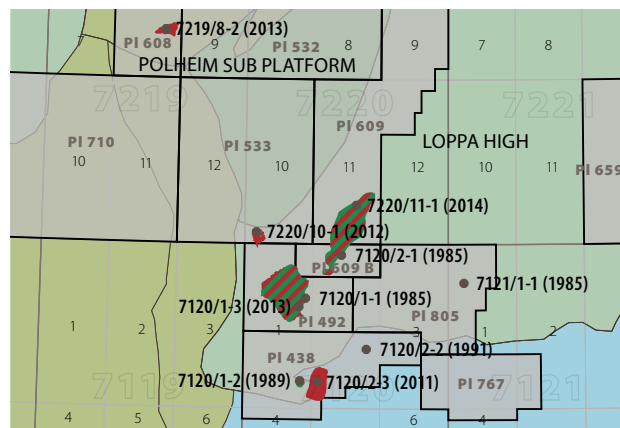
- Exploration wells spudded before 1992
- Production licences at March 1991



- Exploration wells spudded before 2006
- Production licences at December 2000
- Awarded in 1997 as seismic area, defined as PL in 2004



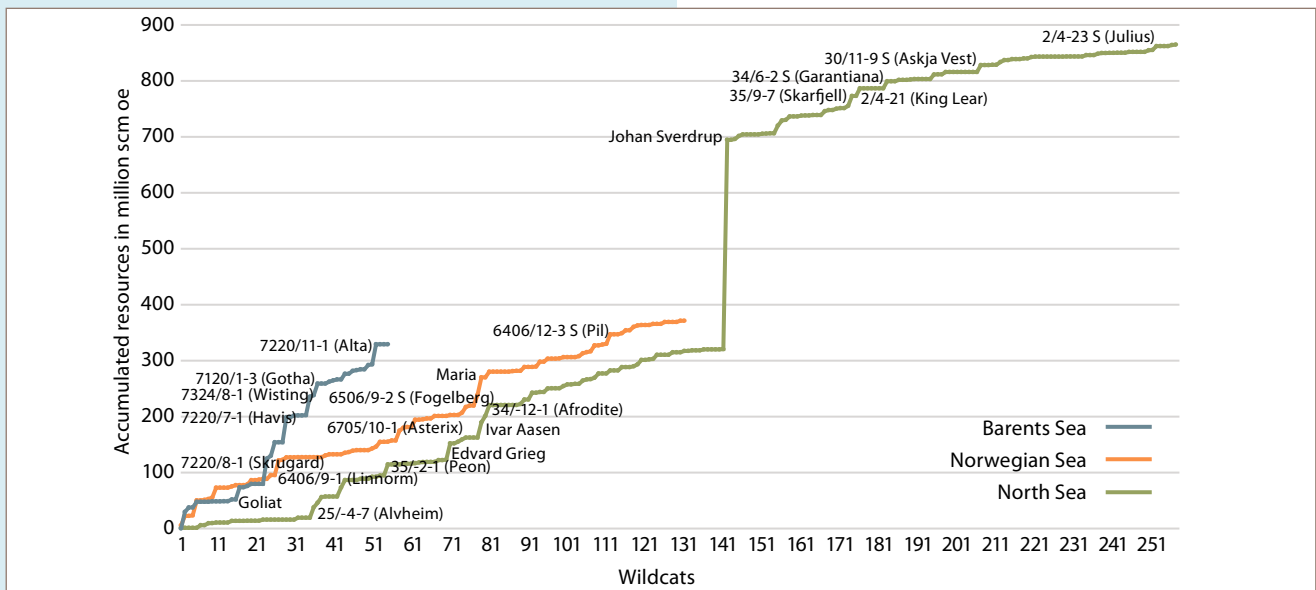
- Exploration wells spudded before 2010
- Production licences at December 2009



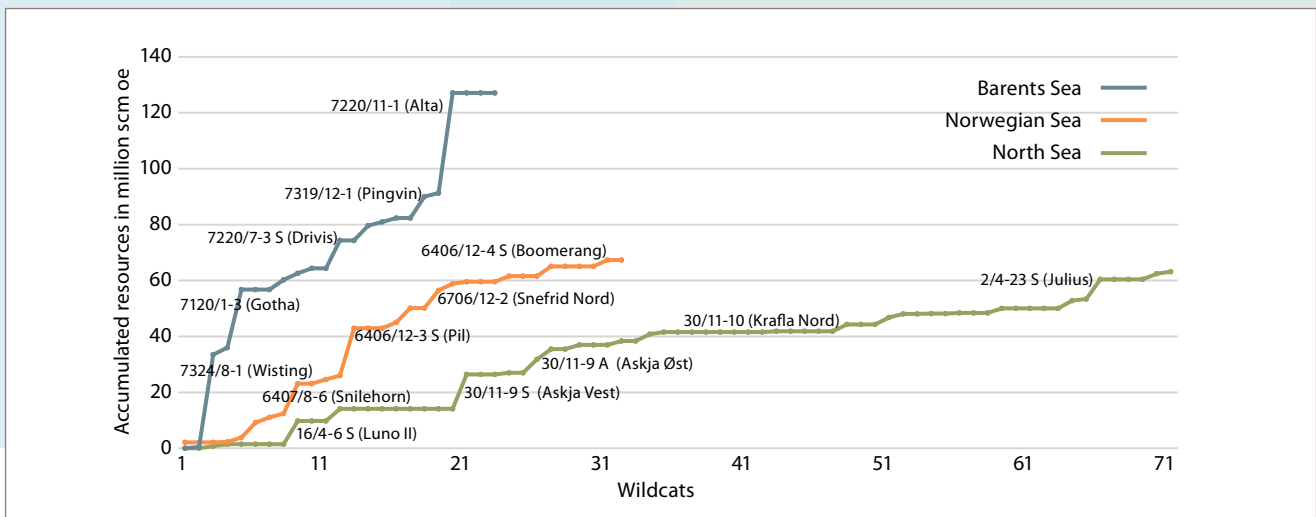
- Exploration wells spudded before 2016
- Production licences at September 2015
- Oil
- Gas
- Oil with gas

Exploration history around 7220/11-1 (Alta) and 7120/1-3 (Gohta).

Creaming curve for the NCS 2000-15



Creaming curve for the NCS 2013-15



The figures show cumulative resource growth in the North, Norwegian and Barents Seas between 2000 and 2015 and between 2013 and 2015.

The horizontal axis shows the number of wildcats in the order they were drilled. When a new discovery is made, the resources proven are presented as cumulative values along the vertical axis. A steep curve shows that considerable resources have been found with relatively few wells. When the gradient is shallow, the proven discoveries are small or many wells have been dry.

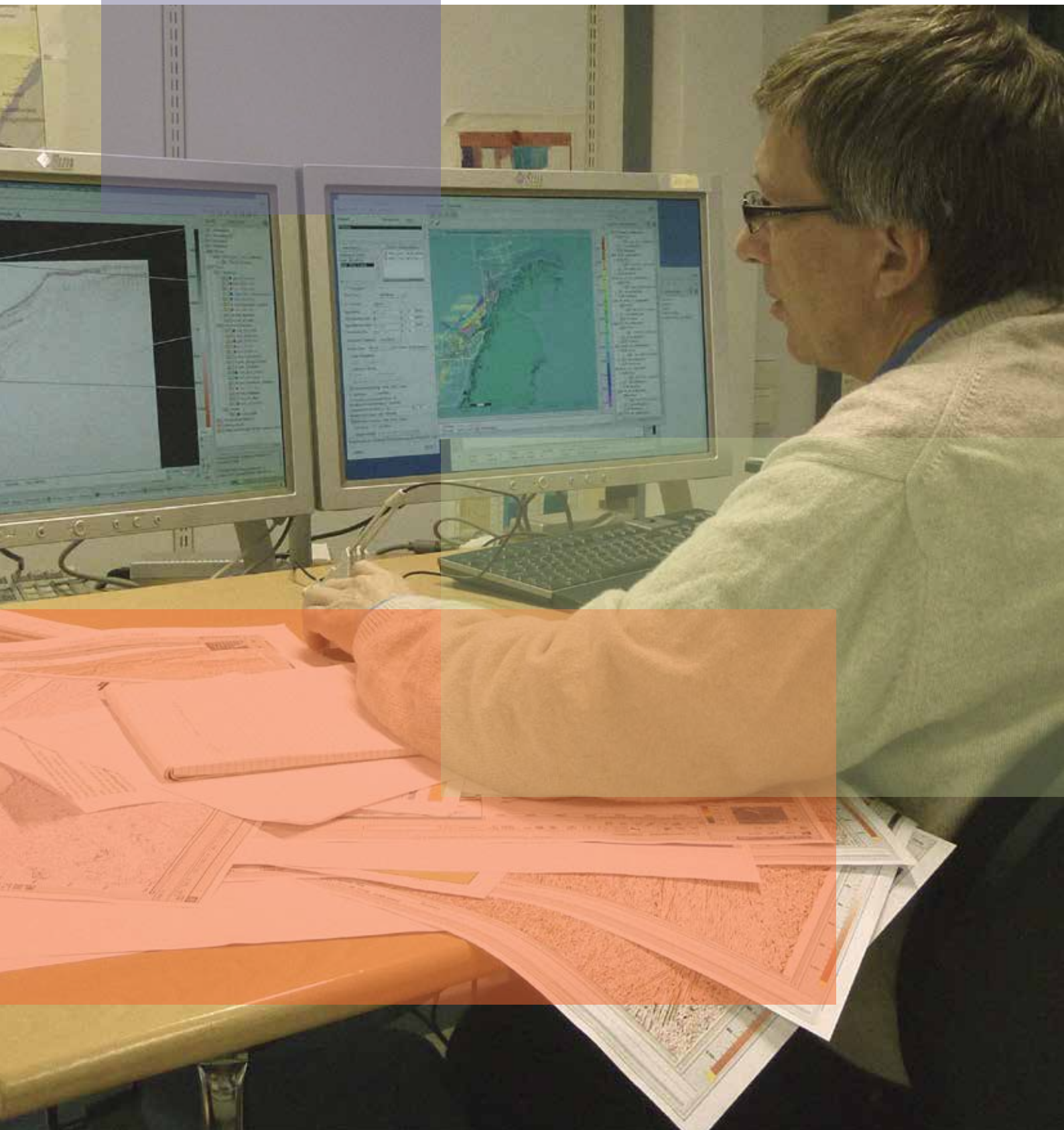
The Barents Sea had the smallest number of wildcats in 2000-15, but these proved relatively substantial resources (the curve is steep). Goliat, Johan Castberg (7220/8-1 and 7220/7-1), 7324/8-1 (Wisting), 7120/1-3 (Gohta) and 7220/11-1 (Alta) were the biggest discoveries in the Barents Sea during this period.

Most of the largest discoveries in the Norwegian Sea in 2000-15 were smaller than in the Barents or North Seas, but the curve

nevertheless shows a steady growth in resources. The biggest finds in this period were Maria and 6406/9-1 (Linnorm).

The graph for the North Sea shows limited resource growth for the early wells, followed by several substantial discoveries which produced a steeper curve. It flattens out again before making a big upturn with Johan Sverdrup. After that discovery, the curve shows only moderate resource growth. Edvard Grieg, Ivar Aasen and Johan Sverdrup were the biggest discoveries in this period.

Where 2013-15 is concerned, the Barents Sea clearly has the highest resource growth with the smallest number of wildcats (23). Resources discovered in the Norwegian Sea were roughly half the size of those in the Barents Sea, but more wildcats (32) were drilled. The North Sea was roughly on a par with the Norwegian Sea for resource growth, but more than twice as many wells (71) were drilled there to prove the same quantity.



Steinulf Smith-Mayer has long experience as an NPD geologist.

Undiscovered resources

The updated estimate for undiscovered resources confirms that total remaining resources provide the basis for oil and gas production over many decades to come. It is roughly the same as the previous estimate in 2013.

Total undiscovered resources are estimated to be 2 920 million scm oe. About half of this is expected to be in the Barents Sea, where the biggest change has occurred in the estimate. It has increased by about 125 million scm oe for this area.

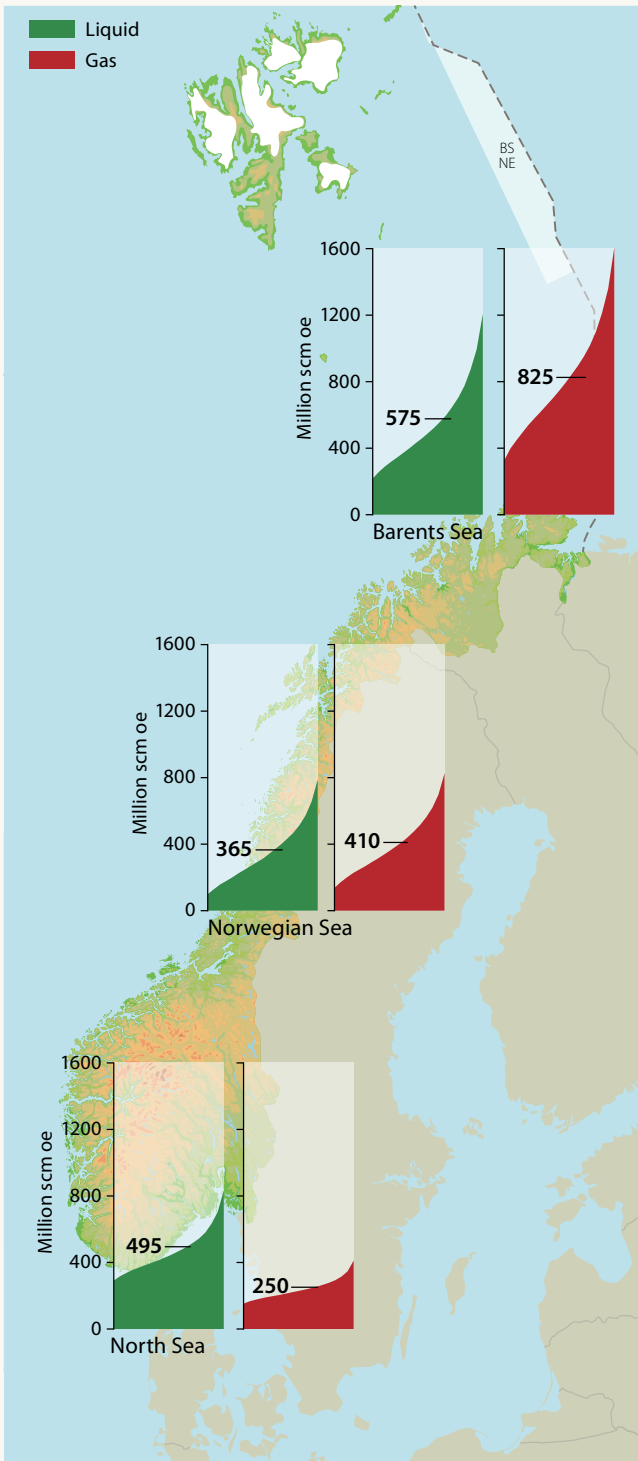


Figure 3.2 Recoverable undiscovered resources for each part of the NCS, broken down by liquid and gas. The expected value is specified in the columns.

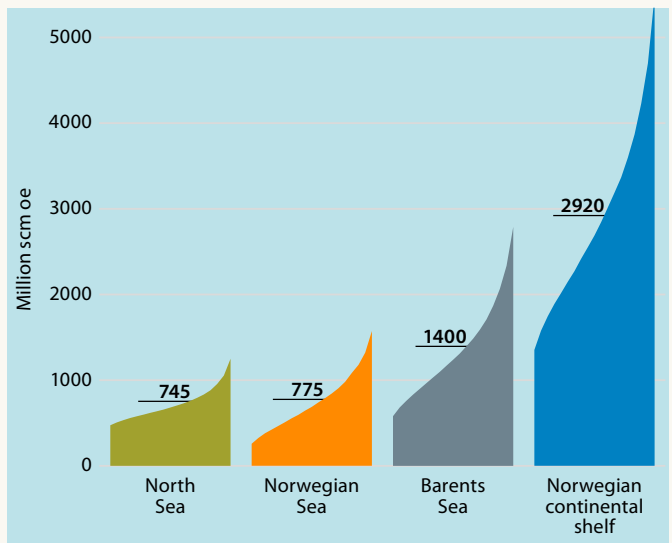


Figure 3.1 Recoverable undiscovered resources in total and for each part of the NCS. The expected value is specified in the columns.

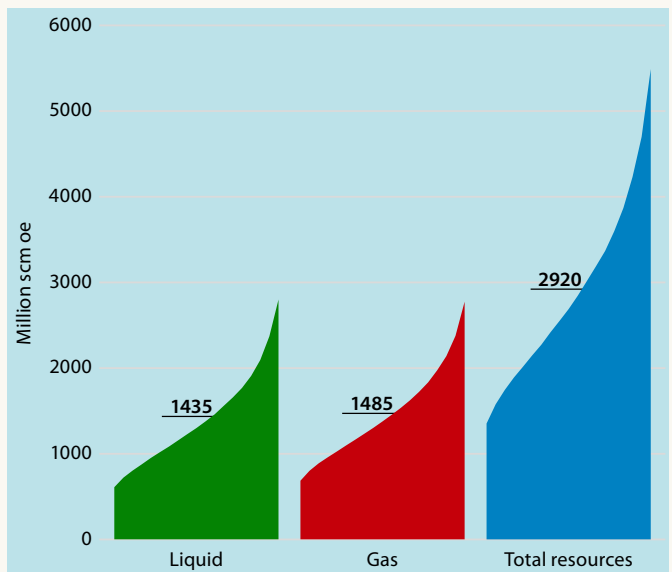


Figure 3.3 Recoverable undiscovered resources in total, broken down by liquids and gas. The expected value is specified in the columns.

The NPD’s updated estimate for recoverable undiscovered resources is about the same as its previous evaluation in 2013. The biggest change in estimated resources is in the Barents Sea, with an increase of roughly 125 million scm oe.

Undiscovered resources are estimated to lie between 1 350 (P95) and 5 490 (P5) million scm oe (figure 3.1). This calculation covers the whole NCS with the exception of Barents Sea North-East (BSNE). See figure 3.2.

The estimates for undiscovered resources are very uncertain. That reflects the difference between the high (P5) and low (P95) assessments. Uncertainty is greatest in areas with limited information and a short exploration history, such as large parts of the Barents Sea. It is considerably smaller in the North Sea and the well-explored parts of the Norwegian Sea (figures 3.1 and 3.2).

Liquid is expected to account for about half the total undiscovered resources (figure 3.3). The estimate for liquid is highest in the Barents Sea and lowest in the Norwegian Sea. Where gas resources are concerned, the estimate is significantly higher in the Barents Sea than in the other parts of the NCS (figures 3.2 and 3.4).

Almost half the total undiscovered resources are expected to be proven in the Barents Sea, with the remainder divided roughly equally between the North and Norwegian Seas.

The Barents Sea contains 70 per cent of expected undiscovered resources in Triassic and older plays (figure 3.5). The Upper Triassic is included in Lower to Middle Jurassic plays in the North and Norwegian Seas, but contributes a smaller share of their resources. Plays older than the Late Triassic account for less than two-three per cent of total expected resources in the North and Norwegian Seas.

About 80 per cent of the undiscovered resources in the North Sea are expected to be in Upper Triassic and Jurassic plays, while the corresponding figure for the Norwegian Sea is about 55 per cent. Jurassic plays account for 24 per cent of total undiscovered resources in the Barents Sea. Cretaceous and Cenozoic plays contribute six, 41 and 17 per cent of total undiscovered resources in the Barents, Norwegian and North Seas respectively (Cretaceous plays in the North Sea include chalk reservoir rocks). This reflects differing geological developments in the three regions.

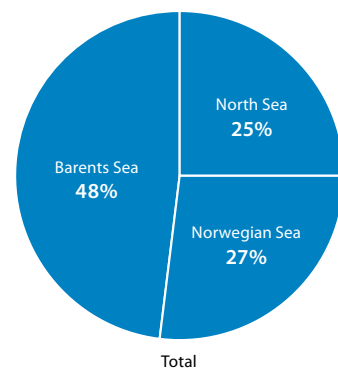
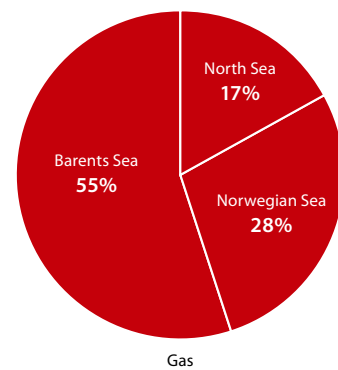
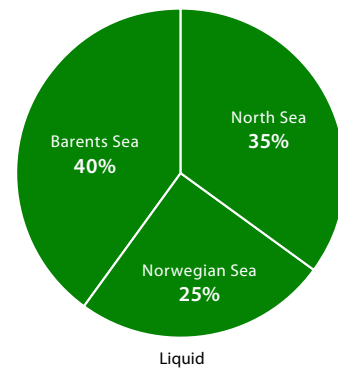


Figure 3.4 Recoverable undiscovered resources for each part of the NCS, broken down by liquid, gas and total resources.

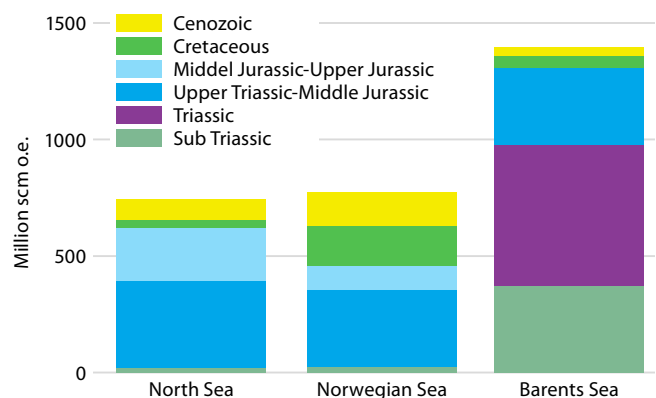


Figure 3.5 Recoverable undiscovered resources for each part of the NCS by geological stratigraphic level.

Changes from the 2013 analysis

The estimate for undiscovered resources at 31 December 2015 shows only minor changes from 31 December 2013. The expected value has been reduced slightly from 2 940 to 2 920 million scm oe (figure 3.6).

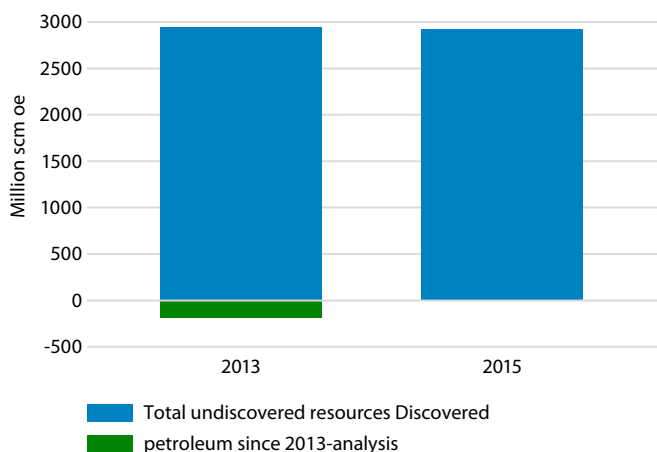


Figure 3.6 Comparison between total recoverable undiscovered resources in the 2013 and 2015 analyses.

Liquid

The estimate for liquid has hardly changed from 2013 to 2015, with the expected value reduced by one per cent from 1 450 to 1 435 million scm (figure 3.7).

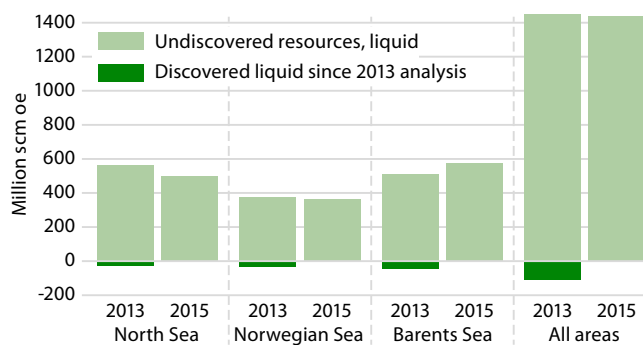


Figure 3.7 Comparison of the distribution of recoverable undiscovered liquid resources for each region and the whole NCS (2013 and 2015 analyses).

Some 30 million scm of liquid have been discovered in the North Sea since 2013. The estimate for liquid has been reduced from about 565 to 495 million scm. Exploration results in recent years which indicate a smaller quantity of liquid than previously estimated are the most important reason for this change, which relates primarily to plays with Palaeocene, Lower Cretaceous and Upper Jurassic reservoirs.

About 35 million scm of liquid have been found in the Norwegian Sea since 2013. The estimate for liquid has been cut by roughly 2.5 per cent from about 375 to 365 million scm. According to the new estimates, liquid is reduced by some 50 million scm for a number of the plays. However, exploration results in recent years and new information have contributed to an upward adjustment of expectations for Upper Jurassic plays. That primarily reflects a reassessment of their potential as a result of such discoveries as 6406/12-3 S (Pil) and 6406/12-3 A (Bue) (figure 3.8).

The estimate for the Barents Sea has been raised by about 13 per cent, from 510 to 570 million scm, primarily as a result of the 7220/11-1 (Alta) discovery. That confirmed the play from Carboniferous to Permian on the Loppa High, and thereby contributed to a sharp increase in its estimated resources (figure 3.9). The well also proved both oil and gas, which helped to strengthen expectations of multiphase discoveries in the area. Exploration history in recent years has also raised expectations of making such finds in more plays than earlier expected.

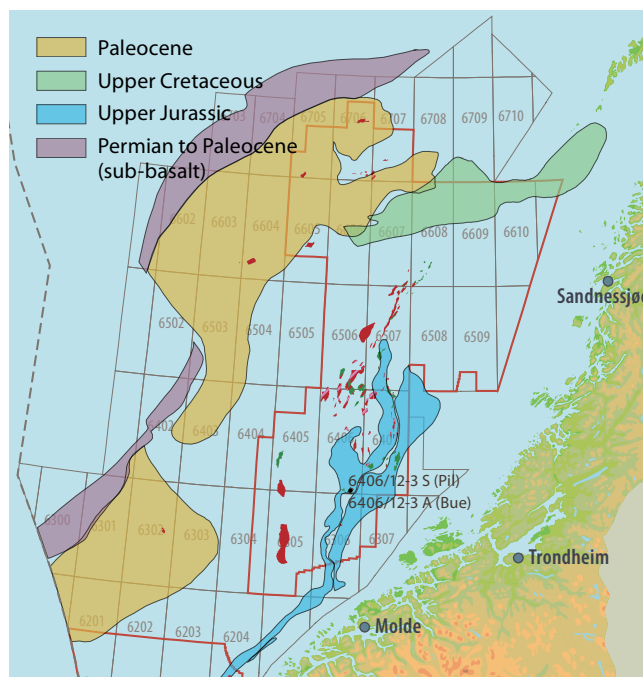


Figure 3.8 Plays in the Norwegian Sea with the biggest changes in undiscovered resources.

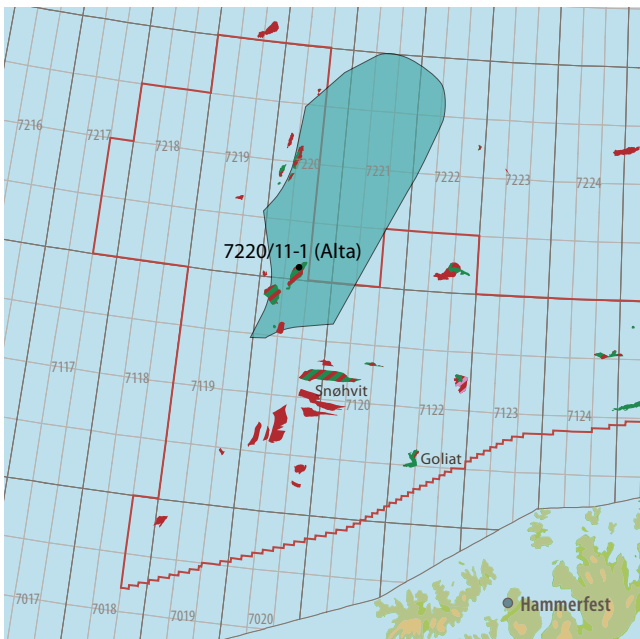


Figure 3.9 Carboniferous to Permian plays in the Barents Sea with the biggest changes in undiscovered resources.

Gas

Undiscovered gas resources on the NCS are estimated to be 1 485 billion scm, down by 0.3 per cent from 1 490 billion (figure 3.10).

No change has been made to the estimate for the North Sea. According to the new analysis, the expectation of finding gas has increased somewhat for plays with Upper Triassic to Middle Jurassic reservoirs. This is because the exploration history of recent years indicates that future discoveries will contain more gas than suggested in earlier estimates. The gas estimate has been reduced to some extent for Palaeocene and Upper Jurassic plays because few discoveries have been made in these and proven deposits are small. Viewed overall, therefore, the expectation for gas in the North Sea is unchanged.

The estimate for the Norwegian Sea is down by about 14 per cent, from 475 to 410 billion scm. Some 30 billion scm of gas has been proven since the previous analysis. The new assessment cuts the gas potential for half the plays by up to 100 billion scm. Downgrading the sub-basalt and Palaeocene plays in deep water and the Upper Cretaceous play by the Træna Basin provides the biggest reductions (figure 3.8). This is offset to some extent by an increase in a couple of plays – particularly the Upper Jurassic – which also account for the biggest increase of liquid.

In the Barents Sea, the estimate has risen by some eight per cent from 765 to 825 billion scm. This reflects exploration results in recent years, including the 7220/11-1 (Alta) discovery, and new evaluations related to the 23rd licensing round.

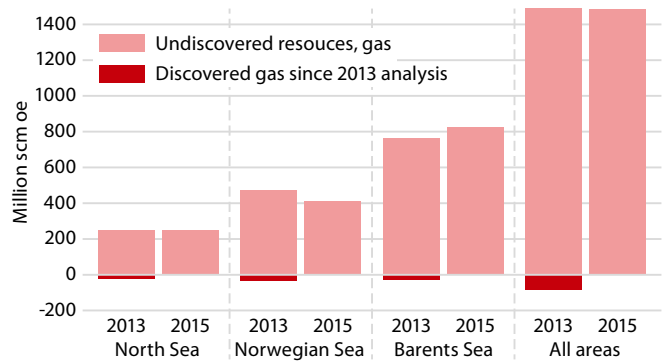


Figure 3.10. Comparison of distribution of recoverable undiscovered gas resources for each region and the whole NCS (2013 and 2015 analyses).

Historical changes

The NPD regularly publishes new figures for undiscovered resources on the NCS. Using the same methodology since the mid-1990s provides a good basis for comparing the estimates. From 1996 to 2015, this comparison shows an increase up to 2002 followed by a decline to 2010 (figure 3.11).

The downturn from 2003 largely reflected a reduction in estimates for a number of Norwegian Sea plays, particularly their gas potential.

In 2010, the reduction was primarily attributable to downgraded expectations of gas discoveries in both the North and the Norwegian Seas. One of the reasons in the latter area was changed expectations of the potential off Lofoten, Vesterålen and Senja following the NPD assessment published in 2010. In addition, exploration results reduced expectations for deep-water plays.

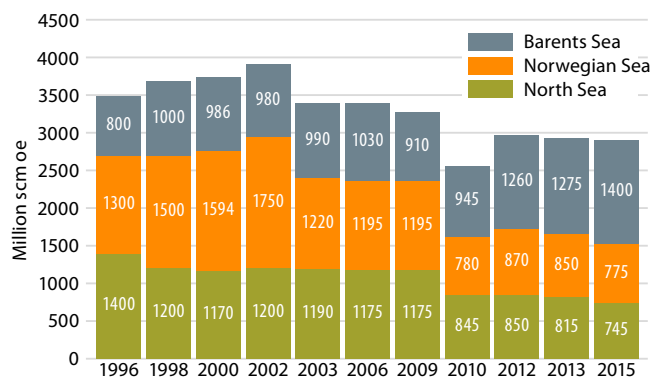


Figure 3.11 Total recoverable undiscovered resources over time for each part of the NCS.

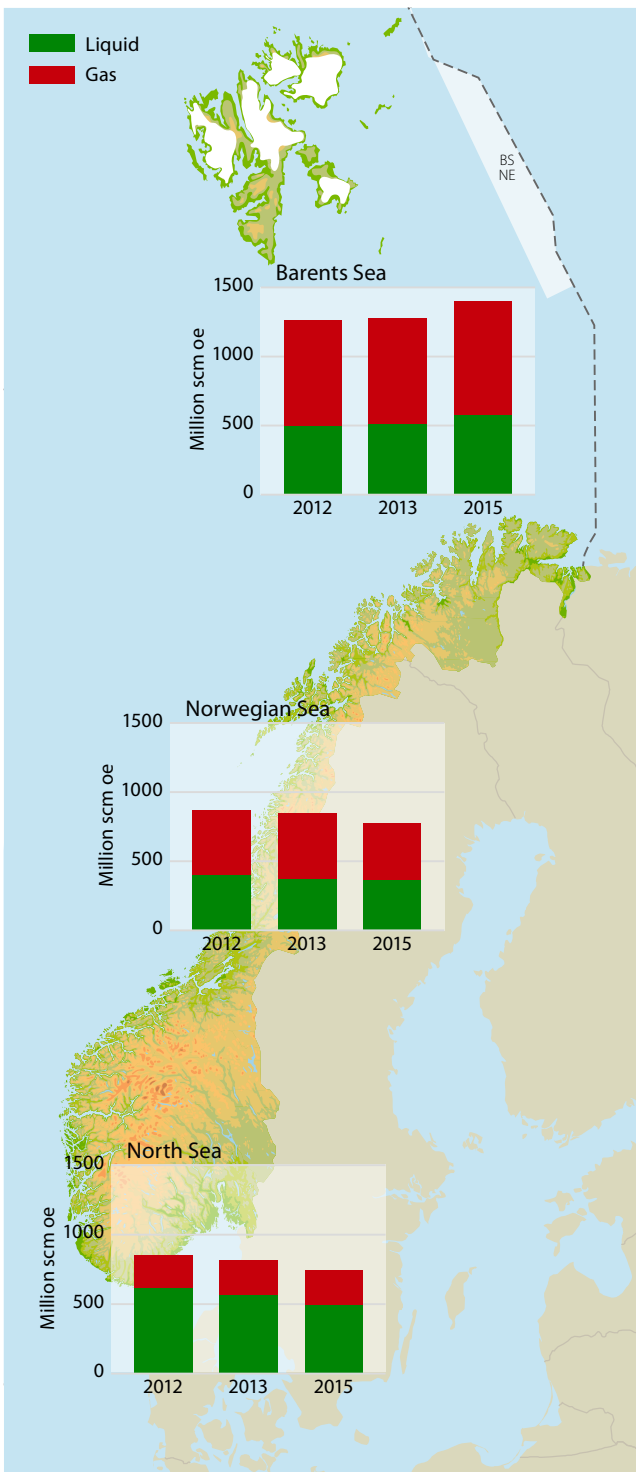


Figure 3.12 Liquid versus gas in the estimates of 2012, 2013 and 2015 for each part of the NCS.

Barents Sea South-East and the waters around Jan Mayen were included in the estimates for the Barents and Norwegian Seas respectively from 2012. That boosted the estimate for total undiscovered resources.

The proportion of gas has increased in the North Sea since 2012. Little change has occurred in the relationship between liquid and gas in the Norwegian and Barents Seas (figure 3.12).

Methodology

Several methods are available for estimating how much oil and gas might have been deposited and generated in an area. The choice of methodology depends on how much is known about the area. Play analysis is the approach used by the NPD.

Whether a play contains petroleum is uncertain until a discovery has been made. If producible petroleum has not been proven in a play, it is unconfirmed. Uncertainty prevails in such plays over one or more of the geological factors which must be present for petroleum to be proven. A confirmed play is characterised by a discovery which has proven producible petroleum. This does not need to be commercial.

The NPD has defined and analysed 74 plays, of which 44 have been confirmed by discoveries (table 3.1).

REGION	NUMBER	Unconfirmed	Confirmed since previous analysis
North Sea	24	4	0
Norwegian Sea	21	9	1
Barents Sea	29	17	1
Total	74	30	2

Table 3.1 Plays by region and status.

Estimating a single play

The following variables form the basis for estimating the undiscovered resources in a single play.

- Area of the play
The play has a delineated area.
- Number of prospects per unit area
The estimated number of prospects is based on an assessment of their density in one or more calibration areas where all relevant elements can be counted. These elements are the number of discoveries, dry wells, mapped prospects, leads and the number of postulated prospects (which could be mapped in the future).
- Size of future discoveries
Estimates of the size of possible future discoveries from postulated prospects and leads generally build on the magnitude of mapped prospects in the play. Information from discoveries is important for confirmed plays. Data from relevant plays will be very significant for all plays, while information from analogues is also important for less explored cases. Calculating the size of future discoveries builds on estimates of volume and fluid (liquid and gas) parameters. Where the various volume parameters are concerned, the estimate for gross rock volume will be the most significant for calculating resources in the prospect. Correlations between volume and fluid parameters are incorporated in order to describe the relationship between the various parameters.
- Probability of success
The probability of making future discoveries comprises the probabilities of a play being confirmed (play probability) and of a prospect becoming a discovery if the play is confirmed. The historical finding rate for this and comparable plays is an important input when estimating the probability of success.
- Probability of phase petroleum
Evaluations of source rock and migration are used to assess the probability of proving oil, gas or a combination of both (multiphase discovery). Information from relevant discoveries is also important for such assessments.

A stochastic calculation method based on the variables described above is used by the NPD to estimate the total resources in each play. All the variables are specified with a probability distribution, except probabilities of success and phase petroleum. The variables and the correlations between certain volume and fluid parameters across deposits provide estimates for resources within each play.

Correlations between parameters and between deposits are of significance for the resource distribution's range. A positive correlation increases the range for the total resource estimates. Total resources in a play represent the sum of the postulated prospects, leads and mapped prospects when the probability of success has been taken into account.

Estimate for each part of the NCS

The NPD uses a stochastic calculation method to estimate resources in the North, Norwegian and Barents Seas. Input data for the calculations are as follows.

- The resource distribution for all plays in that part of the NCS. Each of these regions contains a number of plays (table 3.1).
- Interdependencies between play probabilities in unconfirmed plays. In frontier areas, for example, several plays could be interdependent in terms of the presence of source rocks. Should a well confirm one play, the probability for other plays with the same source rock will increase.
- Correlations between volume and fluid parameters across plays.

Interdependencies and correlations between plays are of significance for the range of the resource distribution in the various parts of the NCS. Expected resources for one area are equal to the sum of expectations for each play. The resource estimate range is greater for an area with interdependencies and positive volume correlations than for ones with few or no interdependencies or volume correlations between plays.

Estimate for the whole NCS

A stochastic calculation method is used by the NPD to estimate the total undiscovered resources on the basis of the plays across the whole NCS. The estimated expected value for total undiscovered resources is equal to the sum of expectations for each region. The range in the total estimate is the result of the range for each part and of the interdependencies in probabilities of success and correlations across the parts of the NCS.

Definitions

Undiscovered resources: The quantities of petroleum which are estimated at a given time to be recoverable from deposits yet to be proven by drilling.

Play: A geographically delineated area where several geological factors are present so that producible petroleum could be proven.

These factors are:

1) reservoir rock: a porous rock where petroleum can accumulate. Reservoir rocks in a specific play will belong to a given stratigraphic level.

2) cap rock: a tight (impermeable) rock overlaying a reservoir rock, so that petroleum can migrate no further and accumulates in the reservoir. The resulting trap must have formed before petroleum ceased to migrate into the reservoir.

3) source rock: shale, limestone or coal containing organic materials which can be converted into petroleum. The source rock must also be mature – in other words, have a temperature and pressure such that petroleum actually forms – and the petroleum must be able to migrate from source rock to reservoir rock. A play is confirmed when producible petroleum is proven in it. This discovery does not have to be commercial. If no producible petroleum has yet been proven in a play, it is unconfirmed.

Play probability: The estimated probability that producible petroleum can actually be proven in a play. This probability is estimated with the aid of a geological assessment of the probability that reservoir, source and cap rocks are present in the play.

Prospect: A possible petroleum deposit with a mappable, delineated volume of rock.

Probability of success: Describes the possibility of proving petroleum in a prospect by drilling. It is the product of the probability that the play exists, the presence of a reservoir and

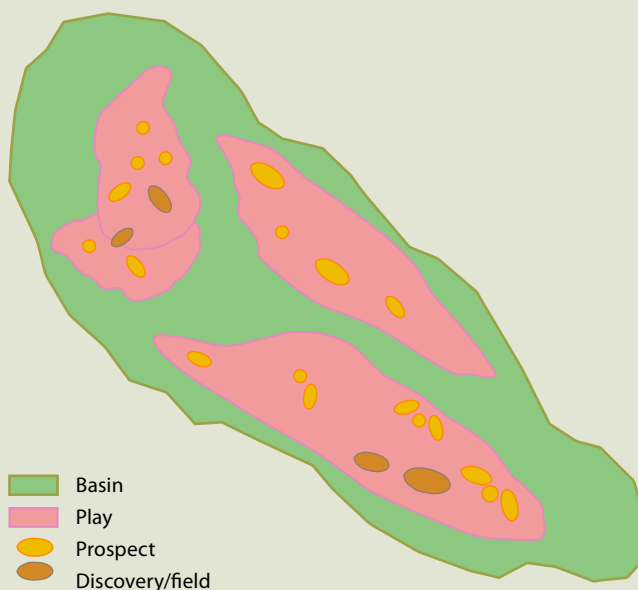
a trap, migration of petroleum into the trap and the containment of petroleum in the trap (see play).

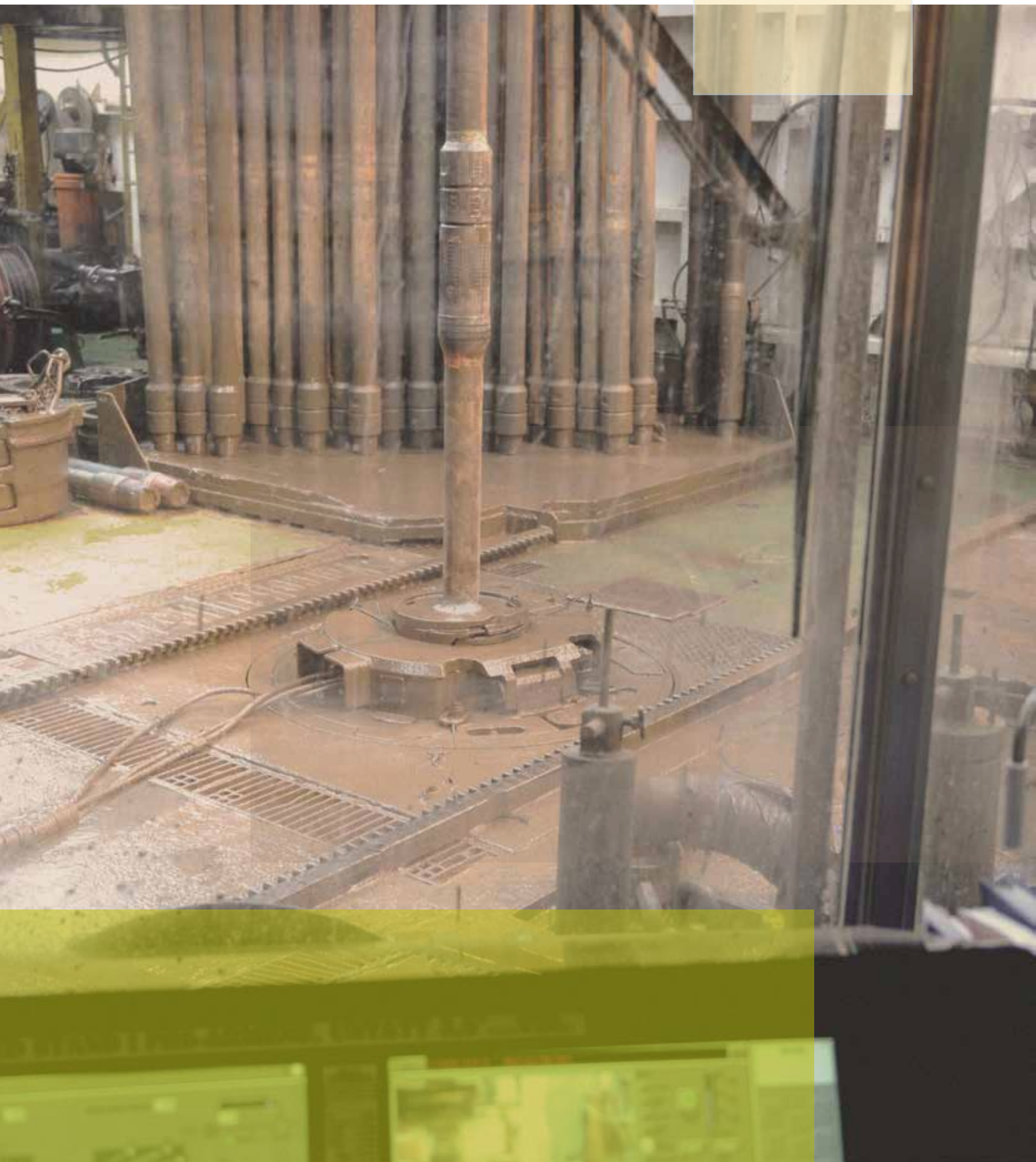
Lead: A possible petroleum trap where available data coverage and quality are not sufficient to map or delineate the rock volume.

Uncertainty: Expresses the range of possible outcomes or results. This can be described in many ways, most often with the aid of high or low estimates (the NPD estimates, for example, that 1 350-5 490 million scm oe of total recoverable undiscovered resources remain to be identified on the NCS).

Uncertainty is usually calculated using statistical methods, such as Monte Carlo simulations. High and low uncertainties can then be described with the aid of statistical concepts. Where undiscovered resources are concerned, the NPD generally uses P95 for the low estimate. This means that, given the assumptions applied in the analysis, the probability of a result equal to or larger than the P95 value is 95 per cent. P5 is used for the high estimate, which means a five per cent probability that the result will be equal to or larger than the P5 value.

Expected value: The average value. This is generally defined as the arithmetic mean of all the outcomes in the statistical distribution. It is much used, and has the property that the expected value for various distributions can be summed to give a sum of distributions.





Full-cycle profitability of exploration

Exploration contributed substantial value to society between 2000 and 2014, according to the NPD's analysis of its full-cycle profitability during this period. Overall net cash flow from discoveries made in these years is estimated at roughly NOK 2 000 billion after deducting exploration costs.

The analysis shows that exploration made a positive contribution to value creation in all parts of the NCS. Both activity and resource growth have clearly been greatest in the North Sea, with Johan Sverdrup as the biggest contributor to value creation. Exploration in the Norwegian and Barents Seas has also generated substantial value.

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Elements not included in the analysis

- Exploration in 2015 has not been included because resource figures for the new discoveries are uncertain. Resource growth from the 16 new finds made in that year is in the order of eight to 20 million scm of oil and 14-40 billion scm of recoverable gas and condensate. These finds are all small and close to existing fields. No estimate has been made of their value. NOK 25-30 billion was spent on exploration in 2015.
- Wildcats provide information on the type, properties and age of the rocks. In areas with few wells, data from each well will be worth a lot in terms of geological information. That value has not been quantified in this analysis.
- Where future field developments are concerned, the analysis has not taken account of the substantial reduction in costs over the past year. The cost estimates applied in the analysis could therefore be somewhat too high.
- Most of the discoveries are expected to be developed as satellites to existing fields. A tie-back to existing infrastructure is cost-effective in many cases, and the only commercial solution for small discoveries. Without this opportunity, many of the latter could not be developed or would have been significantly less profitable. Such tie-backs could help to extend the economic life of the host field, and thereby allow it to continue profitable production and to improve recovery. This additional value can be substantial, but has not been quantified in the analysis.
- Extending the commercial life of infrastructure provides incentives for further near-field exploration because more discoveries can be produced while the facilities are in place and on stream. Such positive external effects have not been valued in the analysis.

- Relatively little infrastructure has been developed in the Barents Sea, which creates great uncertainty over both the value of the resources and the choice of development solution. That applies particularly to the gas resources. Establishing coordinated development and transport solutions could cut costs and/or increase resource recovery from a development, and thereby increase the value of the discoveries. Such coordination gains have only been included to a very limited extent in this analysis.
- Activity on the NCS creates big spin-offs for other parts of the economy. Such effects are also likely to be substantial with the development of discoveries made in 2000-14. These spin-offs and possible socio-economic value have not been quantified in the analysis.

Exploration activity and resource growth in the period

A total of 583 exploration wells were drilled in 2000-14, breaking down as 407 wildcats and 176 for appraisal. Most of the wildcats were drilled in the North Sea (figure 4.1), amounting to 63 per cent for the whole analysis period. The Barents Sea had the smallest number of wildcats – 52, or 13 per cent.

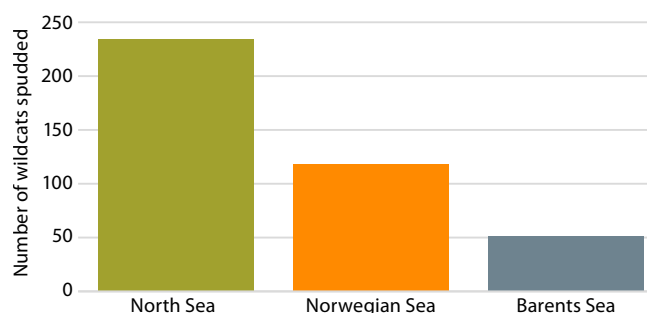


Figure 4. 1 Wildcats spudded 2000-14 by region.

The 407 wildcats yielded 215 discoveries, giving a finding rate of 0.53 for the whole period.

Where certain discoveries are concerned, recoverable resources, reservoir complexity and/or location in relation to established infrastructure could mean that development has been assessed as unlikely even in the long term. Substantial changes in technology or price would be needed to make them commercial. Sixty-four discoveries fall into this category and are excluded from the profitability analysis. In addition, nine discoveries where the resources are included in existing fields – primarily because they are small – have also been excluded. Exploration costs for both types of discoveries have been incorporated in the analysis.

At 1 370 million scm oe, the overall resource estimate for the whole period breaks down as 378 million scm oe gas and 992 million scm oe liquid (figure 4.2).

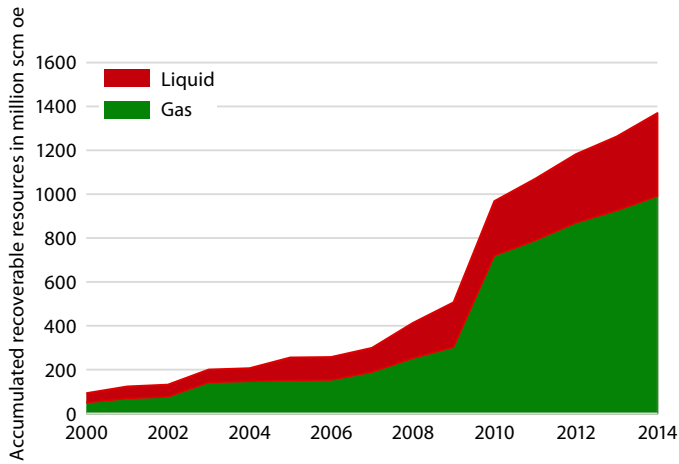


Figure 4.2 Accumulated recoverable resources from discoveries in 2000-14 (million scm oe).

The biggest discoveries made during the period are Johan Sverdrup, Johan Castberg (7220/8-1 and 7220/7-1), Goliat and 7220/11-1 (Alta). Although several large finds have been made, most are smaller than 10 million scm oe (figure 4.3).

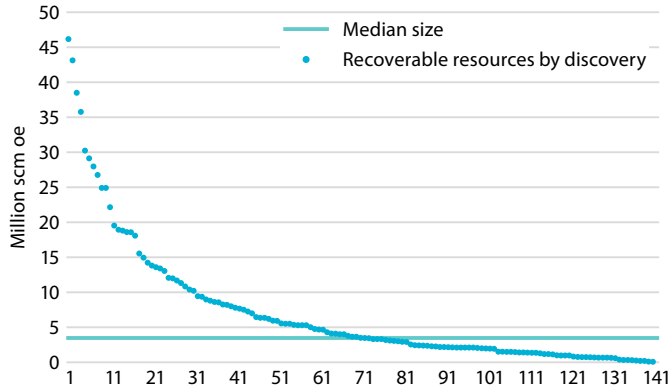


Figure 4.3 Overview of recoverable resources per discovery in 2000-15, ranked by size excluding Johan Sverdrup.

Methodology and assumptions

All phases of the business, from exploration to cessation and removal, are covered by the analysis (figure 4.4). The full-cycle profitability of exploration is defined as revenues from discoveries in the period less costs incurred in every phase from exploration to cessation. Revenue and cost flows are discounted to the same year.

Production and cost estimates reported by the operators have been utilised for virtually all the discoveries. The NPD has used its own calculations for a few finds which had not been evaluated at 31 December 2014. Dates for coming on stream coincide with the assumptions for the forecast in the 2015 revised national budget.

The analysis has been produced at a time of great uncertainty over price developments. Following an assessment of various forecasts, the oil price trend applied has been adjusted downwards from three of the four scenarios in the IEA's *World Energy Outlook* for 2015. The NPD analysis assumes a gradual rise in oil prices from the present level until 2020, when they are expected to remain at USD 90 per barrel measured in fixed 2014 prices. A similar approach has been taken for the natural gas price. The estimate for the latter in 2020 is NOK 2 per scm in fixed 2014 prices. Profitability is calculated using discount rates of four and seven per cent.

Estimated costs for 2016 and beyond reflect the 2014 level. As with product price trends, and not unaffected by these, substantial uncertainty prevails about how the level of costs will develop. It has been assumed that the level of costs reflected in the forecast will roughly accord with an oil price of about USD 90 per barrel. Where future field developments are concerned, the analysis has not taken account of the substantial reduction in costs over the past year. The cost estimates applied in the analysis could therefore be somewhat too high.

The estimates for full-cycle profitability of exploration are uncertain. This partly reflects uncertainties in resource estimates, developments in product prices and the level of costs. Development decisions have yet to be taken for a substantial proportion of the discoveries made in 2000-14. How far these have progressed through the planning process varies, which means that estimates for production and costs vary in quality. When developments will come on stream is very uncertain, too, which will also have a substantial effect on the present value.

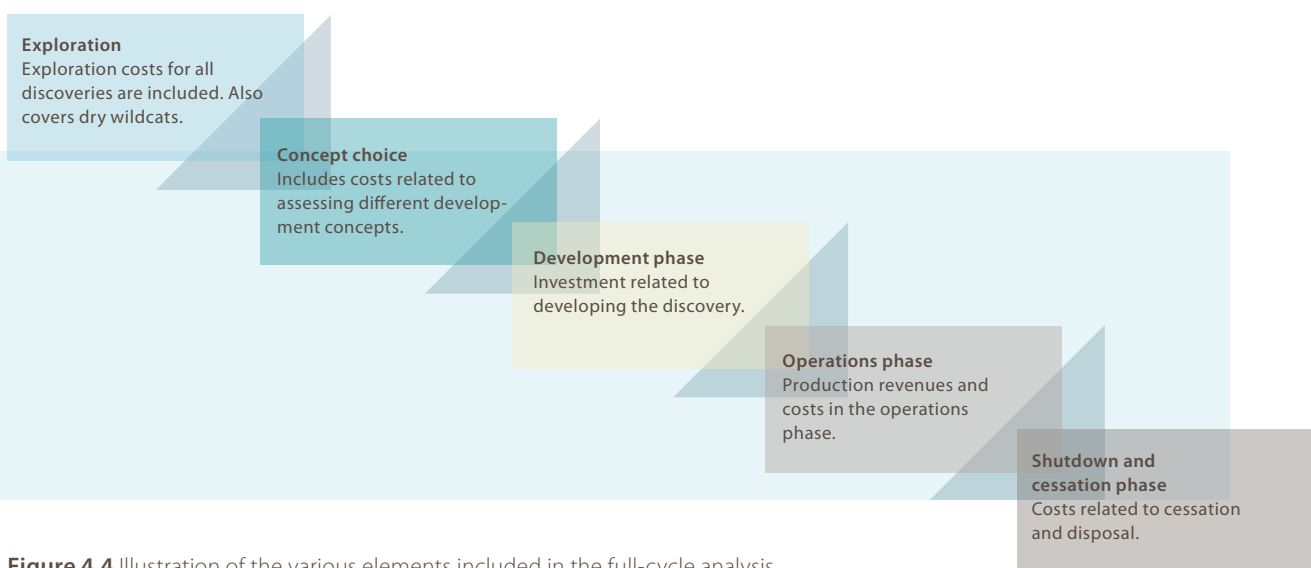


Figure 4.4 Illustration of the various elements included in the full-cycle analysis.

Calculated profitability

Total net cash flow from discoveries in the period is estimated at about NOK 2 000 billion after deducting exploration costs. The net present value is roughly NOK 1 000 billion and almost NOK 600 million at discount rates of four and seven per cent respectively (figure 4.5).

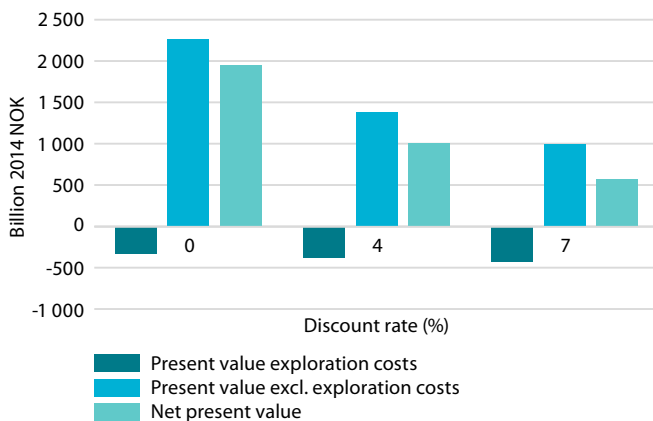


Figure 4.5 Value creation at various discount rates.

These estimates show that exploration activity has been profitable in all parts of the NCS (figure 4.6). Its value has clearly been greatest in the North Sea. Total net cash flow from discoveries in this region during the period is estimated at some NOK 1 400 billion after deducting exploration costs. The net present value is roughly NOK 800 billion and almost NOK 500 million at discount rates of four and seven per cent respectively.

Exploration activity in the Norwegian and Barents Sea has also created substantial value, with a combined net cash flow of around NOK 500 billion.

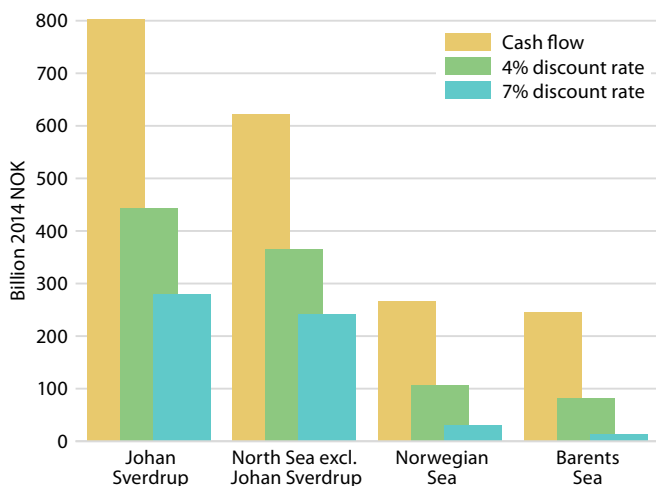
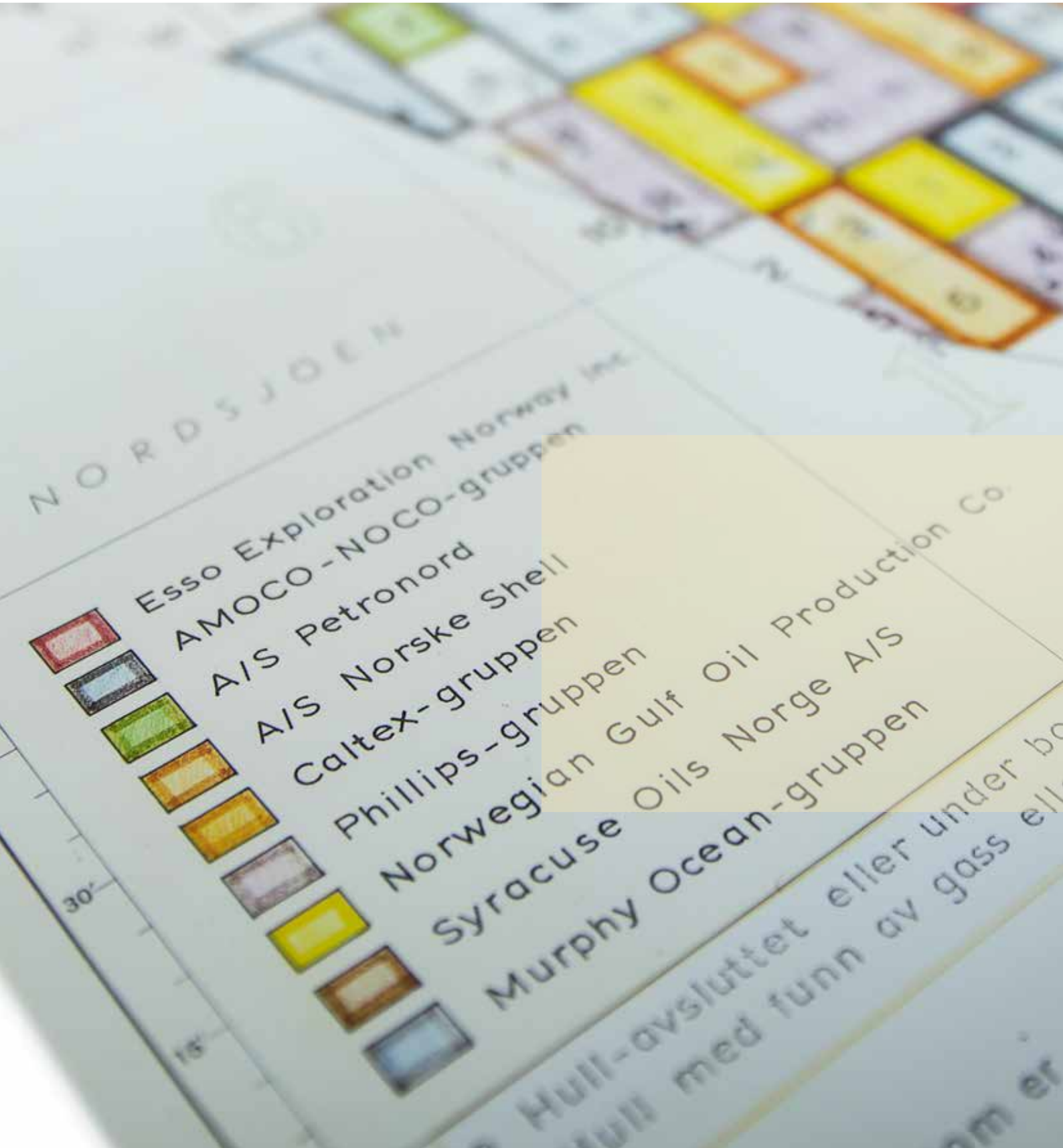


Figure 4.6 Estimated net present value of exploration in 2000-14 by various parts of the NCS.



A section of the very first NCS map from 1965, produced in connection with Norway's initial offshore licensing round. It provides an overview of the companies which secured the first production licences on the NCS.

Player picture

A player picture which reflects the challenges facing the industry in both mature and less mature areas is important for realising the resource and value potential.

Companies involved in the exploration phase today display considerable diversity. The result has been a high level of activity, increased competition and a greater variety of ideas, which have yielded many discoveries and created substantial value for society. A greater number of companies involved in the exploration phase has also increased the number of operators for discoveries and fields.

The many mergers between the big oil companies in the late 1990s and around 2000 left fewer and larger international players. At the same time, the NCS – and particularly the North Sea – had developed into a more mature petroleum province. The resulting decline in discovery size meant challenges were different from before. Opportunities in mature areas of the NCS were of limited interest to several of the big companies.

The government implemented a number of measures both to improve predictability in the licensing process and to widen company participation. These included prequalification, the APA scheme and refunding the tax value of exploration expenses (see the box). Combined with rising oil prices, these steps have contributed to more participants and greater diversity. Many small and medium-sized oil and gas companies and European gas/power enterprises became established on the NCS. So did a number of new Norwegian undertakings. The total number of players almost doubled from 2002 to 2007 (figure 5.1)*. Fifty-three companies were involved on the NCS at 31 December 2015.

Five different company categories

The NPD has divided players on the NCS from 1965 to 31 December 2015 into five categories: large Norwegian companies, majors, medium-sized companies, European gas/power companies and small companies.

Table 3.1 presents the breakdown of players active as licensees on the NCS at 31 December 2015. Petoro is defined as a large Norwegian company, even though it is not an oil company in the conventional sense but acts as the licensee on behalf of the government. Allocation to the various categories is based on a combination of size, nationality and phase (strategy). Size is defined by the enterprise’s market value on the stock exchange. The transfer of companies between different categories has been preserved historically, since they mainly change type as a result of mergers. Over the past 15 years, only Det Norske has changed company category on the basis of discoveries which have increased its market value on the stock exchange.

Having a variety of players in the exploration phase is an important condition for the highest possible value creation. Despite many new participants, the NCS remains attractive for the big companies.

The industry now appears to be entering a new consolidation phase, similar to the one in the late 1990s. The signals are the same as in earlier periods with low oil prices, where the companies first reduced costs and investment before mergers took place. A slight reduction in the number of companies occurred in 2014 and 2015 (figure 5.1).

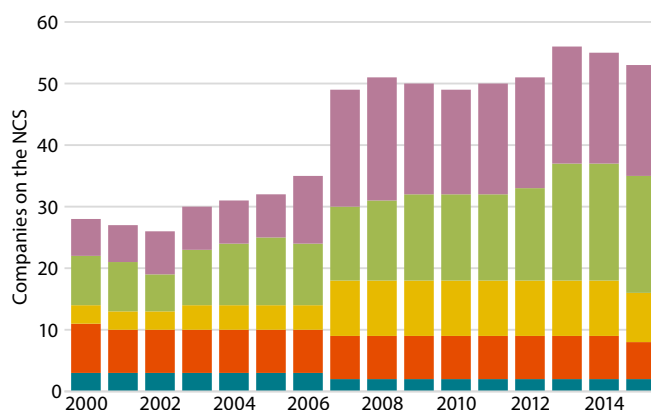


Figure 5.1 Development in the number of companies on the NCS since 2000.

Small companies	Atlantic, CapeOmega, Concedo, Core, Dana, Explora, Faroe, Fortis, Kufpec, Lime, Noreco, North Energy, Origo, Petrolia, Pure, Skagen44, Skeie, Spike
Medium-sized companies	BG, Capricorn, DEA, Det Norske*, Hess, Idemitsu, Lotos, Lukoil, Lundin, Maersk, Moeco, MOL, OMV, Premier, Repsol, Rosneft, Suncor, Tullow, Wintershall
European gas/power companies	Bayergas, Centrica, Dong, E.ON, Edison, GDF Suez, PGNiG, VNG
Majors	BP, ConocoPhillips, Eni, ExxonMobil, Shell, Total
Large Norwegian companies	Statoil, Petoro

*Det Norske ranked as a small company until 2011.

Table 5.1 Categorisation of licensees on the NCS at 31 December 2015.

* This development is described in detail in the 2013 resource report.

Production licences

Large Norwegian and medium-sized companies hold the most production licences and acreage on the NCS (figure 5.2 and 5.3). However, large Norwegian companies have reduced their share of total production licences and roughly halved their proportion of licensed acreage since 2005. Medium-sized companies have increased their share of both production licences and acreage over the same period. The increase since 2012 partly reflects the reclassification of Det Norske from small to medium-sized company.

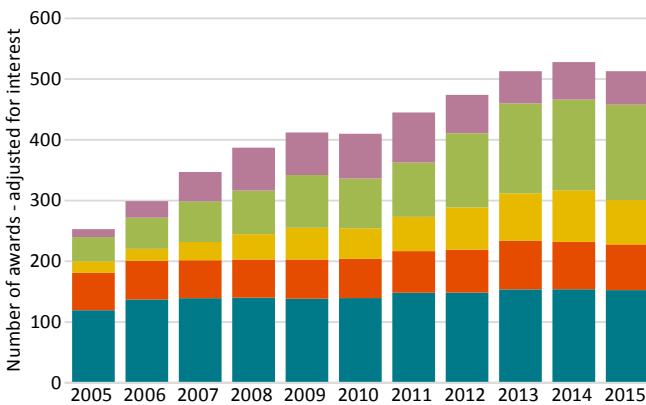


Figure 5.2 Licences by the various company categories in 2000-15.

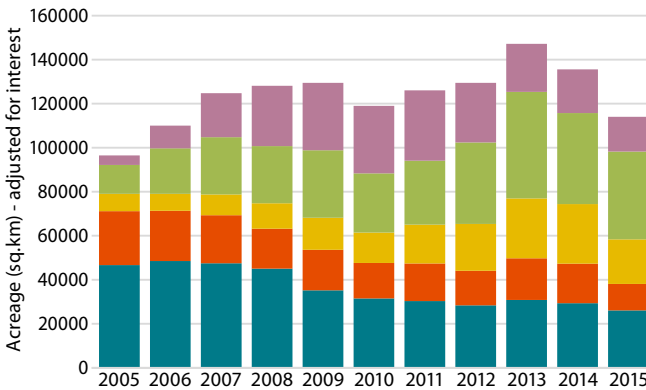


Figure 5.3 Acreage in square kilometres by the various company categories in 2000-15.

Acquisition and divestment of interests

A well-functioning secondary market for trading in licence interests is important for achieving efficient exploration of the resource potential on the NCS.

In line with the rise in the number of companies and licences, and with oil price developments, the secondary market for interests has expanded substantially since 2000 (figure 5.4).

Small and medium-sized companies are the most active participants in the secondary market. Large Norwegian companies and majors are net sellers (figure 5.5), while the other categories are net buyers.

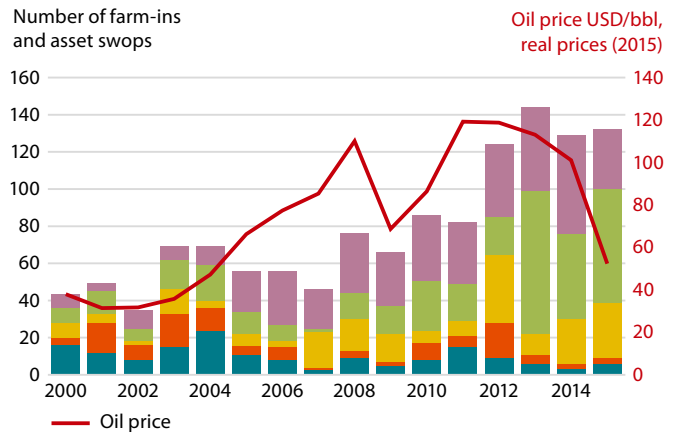


Figure 5.4 Acquisition and divestment of interests in production licences in 2000-15 by company category.

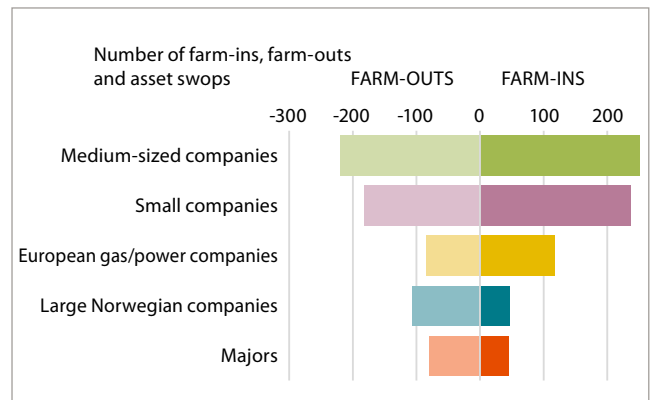


Figure 5.5 Acquisition and divestment of interests in 2000-15 by company category.

Exploration activity and results

Spending and the number of wells can say something about how actively companies participate in exploration, while resource growth and profitability provide an indication of their performance on the NCS.

However, exploration activity and results are also affected by where the companies are exploring on the NCS and the prospectivity of the acreage awarded. Comparing players active in mature parts with those engaged in frontier areas is difficult, because the latter acreage offers a lower average probability of success and a higher probability of making big discoveries than the former. Where companies explore reflects both their own strategy and government licensing policy.

Exploration results such as resource growth and profitability are measurable and can say something about the commitment of the companies. However, they do not pick up company contributions in the form of good exploration concepts and active participation in production licences.

Large Norwegian and medium-sized companies have been the most active explorers during the period, measured by the

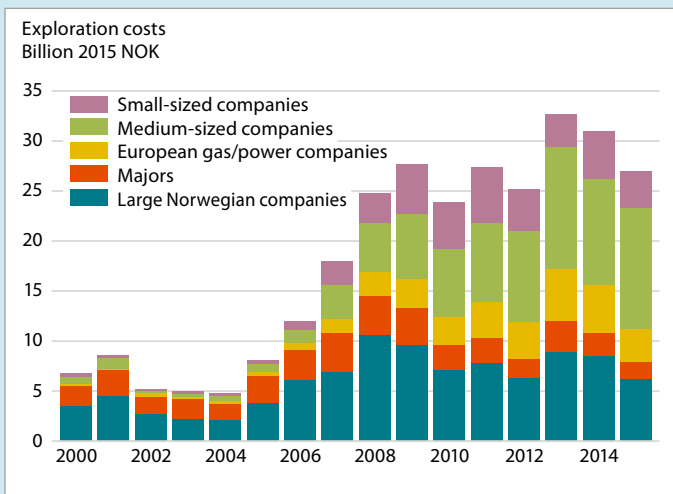


Figure 5.6 Investment in exploration over the past five years by company category.

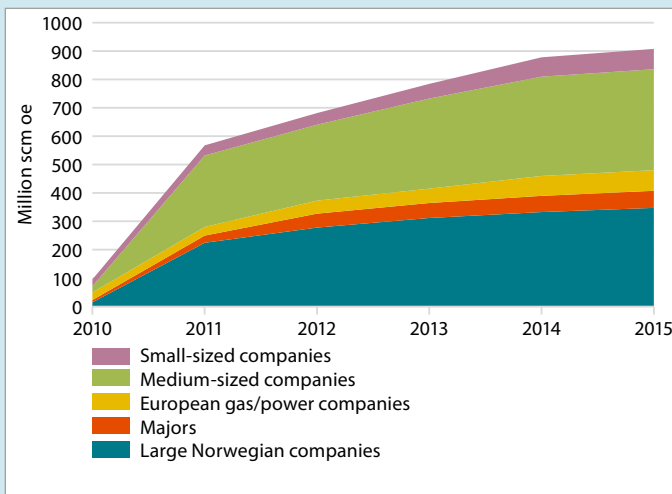


Figure 5.9 Accumulated resource growth in 2010-14 by company category. Excludes discoveries not currently expected to be developed (RC 6).

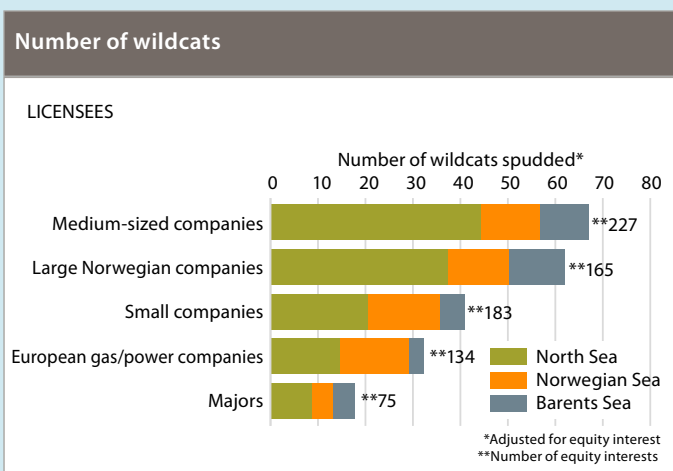


Figure 5.7 Wildcats drilled in 2010-15 by company category and licensees.

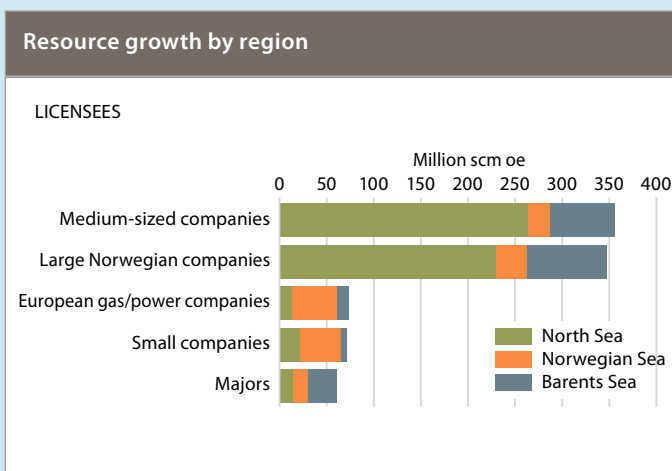


Figure 5.10 Resource growth per region in 2010-15 by company category, licensee.

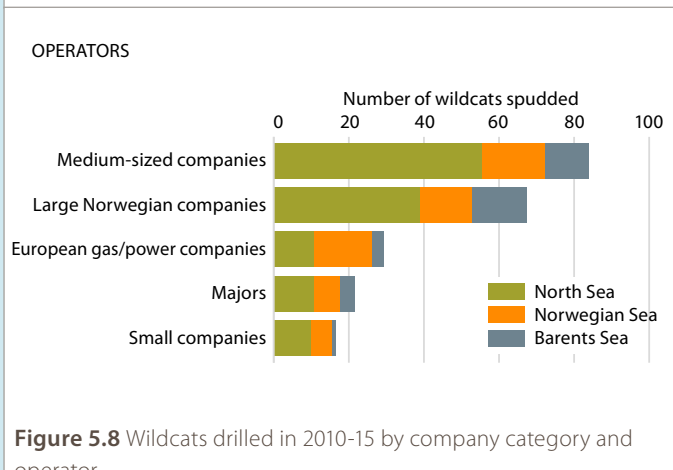


Figure 5.8 Wildcats drilled in 2010-15 by company category and operator.

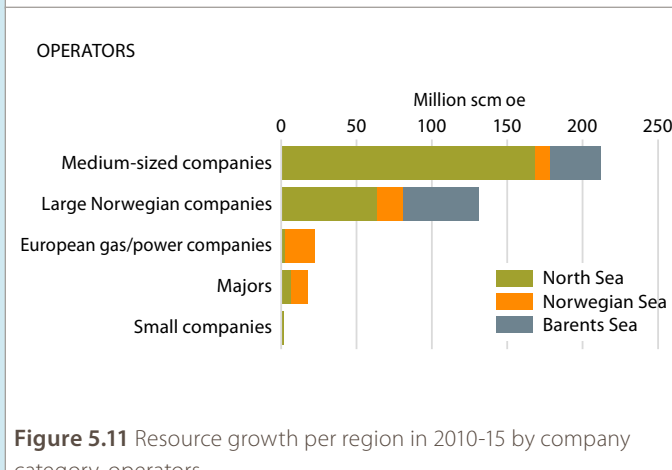


Figure 5.11 Resource growth per region in 2010-15 by company category, operators.

amount invested and the number of wildcats drilled both as licensees and operators (figures 5.6, 5.7 and 5.8). These players have also held the most production licences and acreage in recent years.

During the first half of the 2000s, large Norwegian companies and majors accounted for the biggest investment in exploration. Spending on this activity has increased substantially since 2005, and other company categories have increased their share of total investment. Medium-sized companies have accounted for the biggest proportion of exploration spending in recent years.

Large Norwegian and medium-sized companies proved the largest proportion of resources in 2010-15, both as licensees and as operators (figures 5.9, 5.10 and 5.11).

These players are responsible for the largest share of resource growth through their participation in Johan Sverdrup. Maria and the 6406/12-35 (Pil) discovery represent the most significant contribution to growth from small companies. Similarly, holdings in 7220/8-1 Johan Castberg have contributed significantly to resource growth from majors. The 35/9-7 (Skarfjell) and 7220/11-1 (Alta) discoveries have played a corresponding role for European gas/power companies.

At 31 December 2015, large Norwegian companies and majors owned about 85 per cent of remaining reserves – in other words, resources covered by a development decision – and about 60 per cent of resources yet to be sanctioned for development. The player picture for resources in discoveries is more balanced than for remaining reserves (figure 5.12).

Exploration over the past 15 years has contributed substantial value to society, according to the NPD’s analysis of the full-cycle profitability of this activity during the period as described in chapter 4.

Profitability has been calculated for exploration in 2000-14. Broken down by company category, the analysis shows that its value has been particularly high for large Norwegian and medium-sized companies (figure 5.13). That reflects the big contribution from Johan Sverdrup. Exploration has paid off for all company categories.

Player picture in development and operation phases
Interests were held in discoveries and fields by 45 of the 53 companies on the NCS in 2015. The number of licensees with such holdings has increased since 2000 (figure 5.14).

In the latter year, 27 licensees had interests in discoveries and fields. Growth from 2005 to 2010 occurred primarily among small and European gas/power companies. From 2010 until 1 January 2015, the principal expansion was among medium-sized companies. Before the big growth in numbers between 2005 and 2010, virtually all the players on the NCS had holdings in fields or discoveries. Since then, this proportion has fallen to about 80 per cent.

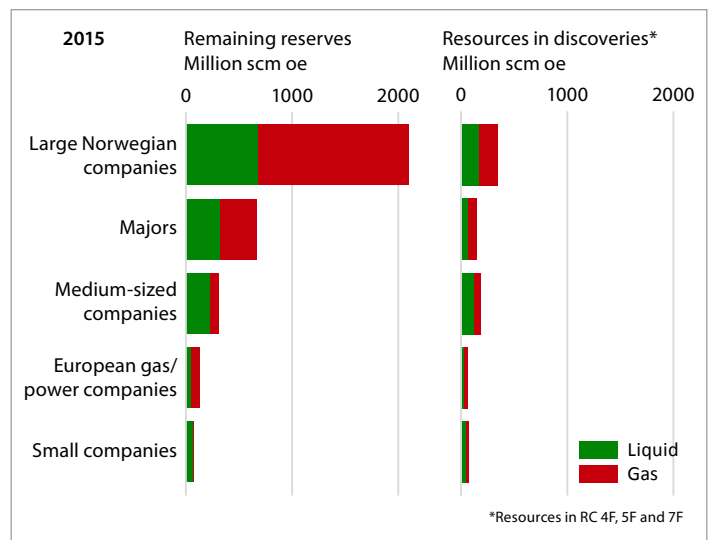


Figure 5.12 Remaining reserves and resources in discoveries on the NCS at 31 December 2015, broken down by oil and gas.

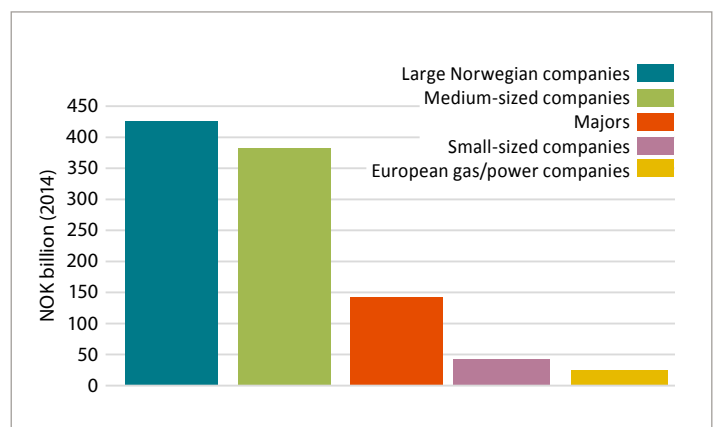


Figure 5.13 Profitability of exploration in 2000-14 by company category.

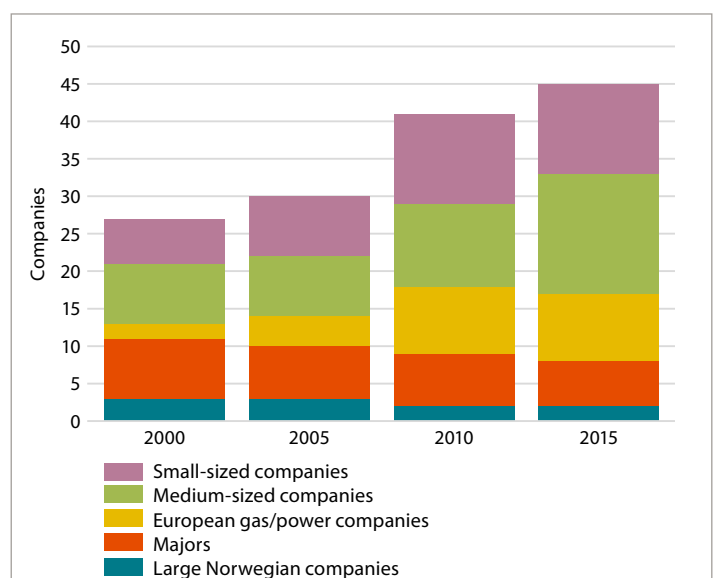


Figure 5.14 Licensees in discoveries and fields on stream.

Thirty-one of 53 companies were licensees in fields in 2015 (figure 5.15). While about 90 per cent of the players in 2000 held such interests, that proportion was roughly 55 per cent in 2015. The reasons could be that a majority of the newer participants on the NCS define themselves as exploration companies, and that it has been easier to make new discoveries than to acquire interests in established fields.

Operators of discoveries and fields

At 31 December 2015, 22 of 45 licensees in discoveries and fields were also operators. Fifteen were operators for fields on stream. That represents almost a doubling over the past 15 years. Many medium-sized and European gas/power companies established themselves as operators in 2009-13. The number of operators has been stable since 2013 (figure 5.16).

The growth in operator numbers partly reflects Statoil's transfer of operatorships to others as well as field developments operated by medium-sized and European gas/power companies.



Figure 5.15 Licensees in fields.

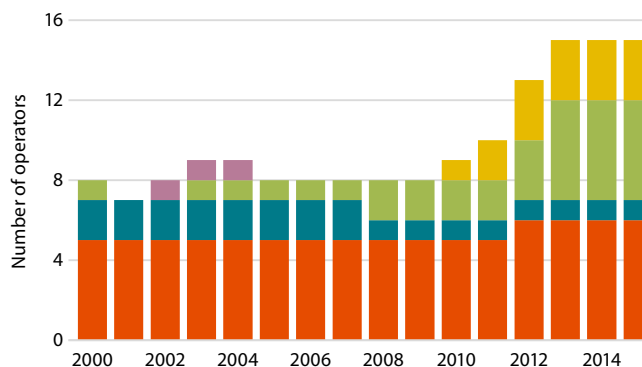
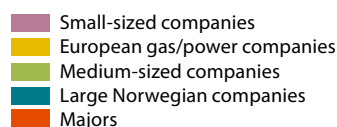
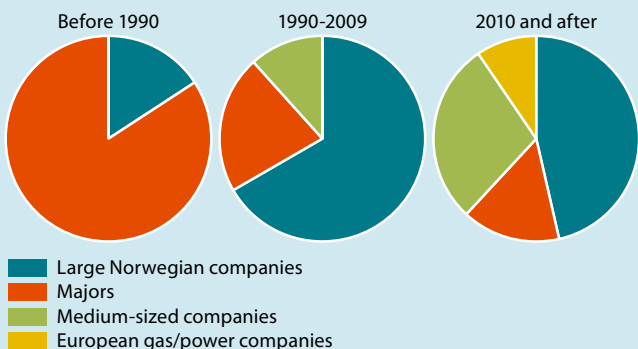


Figure 5.16 Operators with fields on stream on the NCS.



Who develops discoveries?

The graphs presents changes in the type of company operating field developments between three periods.

Majors predominated in the first of these. Hydro and Statoil later dominated development activity before and after 2000. More companies now have responsibility for development projects. The latest period also includes planned developments.

Adjustments to operating parameters

A number of measures were adopted in the first half of the 2000s to stimulate competition and increase company diversity on the NCS. Three changes to operating parameters have been particularly important.

- The prequalification scheme was established to offer companies an evaluation of their suitability for participation on the NCS before they devoted possible resources to assessing specific commercial opportunities. Great interest in prequalification has been displayed since it was introduced, and a steady trickle of companies are still seeking such advance assessment.
- The APA scheme, combined with adjustments to the design of work programmes, provides companies with a regular supply of exploration acreage and ensures that exploration is pursued actively. In this way, the arrangement also facilitates efficient resource use in the oil companies and makes sure that previously relinquished acreage becomes available to players with new ideas. Areas awarded earlier will thereby also be subject to reassessment.
- Refunding the tax value of exploration expenses means that the companies can choose whether to have 78 per cent of their exploration costs refunded the following year or deducted from their tax liability. The scheme was introduced to ensure equal tax treatment of exploration costs, regardless of whether a company already has taxable earnings. That in turn reduces possible entry barriers for new players and facilitates profitable exploration. Established companies with taxable earnings can continuously deduct exploration costs and thereby reduce their tax payments by the 78 per cent figure. Alternatively, players without such earnings can carry the loss forward with an interest supplement (or have the tax value of the loss refunded when ceasing activity on the NCS). This scheme means that small companies which have yet to acquire taxable earnings can reduce tied-up capital and thereby improve cash flow.



Geological mapping by the NPD

Geological mapping by the NPD in unopened and frontier areas of the NCS helps to enhance understanding of the geology and to expand data coverage. Funds for this work are provided over the government budget.

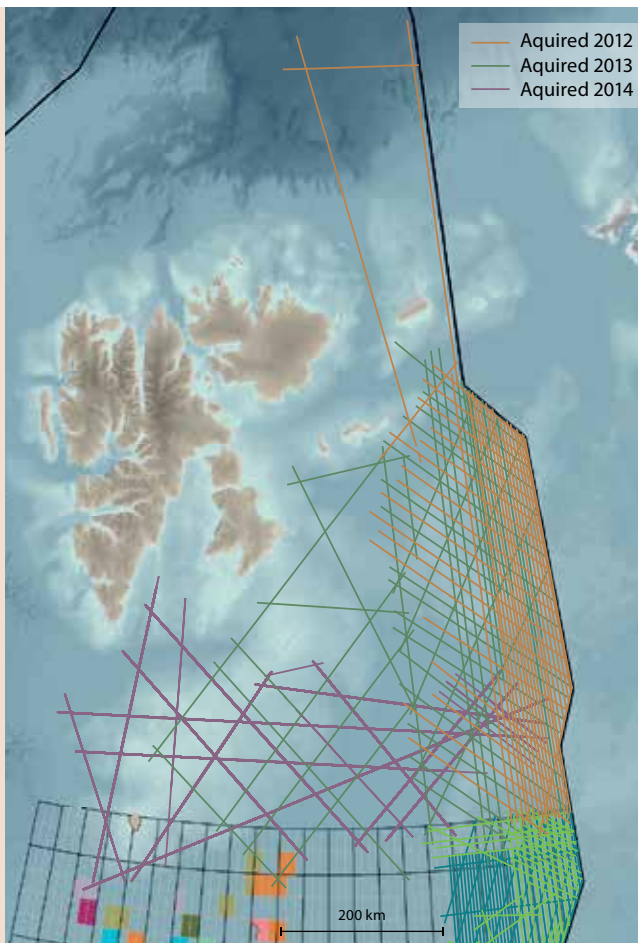


Figure 6.1 Seismic surveys in Barents Sea North and North-East.

Geophysical surveys

Seismic surveys

Acquisition of seismic sections involves generating sound waves from a source above or in the sub-surface. These waves propagate through the strata and are reflected back to sensors on the seabed, at the sea surface or in a well. That makes it possible to form a picture of the sub-surface geology. Seismic mapping of the NCS began in 1962.

2D seismic: Data acquired, processed and presented as separate seismic lines/cross-sections through the sub-surface.

3D seismic: Data acquired as closely packed separate lines, but processed and presented as a three-dimensional volume of the sub-surface.

Gravimetric surveys

Measuring variations in the Earth's gravitational field in order to reveal the composition of the sub-surface.

Magnetometric data

Measurements of variations in the Earth's magnetic field in order to reveal the composition of the sub-surface.

Shallow boreholes

Holes drilled in order to acquire information on the rock characteristics and/or carry out geotechnical examinations for the location of installations and which are not drilled to discover or delimit a petroleum deposit or to produce or inject petroleum, water or other medium (section 2, resource management regulations). The boreholes are cores drilled to a maximum of 200 metres. The consent of the Petroleum Safety Authority Norway must be secured to go deeper than 200 metres. See section 25 of the management regulations.

Acquisition of geological information by the NPD and its mapping of unopened and frontier parts of the NCS help to increase understanding of the geology in these areas and to expand data coverage. A good data and knowledge base is essential for the government to play a crucial role in resource management. Funding of the NPD's mapping work is provided over the government budget.

Seismic surveys in Barents Sea North and North-East

The NPD acquired a total of 32 600 kilometres of 2D seismic data in Barents Sea North and North-East during 2012-14. These surveys were mainly conducted in the area north of 74° 30' N, which has not been opened for petroleum activities.

A total of 13 700 kilometres of long lines were systematically acquired during 2012 in a relatively tight mesh over the new area to the east, close to the boundary with the Russian sector. Previous surveys in this area had been limited. Favourable ice conditions also made it possible to acquire three seismic lines right up to 81° N (figure 6.1).

Data acquisition in 2013 and 2014 took place mainly in the eastern part of Barents Sea North, again close to the Russian boundary, covering 13 200 and 5 700 kilometres respectively. West of the area where Norway and Russia had overlapping claims, older data are available from 1971-97. Their quality is mostly poor, and they were acquired with older technology. Conducting new surveys has accordingly been important in obtaining a better geological understanding of the area.

Gravimetric and magnetometric data were also acquired at the same time as the seismic surveys in 2012-14. This information will help to increase understanding of the geology in the area.

All the seismic data acquired in 2012-14 have been processed. Hard and uneven seabed conditions as well as shallow water made this work very demanding. That applies particularly to the areas around Bjørnøya and up towards Svalbard. As a result, the data are currently being reprocessed (2014-16).

Shallow boreholes in Barents Sea North

Geological mapping in Barents Sea North began with 2D seismic surveys in the mid-1970s. Acquiring geological cores eventually became necessary in order to understand which rocks were producing the seismic signals (reflectors) visible in the data. Learning about the age of the rocks was also important in order to understand the geological development of Barents Sea North over time. Several shallow scientific boreholes were drilled in the late 1980s to increase geological knowledge of the area. The last of these surveys was conducted east of Kong Karls Land in 2005.

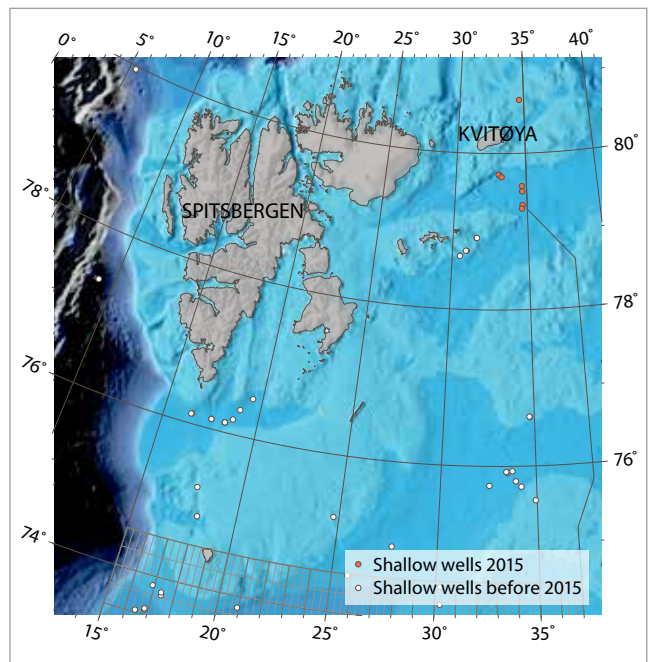


Figure 6.2 Shallow boreholes in Barents Sea North.

In the years following the 2011 ratification of the boundary treaty with Russia, the NPD received funds over the government budget for 2D seismic surveying in the new areas. Knowledge of the rocks there is limited, particularly in the northern part. Acquiring new cores is therefore crucial for mapping the far north along the boundary with Russia.

Funds were appropriated in the 2015 government budget for shallow drilling, and cores up to 200 metres long were collected. The primary area for this work lay south and north of Kvitøya (figure 6.2). Outcropping rocks of various ages are found at the seabed there, with the Triassic series and contact with the underlying Permian of great geological interest (figure 6.3). The water depth is 230-360 metres.

Seven successful shallow boreholes were drilled with depths varying from 52 to 200 metres. Locations were chosen on the basis of 2D seismic data, and the objective was to retrieve cores from stratigraphic boundaries which primarily occur at deep levels in the Barents Sea but which, for various reasons, are found at shallow depths in the survey area. A total of 1 048 metres of cores were retrieved, and knowledge acquired from

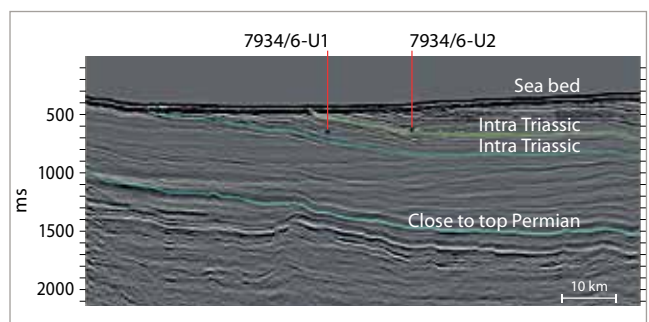


Figure 6.3 Seismic cross-section showing boundaries of rock outcrops.

these will increase geological understanding of the northern Barents Sea.

Preliminary results from the shallow drilling south of Kvitøya show that the oldest rocks are from the Carboniferous and Permian, with deposition of carbonates and shales. The Permian-Triassic boundary is well preserved in the cores. A dark shale from the Middle Triassic found in the cores is expected to be rich in organic material. A borehole drilled north of Kvitøya has revealed dolomites which were probably deposited in the Carboniferous.

Very thick sandstone layers with thin coal beds have been deposited in the Late Triassic. A preliminary interpretation is that these strata were deposited as a big river plain at the northernmost edge of the Barents Sea. This plain was flooded by the sea, with deposition of marine shales, before a new pulse of sandstones was deposited at the Triassic-Jurassic boundary. More exact dating of the material in the cores and studying the chemical properties of the rocks will provide important information for further geological interpretation of the area.

Expedition with ROV

An expedition with a remotely operated vehicle (ROV) was undertaken in 2013 by the NPD in cooperation with the University of Bergen. Covering the north-western part of the Norwegian Sea in just under 3 500 metres of water, it aimed to acquire rock samples from beneath the volcanic basalt in a cost-effective manner. This was done by installing a chain saw in order to cut samples from steep rock outcrops. Locations were determined using seismic and bathymetric information. The material recovered from the southern end of the Gjallar Ridge (figures 6.4, 6.5 and 6.6) reveals the presence of a number of thick intrusions which have solidified as columns. Uranium/lead (U/Pb) dating gives their age as Late Palaeocene (57 million years ago), and they have intruded into fine-grained Upper Cretaceous (Maastrichtian and Campanian)

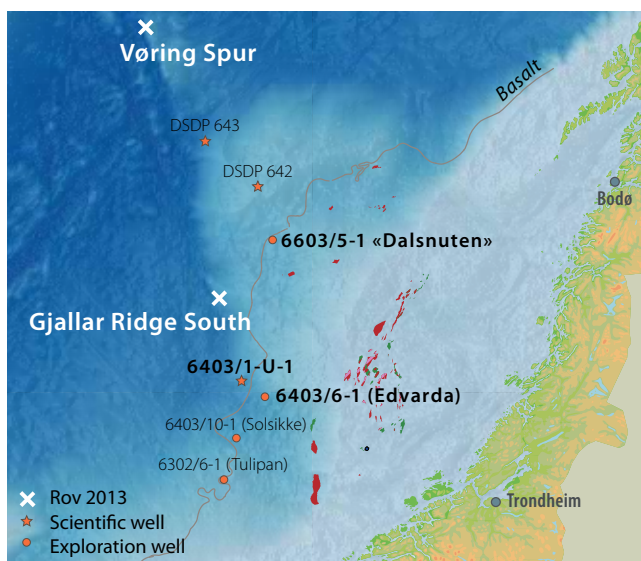


Figure 6.4 Areas explored by ROV in 2013.

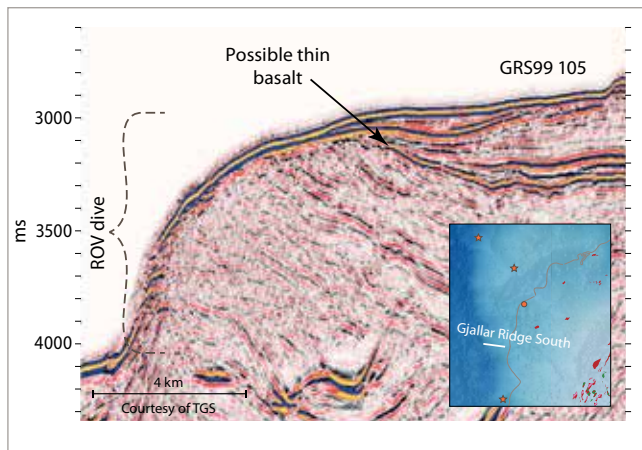


Figure 6.5 Seismic lines illustrating ROV dives on the southern extension of the Gjallar Ridge.

sediments. No sedimentary rocks older than Late Cretaceous were encountered, which accords with the results from the 6603/5-1 (Dalsnuten) exploration well.

Geological samples were also retrieved on the same expedition from the Vøring Spur (figures 6.4, 6.7 and 6.8). Upper Cretaceous volcanic rocks and fine-grained sediments were encountered here. Manganese deposits were also identified in this area.

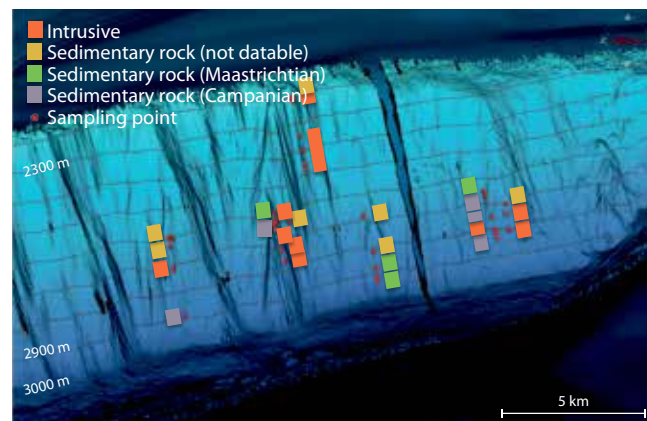


Figure 6.6 The Gjallar Ridge, with sampling points and 100-metre contours for water depth.

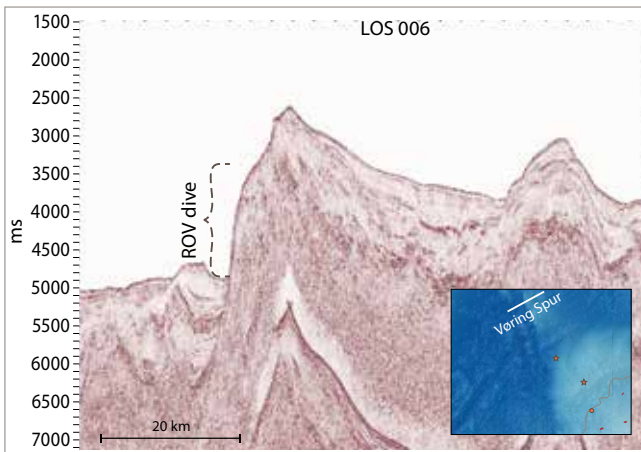


Figure 6.7 Seismic lines showing ROV dives on the Vøring Spur.

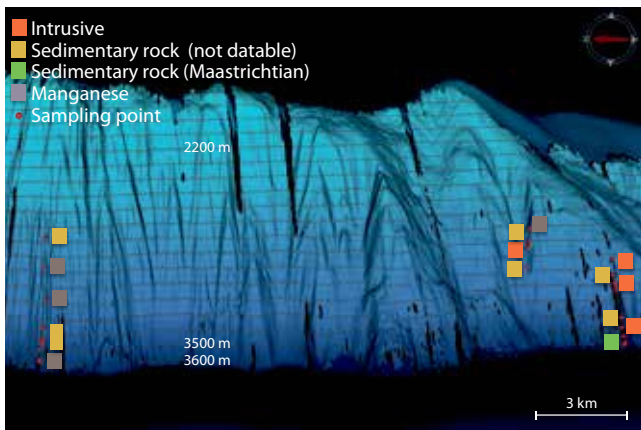


Figure 6.8 The Vøring Spur, with sampling points and 100-metre contours for water depth.

Shallow boreholes in the western Møre Basin

Few data have been acquired earlier in the western part of the Møre Basin. To increase understanding of the geology, shallow boreholes were drilled on the Møre Marginal High in 2014, 40 kilometres north-west of well 6403/6-1 (Edvarda) (figure 6.4).

The water depth in the area surveyed is about 2 100 metres, and drilling was limited to 200 metres beneath the seabed. The primary objective of the expedition was to recover cores from tilted reflectors deeper than 130 metres beneath the seabed in order to clarify whether these are sedimentary and/or volcanic rocks (figure 6.9). The results show that these tilted reflectors comprise volcanic rocks formed by rapid cooling of lava coming into contact with seawater. That provides important information on the geological development of this part of the Norwegian Sea. The drilling yielded no information about possible exploration targets beneath the basalt.

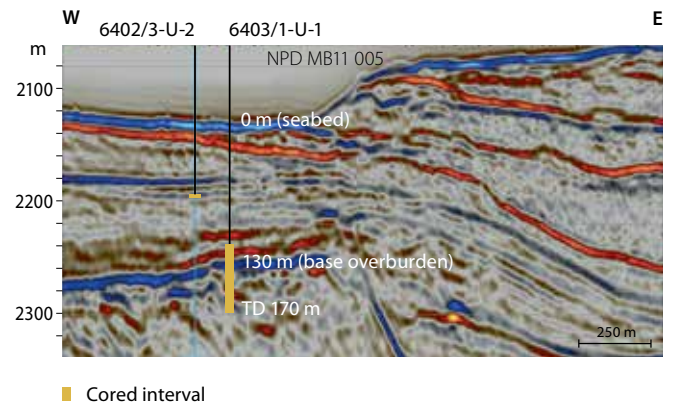
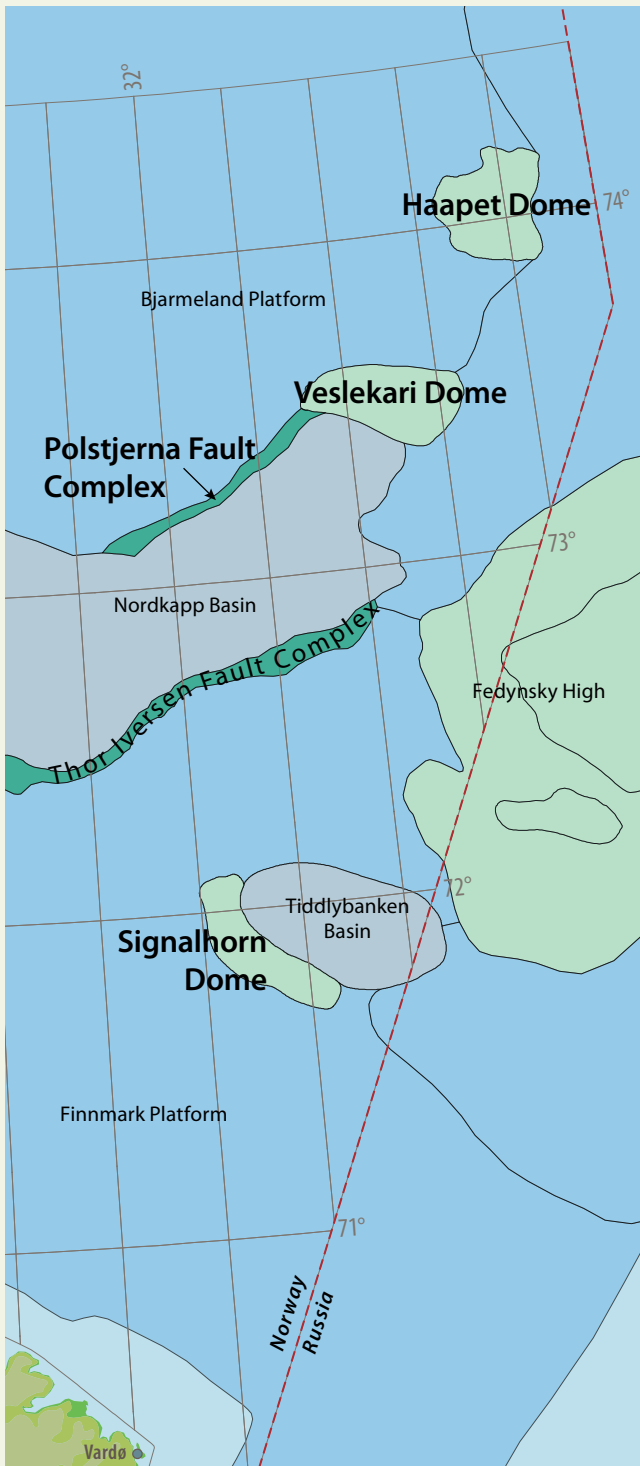


Figure 6.9 Seismic cross-section showing tilted reflectors from depths of 130 to 170 metres.



New structural elements in Barents Sea South-East

Mapping of Barents Sea South-East by the NPD has identified a number of large geological structures in this area. Four new structural elements have so far been defined and formally approved by the Norwegian Committee on Stratigraphy (Mattingsdal et al, 2015). These structures have been named after vessels used for research in Arctic waters.

Haapet Dome: *Haapet* was the sailing ship used by geologist Balthazar Mathias Keilhau for what has been described as the first proper scientific expedition to Svalbard in 1827. The structure is a large low-relief dome with a diameter of roughly 40 kilometres.

Veslekari Dome: *Veslekari*, built in 1918, was the third ultra-robust wooden ship built for Arctic conditions after *Fram* and *Maud*, and carried a number of scientific expeditions in high latitudes. The structure is a large elliptical dome, about 50 kilometres long by 25 wide.

Signalhorn Dome: *Signalhorn*, built in 1914, was an Arctic vessel used for both scientific expeditions in these waters and oil exploration around Svalbard. The structure is a large, oblong, low-relief dome, about 60 kilometres long by 15 wide.

Polstjerna Fault Complex: *Polstjerna*, built in 1949, was used in part for scientific expeditions around Svalbard and ranks today as Norway's best-preserved Arctic vessel. It is on display at Tromsø Museum. The structural element represents a fault zone separating the Bjarmeland Platform from the northernmost part of the North Cape Basin.

Reference:

Mattingsdal, R, Høy, T, Simonstad, E, and Brekke, H, 2015, An updated map of structural elements in the southern Barents Sea. Poster presented at the 31st Geological Winter Meeting, 12-14 January 2015, Stavanger.

Conversion tables

	1 scm of oil	= 1 scm oe
	1 scm of condensate	= 1 scm oe
	1 000 scm of gas	= 1 scm oe
	1 tonne of NGL	= 1.9 scm of NGL = 1.9 scm oe
Gas	1 cubic foot	1 000 British thermal unit (Btu)
	1 cubic metre	9 000 kcal
	1 cubic metre	35.3 cubic feet
Crude oil	1 scm	6.29 barrels
	1 scm	0.84 tonnes oe (toe)
	1 tonne	7.49 barrels
	1 barrel	159 litres
	1 barrel/day	48.8 tonnes/year
	1 barrel/day	58 scm /year

	MJ	kWh	TCE	TOE	Scm natural gas	Barrel crude oil
1 MJ, megajoule	1	0.278	0.0000341	0.0000236	0.0281	0.000176
1 kWh, kilowatt hour	3.60	1	0.000123	0.000085	0.0927	0.000635
1 TCE, tonne coal equivalent	29 300	8 140	1	0.69	825	5.18
1 TOE, tonne oil equivalent	42 300	11 788	1.44	1	1 190	7.49
1 scm natural gas	40.00	9.87	0.00121	0.00084	1	0.00629
1 barrel crude oil (159 litres)	5 650	1 569	0.193	0.134	159	1

See also the dictionary on the NPD website at <http://www.npd.no/en/About-us/Information-services/Dictionary/>



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