North Sea Divers

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www.wigestrand.no

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1st edition: © Wigestrand Forlag, Stavanger 2009
Nordsjødykkerne, ISBN 978-82-8140-082-5

Design: Asbjørn Jensen
Layout/typesetting: Yngve Knausgård
Type: Whitman/Akkurat/Soho
Paper: 130 g MultiArt Silk
Pre-press/graphic production: Norwegian Petroleum Museum and Sæby Fotosats
Printing: ???????????
Binding: ???????????

ISBN 978-82-8140-171-6

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Wigestrand

Source: Acergy

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Foreword to the English edition

This book, originally published in 2009, presents the history of diving in support of the oil industry on the Norwegian continental shelf. In Norway, the people who did this work have come to be known as the North Sea or pioneer divers. They played a key role in the development of the Norwegian oil industry during the first few decades after 1965, but their story has become a controversial one. The work they did has left many of them with injuries or health problems.

As explained in the forewords to the Norwegian edition, *North Sea divers in Norway* was commissioned by Norway's Storting (parliament). It was presented to the North Sea divers by Carl I Hagen, acting president of the Storting at the time, during a ceremony at the Norwegian Petroleum Museum on 22 June 2009. It was well received by the divers. But the "diver issue" remained unresolved.

The group of divers who had sued the Norwegian government for compensation lost in Norway's Supreme Court. However, they took their case to the European Court of Human Rights in Strasbourg and won on one point in a judgement issued on 5 December 2013. The government was found to have failed to take action over the health risks which it knew were present. Particular mention was made of the way the government, instead of insisting that the diving companies used safe standardised diving tables, permitted them to employ tables which demonstrably injured many divers. Both the counsel for the divers and the final judgement from the court referred to this book.

A number of people have subsequently commented that the judgement enshrines a very important principle, which could influence efforts to improve worker safety in other countries. The story presented here for the first time in English is accordingly even more relevant than was expected when it was decided to produce a translation.

Stavanger, 2014

Foreword

"The history of the divers was falsified" was the headline in Oslo tabloid *Dagbladet* in September 1999 when a pioneer diver said what he thought about the limited coverage of oil-related diving at the Norwegian Petroleum Museum. This new Stavanger institution was intended to embrace the whole story of Norway's oil adventure – but the divers felt they had been left out. The museum was also the scene of a political demonstration during its official opening on 20 May of the same year, when a pioneer diver went forward to HM King Harald to deliver documents on the diver issue. Within a short space of time, two specific incidents involving the new museum had thereby shown that the diver issue was rapidly gaining a place in the national consciousness.

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Against that backdrop, a constructive dialogue developed between the diver community and the museum about launching a documentation activity focused on oil-related diving. At the initiative of the divers, a meeting in the museum as early as the autumn of 1999 brought together more than 70 of the pioneers to record their experiences. That session inspired the museum to develop a historical project covering this part of the oil industry. In cooperation with other research and diving specialists, the museum formulated a preliminary project in 2000-2002 which described how the history of North Sea diving and the pioneer divers in Norway could be documented and communicated.

When the Storting (parliament) considered White Paper 47 (2002-2003) on conditions for pioneer divers in the North Sea, its standing committee on local government became aware of the museum's plans, which were then well advanced. The Storting resolved to appropriate funds for the museum to lead a documentation and communication project on North Sea diving and the pioneer divers (Recommendation no 137 to the Storting, 2003-2004). This work was to embrace both a history book and an exhibition at the museum to document the contribution made by the pioneer divers.

The museum has actively pursued the project on that basis since 2005. Historians Helge Ryggvik from the University of Oslo and Kristin Øye Gjerde from the Norwegian Petroleum Museum were commissioned to write the present book. They have interpreted the Storting's mandate to embrace a broad historical presentation of diving's role in the growth of Norway's new oil activity. This details the establishment of a new and unfamiliar industry with substantial challenges. Barriers had to be breached as a necessary condition for industrial progress. The pioneer divers did some of the toughest jobs. For many of them, the price proved very high.

The authors have maintained a continuous dialogue with a book committee comprising people with professional historical or diving expertise. They were:

Finn Erhard Johannessen, University of Oslo (chair)
Ole Andreas Engen, University of Stavanger
Bjørn Wilhelm Kahrs, diver education department, Bergen University College
Albert Johnsen, former diving manager in StatoilHydro and Mobil
Edgar Hovland, University of Bergen (until 2007).

In addition to this committee, a project board was established from the start with representative of the divers, the unions, the government, the oil companies and the diving contractors. This board was kept informed about the progress of the project, and its members provided support and opened doors along the way. They were:

Rolf Guttorm Engebretsen, North Sea Diver Alliance
Roald Wigen, North Sea Diver Alliance
Terje Johansen, Nopef/Industry Energy
Terje Nustad, Norwegian Union of Energy Workers (Safe)
Magne Ognedal, Petroleum Safety Authority Norway
Per Otto Selnes, Norwegian Oil Industry Association
Einar Wold Svendsen, StatoilHydro
Sjur M Lothe, Technip Norge
Finn E Krogh, Norwegian Petroleum Museum.

Leading this project has proved a big and challenging job for the museum because the history of oil-related diving is complex and has become controversial. I would like to thank the authors for their wholehearted commitment to the book over several years. Everyone who has been involved also deserves thanks for the constructive collaboration which has characterised this history project throughout. Finally, it is my hope that the divers themselves will recognise the story presented here.

Finn E Krogh, director/project manager

Authors' foreword

The media often use the expression "the judgement of history", and occasionally also "the judgement of historians". This book is neither of these. It is about North Sea divers and the work they have done on the Norwegian continental shelf (NCS) from 1966 until 2009. We also cover the many conditions which created the operating parameters for this work – the nature of diving assignments, the diving contractors, the development of new equipment and diving methods, experimental dives, medical research related to diving and the government's efforts to regulate the business. But the book has been written under circumstances which have forced us to be clear about the job of history as a subject and the historian's role. The "diver issue" which emerged in the Norwegian media in the late 1990s and continued to be pursued as a political question during the subsequent decade represented in many respects a process whereby society got to grips with the history of the North Sea divers. The Lossius commission of inquiry and the subsequent consideration of its report by the Storting (parliament) were intended to be a way of reaching a settlement with the past. Because many divers were dissatisfied with the proposed compensation scheme, however, the history of North Sea diving also moved into the courts. That created a very special and challenging framework for the project. The divers themselves, the authorities, the diving contractors, the oil companies, the specialists in hyperbaric medicine – all of them important sources for a historical presentation – were at times irreconcilably opposed to each other over an issue where everyone involved had their own interest in how the story was presented and interpreted.

No historian is uninfluenced by their own times. Like everyone else, we also have normative views and moral perceptions which could consciously or unconsciously influence the aspects we have emphasised. But a historical presentation differs from a political or legal process first and foremost because the focus is not on clarifying moral responsibility or guilt, but on outlining and summarising significant events and describing why they happened.

An important basis for this book is provided by a wealth of written sources. The Lossius commission, the divers themselves and their helpers, and civil servants have scoured available archives. We have not had the capacity to delve much more deeply than that. We do not exclude the possibility that written sources could emerge in the future which may cast new light on the history of North Sea diving on the NCS. Nevertheless, it is our belief that the basis for our account builds on more extensive records than a great many other historical works.

The biggest challenge where sources are concerned has been how we should deal with the oral ones. We have conducted a large number of interviews. Under an earlier agreement, we have also had access to the interviews conducted in connection with the writing of Else M Tungland's book *På dypt vann – pionérdykkerne i Nordsjøen* (In deep water – the pioneer divers in the North Sea).

We have also made direct and indirect use of oral sources in the sense that we were present when witnesses gave evidence in the various legal cases or have drawn on recordings of these depositions.

As in similar pioneering groups, a number of stories have been told and retold so many times among the divers that they have become “true” in the sense that it is difficult at a later time to distinguish between what has been personally experienced or simply heard about. We have naturally been conscious of such considerations. In many cases, at least part of the truth about such stories can be confirmed by written sources. In other cases, they can be confirmed by several independent accounts. It seems that the divers are generally very good at remembering details about how they personally experienced incidents under water. On the other hand, it can be difficult for those who experienced an incident to date it exactly and to recall on which rig, platform or diving support ship it occurred. For us as historians, however, even undocumented legends or myths can have a value. This is because they are in themselves part of the conceptual world of the divers, something in which they believe. Moreover, such tales are often re-told and acquire a life of their own because other divers recognise their own circumstances in them.

We have divided the work on this book as follows. The introductory chapter has been written in collaboration by both of us. Chapters 2, 5, 7, 9 and 11 are written by Gjerde, while Ryggvik has written chapters 3, 4, 6, 8 and 19. Chapters 12 and 13 have largely been written by Ryggvik with contributions from Gjerde.

We would thank the book committee, chaired by Finn Erhard Johannessen and with Ole Andreas Engen, Bjørn Wilhelm Kahrs, Albert Johnsen and Edgar Hovland as members, for the work it has done in following the project over four years. Comprising both historical and diving expertise, the committee has given us valuable input at a number of levels. We would also thank Trude Meland for the job she has done in receiving and recording large volumes of archival materials and diver photographs, and in making provision for illustrating the book. Thanks are also due to the director of the Norwegian Petroleum Museum, who has led the project in an open and orderly fashion. Finally, we would express great thanks to all the divers who have contributed by telling their stories, by answering our questions or supplying documents or photographs. Their help has been crucial in allowing us to present the history of North Sea divers in Norway.

Finally, we would like to thank Rolf E Gooderham for his highly competent translation to English.

Stavanger/Oslo

Kristin Øye Gjerde
Helge Ryggvik

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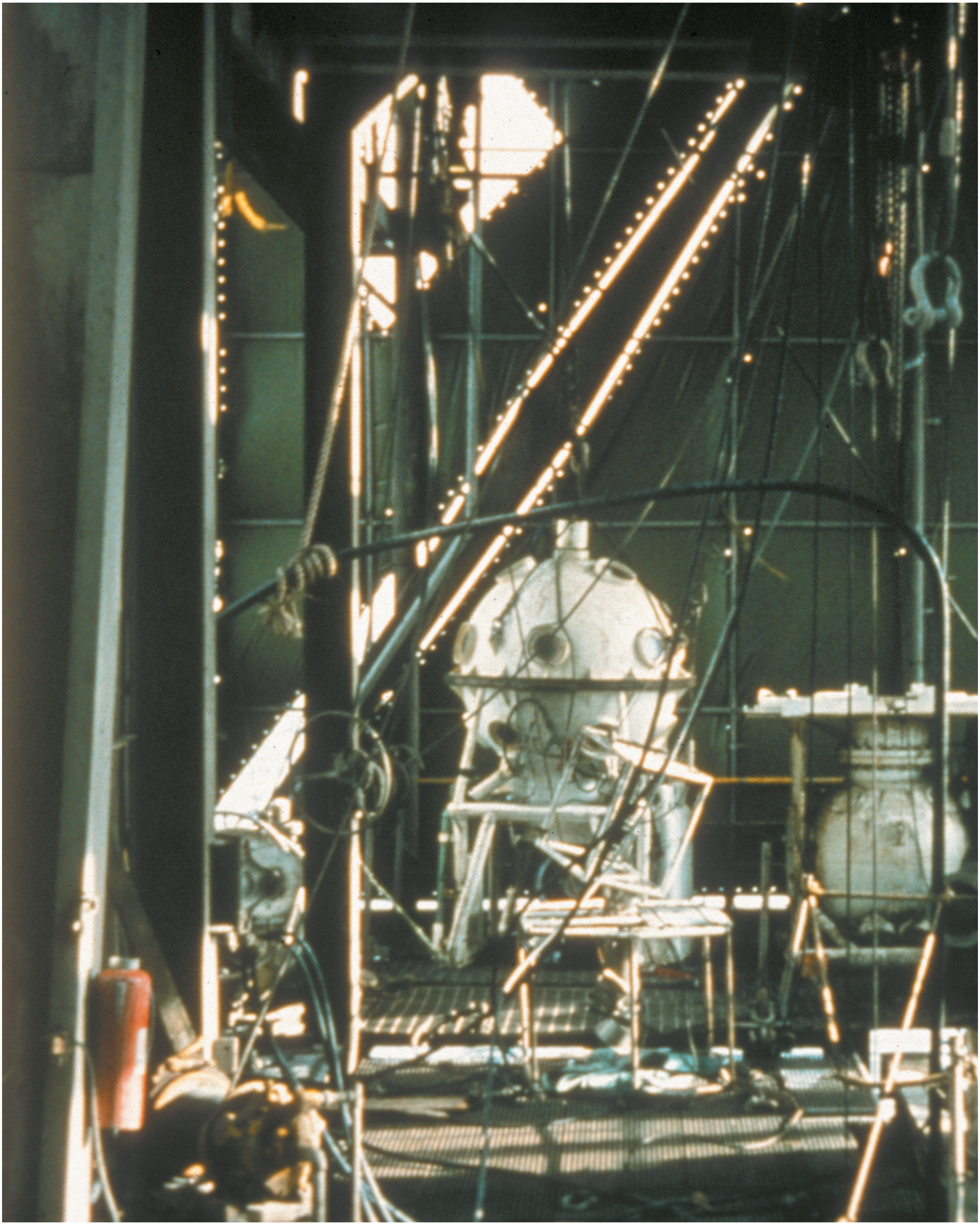

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Chapter 1

Diving and oil exploration

Johannes Straumøy woke up one morning in the autumn of 1969 and wondered why such an unnatural silence prevailed on the *Ocean Viking* drilling rig, where he was working as a diver. Drilling and mud pumps normally created an infernal row when an exploration well was under way. Not a sound was now to be heard and, when Straumøy came up on deck, the odour of oil assailed his nostrils. Buckets full of crude stood all over the deck, collected by the crew from the sandshaker before drilling ceased.[1] Along with the other divers, Straumøy had been down in about 70 metres of water to check that everything was progressing as it should in casting a foundation for the bit on the seabed. Then they had simply waited while the drillers did their part of the job. The sub-surface beneath the rig proved to contain a lot of oil. Together with the rest of *Ocean Viking*'s crew, Straumøy was involved in making the first commercial discovery in the Norwegian sector of the North Sea, in block 2/4 – the field which was later given the name Ekofisk.

Drilling on the NCS had begun on 19 July 1966 from the *Ocean Traveler* rig. Its sister vessel, *Ocean Viking*, started work in these waters in the summer of 1967. These two rigs, operated by American drilling contractor Odeco, were responsible for the bulk of the exploration wells on the NCS until Ekofisk was found. Odeco had a series of contracts with the various oil companies which had received interests and operatorships in the first two licensing rounds. The drillers were the largest occupational category on the rigs. In addition came the people needed to operate the actual vessel – a radio operator, a nurse, catering personnel and so forth. But a rig could not start to drill or abandon a well without divers.

Diving spread on *Ocean Viking*, with the drill string in the foreground. The Comex diving bell and deck decompression chamber (DDC) were installed on the cellar deck immediately below the derrick.
Photo: Sigurd-Tore Anda

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UNDERVANNSBÅTINSPEKSJONEN

DIPLOM

JOHANNES EMIL STRAUMÖY

HAR GJENNOMGÅTT FROSKEMANNSKURS

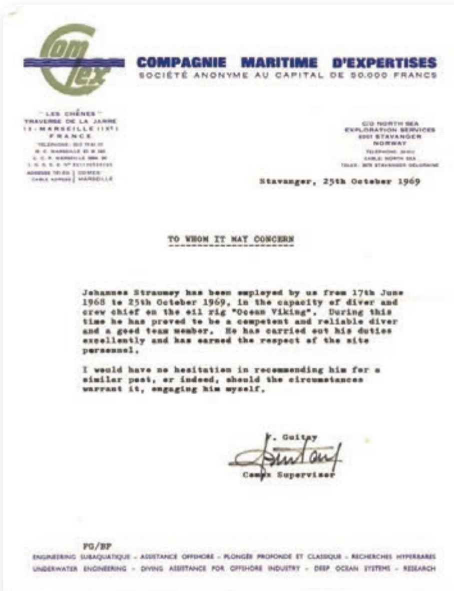
VED SJÖFORSVARETS DYKKER-OG FROSKEMANNSKOLE

HOVEDKARAKTER TILFREDSSTILLENDE

UNDERVANNSBÅTINSPEKSJONEN, den 27/9-66

U.V.B.INSPEKTØR

Johannes Straumøy's diploma from the Norwegian navy.



COMPAGNIE MARITIME D'EXPERTISES

SOCIÉTÉ ANONYME AU CAPITAL DE 50.000 FRANCS

"LES CHÊNES"
TRAVERSE DE LA JARRE
13 - MARSEILLE (IX^e)
FRANCE

C/O NORTH SEA
EXPLORATION SERVICES
4001 STAVANGER
NORWAY

Stavanger, 25th October 1969

TO WHOM IT MAY CONCERN

Johannes Straumoy has been employed by us from 17th June 1968 to 25th October 1969, in the capacity of diver and crew chief on the oil rig "Ocean Viking". During this time he has proved to be a competent and reliable diver and a good team member. He has carried out his duties excellently and has earned the respect of the site personnel.

I would have no hesitation in recommending him for a similer post, or indeed, should the circumstances warrant it, engaging him myself.

F. Guitay
Camp Supervisor

FG/BF

ENGINEERING SUBAQUATIQUE - ASSISTANCE OFFSHORE - PLONGÉE PROFONDE ET CLASSIQUE - RECHERCHES HYPERBARES
UNDERWATER ENGINEERING - DIVING ASSISTANCE FOR OFFSHORE INDUSTRY - DEEP OCEAN SYSTEMS - RESEARCH

Straumøy's reference from his diving job on *Ocean Viking*.

Located in the south-western corner of the NCS, block 2/4 also represented the shallowest part of the extensive area in which oil exploration was initially planned. But drilling for oil in roughly 70 metres of water in the middle of one of the world's roughest seas nevertheless helped to breach barriers for the technologically possible. The same applied to the diving carried out from *Ocean Traveler* and *Ocean Viking*. Only a few years earlier, it had been considered impossible for people to work for any length of time in more than 50 metres of water – the depth where the nitrogen in the air turns into a toxic gas. In association with military research institutes, and with the oil industry as the most important source of demand, a new and small – but rapidly expanding – diving industry was in the process of making major technological leaps into uncharted depths.

Straumøy had learned to dive in the Norwegian navy, and worked as a construction diver for Falken og Høvding Skipsopphugging before becoming involved in offshore oil. He accordingly represented the foremost diving expertise available in Norway at the time. In the North Sea, he was required not only to dive under extremely difficult weather conditions but also to use wholly unfamiliar equipment and entirely new diving methods.

We will take a closer look at diving on the NCS in this first phase, from the start of exploration in the summer of 1966 until the Ekofisk discovery in 1969. What diving technologies were available, and which methods were normally used? What jobs did the divers do during exploration drilling? Even though international firms dominated the diving industry, the first Norwegian offshore diving company was established in this period and served as a "spearhead" into the international community.

A dive in the pioneering period

Diving from *Ocean Traveler* was conducted by US contractor Ocean Systems. The first contract on *Ocean Viking* went to Sanford Brothers, also American. However, France's Comex – Straumøy's employer – took over in 1968. The diving team on *Ocean Viking* comprised four people, with Straumøy as the only Norwegian. One was the diving supervisor. During a normal dive, two men were in the bell. The third team member operated the winch, while the diving supervisor's jobs included maintaining radio contact and calculating how long the divers could be in the water and in decompression. Rigs at that time were small by today's standards, and not particularly stable in high seas. A critical moment in each diving operation was getting the bell safely through the moonpool [opening] in the deck. As soon as the bell with its ballast

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weight had been lifted from the deck by the winch, it began to sway because of the seaway. The trick was to manoeuvre the bell quickly before its motion became too extreme. Inside the bell, the divers were wearing diving suits and breathing apparatus. Once the bell was below the cellar deck, the winch operator had to climb down onto a platform beneath the deck and attach two cables from the bell to the guide wire which ran from the cellar deck to the seabed template holding the blowout preventer (BOP). This could be pretty tricky when the bell was swinging in rough weather.

All these operations had to be done as quickly as possible to get the bell into the sea in order to reduce its sideways motion. Entering the water was another critical moment. In high seas, the hoisting cables could jerk pretty sharply. Everything calmed down once the bell was submerged. It was lowered within a few minutes to 70-100 metres, the normal depth in the initial exploration phase. The bell usually halted a little above the seabed until everything was ready to pressurise it. When that happened, the internal temperature as well as the pressure rose abruptly. The divers could feel dizzy from the sudden change in

***Ocean Viking* had two pontoons parallel to its direction of travel, which each supported four columns carrying the main deck (topside) with drilling derrick, quarters and engine room. Photo: Anders Waale**

pressure, but the one who was going into the water merely had to descend and wait until the bottom hatch could be opened before donning his breathing mask and exiting into the cold, dark water while the other diver remained in the bell. The work usually involved repairs or collecting mud samples around the wellhead after the casing in the well had been cemented. Dives lasted a maximum of 45 minutes, since the time divers could spend in the cold water was limited. They used unheated suits. Although these were porous under atmospheric pressure, they were squeezed thin at the working depth and provided little insulation. At depths below 50 metres, the divers breathed a mixture of helium and oxygen (*heliox*). That made them even colder, since helium dissipates body heat faster than ordinary air. The diver in the water quickly lost feeling and sense of touch in fingers and hands. After his work excursion, he was recovered to the bell stiff with cold. Coming up for decompression could feel good.[2]

The US Navy – a pioneer in diving technology

The method described above by Straumøy, later usually called *bounce diving*, was originally developed for use by the US Navy. Until the end of the 1950s, naval forces played a key role in developing diving technology in a number of coast states – including Norway and Denmark-Norway before 1814.

As early as the 16th century, special diving privileges were awarded by the Dano-Norwegian monarchy with possible profits split between the Crown and the diver.[3] In 1673, diver Jacob Vinskænk reportedly recovered 500 sheets of copper from a ship belonging to treasurer Müller which had been wrecked en route to Hamburg. The copper came from Røros in Norway, and Vinskænk demanded 3 500 riksdaler for the bell-diving job. Diving bells at the time looked like a big wooden bucket sheathed in lead and upended. It was kept submerged by ballast. The bell provided space for the diver and enough air to remain there for a while. Additional air could be provided from barrels. Documents from 1781 show that two divers received pay in Trondheim during salvage work on *Perlen*, a ship which sank off Ladehammeren in the Trondheim Fjord.[4]

Men were specially trained by the navies of several countries in the 19th century to conduct operations under water, based on traditional *free diving*. This is the term applied to the simplest form of diving, where the divers had trained their lungs so that they could remain under water for fairly long periods. The same technique was used by Mediterranean pearl and sponge divers from antiquity.

Clad in helmet diving suits, Arne Jentoft (left) and Leif-Tore Skjerven take a break on their diving assignment off the west African coast. Photo: Arne Jentoft

Diving experienced a technological breakthrough in the early 19th century with the introduction of helmeted suits for divers which were supplied with air from the surface. The Norwegian navy acquired such *helmet diving* equipment as early as the late 1840s.[5] The first "modern" Siebe type of helmet diving gear was introduced to Norway in 1856. The helmet was fitted with valves which allowed the diver to control both inflow and outflow of breathing air. At depths corresponding to those found in most harbour basins, divers could remain on the seabed for very considerable periods. At the same time, they could move around under their own steam. Such equipment ruled the roost in all underwater salvage and construction work for the following hundred years.[6]

The next technological leap forward for diving occurred in the USA because of a number of tragic submarine sinkings in the 1920s, where whole crews died. These accidents prompted a greater commitment to developing military diving expertise in the USA and the creation of emergency systems which would hopefully allow submarine crews to escape to the surface. The development of new technology for diving in deeper water was part of these contingency efforts. To meet the need for better services in this area, the US Navy School of Diving and Salvage

(NSDS) was established at the Navy Yard in Washington DC in 1927. At the same time, the US Navy Experimental Diving Unit (NEDU) was moved from Pittsburgh to the same area. Test dives with heliox were also transferred there, and the first simulated deep dive with people breathing heliox in a decompression chamber was carried out at the DC Navy Yard. Helmet divers had discovered by then that diving with ordinary air in more than 50 metres was hazardous. We know today that this is due to the nitrogen in the air, which causes narcosis – a dangerous form of intoxication. The US Navy experimented by replacing the nitrogen with helium. This was not an illogical move, since helium is a very light gas. That confers a benefit under high pressure because it makes breathing easier. Nor had helium been found to be toxic. Heliox was tested on animals before human trials began. These experiments clearly revealed that the mix had many advantages compared with air as a breathing gas for dives deeper than 50 metres. The divers avoided nitrogen narcosis and were more concentrated and clear-thinking during such deep dives, but also felt the cold more because helium conducts heat better than nitrogen. The human voice also changed – a phenomenon now known as the "Donald Duck" effect.

Decompression chambers were another innovation which was to become highly significant. The navy conducted a number of trial dives in such chambers with various types of gas mixtures. Between September 1937 and May 1939, the NEDU carried out almost 700 such experiments in a wet tank. The deepest of these went down to 150 metres. This new technology revealed its significance when the USS *Squalus* submarine sank under dramatic circumstances in a depth of 74 metres off Portsmouth, New Hampshire, in 1939. Twenty-six of the 59 crew drowned when the three rear sections in which they had been isolated filled with water. But no water entered the two forward sections, where 32 crew remained. A rescue chamber was connected to the submarine, and all the survivors were rescued in four stages. No less than 53 divers took part in this extensive operation and the later salvaging of the vessel. They performed a total of 628 dives. Heliox was used for 255 of these in depths from 67 to 74 metres. The remainder were conducted as air dives. Two cases of *decompression sickness*, also known as the bends, were reported.[7] This condition is caused because gas dissolved in the blood accumulates as bubbles, either in the circulatory system or in tissue, when the return to atmospheric pressure occurs too quickly.

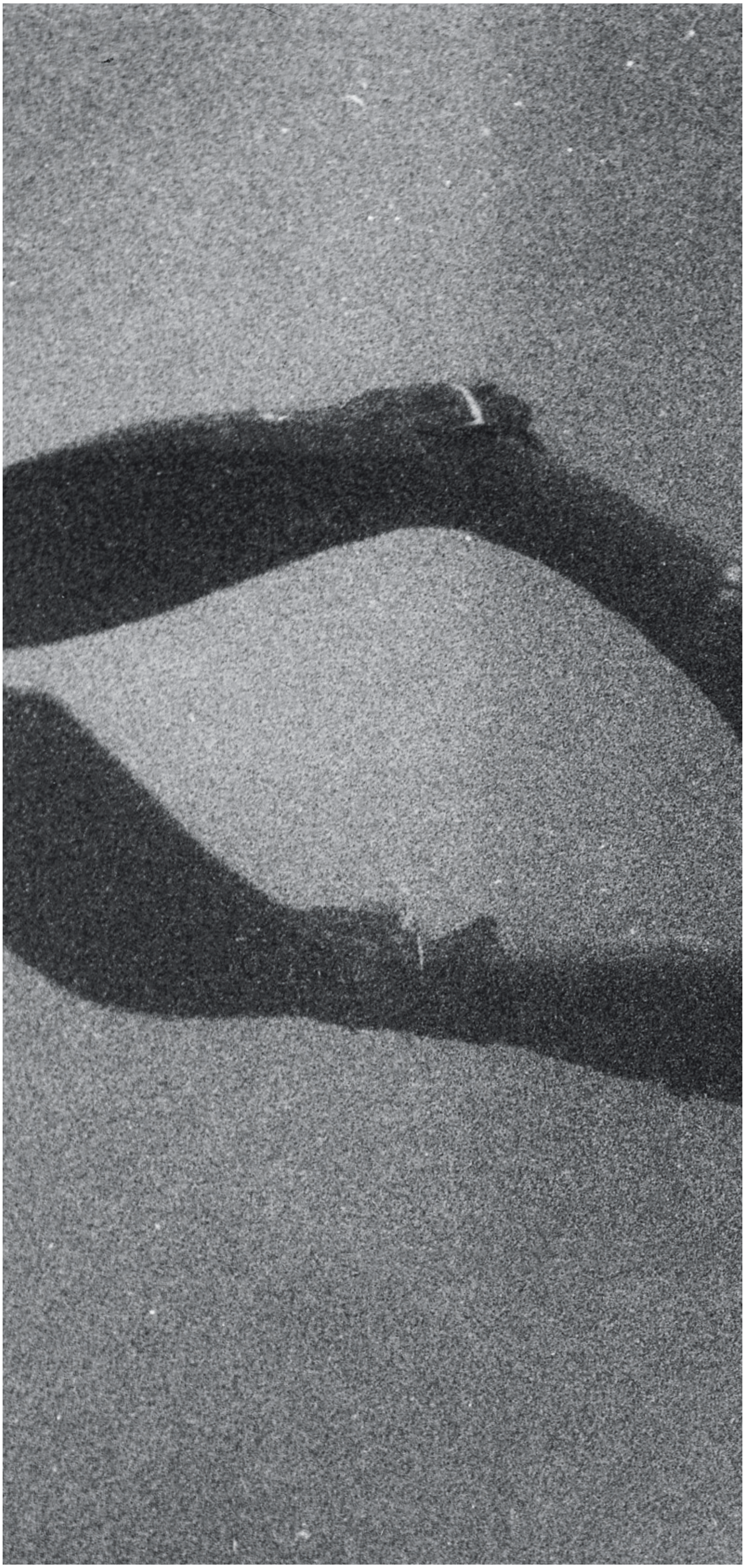
Another area of research involved experiments with various technical solutions for equipping divers with compressed air in cylinders. The breakthrough here occurred immediately after the Second World War with the development of *scuba* (self-contained underwater breathing apparatus) gear, which was bought by the US Navy from 1947 as part of its standard equipment. Although the use of compressed air was not in itself a technological advance (it was more a question of finding a suitable sealed and pressure-resistant cylinder design and a functional valve system), this invention would revolutionise military, commercial and recreational diving. Once compressed air could be stored in cylinders, it was a short step to developing similar equipment for other gas mixtures intended for deeper water.

With the opportunities for deeper and longer dives which the new technology provided, establishing good safety procedures for *decompression* became a matter of urgency. Breathing for long periods in deep water increases the volume of gas dissolved in the body. The only way to compensate for this was decompression – a gradual return to atmospheric pressure which allowed divers to expel excess gases through their lungs. Experiments at the NEDU formed the basis for revised *decompression tables* published by the US Navy in 1937, superseding an earlier set from its British counterpart. These new tables introduced *surface decompression*. Divers first carried out compression stops in the sea at every third metre in accordance with the table. The diver received 100 per cent oxygen in his helmet for the two final stops, at 18 and 15 metres. He was then taken quickly to the surface and placed in a decompression chamber under a pressure corresponding to 15 metres in the water, where the rest of the decompression occurred.

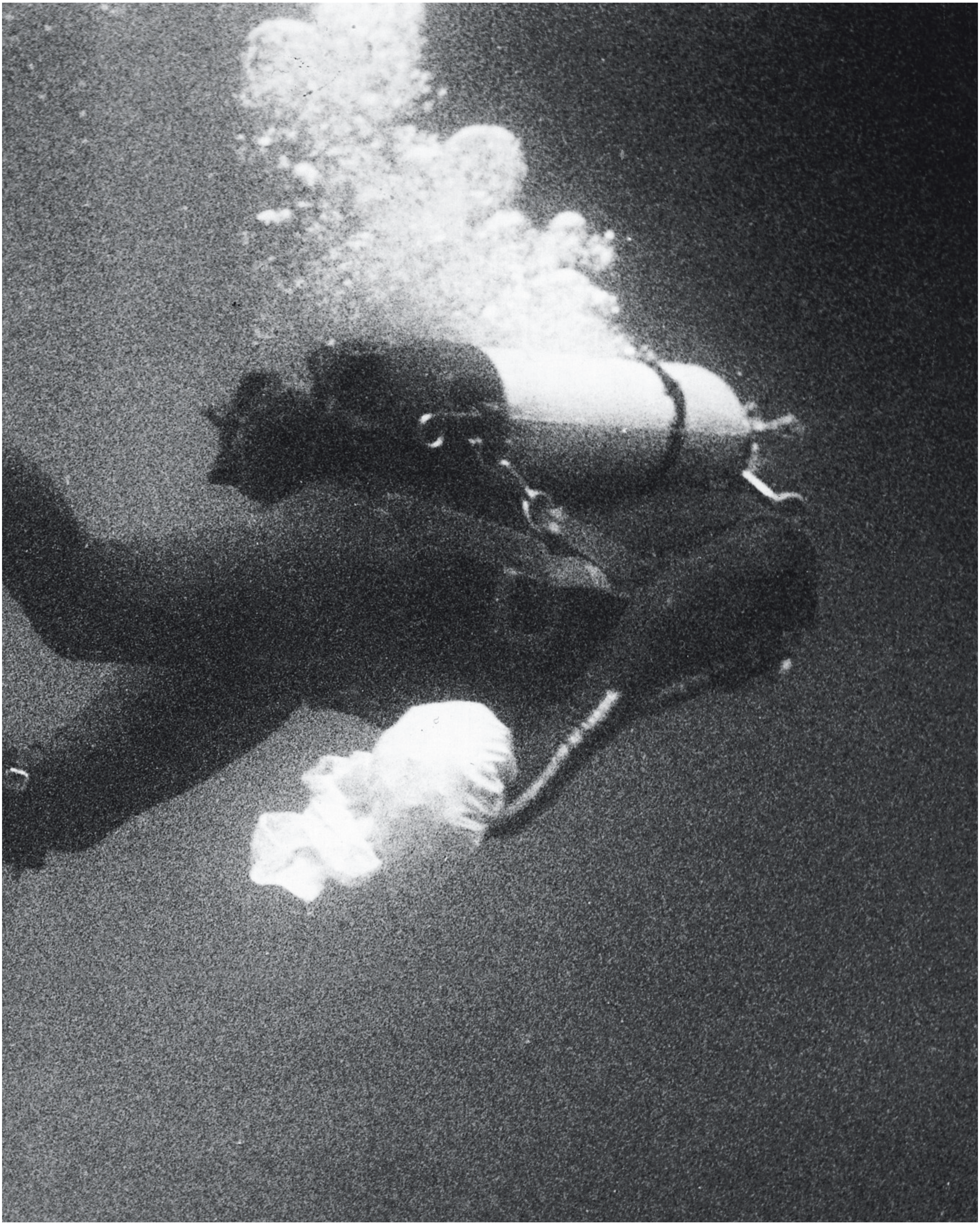
The US Navy's decompression tables were intended for emergency use in rescuing crew from sunken submarines. These could escape by donning diving suits and controlling decompression in line with the tables. A new version based on additional research was issued in 1950, with the depth of the decompression stops where the diver received 100 per cent oxygen changed to 15 and 12 metres. A corresponding adjustment to 12 metres was also made to the pressure in the deck decompression chamber (DDC).[8]

In cooperation with a number of American universities, the US Navy launched an extensive research programme to establish the limits of human ability to cope with high pressure. Large-scale experiments were conducted at North Carolina's Duke University and others. A number of decompression chambers were installed next to each other. The human guinea pigs were subjected to pressure over such a long period and at such a depth that they became vulnerable to the bends during decompression. In mild cases, the gas bubbles dissolved in the blood can cause itching and pain in joints. People suffering more serious episodes can become crippled, lose consciousness and in the worst case die. When a test subject felt ill, he was recompressed and treated for the bends. More than a thousand people took part in these trials.

The US Navy's diving tables were soon adopted for commercial diving. In the 1950s, the laying of huge sewer pipes from the largest US and European cities played a key role in extending depth limits for



Early offshore diving on the UK continental shelf (UKCS). This is scuba diving, with the diver carrying breathing-gas cylinders on his back. Such self-contained diving was used in depths down to 50 metres.
Photo: Mike Lally



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working under water. A discharge pipe from Los Angeles was laid nine kilometres from land in 65 metres of water during 1958. Designed for an operational life of 100 years, it was installed by helmet divers. They breathed air – in other words, operated right at the limits of what was acceptable – and used the new diving tables when returning to the surface. The use of gas mixtures was still at the experimental stage at this time.

Britain's Royal Navy also researched the limits for deep diving. One experiment was carried out in Norway in 1956, when UK naval diver George Wookey set a world record by descending to 183 metres with helmet diving equipment and heliox off Garnes in the Oster Fjord north-east of Bergen. Although Wookey had to be treated for the bends afterwards, the result was described as positive. Norwegian fjords were very suitable for such trials because they are both deep and sheltered from wind and high seas.[9] These experiments eventually became significant for commercial diving in the oil industry. When the latter expanded offshore, it depended on diver assistance from the start.

Initial offshore diving on the NCS

When the first exploration licences were offered off the coast of Louisiana in 1945, no recognised methods existing for drilling under water. The first trials were conducted from a fixed drilling rig in six metres of water in 1947, and proved a success. Kerr McGee, as the drilling company was called, discovered oil after only a few weeks and documented that crude could be recovered from beneath the seabed. This commitment marked the start of a completely new industry – contractors specialising in offshore drilling.

A huge gas field was found in 1959 at Groningen in the Netherlands. This discovery had an interesting geological structure which extended out to sea. That was the direct reason why a number of the world's oil companies began to show an interest in the North Sea. Shell, Esso and Phillips Petroleum initiated seismic surveys in the Norwegian sector as early as 1962. Their findings indicated that further oil exploration would be worthwhile. Esso and Shell began drilling off the Netherlands in 1962, and the first drilling season on the UK continental shelf (UKCS) started in 1964. Since the initial wells in these waters were limited to depths down to 30 metres, the necessary diver assistance could be provided by *surface-oriented (air) diving* with ordinary air.

Those involved with the initial exploration activities in the North Sea basin felt that the Americans were far out in front. But their experience did not go back that far, after all, and the whole business seems in a longer historical perspective more like collective parallel progress.

By and large the same companies, often even the same personnel, operated everywhere using the same groundbreaking processes. The new diving techniques and the depths in which they were applied were still at the research and experimental stages. The US and British navies had devoted much of their limited resources to research on physiological problems related to deep diving. This role was taken over by the commercial diving contractors from around 1970.[10]

During the mid-1960s, the deepest dives were conducted off California. According to a local newspaper, an American record was set when divers from a diving contractor worked three 30-minute stints at 117 metres on an oil repair job in the Santa Barbara Channel in 1966.[11] The report noted that this success was down to "the new popular oxy-helium method, which was developed commercially by local diving firms". The company responsible for this operation was Ocean Systems. At the same time as it was setting records for commercial deep diving off California, the company was winning contracts which could lead to even deeper dives on the NCS.

The extensive awards of blocks in the Norway's first and second offshore licensing rounds, in 1965 and 1968 respectively, committed the oil companies to pursue drilling programmes in water depths ranging from about 50 metres to 130 metres. This was beyond the physical limit for diving with ordinary air. In addition to exceeding the 50-metre boundary, which called for heliox to be breathed, divers would be required to work considerably further out to sea than before. Moreover, weather conditions in the North Sea were far more demanding than in the Gulf of Mexico or off California. High waves made big demands on the equipment. The biggest challenge was nevertheless the cold water in the North Sea, where an average year-round temperature of 5-7°C placed clear restrictions on how long the divers could decompress in the water.

Diving methods and equipment

Both Ocean Systems and Comex had experience from the UKCS when they started work in the Norwegian sector. A substantial share of the work in British waters during the first drilling season had been traditional surface-oriented diving, where the diver breathed ordinary air either from a cylinder or a hose (umbilical) from the surface. That was because drilling operations until then had seldom occurred in depths beyond 50 metres. The divers could enter the water either from small boats or by being lowered from a drilling rig. After the work had been completed, involving a maximum time of 40-50 minutes on the seabed, the divers made a slow ascent in order to equalise the pressure in their

bodies. They halted frequently at predetermined intervals on the way up. This part of the decompression process could take an hour. When the diver reached 12 metres, he ascended rapidly to the surface, was hoisted onto the deck and helped to remove his diving suit and other equipment before entering the pressure chamber for further decompression. This had to happen within five minutes of leaving the 12-metre depth in order to avoid the bends. The procedure was described in diving tables. When the waves were high and the DDC was on a rig more than 15 metres above the sea surface, it could be difficult to reach the chamber within a few minutes. During decompression, the diver breathed pure oxygen for 20-minute periods separated by five-minute breaks until he was back at atmospheric pressure.

The least labour-intensive form of diving involved the diver swimming around freely, without being supplied with air from the surface and guided only by a signal line. All that was then needed on the surface was a diving supervisor and a standby diver ready to descend at short notice if anything unexpected occurred. This duo was often supplemented by an assistant who acted as the signaller and was responsible for maintaining the diving equipment.

Helmet diving, common for construction jobs close to land, was also used in the North Sea for work on the seabed or on fixed installations below water. The diver then wore a copper helmet and whole-body suit, with an air hose and a communication link to the diving supervisor. Either air or a gas mixture were also used for helmet diving. The decompression procedure was the same as with other forms of surface-oriented diving, with halts below water and the final stage in a DDC. While the helmet and suit could be rather heavy out of the water, its weight was neutralised by its volume once submerged. It did not take much experience before the diver's freedom of movement was comparable with most other types of equipment, apart from free swimming. The biggest disadvantage of helmet diving, as for other surface-oriented diving methods, was that the standby diver stayed on the surface. A long time passed before he was able to provide possible assistance.

Both *Ocean Traveler* and *Ocean Viking* carried DDCs. These were designed so that a bell could lock onto them, which made it possible to use bounce diving. The divers were lowered to the relevant working depth in the bell under normal atmospheric pressure. The internal pressure was then raised in the course of a few minutes to the ambient level. This meant that the body was rapidly subjected to several considerable physical loads. First, both pressure and temperature rose rapidly as the bell was pressurised. Second, the diver had to adjust to breathing a heliox mixture instead of ordinary air if the descent went below 50 metres. Then came the temperature shock as he entered the water at 5-7°C close to the seabed. There were always two men in the bell, with the

A diver is got ready for a surface-oriented dive.
Photo: Børre Børretzen

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second – known as the bellman – functioning both as an assistant and as a standby in case anything went wrong with the diver in the water.

The Comex diving system (spread) on *Ocean Viking* involved the diver being supplied with breathing gas from cylinders mounted on the outside of the bell. Nothing came from the surface, and all regulation of the breathing gas was done from a panel inside the bell.[12] The bell was provided with electricity and a radio link to the surface via the hoisting cable and winch, incorporating a cable to the control room. It had no heating. Nor was there any radio communication between the diver outside and the bell or the surface control room. All communication between diver and bellman was based on hand signals, tugs on the hose and so forth. When visibility was good, the bellman had visual contact with the diver through a few small portholes in the bell. The floodlight on the outside of the bell illuminated the worksite well if the water was clear, but often had to be switched off because it worsened visibility when the water was murky. The diver also carried his own torch. Although bounce diving was under better control than normal surface-oriented diving, the amount of time which could be spent working on the seabed was limited. That could prompt a hurried job in order to get as much done as possible.

In the late 1960s and early 1970s, divers wore a tight-fitting rubber *drysuit*. Norwegians generally used the "Viking" suit made in Stavanger, but other types were also worn. British divers opted for a drysuit from Dunlop. From 1970, the Swedish-made Unisuit was also in use. Intended to keep the diver dry inside, the suit was worn over suitable tight-fitting warm clothes. The "teddy-bear" underwear made by Norway's Helly Hansen comprised woolly long-johns and a long-sleeved jumper specially designed for wearing under drysuits. But the divers were still unable to keep particularly warm. The drysuits often leaked, and it then certainly got cold. In addition, the suit became heavy when the diver was pulling himself back into the bell.

An alternative was the *wetsuit*. This was manufactured in neoprene, a porous material with nitrogen-filled pores and good insulating properties. The diver was wetted by the water which penetrated the suit, but kept warm because the temperature of the water between skin and suit was raised by the diver's own body heat. This system functioned best close to the surface, when the wetsuit was six-eight millimetres thick. It was less suitable at working depths below 50 metres, where its thickness was reduced to one-two millimetres and the insulating effect lowered accordingly. With the ambient water temperature not much above 5°C, the diver felt the cold. The chill factor was increased by breathing gas mixtures containing helium. Divers report that they continued to feel cold even after returning to the bell. On the other hand, they describe what a relief it was to feel the warmth flow through them

Jan-Egil Pettersen wearing woollen "teddy-bear" undergarments and his mother's knitted socks while breathing oxygen in the decompression chamber. A diver under decompression breathed pure oxygen for 20 minutes at a time, separated by five-minute breaks, until reaching atmospheric pressure.
Photo: Jan-Egil Pettersen

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Per Birkeland in a Viking drysuit on *Ocean Viking* in 1971.
Photo: Magne Vågslid

The Viking suit

Lieutenant Ove Lund of the Norwegian navy contacted Vestlandske Gummivarefabrikk in Stavanger during 1953 to ask if the factory could extend its rubber boots into a full suit for use by naval frogmen. That marked the start of the Norwegian Viking drysuit. During production, a number of substances with varying properties are added to the raw rubber. The resulting material is coated with a textile to form the inside of the finished suit, cut to pattern and sewed together. All the seams are finally covered with an external rubber strip. After being draped on a mannequin of the appropriate size, the suits are placed in an oven or autoclave to be vulcanised and shrunk to fit the mannequin. Vulcanisation makes the rubber elastic and all suit components melt together to form a sealed garment. Each suit is fitted with a hose and valve to control the entry and exit of air. Cuffs, collar seal and hood are then added, and all the suits get pressure tested when complete. Any holes are as easy to repair as a bicycle tyre. The suit is durable and remains in good shape for 20 years if treated well.

as the gas in the bell was replaced by air during decompression. That represented the biggest advantage of bounce diving compared with the surface-oriented and helmet techniques.

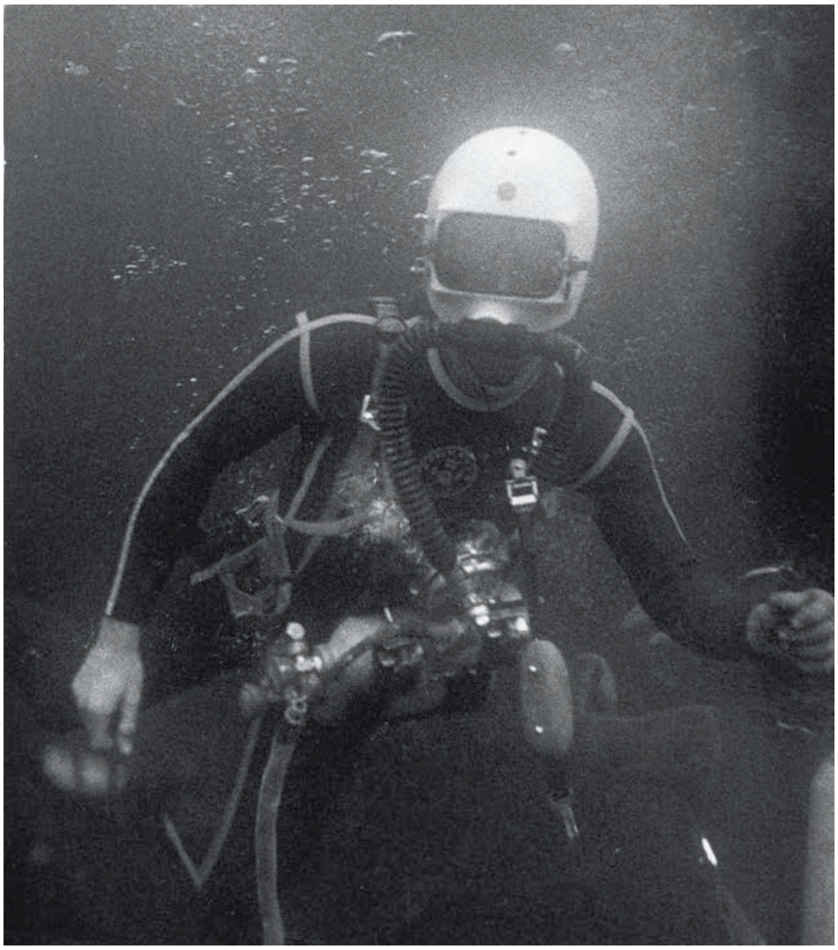
Bounce diving from a bell was safer than surface-oriented diving with air. The disadvantages were that it demanded far more personnel, was more time consuming and was thereby more expensive. Unless the diving spread incorporated several DDCs, work could not continue before one group of divers had completed decompression – a process which took many hours. The time required depended on how deep the diver had gone. Without effective regulation of what was acceptable in safety terms, circumstances could easily arise where financial considerations and haste took precedence over safe procedures.

Diving during exploration drilling

Before the Ekofisk discovery, diving in the Norwegian North Sea related exclusively to exploration. Divers were needed to carry out work before, during and after a drilling operation. A total of 38 wells had been sunk on the NCS by the end of 1969. Sixty per cent of these were drilled from *Ocean Traveler* and *Ocean Viking*.[13] Activity increased year by year, from one well in 1966 to eight in 1967, 13 in 1968 and 16 in 1969. The rigs usually carried a diving workforce of six people. Since several of them moved on and off the NCS, it is difficult to determine how many people were diving in these waters at any given time. With five different rigs at work, around 30 divers could have been employed there in 1969. If some changes of personnel are taken into account, there may have been close to 40-50 people involved in diving during this period.

The actual dive was first and foremost a means of transport to a work site where practical jobs were to be done. In addition to being able to dive, it was important that the diver could do such work. He had to carry out inspections, make repairs, take samples and so forth, had to be able to use mechanical, hydraulic and electrical tools as well as underwater flame cutters and welding equipment, had to have seafaring skills, and needed a good portion of sound common sense and the willingness to set stuck in.[14]

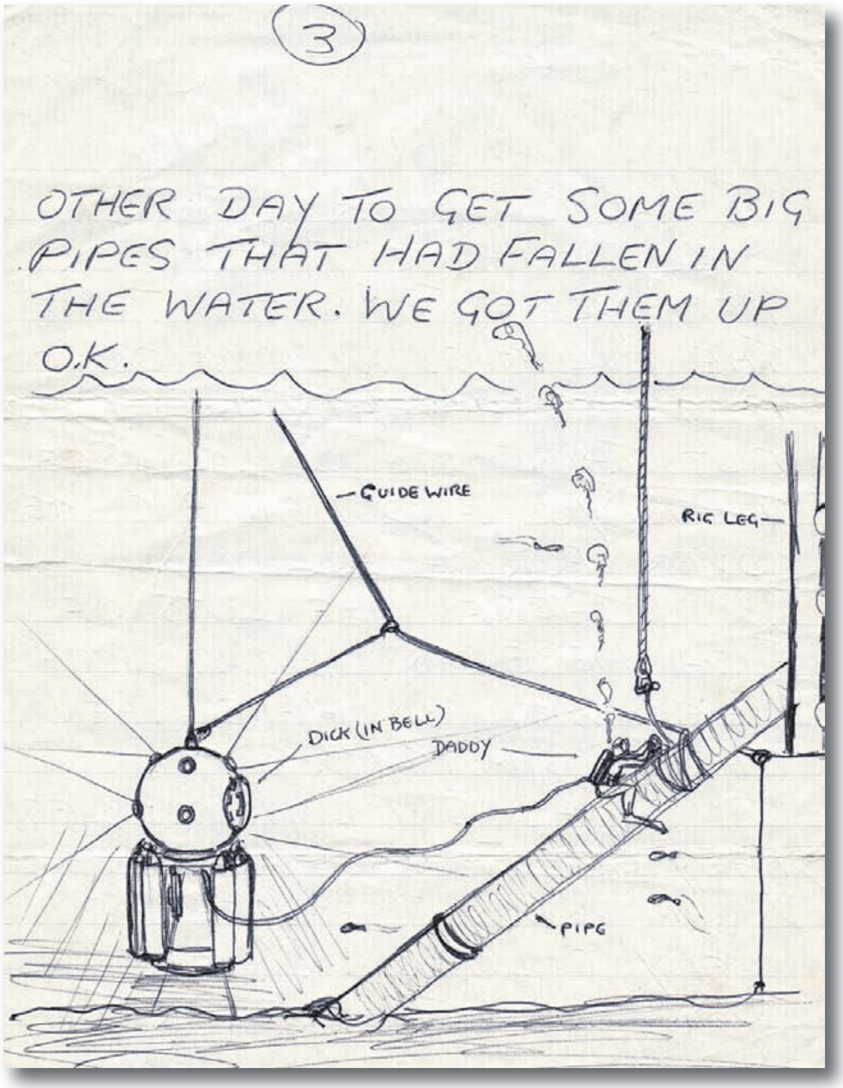
At the initial stage of a drilling operation, a base plate was installed after “spudding in” with a “hole opener” bit measuring from 32 to 36 inches in diameter, and a length of casing was cemented in place. This provided a good foundation for continued drilling and stopped foreign bodies getting into the well. The drilling team depended on divers to inspect this process, including taking samples of the cement used with the casing. These operations could be conducted by the divers under the control of a black-and-white TV camera with a powerful light which



Mike Lally in a wetsuit without gloves during exploration drilling from *Orion* in 1968. The breathing valve is on his stomach.
Photo: Mike Lally

was run on the guide wire on the other side of the BOP. It was otherwise normal practice for the divers to do minor repairs, such as replacing damaged hydraulic hoses. The diver had to take tools he might need down with him or attach them to the outside of the bell. During bounce diving, tools could be lowered in a basket from the surface to the work site.

There could also be periods with little diving and long days of waiting. The divers then maintained their equipment, as well as mixing and pumping breathing gas. They often carried out "dry" training dives to keep body and routines in trim. Since the diving equipment was placed immediately beneath the drill floor, it was vulnerable to being soiled by drilling mud. The drillers water-jetted all the mud off the drill floor, with the result that it ended up one level down on the cellar deck where the diving gear was located. So keeping this equipment clean was no small job. The divers were on constant standby and activated when drilling problems arose. They could then go for days on a minimum of sleep. Straumøy recalls an example of such assignments:


3

OTHER DAY TO GET SOME BIG PIPES THAT HAD FALLEN IN THE WATER. WE GOT THEM UP O.K.

A letter from Mike Lally to his six-year-old son Mark describes a diving operation he took part in.

> I was once down and fished up a length of drill string which had broken during tripping [when the drill bit is replaced]. It lay with its upper section bent out of the BOP and across the seabed. The drillers were terrified that the whole string would fall down the open well and require a complex and expensive fishing operation from the rig. We had oxy-arc cutting equipment with us, and I managed to cut a hole in the string and attach a cable from the rig just above the BOP. Then I cut the string a bit further up, and all they had to do was hoist the thing up.

This rescue operation meant that drilling could rapidly resume, and avoided substantial extra costs for the contractor.

One winter, while *Ocean Viking* spent several months drilling a problem well, most of the pendant buoys marking the location of the anchors were torn free in bad weather. When the rig came to be moved,

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these buoys would have been used by the support ships to lift the anchor from the seabed so that the anchor chain could be wound on a drum. The rig was in raised position, its pontoons awash, and the weather was terrible with a high sea. To get the anchors up from the seabed, the support ship had to attach a cable and a large “chain chaser” collar to the anchor chain. This was then “chased” along the chain until it snagged on the anchor and allowed the latter to be pulled up. The challenge was to lead a line from the vessel around the anchor chain and back. The divers were given this job, which was pretty risky. They were lowered in a bosun’s chair to the “cow catcher” on the pontoon, being tossed around like rag dolls by the powerful wind on the way down. Once on the pontoon, they had to cling on every time a wave broke over them to avoid being washed away. Straumøy was picked up by a wave and thrown under the rig. It was the middle of the night, dark and slippery and difficult to get back onto one of the pontoons by a column where a ladder ran up to the deck, but he managed it eventually. The support ship manoeuvred as close to the rig as possible. One minute it was high above the divers, and the next minute many metres below. The support ship crew first threw a line to the divers which they wrapped round the anchor chair. Then they had to find a calm moment between two breakers and throw the line back. They finally accomplished this after many attempts, all the anchors were raised and nobody was seriously injured.[15] Only the divers could have carried out this operation, but they undoubtedly put themselves in great danger.

3X – first Norwegian offshore diving company

The first American diving contractors brought experienced divers with them from California and the Gulf of Mexico when they started up in the North Sea. It was not long before they had recruited many local divers, who were cheaper. British personnel quickly became the majority on the UKCS.[16] Another advantage of the Britons from the American point of view was that they spoke the same language. Communication was important in diving, not least when a diving supervisor had to instruct the diver about a job, manage decompression and so forth. France’s Comex naturally brought a number of French divers into the North Sea, but had to accept that the working language in the oil industry was English. Comex soon also hired a number of British divers and, as mentioned above, recruited its first Norwegian in the summer of 1968. But Straumøy was nevertheless not the first diver from Norway to get a job related to the oil industry. During the first drilling season on the NCS in 1966, Ocean Systems decided to take on two Norwegians as trainee divers. They were Idar Johnsen and Odd Gåskjenn.

Odd Gåskjenn wearing a helmet diving suit in the 3X warehouse at Strømsteinen in Stavanger during 1969.
Photo: Leif-Tore Skjerven

Before joining Ocean Systems, this pair were interviewed at North Sea Exploration, Stavanger's first oil base. This was located in a former timber yard at Strømsteinen in the city's "East End". During the interview, they were told that they would receive six months of on-the-job training before possibly making their first dive. Yet another Norwegian, Leif-Tore Skjerven, was taken on by Ocean Systems in 1968. An American diver is said to have abused an Esso representative at the Place Pigalle bar in Stavanger's Victoria Hotel.[17] Ocean Systems had no desire to be on bad terms with the world's largest oil company, and an opening accordingly appeared for yet another Norwegian.

All three of these Ocean Systems recruits had undergone diver training in the Norwegian navy and were working for the Nord-Norges Dykker- og Froskemannsservice company in Tromsø when an opportunity to dive in the North Sea opened up. While doing military service in the navy, conscripts could attend its diving and frogman school and also take a helmet diving course. This was the best diver training available in Norway during the 1960s. But the Norwegian divers quickly discovered that working in the North Sea was considerably more demanding than in the navy and as professional divers in northern Norway. None had done bell dives with the type of heliox mixture used by the companies in deep water. Skjerven recalls:

The Banana deck decompression chamber (DDC) in the warehouse at Strømsteinen, with a helmet diver in the foreground and Leif-Tore Skjerven operating the winch.
Photo: Leif-Tore Skjerven

> ... we had only dived to 60 metres, had never seen a diving bell – except perhaps in bad science fiction films – and all we knew about helium was that it was one of seven noble gases which were apparently non-toxic.[18]

The American training system involved working under the supervision of an experienced diver and receiving practical and theoretical instruction in gas mixing and decompression with a heliox mixture. The Norwegian divers seem to have learned very quickly. As early as 1 September 1968, three of them were involved in founding the first Norwegian diving contractor, 3X or ThreeX. Gåskjenn, Gunnar Møllegaard and Skjerven were shareholders. The share capital was NOK 20 000. To begin with, they leased a small office in the North Sea base at Strømsteinen, furnished it and secured a telephone line. The rest of the share capital was spent on gas cylinders and diving suits.[19] Little money was left for pay if the company failed to win work.

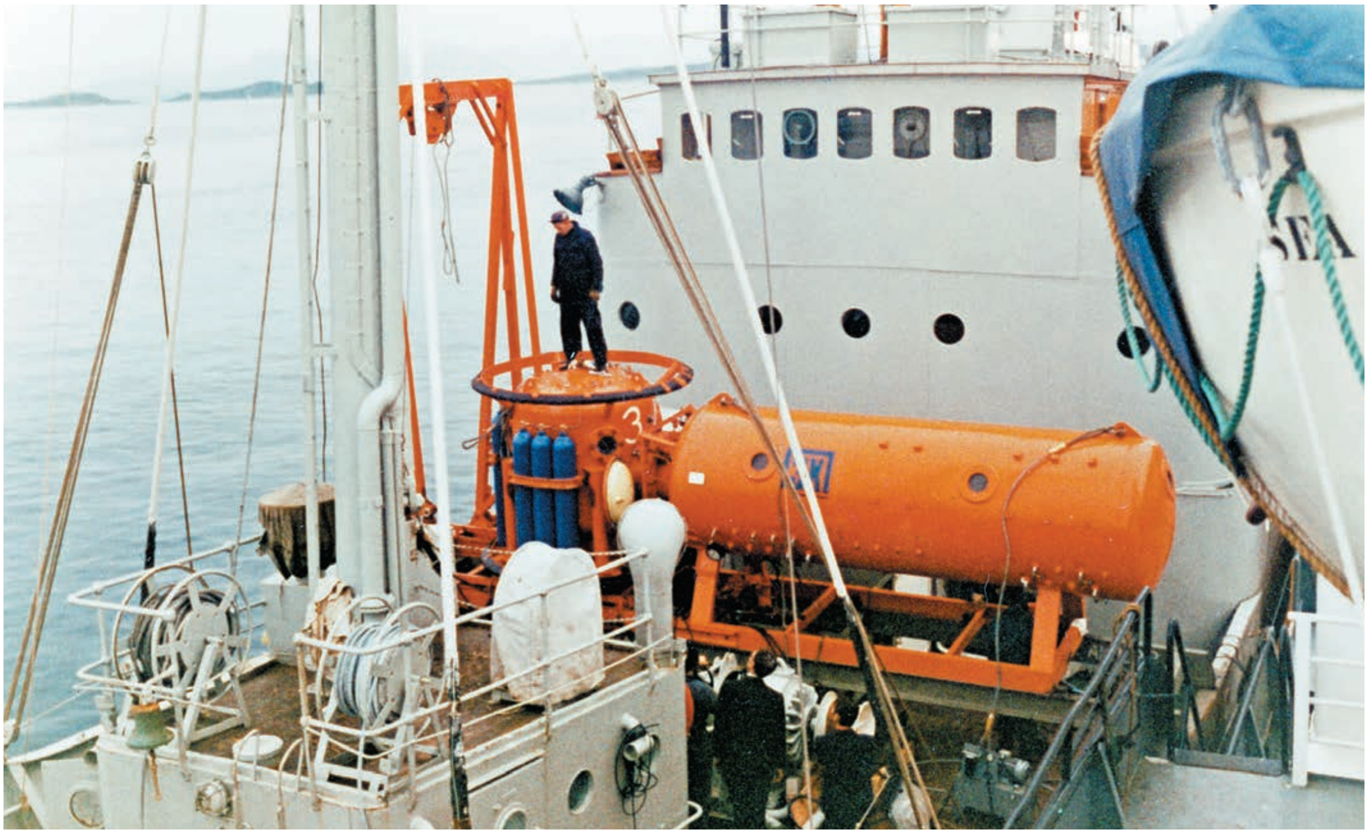
Initially, 3X hired out personnel to Ocean Systems and Comex. The divers could also get jobs in other countries, particularly during the winter months when activity was low in the North Sea. Divers from 3X were hired out to Ocean Systems, for example, for an assignment in Mauritania on the west African coast in the winter of 1968-69. Operating from the *Glomar North Sea* drill ship, drilling-related diving was conducted in 75-125 metres of water and gave 3X valuable experience. The fact that leave could be spent in their own *appartementos* in Las Palmas was attractive.[20]

In October 1968, the company purchased an underwater camera with 200 metres of cable. This cost roughly NOK 100 000, compared with about NOK 10 000 for the TV monitor in the control room. The camera made work safer, and jobs could be better planned in advance.[21] In 1969, 3X invested in its first DDC – nicknamed the Banana since it was painted yellow. And, in August 1971, it acquired its first diving bell with DDC, made in Stavanger by AS Alfred Paulsen. Gåskjenn, Skjerven and Møllegaard designed the bell, Alfred Paulsen handled drawings and manufacture, while the naval department of Norwegian shipbuilder Horten Verft helped to check the plate thickness calculations.[22] The bell was just over 1.6 metres tall, giving no room inside for the divers to stand up, and was connected to the deck chamber through a pressure hatch on the side. It was also equipped with an obligatory bottom hatch, which the diver used to get in and out the bell when working under water. Several accidents when the divers felt trapped inside the bell led to it being dubbed the Rat Trap.

Transition to the development phase

During the initial exploration phase on the NCS, a number of new and previously unknown occupational titles entered the Norwegian language. Translations had to be found for driller, derrickman, roustabout, casing operator, cementer, mud logger and so forth. Being an offshore diver during a drilling operation was also a novelty. This job was primarily done by experienced American, British and French personnel with a naval background. There may perhaps have been no more than 40-50 of them in the 1966-70 period. A handful were Norwegian.

North Sea diving built during the next phase on the expertise of these people and of the earliest contractors. After oil and gas had been found, Ekofisk and later Frigg were to be brought on stream (into production). A large number of installations and pipelines needed to be put in place, while exploration activity continued at full pitch on other NCS blocks. This was when work in the oil industry really took off, and



The Rat Trap (left, with man standing on top) ready to blast free a subsea wellhead in 1972-73. Photo: Leif-Tore Skjerven

the number of people employed in this sector seriously increased. That also applied to the divers, whose ranks quickly swelled. The number of diving contractors rose from a handful to around 15 by 1973. Activities related to the Ekofisk development were largely responsible for the breakthrough of 3X and several other Norwegian diving companies. The diving work required in the development and production phases for the first Norwegian offshore fields, the scope of this activity and the continued progress of diving technology will be covered in the next chapter.

The Rat Trap

This 3X diving bell was first dubbed the Rat Trap during initial testing alongside the quay at Strømsteinen, where the company had its office and warehouse. "Eyolf Assersen was in overall charge, and Kjell Lilledal operated the winch. There couldn't have been more than seven-eight metres of water off the quay. Inside the bell were Kjell's brother Bjørn and Arne Jentoft. It was only going to be a short dive, so the umbilical hadn't been connected – therefore no communication. The bell was submerged. Someone had forgotten to install the O-ring to seal the side hatch. Bjørn and Arne undoubtedly felt like rats in a trap as the water poured in along the side hatch flanges. They found themselves sitting in water up to their necks, and nobody on the surface heard their undoubtedly desperate cries for help. When the bell was back on the surface and the tale told, it was nicknamed the Rat Trap." The gallows humour often widespread in the diving community meant that this name was not forgotten.

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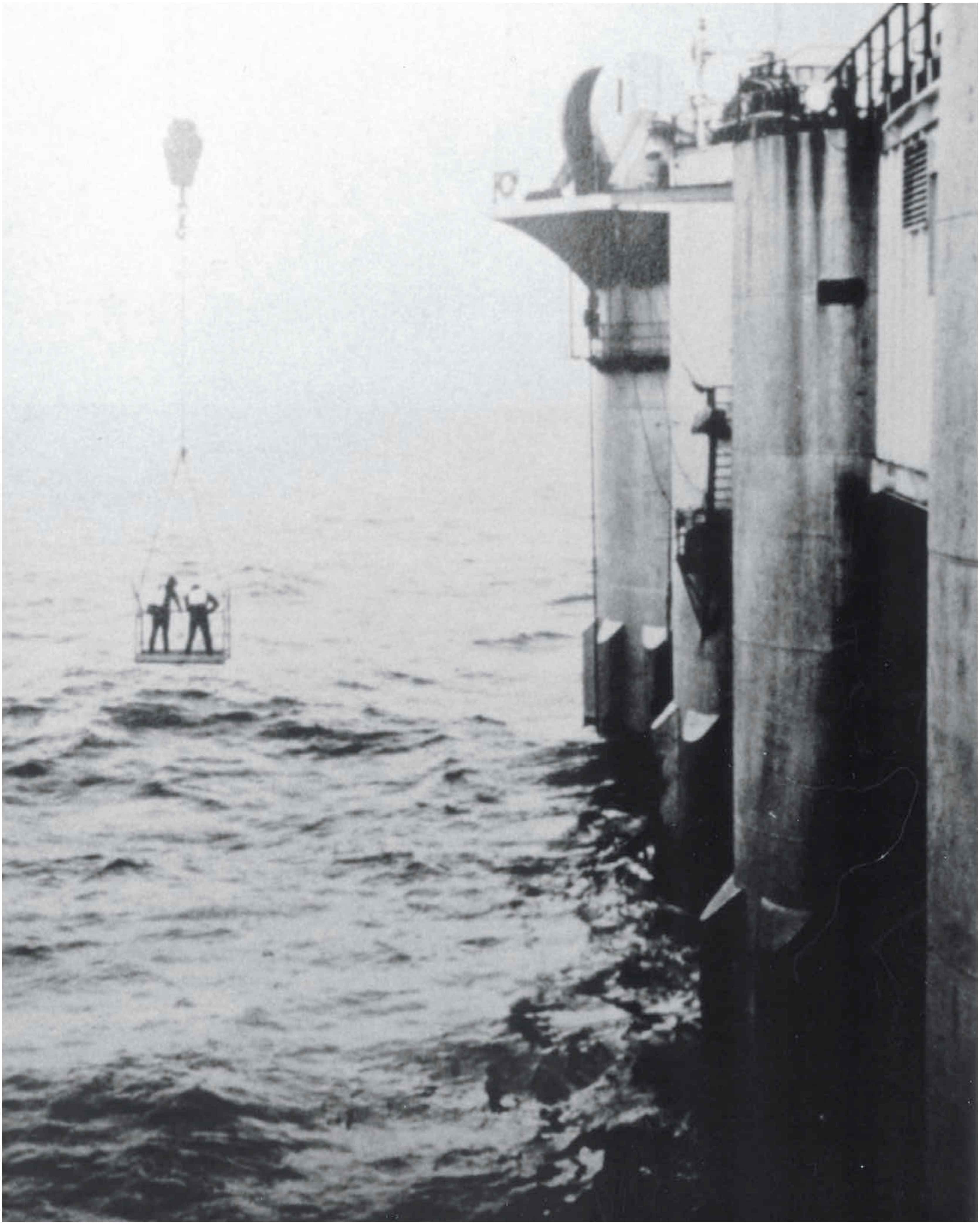

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Chapter 2

New challenges on Ekofisk and Frigg

Work now began in the middle of one of the world's roughest seas on constructing small "platform towns" – offshore factories. Oil and gas were to be produced for the first time on the NCS from Ekofisk, while Frigg – straddling the UK-Norwegian boundary – ranked at the time as the largest offshore gas discovery to be brought on stream. Many groundbreaking technological advances were made in developing these fields, not least with regard to diving. The divers performed a number of jobs – installing, inspecting and repairing equipment, flame cutting and welding under water, helping to lay and connect pipelines, and so forth. Demand for diving work rose as the development projects increased in scope, making this a technological bottleneck. Expensive drilling operations and other activities had to wait while divers did their underwater jobs.

Well-known methods such as surface-oriented, helmet and bounce diving were used in connection with test production on Ekofisk. But *saturation diving* was adopted for the subsequent development of fixed installations and the laying of oil and gas pipelines to land. This new technique was suited to deeper water and longer dives.

The time and depth limits for diving work were constantly being stretched, with the oil companies and international diving contractors as the prime movers. With rising oil prices and a demand for oil deliveries from politically stable regions, the pressure was on to get production started and ensure reliable supplies to the markets.

Divers on the way down in a basket from *Ocean Viking*.
Photo: Per Birkeland

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Quick start to oil output from Ekofisk

Its oil and gas reserves make Ekofisk one of the world's 100 largest fields. Since coming on stream, it has contributed a fifth of Norway's petroleum output and could continue producing for as much as 50 years. As soon as the field was proven in 1969, the need was to get it quickly on stream so that operator Phillips Petroleum Company Norway and its partners could start to earn money. An application was submitted to start test production. This plan called for the *Gulftide* jack-up– originally a drilling rig – to serve as a production platform from June 1971. It would produce from the first four exploration wells on the field, which had all revealed substantial reserves. *Ocean Viking* was chartered in the spring of 1971 to re-enter these wells and complete them for production. Diver assistance was required in this context, and Comex was given the contract. British diver Thomas Michael (Mike) Courtny Lally, who worked for the French contractor, died during this work. The pressure to get drilling started meant that many of the usual safety measures were ignored on this occasion. That included failing to use the diving bell, since it was faulty. Combined with the fact that Lally was on extraordinary call-out after a long stint, the cold and high seas during the dive imposed great physical burdens on the diver. This accident and the issues it raised are discussed in detail in a later chapter.

The four "Xmas trees" (valve assemblies) installed on the seabed around *Gulftide* each controlled one well and were the first subsea installations on the NCS. Flowlines carried the wellstreams from these wellheads to the temporary production platform, where oil, gas and water were separated in a simple plant. The gas was burnt off from a flare boom above the top of the derrick, the water went back into the sea and the oil was piped to two loading buoys.[1] Brown & Root, a major US engineering contractor, had the job of installing *Gulftide*, laying the flowlines from the four wellheads and positioning the risers which carried the wellstreams up to the platform. Taylor Diving & Salvage Company did the diving work when *Gulftide* was installed. The unusual feature of this job was that Taylor Diving brought in two saturation diving spreads for the Ekofisk project. One was placed on a barge and the other on *Gulftide*. Installing that platform accordingly marked the first use of saturating diving on the NCS. It was groundbreaking, but likely to have been controversial at the time. Taylor Diving was also responsible for connecting up the first well, while the other three were handled by Ocean Systems. Phillips required the latter to have a saturation diving spread as back-up, but it was not used. Ocean Systems preferred to utilise well-proven but heavy helmet diving equipment. It did not even use a bell to reach the seabed. The advantage was greater flexibility with regard to working in high waves. A diving bell could not

Mike Lally was one of the divers killed while diving from *Ocean Viking* during the hectic start-up phase on Ekofisk in the spring of 1971. He wrote a letter to his son to explain what Daddy's job was like.

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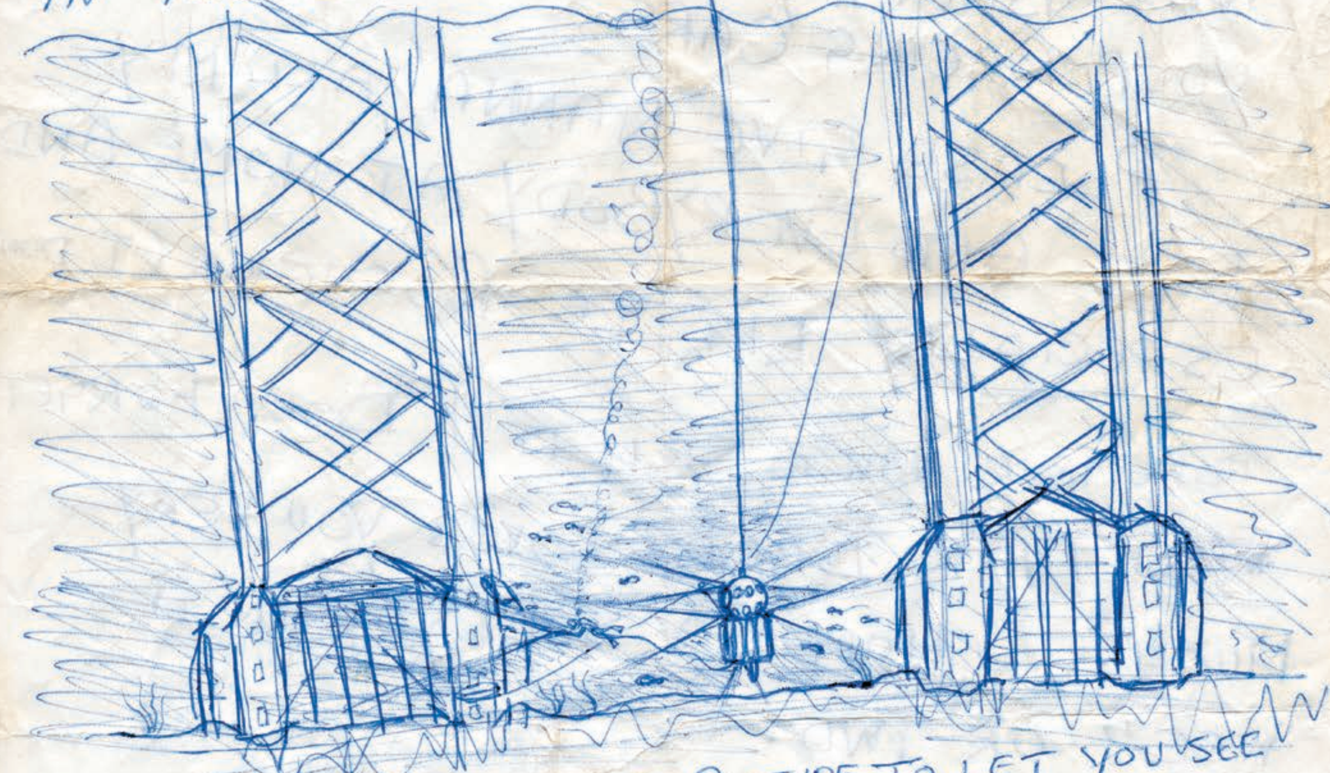
1

FROM DADDY,
OIL RIG 'ORION'

DEAR MARK,

I HOPE YOU ARE BEHAVING YOURSELF AND GOING TO THE NURSERY EVERY DAY. I WENT DOWN UNDER THE WATER LAST NIGHT IT WAS VERY DARK AND COLD BUT I SAW LOTS OF BIG FISHES SWIMMING IN THE LIGHTS OF THE DIVING BELL.



I HAVE DRAWN A LITTLE PICTURE TO LET YOU SEE WHAT ITS LIKE UNDER THE SEA AT NIGHT BUT WE CAN SEE LOTS OF THINGS WITH OUR LIGHTS ON. THE BIG CRISS CROSS THINGS ARE THE LEGS AND FEET OF THE OIL RIG AND WE HAVE TO GO DOWN AND LOOK AT THEM EVERY DAY.

DIVCON

P.T.O.

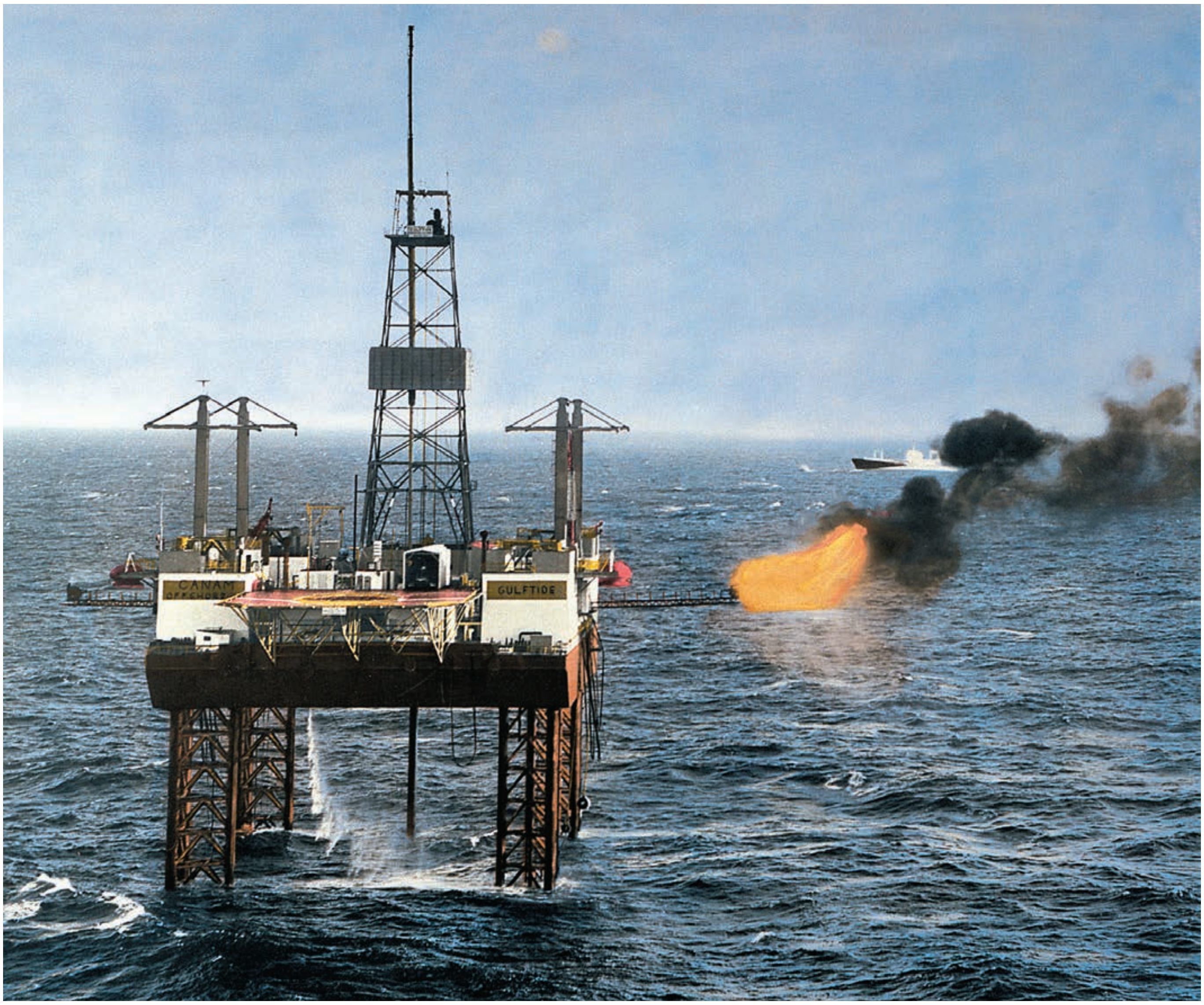
cope with much of a seaway, while helmet diving equipment functioned fine once the diver had reached a sufficient depth. Ocean Systems was more than a little proud of being able to do the work with a crew of 12 compared with the 30-strong team needed by Taylor Diving.[2] Per Birkeland, who had been hired out from 3X to Ocean Systems, reports that much toil and many adjustments were needed for everything to go as planned. Mechanical connectors which required crane capacity were used. The final well was made ready in five days, which Phillips found very satisfactory.

A Dutch vessel installed the two loading buoys a few kilometres to the south of the platform. Taylor Diving worked on the first, while France's Cosean diving company connected up the second with assistance from 3X divers. The connection was made by attaching a loading hose to a flowline which lay on the seabed under the buoy. A buoy also hung beneath the sea surface to give the loading hose an S-shaped profile in order to avoid damage during bad weather. Six anchors held the buoy in position, immediately above the flowline on the seabed.[3] While the loading buoy was being installed, a tanker lay ready to receive the first consignment of crude when production began. Installation was an urgent business.

Diving work with *Gulftide*

A permanent six-strong team of divers was stationed on *Gulftide* after it begin producing. They worked the same tours of duty as the other offshore workers – 14 days offshore and 14 on land.[4] All diving work associated with buoy loading and platform maintenance was managed by the marine department at Phillips. Established in 1971, this unit comprised two-four people stationed partly on land and partly offshore. They were responsible for commissioning diving companies to do the actual work.[5]

Gulftide was equipped with a diving spread which comprised a control room, decompression chamber, diving bell, hoisting winch, low-pressure compressor, high-pressure cylinders for oxygen and helium, and some smaller items of equipment. Once the platform was on stream, the divers had a number of jobs to do. This work took place largely at depths of 65-72 metres. All the flowlines with their seabed connections had to be checked. The platform's four steel legs needed regular inspection, plus checks that they were not being undermined on the seabed.[6] When such erosion occurred, the divers had to pile sandbags around the legs. They also looked for possible erosion around the base plate for the risers. Moreover, the flanges on the oil flowlines to the loading buoy involved a lot of work. A flange is a collar on the pipe which can



Gulftide **served as the test production platform on Ekofisk. A lot of diving went on, particularly in connection with offshore loading. Photo: Harry Nor-Hansen**

be bolted to another flange to make a connection. When anything went wrong, the divers carried out repairs and replaced flange gaskets, for example. At least one leak occurred in a flanged connection.[7]

A diver usually spent one-two hours in the sea before returning to the platform or a workbarge and removing all his gear. Most of the diving from *Gulftide* was surface-oriented. The diver then had air or a gas mixture supplied from the surface through hoses, a full face mask with communication to the diving supervisor, and cylinders on his back to provide emergency air/gas. He descended as quickly as possible to the required depth and carried out the work to be done, before ascending to the surface in compliance with the decompression tables which told him where to stop on the way up. A rope with depth markers was sometimes used to tell the diver where to halt. If he was in communication

The Ocean Systems bell diving spread, with bell, deck decompression chamber (DDC) and control room, on *Gulftide* in 1974.
Photo: Hans Claesson

with the diving supervisor, the latter kept an eye on the time. This form of diving meant that the diver often needed decompression on the surface as well as in the water. The diver was usually thoroughly chilled after the dive. Even with a thick layer of wool from top to toe under the drysuit, he became very cold because the suit provided no other source of warmth than his own body heat.

Complications with offshore loading

The first cargo of oil from *Gulftide* was shipped to the Slagen refinery near Tønsberg on the Oslo Fjord in July 1971, and Shell's Sola refinery outside Stavanger received its first consignment of Ekofisk oil on 4 August that year.[8] Several Greek shipowners were involved in the offshore loading operation. Two ships alternated the job to ensure a continuous oil flow. Each tanker carried 300 000 barrels and the field was producing 42 000 barrels per day, so it took about a week to fill one vessel.[9] Loading could only continue when the wind was below gale force and waves no more than 5.5 to six metres high. Production had to cease if the weather was more extreme and the licensees lost money. So it was important to ensure that loading could continue without interruption for as long as possible.

A simple buoy mooring system was used during loading. A hawser with a pick-up line and loading hose floated in the sea, so that the tanker could retrieve them easily. The mooring hawser was attached to the ship, while the hose connected to its loading system with flanges. Two valves installed in the loading buoy always had to be opened before loading began and shut when it was completed.[10]

A loading buoy with *Gulftide* in the background.
Photo: ConocoPhillips

The divers carried out regular inspection and maintenance of the loading buoys and their mooring systems from the service vessels which were constantly present on Ekofisk. Virtually every time the wind reached or exceeded gale force, hoses and hawsers became entangled and had to be separated. The service ships seldom managed to handle this problem, leaving it up to the divers. It was fairly often the case that all or part of a loading hose had been torn free and vanished, and repairs had to be effected as soon as weather and wave height permitted.[11] But these jobs were risky and could only be done in good weather. Big dimensions were involved. The hawsers used to connect buoy and tanker were the largest used operationally at sea. Divers also had to assist when the hawser was to be disconnected.[12]

Connecting up flanges on a moving loading buoy often represented a difficult and dangerous job for the divers. Former diver Paul Roy Pallesen recalls a connection job of this kind in 1974-75 which proved fairly out of the ordinary:

> The loading system on Ekofisk was called single buoy mooring (SBM), which hailed from Switzerland. Its loading hose swivelled so that the tanker could swing around the buoy. On one occasion, the gasket in this swivel had failed and we were working to remove it. I was sitting and working on the "swan's neck", which was connected to the pick-up line retrieved by the tanker. Both hands were needed for the job, and I had to hold on with my legs. That was probably the worst part of working on the surface. In such operations, with everything in motion because of the waves, two small diver hands weren't up to much. It was very easy to get a finger in between.
>
> Then something happened which could quickly have become a disaster. We were working on the surface with the buoy, more or less in the splash zone, so we were wearing wetsuits but not breathing gear. Somebody then opened the wrong valve on Ekofisk, and crude oil suddenly flooded out. Many tonnes poured into the sea. The barge we were working from was there, of course, but those on board were afraid that the oil would explode, so they pulled away from the flow. That left three-four us on the buoy. Nor could the helicopter take us off, either, because of the explosion risk. The sea was black with oil, and we heard people on the barge saying that nobody must smoke. We could have been blown skyhigh if anyone had dropped a spanner and caused a spark. After deciding that this was no place to stay, we dived into the water. Finding ourselves between the devil and deep blue sea, we opted to swim the 100-150 metres through the crude oil to the barge. When we reached the barge, our wetsuits dropped off us like chewing gum. They had been dissolved by the oil. We were literally coal black. All you could see was the whites of our eyes – which were yellow, probably because of the gas. We had to clean ourselves with ointment to get [the oil] off and protect our skins. So it all went well in the end.[13]

This episode may have been a one-off occurrence, but the divers faced plenty of demanding challenges on Ekofisk in the construction period.

Diving in the Ekofisk development proper

Construction of the first fixed installations on Ekofisk began in the late winter of 1971 and continued during the spring and summer of 1972.

Three wellhead platforms were installed to bring up oil and gas and transfer them to a processing facility. The very first job was positioning the supports for the bridge linking the flare stack to the Ekofisk centre. Then came the steel "jackets" (support structures) for Ekofisk 2/4 A, 2/4 B and 2/4 C. Teddy Broadhurst, who was a roustabout on *Gulftide*, recalls the process:

> From *Gulftide*, we could observe ships and crane vessels in operation. The Americans said 'They're placing a jacket here and a jacket there'. We hadn't a clue what they were talking about, and didn't quite grasp what was going on. What was a jacket? But they sprang up like mushrooms around us.

The ordinary offshore worker received little information about what was going on. While offshore, they had no access to newspapers, radio or TV. After a 12-hour shift, they watched a film and were so tired afterwards that they fell asleep. So even the closest witnesses of the big development process on Ekofisk did not quite understand the scope of what was happening.[14] The divers were in the same position. They were assigned to carrying out part of the work, and had little chance of understanding the scale of the major projects in which they participated.

Crane barges were used in 1971-72 to install and pile most of the platform jackets and bridge supports for what was to become the Ekofisk centre. If and when required, the diving team from *Gulftide* was transferred to a crane barge. But the latter was provided with its own diving team when underwater work had to be done on a large scale. The vessel was equipped with a bell system which was used a good deal for the deeper jobs. However, the bulk of the diving was surface-orient-

A hectic construction phase. The prefabricated steel platform jackets were shipped out to Ekofisk on barges and piled into place. The divers had to investigate the seabed before a jacket was installed.
Photo: Hans Claesson

Surface-oriented diving on Ekofisk. Photo: Hans Claesson

ed.[15] Conducting such diving to a depth of 72 metres is not considered acceptable, but was done sometimes – on *Ocean Viking* among others – when the bell system was out of order. The divers then breathed heliox below 50 metres, which made them even more chilled. Without a bell to retire to, they had to spend a long time in cold water during decompression. They then became so chilled that it posed a safety risk.

However, bell – or bounce – diving was the usual technique for depths below 50 metres. The diver could then work for an hour in the water during a dive lasting three hours. But that was not very efficient for major operations. Other divers had to be sent down to complete the work started by the first. Having several diving teams in action simultaneously was resource-intensive.

Diving industry expansion

The amount of work generated by increased exploration activity and the Ekofisk and Frigg developments created space for more diving contractors in the market. By December 1973, about 15 of them were working on the NCS.

Of the French companies, the diving department of C G Doris was active for a short period on the Ekofisk tank and otherwise on the field. Comex Diving, probably the world's most technically advanced specialist in the business, expanded quickly. It had 55 per cent of the international diving market in 1969 and was the biggest contractor on the NCS by the mid-1970s. Its name was short for Compagnie Maritime d'Expertises. The company's main base in Marseilles had a well-developed hyperbaric centre, which pursued extensive technical and medical research. We also know that Cosean worked on Ekofisk.

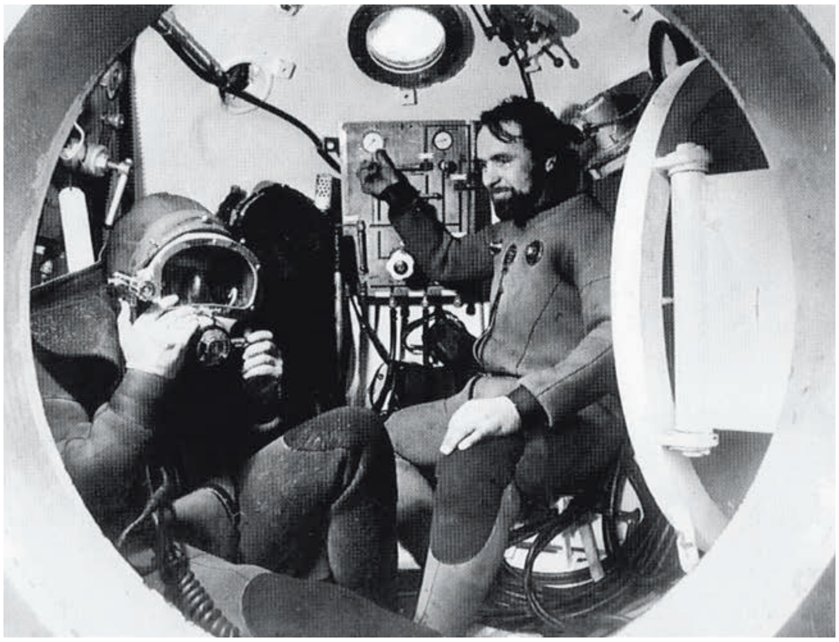
The American diving companies which played a very important role in the start-up phase also held their ground, and were supplemented by new arrivals. Ocean Systems International Inc was the largest on the NCS in the early 1970s. While the offshore diving division had its head office in Santa Barbara, the company was headquartered in New York with a development department in Washington DC and a research unit in Tonawanda. Ocean Systems was characterised by close relations with the US Navy.[17] Taylor Diving & Salvage Co Ltd was active in pipeline-related diving on both Ekofisk and Frigg. It had close ties with Brown & Root, which held the biggest engineering contracts on these fields. Oceaneering Int was a new and fairly small diving company in 1969, and acquired the five-times larger but financially troubled Divcon company in 1971. That suddenly made Oceaneering a major international player, with activities around the world and its head office in Houston. It also had contracts on Ekofisk.[18] McDermott Int was another US contractor, which carried out several assignments on Ekofisk and Frigg as well as laying a third of the oil pipeline from Ekofisk to Teesside in the UK.

Some British companies, such as North Sea Diving and Strongwork Diving, probably also worked on the NCS, but their involvement was relatively brief.[19] Britons Ric Wharton and Malcolm Williams, known as 2W, left Comex to form their own company in 1977. This entered into a collaboration with Norway's Wilh Wilhelmsen and later changed its name to Rockwater.[20]

New companies were also established in Norway, where the domestic oil industry enjoyed broad political support. Foreign companies were required by the government to use Norwegian goods and services as far as possible. To satisfy this condition, some foreign diving contractors registered Norwegian companies. Comex led the way.[21]

The north Norwegian Nordive company, which had experience from construction diving, opened a branch in Stavanger in June 1972 while retaining its main base in Tromsø. Six-eight of its 12 divers were employed offshore, usually by being hired out to larger companies. All had attended the Norwegian navy's diver and frogman school in Bergen. In addition, they had to undertake a three-four week training programme with dives to 150 metres before being ready to work in the North Sea.[22]

An agreement to form a new diving company named Seaway Diving AS was signed in July 1973 by Odd Berg of Tromsø, Nordive's Jon Berg and Jacob Stolt-Nielsen AS in Oslo. Jon Berg was elected chair at the statutory general meeting and, largely for that reason, the company chose to have its head office in Tromsø. The goal was nevertheless to



Terje Skreien and Ernst W Amundsen wearing wetsuits in the bell before a bounce dive. There were always two men in the bell, but only one went outside to work. The other remained as the bellman and stand-by. Photo: Ernst W Amundsen

A bell dive

Alf Schønhardt, who started out as a diver on Ocean Viking in 1971, has described what a bounce dive with a bell was like. One of the jobs he worked on involved overhauling the Xmas trees which controlled the wellstream flow to *Gulftide*, at a depth of 70 metres:

> There is just about room for two men in the bell, which hangs from a cable. Through [the middle of] the cable runs a communication line and a 440-volt power line. Breathing gas is limited in volume and stored in cylinders on the bell. The bell is tossed around in the waves when it reaches the surface, and you have to hold on tight. The whipcracks from the cable as it tightens are not exactly confidence-inspiring. Once we're 10 metres down, we don't get tossed around any more, and the bell is lowered slowly to the Xmas tree on the seabed. It gets blacker outside, but it soon becomes lighter as we approach the bottom. The work site is lit by strong floodlights, and we orient ourselves through the windows in the bell. Ready for compression. [We're] dressed in Viking drysuits with a Dunlop neck seal. Our head and throat are uncovered, in other words, and in direct contact with the sea. The helium we're compressed with conducts heat six times better than air. If you get helium in your suit, it feels incredibly cold. So we have a cylinder of air with us and a hose to fill our suits during compression.
>
> When we're ready with mask, gloves and all that, the countdown to compression starts. Five, four, three, two, one – and the blowdown valve is opened fully. In the course of one-two minutes, the pressure rises from zero to 70 metres, and the temperature climbs suddenly by 10-15°C to more than 40°C. Once the pressure inside the bell is greater than the ambient pressure, the bottom hatch clangs open and you shoot out into the cold water. The warm gas in the mask is immediately cooled down and the faceplate covered with condensation. Dizziness after the rapid compression, the shock of the ice-cold water on neck and throat, and a faceplate full of condensation mean you stumble about to find the job. The TV camera is positioned with the floodlights on the guide wire, and this is when they decide if you're going to be heading back to land on the first helicopter ... Time on the bottom is limited, and calculated from the start to compression until decompression begins. We have an hour to do the job. That's followed by decompression in bell and chamber. In all, the dive takes about three hours. You dive once per 12-hour shift. After a week, your lungs burn from all the oxygen-breathing.[16]

secure offshore-related contracts on the NCS.[23] The company was later known as Stolt-Nielsen Seaway and then as Acergy.

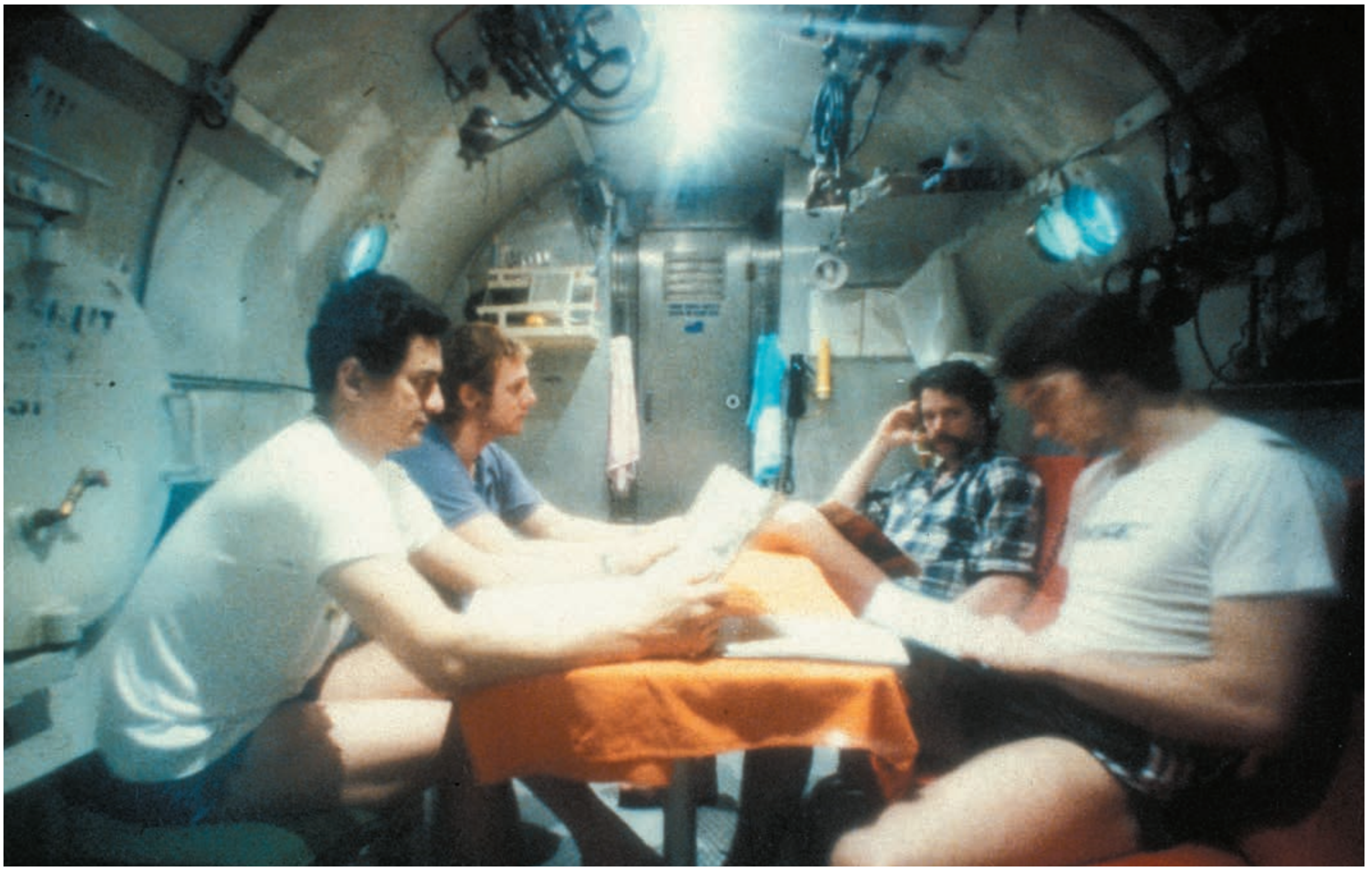
3X also expanded, with its workforce rising from 10 in 1971 to 14 by June 1972 and 20 in October of the same year. Although the volume of work increased with growing activity, particularly on Ekofisk, it was not always easy to maintain permanent employment for them on the NCS. The company supplemented work there with jobs off Ireland and Israel. But the breakthrough came in 1972, with its first independent contract on the *Ocean Tide* diving support ship (DSV) for oil company Conoco.[24] Two new contracts for offshore work were secured by 3X in July 1973. One was with Netherlands Offshore Co for construction work on the UKCS near Ekofisk from *Orca*, a Dutch pipelay barge. Nine divers were involved in this job. The other covered inspection work from *Ocean Tide* south-east of Ekofisk and close to the Danish North Sea sector. Awarded by French oil company Elf, this one-year assignment involved five divers from 3X. At that time, this was the only company in Norway with contracts for offshore diving.[25] It continued to expand through jobs in Norwegian fjords during the construction of the Condeep concrete gravity base structures (GBSs) for production platforms.

Saturation diving – a new method

Although the water depth on Ekofisk was not beyond the acceptable range for bounce diving, this technique had limitations which made underwater work a technological bottleneck. That delayed other operations on the field. Drillers waited impatiently while the divers corrected faults which arose so that drilling could continue. Construction work depended on divers in certain phases. Pipelaying between platforms and from the Ekofisk area to land demanded a lot of diving. And, finally, divers were required to inspect and maintain all the equipment installed below water. A clear need existed for methods which made diving more efficient, and it would be a great advantage if the divers could work for longer periods once they were in the water.

Saturation diving was the answer to these challenges. As mentioned above, this method had been introduced to the NCS by Taylor Diving on Ekofisk as early as 1970. It was then still at an experimental stage, and had been used already for dam work in the USA and offshore assignments in the Gulf of Mexico.

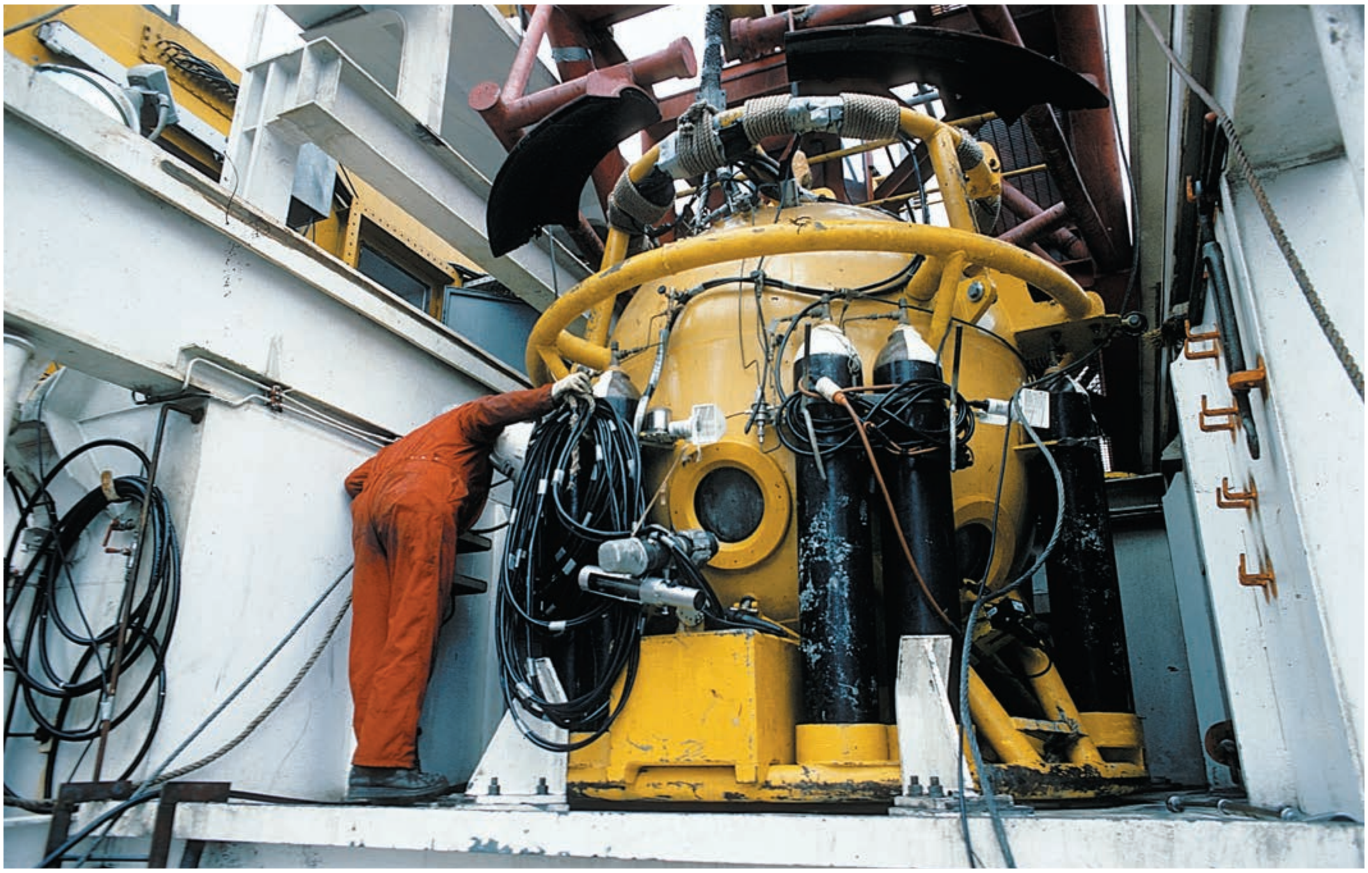
This technology was first used to do a job in 1965 on the Smith Mountain Dam in the Virginia mountains. Its inventor, Alan Krasberg, had developed the necessary equipment in cooperation with the undersea division of Westinghouse. Repair work on the dam was carried out at a depth of 60 metres and took five days – significantly quicker than



Four divers in saturation on Ekofisk. Adopted around the mid-1970s, this technique revolutionised diving. The diver's body was adapted to the pressure at the working depth in a saturation chamber.
Photo: ConocoPhillips

would have been the case with bounce diving. Put briefly, the new technology meant that the diver lived in a sealed chamber (habitat) under a pressure equivalent to the working depth. During the compression phase, his body became saturated with inert gas – nitrogen, helium and so forth – so that he could remain at this depth for a considerable time. The habitat itself was placed on the surface, so that the diver could be kept under constant supervision. (Experiments were also conducted at this time with divers in a habitat – Sealab – on the seabed.) A surface location meant support personnel could check its internal environment more easily for pressure, temperature and gas mixture, serve meals to the divers, carry out repairs and so forth. A diving bell was used to get to and from the work site. The divers performed one work excursion per day. Their final period in the habitat was used for decompression, bringing them gradually back down to atmospheric pressure.

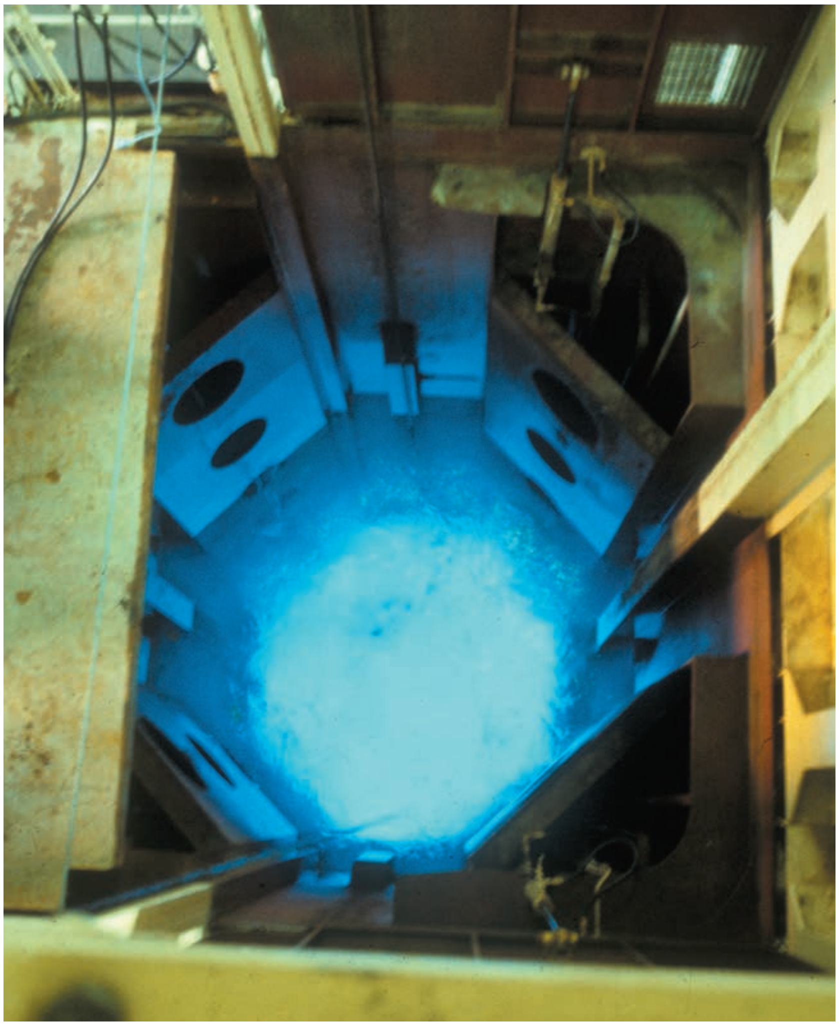
At the same time that Krasberg was able to test his Cachalot chamber system, Taylor Diving demonstrated a virtually identical deep-diving solution called Mark DCL. This was tested for the first time in the Gulf of Mexico. It was Taylor Diving's commitment which helped to make saturation diving commercial. Brown & Root's parent company, Halliburton, acquired 80 per cent of the diving company in 1967. That



A diving bell is readied for use.
Photo: ConocoPhillips

strengthened Taylor Diving financially, allowing it to continue investing in research. The undersea division of Westinghouse was also taken over by Sanford Brothers. But this company's interest in saturation diving faded away, and the Cachelot system was sold to Taylor Diving. Ocean Systems was also involved in this field with a bell system called ADS-III, and set a record in diving to 187.5 metres for 53.5 hours in August 1967. The divers spent seven hours in the water. McDermott, Brown & Root's competitor in the engineering sector, also began to invest in developing saturation diving technology in 1967.

As mentioned above, however, Taylor Diving was the first company to apply this technique on the NCS. That occurred during the transitional phase when discussions on the effectiveness of the system were still in full swing. Taylor Diving needed to convince its customers that saturation diving paid off. The arguments were purely financial. One hour of work for a bounce diver costs USD 10 000. Using saturation could cut that price by 20-30 per cent. Although the cost per diver per day was actually higher, the method came out cheaper because he could spend longer in the water and do more work. A bounce diver descending to a depth of 90 metres earned USD 1 200 per day. He worked for 30 minutes and had to decompress for five-six hours. The saturation



The moonpool, a shaft through the bottom of the ship where the diving bell was lowered into the sea.
Photo: Børre Børretzen

diver usually cost three times as much per day, but his productivity was increased a hundredfold. Savings from getting work done faster were substantial. Instead of deploying a barge for 10-14 days at a cost of USD 75 000 per day, Taylor Diving could do the work in a single day with saturation divers. Claims of greater efficiency won through as the method was tested in practice. The oil companies were impressed when work was done quickly and efficiently, and the saturation approach soon accounted for virtually all offshore diving.

Taylor Diving, one of the leading diving contractors, had nine saturation diving spreads operating around the world at peak – in the Gulf of Mexico, the North Sea and the Middle East. All were involved with pipelaying, covering pipelines, installing risers and welding underwater. Some of the spreads were pressurised continuously for more than a year. They say that the habitat on the *BAR 279* barge in the North Sea was continuously pressurised for three years.[26]

The big transition for divers on the NCS occurred around 1974-75, when saturation diving was adopted for pipelaying and inspecting pipelines and fixed installations on Ekofisk, Frigg and other fields. This technique changed the working day for divers so radically that it can be described as a paradigm shift for the industry.

Seaway Falcon – first permanent DSV on Ekofisk

Phillips chartered *Seaway Falcon* in August 1975 as its first permanent DSV and fire-fighting vessel for the Ekofisk area. This ship was specially built and outfitted with a saturation diving spread. That included a pressurised habitat for the divers under saturation. To conduct diving operations on the open sea and in deep water – with pipelines, for example – the ship was equipped with modern navigational equipment. It was dynamically positioned, which meant that the navigation system and propulsion machinery were connected. Thrusters were installed in transverse tunnels fore and aft. Combined with the main propeller, these allowed the ship to move in any direction or to maintain position over a fixed point on the seabed virtually regardless of weather, current and wind conditions.

Seaway Falcon gave little external evidence of being a diving support vessel (DSV). Main and auxiliary cranes dominated on deck. The whole diving spread, with bell and chamber complex, gas banks and control room, lay below deck. The diving bell descended through a midships moonpool. At the heart of the spread was the chamber complex, where several large steel pressure chambers were connected together with air locks. One was used for compression and decompression of the divers. Another, known as the transfer chamber, functioned as a workplace and connection point for the bell and contained a shower and toilet. A large diving spread usually contained two big habitats, where the divers lived and slept while under saturation. Ideally, a chamber equipped for rescue would also be included.

A life support system was used to maintain the correct pressure, humidity and temperature in the habitat while supplying oxygen and removing carbon dioxide. This was run from the saturation control centre. The DSV carried a number of gas banks to supply chamber complex, diving bells and divers with the right gas mixture.[27]

Diving support vessel (DSV) *Seaway Falcon* was permanently stationed on Ekofisk. Photo: N Ruscio

Routines and living conditions in saturation diving

The divers entered the saturation spread in good time before a job was to start and were pressurised to the depth to be maintained during the actual work. Divers on Ekofisk were pressurised to two different levels – one at 30 metres and the other at 50-58 metres, depending on the job to be done. The living depth was usually 10-20 metres shallower than the working depth. That improved diver comfort, since they were living under lower pressure. The subsequent decompression period could also be reduced by up to a day, which saved diving time.

Once the DSV was positioned over the work site, its bottom weight was dropped into the sea through the moonpool. Full activity now prevailed inside the chamber complex. Work procedures were reviewed and tools prepared. Diving equipment and communications were checked, particularly the masks, along with the diving bell with gas hoses, communication lines and power cables. When everything was ready, the divers donned their suits and took their place in the bell.[28] The latter was more than simply a means of transport. The diver's life hung literally by a thread. An umbilical 300-400 metres long ran from the surface down to the bell, with a further 30-metre section linking the diver in the water with the bell. Both breathing gas and hot water to heat up the diving suit were supplied from the surface through this set of hoses. The best suits allowed the diver to regulate his own temperature. Surplus water mainly exited through the wrist and ankles. Hot water was additionally used to heat the breathing gas. The umbilical also incorporated cables for the communication equipment which kept the diver in contact with the control room as well as for power, TV transmission and depth measurement.

Two divers were always sent down simultaneously, one to serve as the bellman on stand-by and the other to work outside. The bellman fed out the hose while the working diver was exiting, took in the slack on the latter's return, and monitored gas and hot water supplies. He was only permitted to leave the bell if the outside diver needed assistance. The actual work was performed at a water depth where it was cold and dark. Illuminated by the floodlights on the bell, the working diver kept the bellman informed about what he was doing. A job could last from three to eight hours – in other words, significantly longer than with a bounce dive. As soon as the work was finished, the outside diver returned to the bell. The bottom hatch was sealed and the bell hoisted up, while its pressure was matched to that in the chamber complex. The passage through the wave zone could be lively in choppy seas, and it was a good feeling when the bell left the water.[29] It then rose through the moonpool and was connected to the transfer chamber.

The habitat in which the divers lived between dives was much roomier than the bell, but very cramped by normal living standards. It could measure 30 feet (9.14 metres) long and six feet (1.83 metres) in diameter, with bunks for four-six divers and virtually nothing else. The

An image from the TV monitor in the diving control room showing five men in the saturation habitat.
Photo: Geir Ivar Jørgensen

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men slept, ate and spent their leisure hours there. Food and drink were served through air locks in the habitat wall. Clothes and equipment were taken out the same way, cleaned and returned. During their free time, the divers could listen to music and the radio, read magazines, play cards and chat. But their immediate companions were always the same. They lived in an isolated world, but nevertheless under constant video monitoring from the control room – even when using the toilet. It was much like today's Big Brother reality shows, with the difference that the breathing gas and high pressure distorted the vocal chords in a strange manner. Even a man with the deepest bass talked like a furious Donald Duck. It sounded laughable, but was part of the job. Such was the diver's existence, hour after hour, day after day – indeed, week after week. The length of a saturation dive varied from job to job, but normally lasted 21-30 days on the NCS. Once the work was finished, decompression began. Its duration depended on the pressure the divers had been placed under. As a general rule in the 1970s and 1980s, a diver was considered to need one day's decompression for each 30 metres of depth. But the exact time was determined by the diving tables.[30]

Heavy pressure of work for saturation divers

Saturation dives could also last for more than a month. Paul Roy Paulsen recalls periods of up to 45 days in saturation:

> You weren't the same man when you came out as when you entered. In weight terms, it wasn't unusual to lose more than 10 kilograms during such a period. The helium conducted so much heat that your body had to burn a lot just to maintain its temperature and we lost weight. You ate bacon and sandwiches, and the mayonnaise squished out, but not enough calories went down. You lost a lot of weight and were just like an infant calf when you came out. Weak in the legs, just like a new-born calf. So it probably wasn't healthy in the long run.[31]

Karl Jørgensen, who worked for Scandive on *Arctic Surveyor*, also recalls hard toil and being used to the full when in saturation:

> We could work 10-12 hours on the seabed in busy periods. At other times, the stints were fairly short. I often thought the stints were unfairly distributed. There were six of us, after all – two down at a time while the other four rested. If you'd been down for 10-12 hours, it was a case of a shower, some food and then lying down to sleep. The next pair were perhaps only down for six hours before coming up. I heard

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in my sleep that the bell was on the way up, and knew they'd soon be calling out that we had to get ready.

There were eight bunks in the chamber, but there were never more than six of us. We had an eating space, a habitat, where we attached the bell. That's where we took off our suits and showered. In the other chamber, we relaxed and ate. Then we had an emergency chamber, but we also used it for decompression. It was only possible to eat some bread and drink a cup of coffee in the emergency chamber. Food and drink arrived via a small medical air lock. That wasn't as big as the others. When we were under decompression, we spent three days in there without the opportunity to use the toilet. We had a toilet bucket with a lid. I remember one day when I was finished with decompression and had come up and out. The fresh air was lovely, but I'd forgotten something and had to go back inside. I almost fainted. Ugh.[32]

Hygiene in a pressure chamber presented challenges. Because they were breathing helium, the divers needed the temperature to be high – around 29°C. Unfortunately, bacteria thrived in this hot and humid climate. The divers often suffered from ear inflammation and athlete's foot when they were in saturation. Conditions could get so bad that the dive had to be halted. The chambers had to be washed down once a week at least and the hatch covers removed to ensure the healthiest possible conditions for the divers.

Oil pipelines on the seabed

Pallesen and Jørgensen worked as both surface-oriented and saturation divers on pipelaying work related to landing the oil from Ekofisk. When the development solution for this field was chosen, piping oil and gas to Norway was considered technically impossible. The Norwegian Trench, a submarine valley just off Norway's southern and western coasts with depths down to 360 metres, could not be crossed with existing methods. Instead, the Storting resolved on 26 April 1973 that Ekofisk oil and gas would be landed by pipeline to receiving terminals at Teesside in the UK and Emden in Germany respectively. Since Phillips had already made all the practical preparations, work on pipelaying to Teesside could start the day after the Storting vote.[33] This was the operation in which Pallesen and Jørgensen participated.

Laying the line to Teesside was managed by Phillips from Great Yarmouth. A number of companies were involved simultaneously. Brown & Root, McDermott and Santa Fe International installed their respective

Diver Karl Jørgensen at home between tours. Photo: *Stavanger Aftenblad*

The toilet in a pressure chamber. Photo: Geir Ivar Jørgensen

sections from May 1972. American diving contractors dived from the various laybarges which started from Teesside, while Norway's *Arctic Surveyor* provided diver assistance for pipelaying from the Ekofisk centre. Registered in Tromsø, the latter was the first Norwegian DSV and could work much more quickly than the barges because it had dynamic positioning. Four computer-controlled propellers/thrusters held the ship in the desired position. The computer determined its location with the aid of at least three reference points on the seabed. When the DSV moved, all it had to do was retrieve the divers and haul up the reference points. It could be on its way within 10 minutes. By comparison, the barges had up to eight anchors which needed to be laid out to hold them in place. Getting all these up before moving to a new site took time. Moreover, the anchors had an unfortunate tendency to damage the pipeline when they were being laid out.[34]

Ahead of the pipelaying, the divers carried out route surveys and topographic measurements. The seabed was investigated in advance to find the best track for the pipe. In addition, the divers provided assistance throughout the laying operation. A number of their jobs were performed as surface-oriented dives along the stinger – the extension to the barge over which the pipeline was fed on its way to the seabed (so called because of its resemblance to a scorpion's tail). The divers checked that the pipeline lay properly and slid down as it should, and that the stinger was not damaging the pipe coating. They also made sure that the angle of the descending pipeline did not become too sharp, so that it ran the risk of snapping. The divers were responsible for adjusting valves and checking or replacing lights and cameras on the stinger. Down on the seabed, they checked the line, made connections, operated valves and inspected pipeline burial or trenching.[35]

Jørgensen worked with pipeline connections on the seabed along the oil line from Ekofisk to Teesside – when the pipeline was to rise up to the compressor platforms, for instance – and at the landfall. He worked then in saturation. To start with, the connection work was done mechanically. According to Jørgensen, the connectors were "some huge beasts" which lay on the deck of *Arctic Surveyor* before being lowered to the seabed with the aid of cranes. Before the connector could be attached to the pipeline, the diver had to cut away a piece of the concrete coating on the facing pipe end with hydraulic cutting equipment in order to obtain a good edge. The connector was then pulled into place with the aid of a "comealong" cable. Only one man, the diver, was available to do this, and it was heavy work. According to Jørgensen, the actual diving was only 25 per cent of the job: "If you couldn't work with your hands, you had no place there".[36]

His work stints could involve up to 12 hours in the water. The diving team was in saturation, pressurised to a working depth of 60-70 meres.

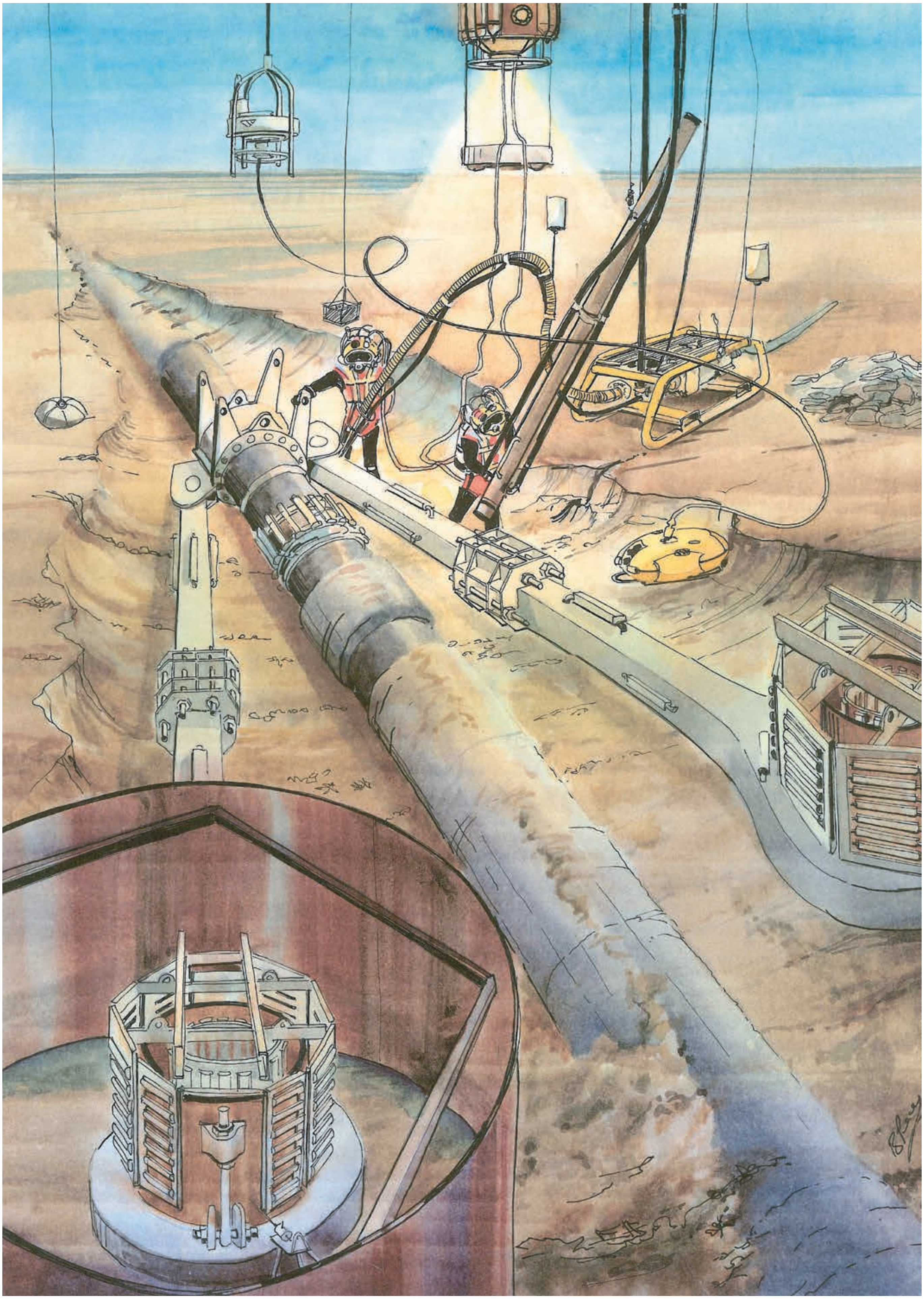
The *Semac* pipelay barge on Frigg during the development phase. Its stinger is clearly visible.
Photo: Frigg collection at the Norwegian Petroleum Museum

When the weather was fine, pipelaying continued around the clock. It was then important for the diver to take breaks and make his life a little pleasanter:

> I returned to the bell now and then to make instant coffee or drink juice. We also needed to eat a little, but only got hot food up in the chamber after the end of our stint. I smoked at the time, but that was impossible in the bell. Instead, I took a pinch of snuff. It didn't matter if I took a few minutes of extra break, because we had plenty of time, and if I was tired I could sit on the pipeline we were working on and rest a little.

Although the work was hard, it could also have its charm. Jørgensen recalls an unusual break when working on the pipeline:

> I think I'm the first person who's gone fishing at the bottom of the North Sea. We had lights on at night, so that masses of plankton gathered and attracted fish into the hatch opening on the bell. I didn't have a hook, but bent a small hacksaw blade and attached it to a rope. I pulled up a cod and a saithe, gutted them and hung them up to dry



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> at the top of the bell. When we came up, I asked the cook to serve up the cod because I wanted fresh fish. But I was bawled out for getting fish guts in the bell. Colossal amounts of fish were attracted when the lights were on. We often lost visibility completely because there were so many of them. One time, when I was entering the bell, I felt something tugging at my suit. It turned out that plankton had become attached to the material, and the fish were grazing on it. I got a fantastic feel for the water. I felt exactly like a fish, even though I was wearing mask and suit.[37]

Alf Schønhardt, on the other hand, describes how the work could be mentally exhausting:

> I'm sitting and staring out of the window in the diving bell. The dark grey colour of the sea changes to azure blue as we're hoisted to the surface. Tiny bubbles of gas glitter like diamonds when occasional sunbeams penetrate through 50 metres of crystal-clear sea. I look across at my partner, Bjørn. His eyes are downcast and he looks weary and dejected. Twelve hours at a depth of 70 metres can finish off the strongest person. We've been down working on the Teesside pipeline, and yet another shift is over. It was pitch black when we started, now it's daytime. The sunshine which penetrates down to us through the water is the only form of natural light we've seen for a month. The bell starts to jerk about. We've reached the moonpool and it's dark outside for a brief minute. Then we emerge from the water and the light returns – but now in the form of floodlamps. More banging, the scraping of metal, we notice hectic activity outside the bell, and soon the loudspeaker crackles: "Open the equaliser in the bottom hatch". The heavy hatch opens, and we feel the warm gas from chamber 2 streaming towards us. I haven't noticed that we've been sitting and shivering for the past four-five hours. The main thing now is to climb down the ladder, strip off the cold, wet suit, get into the hot shower and warm your body up again.[38]

After many long hours, work on the Teesside pipeline was completed on 21 October 1975. That marked the official opening of the line and the receiving terminal. When the taps were turned on, the oil had taken four days to travel the 345 kilometres from the field.

Fire on *Arctic Surveyor*

The running-in period for *Arctic Surveyor* was not without its problems. This vessel was a prototype, and faults in the equipment had to be cor-

Pipelaying operations on Ekofisk. Illustration: Barry Pearson

rected. The dynamic positioning system failed a number of times, causing the divers to be towed behind the ship – on one occasion as far as 1.5 kilometres. Another difficult area was the valves which controlled the gas supply to the divers. One diver was supplied in error with pure helium. Albert Johnsen, a diving superintendent at the time, reports that there were up to 12 cases of divers fainting under water when running-in *Arctic Surveyor.*[39]

A dramatic oxygen fire broke out on 30 March 1975, while the ship was involved with pipelaying operations on Ekofisk.[40] Jørgensen, who was a qualified fire-fighter in addition to being a diver, did a heroic job together with colleague Eyolf Assersen. When the explosion and the consequent fire occurred, four divers were in decompression at two different depths. Two Britons were in the emergency chamber, with an American and a Norwegian in the habitat. Jørgensen relates:

> Somebody had opened a valve at the bottom, I think, of the diving bell. When the oxygen burst out, some of the hoses snapped and fire broke out. An oxygen blaze occurred. The worst aspect was that the cables, hoses and communication equipment which caught fire were wound around the emergency chamber, which contained two men. A lot of smoke was generated by the flames, and getting at them with extinguishing gear was not easy. *Arctic Surveyor* had a box which supposedly contained smoke diving equipment and cylinders, but it held only one set. That was idiotic. So I [as a fire-fighter] broke out a conventional oxygen cylinder plus a steel tube and a hose to breath through for my use. Assersen used the smoke diving set.

Assersen recalls how he experienced the incident as the other "fire-fighter".

> All the hoses in there were alight. A jet of flame squirted right across the compartment. Some wallboards which were stood against the wall on the other side also caught fire. As they burnt, they exploded and jumped about and set everything that could burn alight. The fire got a hold in the insulation above the emergency chamber, creating an incredible amount of smoke. In the next chamber, the poor divers who were in saturation twisted desperately around without being able to affect their fate. We had 700 tonnes of fuel in the bottom of the ship – if that caught fire, it wasn't only the fellows in saturation who were in trouble. Quick action was needed. The crew started the fire pumps, but the pressure was too low. Everyone had a hose, so that only a dribble came out of each. I leapt up to the deck and tied a knot in every hose except one. That meant we had at least one which worked.[41]

Arctic Surveyor **was the first Norwegian diving support vessel (DSV). It was used extensively for pipelaying operations on Ekofisk.**
Photo: Michael Davis

Jørgensen crept into the smoke-filled compartment, dragging the one working hose. He poured on water and managed to extinguish the flames. He relates:

> The divers in the chamber were pressurised to 30 metres. This was so close to surface pressure that they could have escaped the fire if they got the hatch open and entered the bell, which could then be lowered into the water. That's probably what they'd thought … When we succeeded in putting out the fire, I think the fellows in the chambers were happy. I banged on the portholes you could see in through, they saw my face and were undoubtedly relieved. They thought quite simply that we'd abandoned ship … After I came out of the fire area and out on deck for some air, I saw that the others had swung out the lifeboats. I can't forget that. An American was sitting the lifeboat with his lifejacket and everything, quite alone. When I went up to the skipper, I saw that ships were racing to help. The skipper had sent out a Mayday.[42]

The fire could easily have had fatal consequences for the divers in saturation, and demonstrated how vulnerable they were inside a saturation

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spread with no chance of evacuation. Thanks to the swift response by the two Norwegian divers, all went well in the end. Everyone was alive and well, and efforts were subsequently made to learn from what had gone wrong.[43]

Inspecting the Emden gas line and other pipelines

The gas line from Ekofisk to Emden was the other big pipeline which gave the divers a lot of work. It was intended to ensure stable supplies of natural gas from the NCS to households and industry in Europe. Two compressor platforms were installed along the 440-kilometre route to boost gas pressure on its journey. This 36-inch pipeline ranked as the longest welded steel structure in the world when it opened in September 1977.

Used for pipeline inspection, *Seaway Falcon* was staffed for diving around the clock and had divers in saturation at all times. Bjarne Sandvik was one of the divers who followed the pipeline to Emden. He recalls being in saturation at a living depth of 65 metres. The divers swapped constantly between depths from 20 to 75 metres – a range of 55 metres, which puts a big burden on the body. A limit of nine metres up and down was introduced in 1991, which represents a depth range of just 18 metres.[44]

The pipelines were regularly cleaned by pumping a "pig" through them. If anything unexpected was observed during a pigging operation, divers were always sent to make an external inspection.[45] These were initially conducted in a fairly unconventional manner. A large drop weight hung on the outside of the bell to hold it at the required depth. The diver then sat on the weight, with a personnel basket lowered through the moonpool hanging a little behind him as a reference point. That allowed the diver to direct the movements of the support ship. During an inspection run, the pipeline was seen to be lying in one place with a free (unsupported) span of 60 metres. To avoid excessive stress which could cause the line to break, it had to be supported with sandbags. Sand was requisitioned in its own ship, and arrived a couple of days later. The divers were still in saturation, and the bags were lowered in nets down to the man on the seabed so that he could lift them into place beneath the pipeline. This was heavy physical work.[46] The divers also had the job of covering the Emden pipeline with sand where it crossed Denmark's continental shelf, as required by the Danish government.

The internal transport system connecting the four Ekofisk-area fields embraces 1 400 kilometres of seabed flowlines.[47] Laying all these

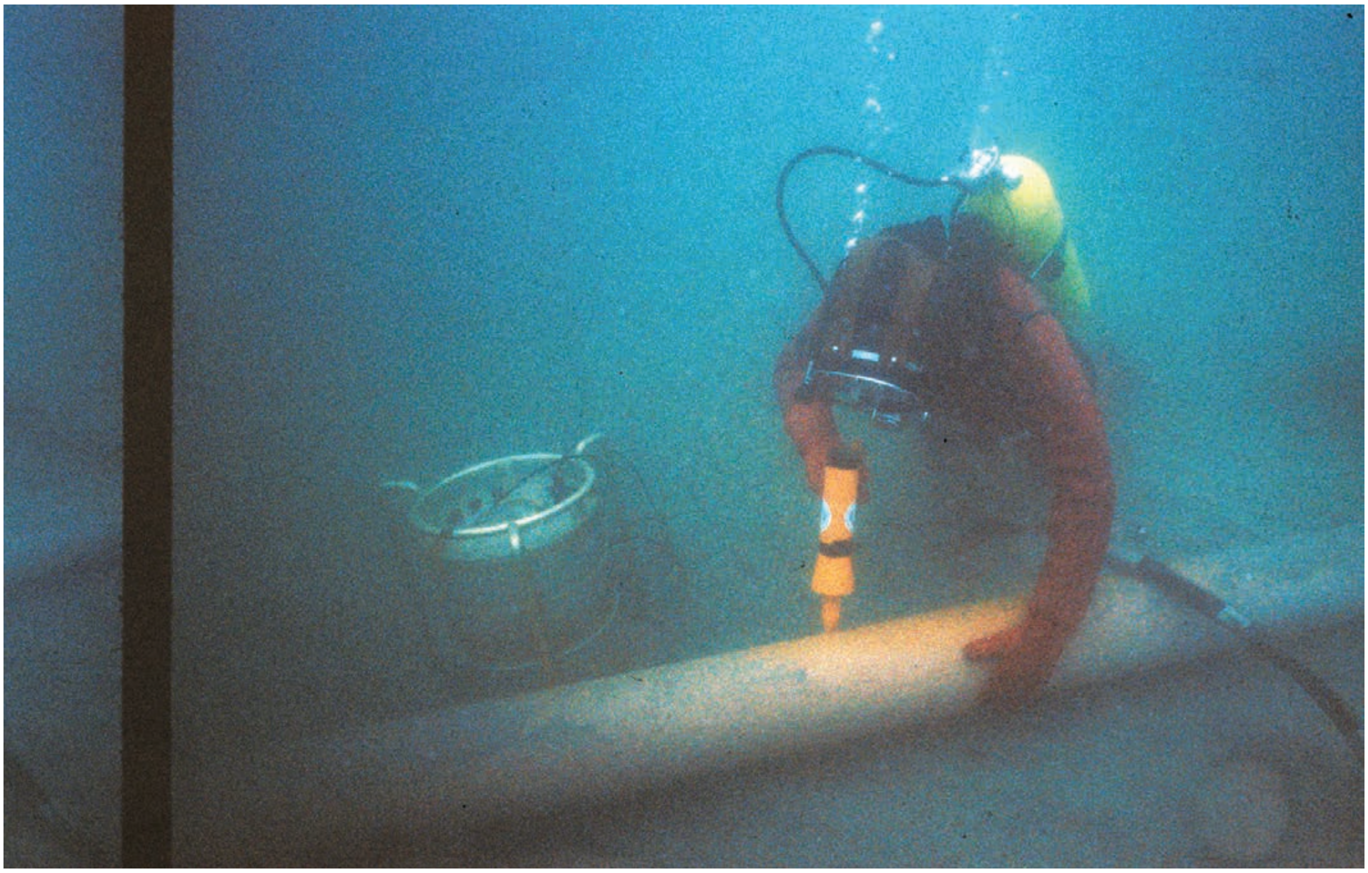
Readying sandbags to cover the gas pipeline from Ekofisk to Emden.
Photo: National Library of Norway, Rana

pipes was a major job involving a number of diving contractors and many divers. Both Comex and Ocean Systems took part, but the bulk of the work in the 1970s was done by Brown & Root in cooperation with Taylor Diving.[48] A lot of follow-up work was required after the flowlines had been installed. New environmental standards required them to be buried to avoid damage from or to fishing nets. Concrete caps were installed over gaskets to improve safety. Pressure and heat from the well-stream caused pipes to expand. To prevent this becoming a problem, a bend was incorporated in the flowline close to platforms.[49] Such operations called for a lot of diving work, with the divers assisted by remotely operated vehicles (ROVs).

Subsea inspection and maintenance on Ekofisk

The Phillips marine department was responsible for day-to-day underwater inspection and maintenance on Ekofisk. From 1975, it had a staff of two at head office in Tananger outside Stavanger and roughly six people stationed offshore.[50]

During the early years, with continuous construction work, the divers were used for such jobs as making accurate topographical and geotechnical measurements or levelling out the seabed where an installation was to be placed. The North Sea has a level sandy bed, and the divers could wear seaboots with lead soles weighing one-two kilograms when doing such work. Flippers were not needed. Equipment also had to be installed, pipelines laid or connected up, and trenches measured. From time to time, the divers had to located and retrieve objects which



Magnetic particle inspection.
Photo: Øistein Th Berge

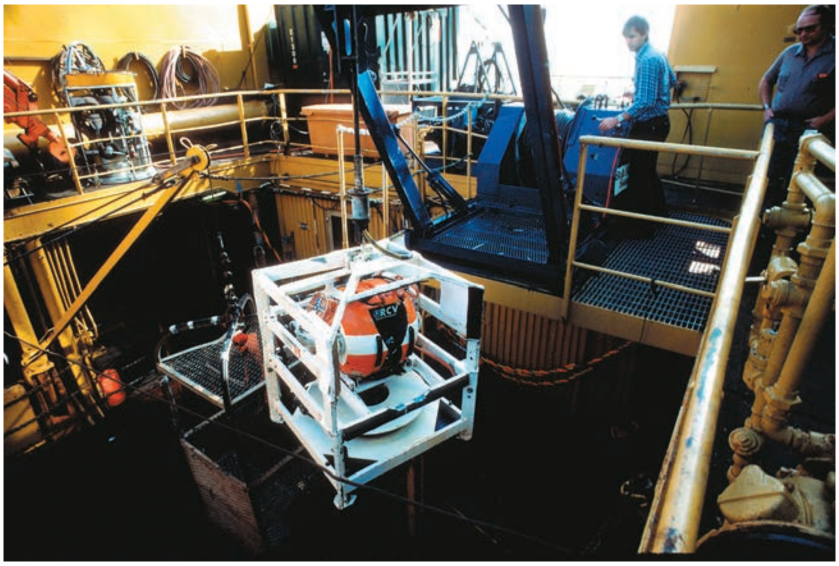
had been dropped from the platforms. They also did flame-cutting and welding under water.

After the field came on stream, the divers carried out inspections and repaired faults. Phillips was the first operator in the world to conduct inspection diving. Most of the inspection and maintenance work was done from April to October, when the days were longest. Inspection was conducted in cooperation with Norwegian classification society Det Norske Veritas (DNV), which always had a representative on the DSV and its own inspection divers. Phillips developed inspection procedures in cooperation with DNV.[51]

The inspectors looked for cracking and corrosion. The most exposed areas were from the splash zone and three-four metres further down. Damage, particularly to the steel bracings, quickly occurred when vessels bumped against the platforms. Inspection work in this area was done by the divers with normal scuba gear. Their first job was to remove fouling (marine growth) using a brush or high-pressure water jetting. The risers were then checked using magnetic particle inspection (MPI). That was done at night. The area to be inspected was magnetised using a kind of magnetic ring before being sprayed with a fluorescing liquid which contained iron particles. These particles gathered in any cracks which might exist. The latter could then be identified when the working light was switched off and the site illuminated with an ultraviolet beam. A report was written and a deadline set for repairing possible damage. Where the site was not too deep, a welding habitat was established around it and the water pumped out so that a repair could be made. Pressure in the habitat matched the surrounding water. When the site lay deep, the diver descended in a bell to access the habitat. Inspection jobs normally took no more than one to four hours, and were very different from work diving.[52]

Cracking in a riser could be extremely dangerous. Such damage six metres below the surface caused a fire on the Ekofisk 2/4 A platform on 1 November 1975. Divers had just finished an inspection and returned to *Seaway Falcon* when the explosion happened, and a big blaze developed.[53] The fire broke out because a section of the pipe's concrete coating had fallen off in the splash zone. Seawater and internal heat had caused corrosion which ate through the metal wall, and the blaze began when a mixture of oil and gas under high pressure encountered the oxygen in the air. A blaze of this kind was one of the worst accidents which could happen offshore. In the wake of the fire, a big effort was launched to prevent a recurrence.

Together with the Norwegian Petroleum Directorate (NPD) and DNV, Phillips had to find a new solution for the risers. The result was that similar pipes on the various platforms were replaced with a safer and more robust solution. Both the inspections and the replacements created extensive work for the divers.[54] That included heavy jobs such as replacing riser gaskets measuring up to 1.3 metres in diameter. This was done in 10 metres of water with scuba diving.[55] Divers report that a number of them suffered from the bends when doing maintenance on



An ROV used for inspection on Ekofisk. Photo: ConocoPhillips

the risers at that depth. Things were so bad that 13 divers got the bends on 15 dives. The eventual outcome was that the US Navy's tables had to be modified, not least by enforcing longer stops in the water during decompression, and the number of cases of the bends declined.[56]

After the Ekofisk 2/4 A fire, a map of the jackets for all the platforms on the field was produced to guide the divers more accurately under water. People worked around the clock to prepare this system. All the nodes on a jacket were given names on a large drawing, and these designations were used by the diving supervisor when identifying points on the map and guiding the divers – the names were not inscribed on the actual underwater structure. The diving supervisor always knew what depth a diver was at, which was important for controlling the latter during decompression.[57]

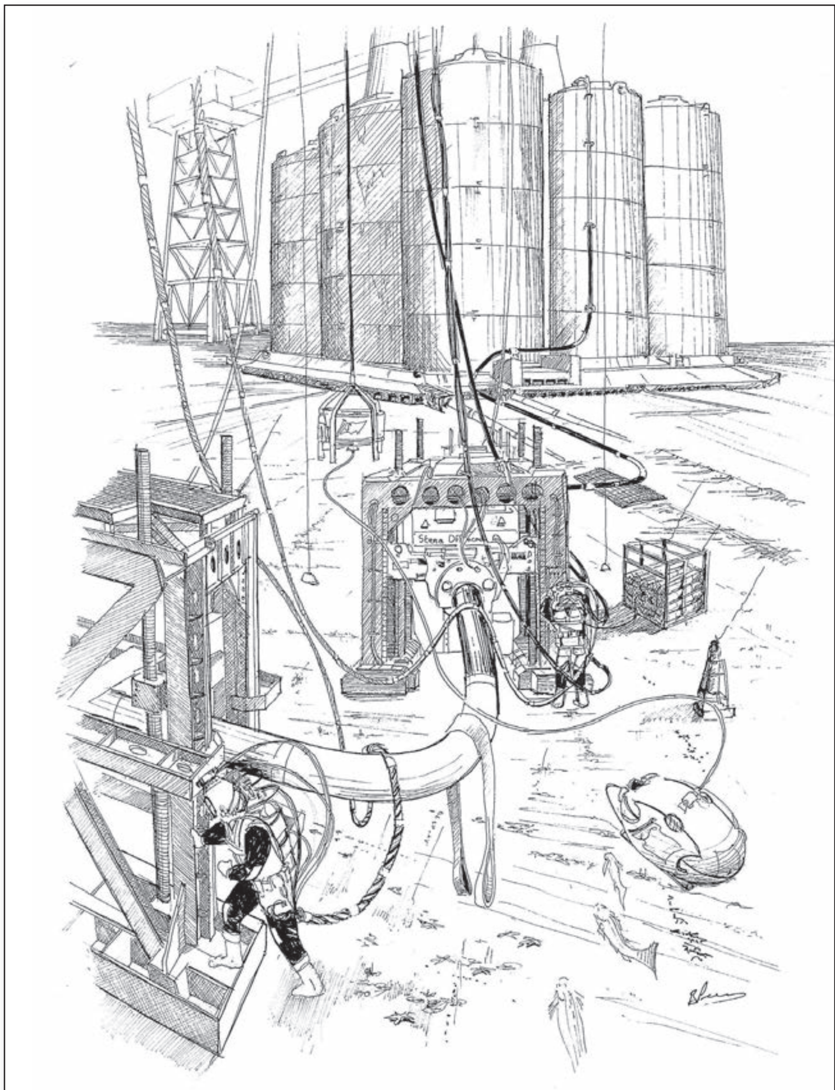
All the platforms on Ekofisk were inspected under water annually or every other year with the aid of divers or ROVs, as were all the subsea installations. Risers/pipelines were inspected from the splash zone to 500 metres from the platform, where they were buried in the sand.[58]

Diving to support Frigg pipelaying

Frigg was the other major discovery proven on the NCS at an early stage. Operated by Elf, it had a thin oil zone which could not be produced with the technology of the day. However, the gas reserves were huge and easy to recover. The field straddled the boundary between Norway and the UK, with 61 per cent of the reserves on the Norwegian side and 39 per cent in the British sector. Frigg was developed with five fixed steel or concrete installations, while satellite fields discovered later were brought on stream from subsea facilities.

Although Frigg was closer to Norway than the UK, the market for the gas was in Britain and all the gas produced on the UK side was sold to British Gas for political reasons. Norway offered no domestic market for natural gas and had no infrastructure for distributing this commodity to possible consumers. Nor was it technically possible to cross the 360-metre-deep Norwegian Trench with a gas pipeline. So Norway's gas was also sold to British Gas. It was resolved at an early stage that twin pipelines would be laid to a receiving terminal at St Fergus in Scotland, with French oil company Total as operator.

The decision to lay two pipelines 70 metres apart reflected the reality that a single line would have insufficient capacity to transport all the gas. One line was British and the other Norwegian. They ran almost entirely on the UKCS. A compression platform was placed roughly midway along the lines to maintain sufficient gas pressure. The water depth on Frigg was about 100 metres, and 80 per cent of the pipelines lay



It is dark under water and difficult to take photographs. Produced by an ROV pilot, this drawing shows the welding habitat used to connect a gas pipeline to the riser on one of the platforms. An observation ROV can be seen in the foreground.
Illustration: Barry Pearson

in 100-150 metres. Depths were even greater in some places. This was the first time pipelines had been laid in such deep seas. Laying began in 1974. Lengths of line pipe were welded together on the deck of the laybarge and fed out from the stern over the stinger. The vessel moved forward as each section was welded on. It took three years to complete this operation, partly because of the length involved and partly as a result of much bad weather in the North Sea.

Automated CRC welding was tried out on Frigg, with machines used to weld the line pipe sections together. This work was done by two types of machine, one inside and the other outside the pipeline. Test in 1976 showed that all the welds had been made satisfactorily. Pipelaying was largely confined to the summer season from April to October, but bad weather even then halted work for 50 per cent of the time. On such occasions, pipeline sections were laid on the seabed to be welded

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together later. That work marked the first use of hyperbaric (high-pressure) welding in an underwater habitat.

Ahead of this advance, Taylor Diving and Comex had carried out a major test programme to optimise the welding process under high pressure. Trained welders with diving competence were given the job. A habitat – a kind of chamber with an open bottom, large enough to encompass the whole area around the pipeline sections as well as the welder and all his equipment – was installed over the welding site. The water was blown out, the habitat filled with a suitable heliox mixture, and the pressure raised more or less as in a diving bell. Everything had to be dry before the welding started. Pressure in the habitat corresponded to the ambient seabed level, in this case 15 bar. The welding diver wore light diving gear or could use surface-oriented breathing equipment instead of a helmet. After the welding had been completed, an X-ray was taken of the weld to make sure that it could cope with the pressure.[59] A three-man team did the welding, living in saturation for 21 days at a time.

When the weather was good, pipelaying continued around the clock. The record was 4.3 kilometres in 24 hours, which remained unbroken until Alwyn North was developed on the UKCS in the late 1980s. Both pipelines were trenched to a depth of one-three metres beneath the seabed. A trench was dug and the pipe laid in it, with the excavated material placed alongside. The currents ensured that the trench was eventually refilled. That provided extra protection against damage from trawling and reduced the risk that stretches of the pipeline would be unsupported on the seabed.[60]

Trial and error in the development phase

The very earliest years of developing and starting production on Ekofisk and Frigg in the 1970s was a time when many things in the Norwegian oil industry were being done for the first time. That applied to all parts of the business, and not least to underwater activities. The international diving contractors brought with them their equipment, their experience of how to do the work, the diving tables to be used and so forth. But a tough climate and deep water presented new challenges.

Starting test production from *Gulftide* was the pilot project. Saturation diving as a technique was adopted for the first time on the NCS when this jack-up came to be installed. Bounce diving with a bell and surface-oriented diving were used in the subsequent work of installing Xmas trees on the production wells, underwater inspection of the production platform and getting offshore loading to function. Work was done at depths down to 70 metres, at the absolute limit of what could be accomplished efficiently with these methods.

The same challenges were repeated during the construction of the fixed installations on Ekofisk and Frigg. Since so much was happening at once, diving operations became a bottleneck. That can also be said about laying the oil and gas pipelines from Ekofisk and Frigg to Teesside, Emden and St Fergus. These operations were conducted over such long periods that bounce diving – which provides a very limited period of work in the water – became a source of delay. Pipelaying was well suited to the newly developed saturation diving method. The divers were then pressurised to a specific working depth over a three-week period, and could spend many hours in the water on each dive because their suits were heated by hot water. That significantly improved diver efficiency. Saturation diving contributed, in other words, to eliminating the technological bottleneck represented by bounce diving. At the same time, it increased the burden on the diver. He was at work for three weeks or more at time, without the opportunity to take a break unless a crisis occurred.

Diving work was seldom routine. Tales are told of many dangerous conditions faced as a result of equipment failures or because excessive risks were taken. Time was often short. The divers were called in when something went wrong, and spent longer in the water and in saturation than is now considered acceptable. Their stories demonstrate just how weak regulation was for training, working hours, working depths, and so forth in this first phase of development and production on the NCS.


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Chapter 3

How special were the North Sea divers?

There was surely something special about the North Sea divers? How else can one explain why anyone should choose the extreme conditions which prevailed under water in the pioneering days of Norway's oil industry as their workplace? It was not unemployment and privation which drove youths and young men to become divers in Norway at the end of the 1960s. Divers not only chose their career freely, but many of them also battled hard to join this profession. To determine whether a specific diving culture existed, we must first establish who actually became divers. The next question is how far conditions in their chosen work helped to encourage specific ways of relating to diving colleagues and the world at large which differentiated divers from other workers. Although our main focus in this book is on the Norwegian North Sea divers, we cannot ignore the fact that most of the diving was carried out for a long time by Americans and Britons. The Norwegian divers joined work organisations where strong norms about what was right and wrong might appear to exist already. Americans dominated the first diving teams on *Ocean Traveler* and *Ocean Viking*. Their equipment and expertise impressed the small Norwegian diving community in the 1960s. This was nevertheless an industry in a pioneering phase. That characterised the technology, the companies the divers worked for and the divers themselves.

Torger Berge with a six-pack and ice lolly in New Orleans on the way home from diving on *Huakabil Dolphin* in the Gulf of Mexico during 1982.
Photo: Torger Berge

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New Orleans – best known for jazz and its entertainment industry – became the centre of a new offshore-oriented diving industry together with Morgan City, also in the Mississippi delta.
Photo: Torger Berge

Americans and Britons

When oil company activities were confined to less than 50 metres in the calm waters of the Gulf of Mexico, little had distinguished offshore diving from the traditional construction activity pursued with helmet and hose off quays. Moreover, scuba gear had been adopted with increasing frequency during the 1950s. Diving work was usually done by small companies, often with divers who owned their own equipment. A diver could retain their own tender (assistant). Many had a background in the US Navy, which used tough physical and mental selection processes and recruited nationwide. For natural reasons, people connected with the coastal areas of Alabama, Mississippi, Louisiana and Texas were nevertheless well represented among offshore divers. Even experienced naval divers often had to start out as tenders before they got work on the oil fields. The tender system also gave some people a chance to start offshore diving without naval service.

However, the technical innovations and company type which came to characterise diving on the NCS were first developed during oil drilling off California. Diving with a bell, deck decompression chamber (DDC) and various kinds of gas mixture required both extensive investment and far more complex organisation of the work. In the early 1960s, California-based Ocean Systems also sought to introduce these new modes of working to the Gulf of Mexico. *The History of Oilfield Diving* by Christopher Swann describes how this created tensions in the diving community. Many of the Californian divers who accompanied Ocean Systems reacted badly to the humid swamps along the Mississippi delta and went home. But it was not long before a number of companies emerged which were conversant with the new technology and had roots along the US Gulf coast. Despite the fairly substantial cultural differences between California and the Deep South, a common denominator was that both had communities closely affiliated with the US Navy and its associated research institutes around the USA. That also meant that a substantial number of the American divers who ended up in the North Sea had seen active service during the Vietnam War.[1]

The most important reason why the British had taken over as the largest group of divers in the North Sea by the start of the 1970s was undoubtedly the high wages paid to US divers. Swann reports that British divers earned only half the amount paid to their American counterparts.[2] Employing Britons also offered other benefits for the oil companies and the largest diving contractors. As in the USA, the UK had a professional army where diver training was a key element. Both the lists of employees submitted by the diving companies to the Norwegian authorities and oral accounts by pioneer divers confirm that the majority of the British divers had served in the Royal Navy. Helmet diving was also an important profession with a long history in British ports. With the same type of education and a shared language, the British divers fitted quickly into the work organisation and culture in the US companies. Since the Britons lived closer to the workplaces out in the North Sea, they were more accessible than their US counterparts, who were not particularly keen to sit in Aberdeen or other British ports waiting for good weather.

At the same time, diver Jim Limbrick demonstrates in *North Sea Divers. A Requiem* how the social background of British offshore divers varied. They included everyone from seafarers, miners and construction workers to university undergraduates.[3] Limbrick also makes it clear that the high rates of pay were one reason why many divers opted to work in the North Sea. But he identifies other motives which were equally important for many people when they initially chose to become divers, and then later ended up offshore. One was a fascination with diving itself. Another was the sense of adventure and enthusiasm of being involved in a pioneering time – the feeling of taking part in something new:

> Not exactly on a par with astronauts walking on the moon, … but nevertheless, when major goals are achieved, it often seems just as fantastic, considering that the underwater world is still almost as totally alien to man as it was a million years ago …[4]

A special love of water?

Nor were Norwegians originally driven to start diving by the prospect of a well-paid offshore job. After all, the small group of divers in Norway who secured North Sea work as early as the late 1960s could not know how important the oil industry was to become for their country when they began to dive. A number of Norwegians who started diving offshore in the 1970s and 1980s have subsequently reported that a great fascination with the underwater world was the key attraction which eventually brought them into the business. Most were recreational divers before they decided to go professional. Virtually all of them can relate fantastic diving experiences: "I felt I was merging with the elements", "I was captivated the first time I tried on a diving mask" and "I saw Jacques Cousteau's fantastic underwater pictures, and had to try this for myself".

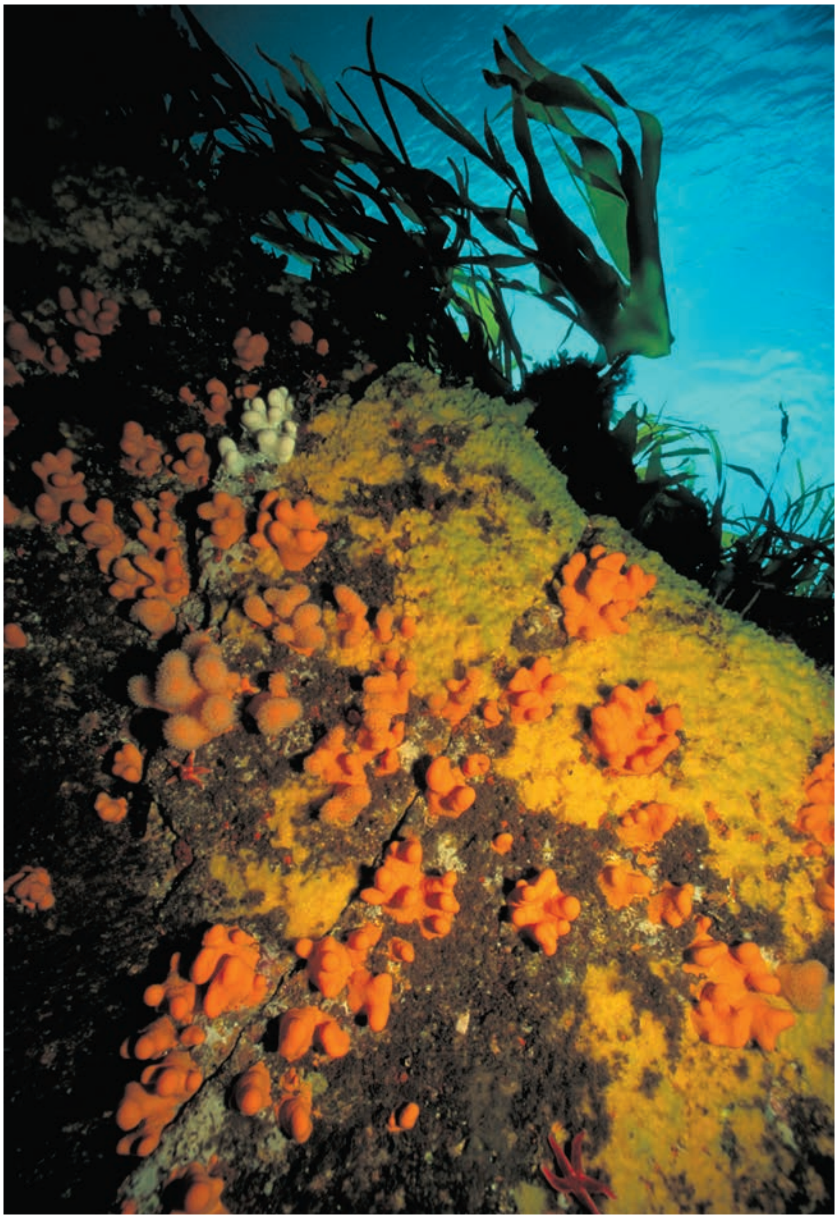
These and many similar descriptions from Norwegian divers could undoubtedly be used to support a thesis that they had a special love of water.[5] The reality of North Sea diving – with the cold water quite literally penetrating the body and transforming the air breathed into a toxic gas absorbed by the tissues – could provide similar and far stronger support for a conclusion on which serious scientists fairly generally agree: no particular indications suggest that the human species, in its relatively brief history, has developed any special genetic properties suited for remaining in and under water. But humans can learn to swim – and to dive. The motive has been what usually drives a person: the struggle for a livelihood. When divers so often emphasise an urge to explore, a sense of curiosity and aesthetic experiences under water, this can be related to other basic human characteristics.

Like other Norwegian oil workers, North Sea divers were recruited from a wide geographic area. But substantial differences also existed. Norwegians who got jobs on the first drilling rigs had much in common with the workforce on typical construction sites in the 1960s, with an over-representation of people who lived in traditional farming communities and small industrial towns in the Jæren region south of Stavanger.[6] During the hectic exploration and development phase in the early 1970s, many offshore personnel came from the crisis-hit shipbuilding industry. Although initially former seafarers, they were increasingly industrial workers from engineering works.

Diver recruitment has followed a more stable pattern. Divers have been recruited throughout from those parts of Norway where interest in diving has been greatest – in other words, along the coast from Finnmark in the far north to Østfold south-east of Oslo.[7] The only inland town where a certain number of North Sea divers can be found is typically enough Gjøvik, which stands on the country's largest lake, Mjøsa, and has its own active diving club. Bergen, Haugesund and Stavanger with surrounding areas along the south-west coast have the biggest concentration of divers. Compared with every other category of Norwegian offshore work, a remarkably high proportion of the North Sea divers grew up along the outer Oslo Fjord, particularly the stretch from Vestfold to Grenland – a region with an active recreational diving community.

Diving in the Norwegian navy

Apart from a burning interest in diving as such, a background as a naval diver again provided an important shared source of experience for Norwegian offshore divers. Diver training in the navy was not the only route into the North Sea, particularly in periods when labour shortages were most acute. Some got in with a simple frogman course and recreational diving as their only experience.[8] Divers tell tales about people who bluffed about a diving past and went into the water in the North Sea when they had scarcely worn a diving mask before.[9] People with



Jacques Cousteau's TV images inspired many people to take up diving. The reality which confronted the North Sea divers was different from the colourful underwater world found in Norway's kelp forests or on shallow coral reefs in warm climes.
Photo: Norwegian Petroleum Museum

helmet diving certificates and long experience as harbour and construction divers were significantly better placed. But a majority of the North Sea divers had attended the naval diving courses at the Haakonsvern base in Bergen.

The training of Norwegian naval divers had much in common with similar programmes in the UK and the USA. Trainees used much the same equipment, diving tables and so forth. But the training bore little relation to the challenges faced by North Sea divers in terms of depths, diving methods or equipment used – not to mention the complex jobs offshore personnel were required to carry out. Haakonsvern had two types of trainees.[10] *Marinejeger* were commandos, corresponding to the

The Norwegian navy's diver and frogman class of 1966. Johannes Straumøy, the first Norwegian North Sea diver, is on the right in the back row. Of the 36 who started the course, only five graduated.
Photo: Johannes Emil Straumøy

UK's Special Boat Service or the USA's Seals. Diving to them was primarily a transport method. The standard depth during operations was seven metres. *Mine clearers* might descend rather deeper, but never below 50 metres. Only some of them received a limited training in the use of gas mixtures in naval operations.

As long as no other systematic diver training was offered in Norway, the naval course was the best available. "After being in the navy, we could work under water without thinking about the fact that we were diving."[11] Companies which recruited divers for the North Sea also knew that divers trained by the navy had been through a number of tough physical and mental trials as part of a rigorous screening process. Candidates needed to be in very good physical shape to be considered at all. Second, they were put through challenging physical and mental tests. Only a small proportion of those who applied were accepted. Fewer than 10 out of a batch of 25-40 might cross this hurdle. In other words, people who become naval divers were strongly motivated.

For some, mastering the physical tests at the naval diving school was in itself a motivation to become a diver. Unlike the USA and the UK, Norway's naval diver training formed part of a general duty to perform military service. Serving as a naval commando (*marinejeger*) was regarded as one of the toughest jobs in the defence forces – perhaps the toughest. Many say that they wanted to prove to themselves that they could get onto and through the course. Such a background undoubtedly influenced the self-image of many Norwegian North Sea divers. Leif Tore Skjerven describes the naval divers as follows:

> In addition to acquiring the constitution of an ox and overcoming cunning mental challenges, we received a solid education in diving medicine and theory. We could race a tractor until it ran out of petrol, beat up any military policeman, and knew everything about diving. We acquired a solid ego, and knew we were hard – compared not just with most others, but with everyone.[12]

Like Limbrick and many others, Skjerven nevertheless emphasises that the challenges faced in the North Sea were another matter entirely. Norwegians with a naval background had the advantage that their training was to a great extent the same as that of many American and British divers – who had also been in the navy, of course. They needed to be familiar with the basic international terminology of diving. Nevertheless, Norwegian divers had to start literally at the very bottom of the hierarchy already established in the diving companies operating on the NCS, where the British and American divers and diving supervisors had acquired leading positions. But that did little to undermine the self-image which many of the Norwegian divers brought with them to the North Sea. Perhaps the opposite was true. The special selection mechanism many of them had been through may have meant they bit the bullet even more strongly in order to show that they were equal to the challenge.

Diver training in the Norwegian navy lasted only 18 months. That was significantly shorter than the period of service for British and US naval divers, who signed up for a four-year stretch.[13] To be sure, a number of the Norwegian naval divers were expected to enlist after completing their national service. But that was in principle voluntary. Newly recruited Norwegian offshore divers did not have to be diving long in the North Sea before they had experienced significantly more drama than they ever saw in the navy. Nevertheless, their naval service provided Norwegian divers with an important frame of reference. They had developed a common language there, forged close friendships, and got to know each other. That proved crucial for many of them when seeking work. Naval divers were well regarded anyway, of course. But if a diver

The Norwegian naval base at Haakonsvern outside Bergen also trained civilian divers. A number of the graduates from the class of 1972 ended up in the North Sea.
Photo: Lars Bjarne Hakestad

from a specific class once got inside, others from the same group soon followed. Since divers often moved from job to job, contacts were also important for getting in where the best conditions prevailed.

Naval divers had been through a regime which involved a lot of unquestioning military discipline, but there were aspects of the navy which many had no desire to see in the North Sea. Officers who had a reputation for pushing others around got no help:

> He'd been an officer at Haakonsvern. Everyone agreed that he was a bastard. After a couple of years, he also tried working in the North Sea, where he continued pushing people around. I told him bluntly that stars and chevrons didn't count for anything out here. Others clearly shared the same view. I don't quite know what happened, but he was said to have been beaten up during a spell ashore. He never came out again.[14]

Pride and pioneers

The aspect which helped more than any other to shape the identity of the North Sea divers was the work they did. The pioneer divers found themselves right in the front line of the great technological experiment which developing the NCS actually represented. They felt involved in something big and important, and constantly helping to break new ground. This was a feeling the divers shared with many other groups of offshore workers. While personnel on Ekofisk, Frigg and Statfjord moved from a turbulent development and running-in phase to a more stable production stage, however, the divers were constantly drawn towards new challenges. That was to some extent inherent in the nature of the technology. Where the challenges had been overcome, it was easier to replace human labour with robust, automated technical solutions. Operating at the limits of the possible was more dependent on specific adaptations, improvisation and ad hoc solutions – in other words, jobs which were performed most efficiently with human hands. The divers were accordingly required to carry out increasingly complex assignments in ever deeper water, until the depth no longer acceptable for people was reached.

Even though everyone who worked in one way or another with the early diving operations on the NCS shares a pride in having been involved in moving boundaries, however, the Norwegian divers found themselves in positions which pulled them in different directions. A number moved fairly early on into senior posts in the diving companies, not only as diving superintendents but also in key management posts on land. Some divers climbed the full career ladder, from the naval diving course and a job as a "rank and file" offshore diver to senior posts in oil companies such as Statoil and Norsk Hydro. Others exploited their experience to build up their own Norwegian diving companies in fierce competition with their foreign counterparts. A few secured jobs related to the research work conducted at the Norwegian Underwater Institute (NUI). And diving was a brief experience for many, before they moved on to completely different work.

The great majority remained ordinary working divers. But this group also breaks down into a number of sub-categories. The one which has left the largest number of traces in the form of written documents comprised those divers who worked for Norwegian companies. Their working conditions were relatively regulated. They were permanently employed. At least as many worked for diving contractors registered outside Norway, with considerably worse terms of employment. A third sub-category worked either for small companies or for no company at all. They were hired on short-term contracts when required.

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The Norwegian sector of the North Sea presented the world's toughest diving conditions. High waves were frequently encountered both summer and winter.
Photo: Norwegian Petroleum Museum

That the divers ended up choosing differing career paths was no different from what happens in any industry. The mechanisms which came into play were probably the same as those found elsewhere in society. It appears that those who had a theoretical education of one kind or another often ended up in management jobs. That was naturally a question of ability, interests and drive. But it is also clear that the firstcomers had advantages over later arrivals, a phenomenon which seems to characterise many new, strongly expanding industries. A "pioneer factor" of that kind was evident in the Norwegian oil industry among certain civil servants, the original drill floor personnel on *Ocean Viking* and *Ocean Traveler* and the initial employees in Statoil. The first Norwegians to get a foot in the door remained overrepresented in senior jobs for many years.

The firstcomers

"Pioneer diver" is a term which has been applied to all those who worked under water from the late 1960s until well into the 1980s, when diving became more regulated.[15] No general agreement exists among the divers themselves over whether the years from the first exploration well in 1966 to the intensified drilling activity immediately after the Ekofisk discovery constitute a special period. The number of Norwegian divers was so small at the time that we can follow their careers on an individual basis.

Idar Johnsen, who was the first Norwegian diver alongside Odd Gåskjenn to get a job in the North Sea, came from Odda and had gone to sea at the age of 15 before learning to dive in the navy. Gåskjenn came from Tvedestrand, while Skjerven, the third Norwegian to join Ocean Systems, hailed from Vestfold. Johannes Straumøy, the first Norwegian diver in Comex, was from Herdla near Askøy outside Bergen and trained in the navy. After joining Comex, he was sent to Marseilles for a two-week course in deep diving.


Leif-Tore Skjerven and Gunnar Møllegaard were two of the pioneers in 3X. Photo: Leif-Tore Skjerven

Many chance events determined who ended up where in the little community of Norwegian North Sea divers. Straumøy, who was present at the Ekofisk discovery in 1969, left *Ocean Viking* even before this find had been made public. During the following years, he worked as a diver in Singapore before moving into a different field. Johnsen had been involved in the discussions on establishing 3X, but instead accepted an offer to work as a diver for a British company.[16] He stayed there for three years before deciding to quit, having already experienced many of the toughest sides of the diving profession. With a family waiting at home, he could no longer live with extremely long periods of work and what he regarded as unacceptable diving standards. He had suffered the bends several times. He got a job instead as a roughneck (drill floor worker) on one of the rigs where he had served as a diver, and rose rapidly through the ranks. In the late 1980s, Johnsen became head of Statoil's drilling department and led one of the company's international operations during the 1990s.

Gåskjenn, Gunnar Møllegaard and Skjerven, who created 3X as Norway's first diving company as early as 1968, went straight into the role usually called entrepreneurship by economic historians. Working on their own account meant they were freer than if they had climbed the career ladder in a foreign company. One of their motives was clearly financial. The Norwegian divers had found that, as apprentices, they earned a fraction of the money made by the Americans. British divers were also better paid initially than the Norwegians. By submitting a bill for work done, they escaped a pay system where social differentials between the various groups of divers played a role. That gave them an opportunity to earn more. But a condition of making anything at all was that the company got enough work. The trio hoped that forming the first Norwegian company would give them an edge. Everything ultimately depended on whether diving operations on the NCS would really take off. Nobody knew that with any certainty in 1968.

As it turned out, 3X won revenue-generating jobs soon after its creation. But these involved a simple type of diving compared with what was going on in the North Sea. The knowledge base of the little Norwegian company was small compared with Ocean Systems and Comex. After all, the Norwegian divers had hardly completed their first deep dives before starting up on their own account. The method adopted by the 3X founders to reduce the lead enjoyed by the foreign companies was the one which has almost always been used to disseminate technology. They identified the companies they thought had made the greatest progress, and sought to imitate them as best as they could. The story of how Skjerven and Gåskjenn "accidentally" came across the Comex diving bell and deck decompression chamber (DDC) on the quayside in Stavanger, whereupon Skjerven measured and Gåskjenn made notes, has found its place in Norway's industrial history.[17]

Well-executed lunacy

Although 3X never succeeded in becoming a genuine competitor to the most advanced foreign diving contractors, it was the Norwegian pioneer among the companies. Many of the divers who later played a key role in the development of Norwegian diving – whether as leading union officials, supervisors, company executives or diving managers in the oil companies – started precisely there. Albert Johnsen, who became a diving superintendent in Mobil and Statoil, Arne Jentoft, later a key official in the Norwegian Oil and Petrochemical Workers Union (Nopef), Rolf Guttorm Engebretsen of the North Sea Divers Alliance (NSDA) and Einar Wold Svendsen, who went to Statoil and the Norwegian Oil Industry Association (OFS), are just a few of the many divers with a background in 3X who later rose to prominence.

The sealer *Brandal* in its right element, before 3X installed diving equipment on board. Photo: Norwegian Petroleum Museum

The company was not alone in forging a tight-knit community. Together with Skjerven, Svendsen established a shop for diving equipment at Øvre Holmegate in downtown Stavanger. Hailing from Bergen, Svendsen had taken the navy's mine clearance course. The little shop became a place where divers dropped by for a chat in the mornings. A number of divers report that their interest in diving was aroused by studying the equipment on display in the window. Inside the shop, they received good advice about how to acquire the expertise needed to try their luck in the North Sea.

The story of how a small community of Norwegian divers sought on their own initiative to get to grips with the challenges posed by offshore diving provides a good insight into the culture which prevailed in this

Stavanger's diving equipment shop in Øvre Holmegate served for many years as a meeting place and office for the small Norwegian diving community.
Photo: Leif-Tore Skjerven

period. We have seen that marked differences exist in the way stories of hazardous dives are presented. Tales are told on the one hand of dives carried out in a pioneering spirit, where a Norwegian diving community struggled to master major new challenges under water in competition with foreign companies, and on the other the talk is of divers who felt pressured to undertake dangerous dives owing to the discipline in an established diving company.

A typical pioneering story is related by Skjerven in his article on *Dykking fra selfangerskuta* Brandal (Diving from the *Brandal* sealer)[18]. It deals with a diving job performed by 3X for Shell in the summer of 1972, which involved blasting free a wellhead on an abandoned duster (dry well) in 104 metres of water out on the Viking Bank. An old sealer was chartered by 3X for the job, with most of the equipment leased from Ocean Systems. This gear had been stored in Stavanger for a long time without much maintenance. When the little ship set sail, it was overloaded with equipment. A borrowed DDC was lashed down on the starboard side, with a diving bell stored in the hold on the way out. The gas mixture stood on the foredeck, while cases of explosives were positioned aft. Gåskjenn was the only diver on board who could claim some experience of deep diving. Two of the others, Albert Johnsen and Inge Eriksen, had just completed the helmet diving course at Haakonsvern.

Brandal was basically far too small to handle a three-tonne bell. Its hoisting gear was incapable of getting the bell back on board and connecting it to the DDC. The divers accordingly had to get in and out of the bell while it lay bobbing on the surface. Part of the operation was also performed with helmet diving equipment which was not fully run in. Decompression was based on estimates. The gas mix equipment was partly defective. The divers had to put up with a strong and nauseating smell of oil. There seemed almost no end to the problems. But the divers

The North Sea Exploration base at Strømsteinen in Stavanger, where Ocean Systems had its equipment depot in the early 1970s. Photo: Asse-Sandvik

always managed somehow or other to find a solution. The moral of the story emerges clearly at the end. The British diver who had loaned out the equipment from Ocean Systems was waiting for the Norwegians when *Brandal* returned to Stavanger:

> Winters stood on the quay at Strømsveien to take delivery of his equipment. He was astonished that both helmet and bell diving had been conducted in a depth of more than 100 metres with the gear on board. A touch of respect actually showed on his face. The lads in the industry knew very well what this had involved, and respected well-executed lunacy for what it was worth.[19]

There was no lack of willingness and courage in the little Norwegian diving community. People learned through trial and error. The overriding consideration for the first divers was to demonstrate that they could master the challenges, almost regardless of the cost. In Skjerven's story, no conflict of interest existed between Gåskjenn – who was both owner and operational diver – and the rank-and-file divers. This is in all probability an accurate portrayal. One of the newly qualified divers, Albert Johnsen, suffered a serious case of the bends as a result of the dive. He nevertheless confirms Skjerven's account of the pioneering spirit which prevailed.[20]

The *Brandal* story also confirms that 3X, four years after its foundation, was still a long way from being able to compete with the foreign diving contractors. Ocean Systems willingly lent its equipment because the little Norwegian company was regarded as a subcontractor. Right from the start, however, 3X knew more about one subject than any foreign company. With their background in the navy and experience from the domestic helmet diving community, its founders were better informed than its competitors about what was going on among Norwegian divers. During its early years, 3X functioned primarily as an agency for replacement workers, supplying labour to the experienced diving companies. The latter probably benefited most from this arrangement. They could get extra divers at times when the level of activity was particularly high. For its part, 3X gained access to expertise it could not possibly have developed on its own.

A new industry

Nevertheless, most of the Norwegian divers who joined 3X quickly ended up working for the foreign contractors operating on the NCS. Although their number rose substantially throughout the 1970s, Norway's divers remained a minority in the North Sea. The country quite simply

A Norwegian diving team in the Port of Rotterdam before a new assignment in the early 1970s. From right: Henning Christensen, Karl T Jørgensen, Kjell Lilledal, Roald Wigen, Anders Lindahl, Guttorm Engebretsen and two unknown people.
Photo: Leif-Tore Skjerven

lacked sufficient diving expertise to meet the growing demand generated by the explosive rise in activity. No exact statistics exist for the number of divers who worked on the NCS at any given time.[21] We have seen how the scale of diving in the first few years correlated directly with the pace of offshore drilling. The latter entered an intensive phase immediately after the Ekofisk discovery. For a start, Phillips initiated extensive drilling to prepare for production. At the same time, the general optimism gave other companies renewed faith in the opportunities on the NCS. The scope of diving expanded further when construction really got going on Ekofisk from 1973, and during the development of Frigg, Statfjord and Valhall. Activity reached a peak in the early 1980s.

Measured by diver numbers, developments were more or less as follows. Until 1969, there were seldom more than 20-30 divers working simultaneously on the NCS. Three-five of these were Norwegian. At that time, diving was confined almost exclusively to the summer season. Many of the relevant drilling rigs worked on both sides of the UK-Norwegian boundary in the North Sea. In 1970-73, we estimate that somewhere between 100-150 divers worked on the NCS. By then, the number of Norwegian divers had reached 20-30. Ocean Systems, which was diving from *Gulftide* and the *Glomar Grand Isle* rig in 1971, had about 20 divers at work on the NCS in that year. A report from the Norwegian Labour Inspection Authority (NLIA) on the background of these employees provides an interesting cross-section of the diver population at that time.[22] The British were clearly the largest group. However, some Americans, a Canadian and a Dutchman were also on board. Only three were from Norway. The report reveals, moreover, that the Norwegian divers not only had less diving experience but were also considerably younger than their foreign counterparts. Most of the latter had been diving for seven to 17 years, and were aged between 30 and 40. The three Norwegians were all in their mid-20s, with offshore work experience of six months, one year and four years respectively. All the divers had a background in naval diving. But the Norwegians differed from the others here as well. They had only a brief spell in the navy behind them, corresponding to their military service. Both the British and American divers had many years of naval experience, and had served as professionals.

A Norwegian official report from 1975 showed that 150-250 divers were involved in offshore-related activities.[23] Just under 800 people worked in the NCS diving industry in 1978, including roughly 550 as divers. The rest were assistants, surface personnel and so forth.[24] Norwegians numbered around 200 at that point. At peak, in the early 1980s, 700-800 divers were associated with the Norwegian oil industry. Norwegians accounted for about 300 of them at the time. With land-based personnel, the total workforce related to offshore diving in that period thereby exceeded 1 000 people. North Sea diving had become an industry.

Comex was clearly the largest diving contractor on the NCS for a long time. It established a Norwegian subsidiary in 1973. Ocean Systems cut back on the NCS as the 1970s progressed. On the other hand, US companies such as Taylor Diving and Oceaneering strengthened their position. Both had roots in the Gulf of Mexico's diving community and strong ties to the US Navy.[25] But the huge expansion in activity created space for even more. Companies such as K D Marine, Subsea Oil Services, C G Doris, Strongwork, Wharton Williams (2W) and Halliburton Sub Sea eventually became well known in the Norwegian diver community. The various companies often had complex histories. In some cases, they were spin-offs from other, larger companies. This could involve a small number of divers who quit and hired themselves out when the market peaked, as well as bigger splits where the aim was to establish a large pool of equipment in order to take on bigger assignments. During the 1980s and 1990s, the trend was in the other direction as former competitors joined forces to create larger entities.

A Norwegian company had to surmount many barriers to get established as a serious player competing for the biggest contracts. Comex and a number of the US companies had clear advantages in being able to exploit the knowledge base and research which had been developed in and around the French and American navies. Although the UK companies also recruited naval divers, they had less systematic links to government-funded underwater research by the military. As with their American and French counterparts, however, the British firms had enough expertise as well as the networks required to obtain and develop the necessary equipment. This was not merely a case of knowing about suitable decompression tables. Naval demand had prompted the development of a supplies industry with long experience of every aspect from building bells and chambers to a diver's personal gear. The whole diving community in these countries was far larger and had a much broader composition than in Norway.

An opportunity existed to buy a good deal of the expertise possessed by the foreign companies. But that called for more capital than little 3X initially possessed. After all, the company had been built up from scratch by practising divers, based in part on private loans. However, Norway's diving sector became better capitalised in 1973 when Norwegian shipowner Jacob Stolt-Nielsen established Seaway Diving in Haugesund, just up the coast from Stavanger. As early as 1974, Seaway could mobilise *Seaway Falcon* as a brand new DSV with a great deal of advanced equipment on board. The company expanded rapidly and soon became the biggest Norwegian diving company, typically enough with a number of divers who had worked for 3X as employees. Seaway had almost 200 personnel by the late 1970s.

3X also had to accept that significantly more capital was required to secure the equipment needed in order to take on larger and more long-term contracts. After a share issue, the three original owners were left holding 10 per cent of the stock. Norwegian shipowner and industrialist Fred Olsen became the new dominant owner. The company changed its name to Dolphin in 1975 and then to Subsea Dolphin after joining forces with an Aberdeen partner. The first pioneering era was over for the 3X founders. Power in the company shifted to Oslo and later to Aberdeen. The original trio found it difficult to adapt to the new structure. Gåskjenn left to start Scandive, which thereby became the third Norwegian diving company focused on offshore-related work. Møllegaard and Skjerven also departed soon afterwards.

Diver organisation

The pioneering days were far from over, even though the companies had become bigger and powerful capitalist interests outside the core diver community had acquired a more dominant position. Explosive growth primarily helped to make diving more complex. It became clear to a lot of the very first Norwegian divers, as well as to a majority of the many who followed them, that their profession placed them at the bottom of a hierarchy where they had little control over their everyday lives. An able diver could take the step up to being a diving supervisor. However, their continued climb up the career ladder had become very long, particularly for those with no theoretical education. Divers became wage slaves. Many were paid relatively well compared with other Norwegian skilled workers. But most had a working day characterised by great uncertainty. This was not just a matter of fearing that something might go wrong at work. Although demand for diving services was generally high, the seasonal nature of diving, short contracts and unclear terms of employment created insecurities about the individual's future. The new entrants were still young, but it was now becoming clear to a growing proportion of the divers that they had found their metier. That realisation changed the way they perceived their working day. Stories told by Norwegian divers from this period are coloured less by a sense of community and a pioneering spirit and more by dissatisfaction and underlying conflict. While that applied particularly to those who worked for the foreign companies, it also affected personnel at Norwegian-owned contractors.

The actual organisation of diving work on the NCS was relatively simple. Being tailored to the prevailing technological solutions, it varied little from company to company. A typical diving crew on a drilling rig with bell and DDC comprised five to seven men. In addition to two divers in the bell, a stand-by diver was available on the surface. Two men were also needed to pay out, keep untangled and haul in the umbilical. This was work which could be done both by experienced divers – including the stand-by man – and trainees. The immediate boss was the diving supervisor. While a dive was under way, his place was in the control room. He might also have a personal assistant who helped to check the instruments.[26]

It is difficult to find anything in other occupations corresponding to the special relationship between supervisor and divers involved in a complicated deep dive. A pilot at a busy airport may be equally dependent on receiving the right instructions from an air traffic controller to ensure that nothing goes wrong. However, the pilot has full control over their own aircraft and no need to deal with a traffic controller once on the ground. The diving supervisor's form of leadership differed greatly from the traditional foreman's role in a manufacturing company, whose most important functions were overall supervision and allocation of work. He performed a whole variety of management functions at one and the same time – while also doing a number of specific jobs.

The controls which a diving supervisor had to master became gradually more complicated. Photo: Geir Ivar Jørgensen

Through the radio link, he could give detailed instructions about how the underwater work should be done. As the technology progressed, he could follow the movements of the divers on camera and was responsible for controlling vital supplies of air/breathing gas and possibly hot water. He had to retain an overview of depth and time, and ensure that descent/ascent speeds, decompression halts and so forth were conducted in accordance with the relevant table. Since diving at such depths imposed big physical and mental burdens, the supervisor had to make assessments which involved acting simultaneously as both physician and psychologist. That applied when the diver was in the water, in the bell and in the DDC. From the control room, the supervisor also managed the surface part of the team – operating the winch, handling the umbilical, sending down and hauling up tools for the divers, and so forth.

Diving supervisor Geir Ivar Jørgensen was responsible for divers working under high pressure on the bed of the North Sea. His job demanded full concentration.
Photo: Geir Ivar Jørgensen

Next to God

The close control exercised by the supervisor did not mean that the diver functioned as a mere robot while operating under water. Even on routine dives, he had to make a number of independent assessments and choices. Versatile expertise and the ability to improvise were crucial for difficult jobs or in emergencies. This book is full of examples of that. Nevertheless, the diver was extremely dependent on the supervisor during a dive. "Next to God" is how they often describe the supervisor's position during this period.

The depiction of the supervisor as a godlike figure also reflects his sovereign right during the early years to determine who was hired. In some cases, the supervisor was involved in the appointment process on land, but most divers first met him offshore. This was the real hurdle. Many stories are told about divers sent ashore before they got a chance to dive because the supervisor did not like them. The other and crucial hurdle was naturally how far the diver measured up under water. As long as no form of regulation existed for the time divers could spend in the water, how many days they could work continuously and so forth, they were forced to comply with the supervisor's demands. Idar Johnsen recalls one occasion in the early 1970s when he came home on Christmas Day morning after 40 days offshore, only to be called out for another 40 days the same afternoon.[27] He knew that a refusal would make it much more difficult to find work later. That was what life was like for a lot of divers. And it stayed that way for many years.

In 3X, the original owners themselves went in and out of the diving supervisor role. When the company hired out divers to the foreign companies, including members of the top management, they all went offshore as rank-and-file divers at the bottom of the hierarchy. Some Norwegian divers got jobs as supervisors during the second half of the 1970s. Well into the 1980s, however, when the proportion of Norwegian divers had increased considerably, most of the supervisors were still Americans or Britons. A number of Norwegian divers recall how many of these could have an abrasive style with something of a military tone. However, most of the supervisors are described as able professionals.

The supervisor's powerful position in relation to the divers primarily reflected all the roles encompassed by the job. As long as no form of effective regulation existed, as long as divers had no educational institution other the navy to qualify competent personnel, and as long as so much responsibility and so many functions were embodied in a single job, the person who held that position was bound to possess great authority. He was also subject to strong pressures from above. Out on the drilling rigs, supervisors were subordinated to platform managers and oil company representatives pushing to get the work done. When a drilling operation was completed, a rig could not move on until the divers had done their work. This was expensive downtime for both oil company and drilling contractor. At the same time, the diving supervisor was responsible to the management of his company on land, which had contracts to fulfil.

Diving supervisors still play a very important role in all forms of commercial diving. But their autocratic position in the earliest years of diving on the NCS changed somewhat with the introduction of saturation diving from DSVs in the mid-1970s.[28] The diving teams on *Arctic Surveyor* and *Seaway Falcon* were more than twice as large as the ones on the drilling rigs. The supervisory functions became quite simply too numerous for one man to handle. A *diving superintendent* was introduced as the overall head of diving operations on board, handling all communication with the oil company, the drilling contractor and his own company's management on land. He also ensured that the necessary equipment was on board at all times. During particularly difficult operations, too, he could become specifically involved by communicating directly with divers under water. Management of the actual diving operation still lay with the supervisor, who had now been designated a *shift supervisor*. Since saturation diving was conducted around the clock, the usual practice was to have two shift supervisors on board. A number of the other functions performed by the surface crew had also acquired more technical titles, such as *life support technician* and *gas technician*.[29] At this stage, certain national differences emerged in the way training was conducted. The British and US contractors retained the arrangement with a personal *tender* – a trainee who acted by and large as a servant for a diver.

This new and more differentiated division of labour on the DSVs also changed the balance of power, and thereby the social relationships between divers. It was still the case that a diver had to be approved by a supervisor to retain his job. In the largest companies, however, recruitment and other personnel issues were primarily a matter for the diver on the one hand, and the superintendent and the land-based management on the other. In cases where a supervisor acted unreasonably, the diver had an opportunity to appeal to a higher authority. Moreover, circumstances could arise in which the operational part of the diving team – including the supervisor – had interests which conflicted with those of the superintendent or administration on land. It was no accident that divers first formed trade unions on the new DSVs.

Myths about the North Sea divers

North Sea divers were offshore workers. Collectively, the latter designation covers a broad range of trades, from catering personnel to drillers and process operators. But divers are regarded as a special group in Norway, and not only because of the attention paid to them by the Norwegian media in recent years. This difference dates right back to the pioneering years. North Sea divers have always had a special status in Norway, but one which has in many respects been contradictory.

A particular mythology has grown up in Stavanger and Haugesund about the way the first offshore workers flashed their money around in local restaurants and bars. That happened particularly in such bars as Dickens, Alliken (Kafe Alexanders) and Place Pigalle in Stavanger and Captains Cabin in Haugesund. Such stories are repeated again and again when people talk about the early years of the oil industry in Norway, and are naturally picked up by journalists and others who want to describe the period. The workers were regarded as tough types. They worked hard out to sea. They had earned a lot. During their time on land, they partied away their money. It was important to display their

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With another tour over, on the way into Stavanger and ready to go out on the town. Photo: Geir Ivar Jørgensen

affluence. A common symbol was an expensive Rolex watch, clearly visible on the wrist of a worker wearing a short-sleeved pullover or shirt. Many wore gold jewellery. On some occasions, people went out on the town with a big roll of bills in their pocket. These stories are told about both drillers and divers. But they relate almost entirely to the latter in Haugesund, which became a base for diving from the mid-1970s.

The story of the Rolex watch has a special background. These timepieces were a status symbol for millionaires, like a Rolls Royce. Ask a diver more than 30 years later, and you will not find many who personally wore a Rolex. But a lot did. The Rolex factory had collaborated with Comex in the 1960s to develop a model which was not only watertight but also functioned under high pressure at great depths. When the Rolex Submarine was ready for production in 1967, Comex received a number of them engraved with its name. These watches were handed out to a number of the divers it employed – including Norwegians.[30] Nevertheless, many divers can confirm that the stories of free-spending ways in the Dickens bar have a kernel of truth. "That's the way it was, I saw it with my own eyes," they say. Similarly, many Stavanger residents insist that they personally witnessed it. Young Stavanger men yet to finish higher education took notice when they met former classmates on the town who had dropped out of school early and who now sought to

Divers in front of the Dickens bar in Stavanger. Photo: Geir Ivar Jørgensen

show they were well-heeled. This does not need to have happened that often. Precisely because the experience was associated with the big new industry, however, it became highly significant.

If few divers will admit to walking around with expensive watches and the like, a considerable number concede that there was a lot of partying in the early years. Only a minority of the divers in the 1970s were more than 30 years old. Many had yet to start a family. That was why some ended up hanging around restaurants and bars near the bases during their free time. They could meet up there with British and American divers. Even in the first few years, however, many divers gave priority to getting home when they could. As the average age rose, the typical social pattern became similar to that of many groups of offshore workers – you met other divers during an intensive tour of duty, and usually returned to your home community when back on land. If there was anything special about divers in this respect, it was that they had an even more diverse geographical background than many other categories of offshore personnel.

Many divers prefer to emphasise long stays in Aberdeen or other places abroad when talking about the times they partied a lot.[31] The Norwegians were no different in that respect from their British counterparts. When you were waiting on work in foreign towns, living in a hotel without a social network in the rest of the community, you naturally gravitated to a pub or bar where you met other divers. British and US divers waiting in Norway similarly spent a considerable part of their free time in local bars. The difference was that far more British divers worked on the NCS than Norwegians did in UK waters. And the marked pay differential between Norwegian and foreign divers could also have social consequences. Many Norwegian divers who spent free time with their US and British counterparts report that it was difficult to keep up simply because they lacked the money.

Notions of offshore workers and divers wearing Rolexes at Dickens in Stavanger in the 1970s have become an image of times – like rock operas in the late 1950s and hippies in the 1960s. A closer look at such events often reveals, when all is said and done, that not many people participated in the incidents which have later become legendary. These have acquired a symbolic significance because they represented something new, which would become deeply significant in the future.

When the Rolex Submarine model was ready for production in 1967, Comex received a batch of these watches engraved with its name. They were distributed to a number of the company's divers, including Norwegians. Photo: Rolex

Pay

Many newspaper reports about diving in the 1970s focused precisely on diver pay.[32] These people had gained a reputation for high earnings. Those divers who chose to flaunt that in the form of status symbols helped to build up such perceptions, of course. For many reasons, it is difficult to reconstruct how much Norwegian divers earned in the 1970s. An article in the *Bergen Arbeiderblad* newspaper in 1975 claimed that a diver was typically paid NOK 7-8 000 per month.[33] That gave a basic annual pay of around NOK 100 000 for a diver who was in work throughout the year. Converted to a price index for 2008, that corresponded to around NOK 460 000. This was not dreadfully high, but seemed more to the people who read the newspaper story in 1975. Average pay in 1975 was NOK 56 000 per annum.[34] In other words, diver earnings were almost twice that.

In reality, diver earnings for the year could be both above and below this figure. Great variations existed from person to person. Only a minority of Norway's divers had a full-time job throughout the year. Even those who worked for a company could find themselves laid off in the winter season. No overall pay agreements had yet been negotiated for divers. On the other hand, many of them secured jobs abroad. Next to seafarers, no other occupational group in Norway worked in a greater variety of exotic locations. Mexico, Morocco, Italy, Mauritania, Algeria, the Persian Gulf – the list in the 1970s was a long one.

However, such foreign jobs were often small and brief. Norwegians became involved because the explosive growth in offshore diving had created an international shortage of experienced divers. A diver who worked year-round and obtained the saturation supplement could make well over NOK 100 000 per annum. A number of Norwegian divers working for foreign companies could also supplement their official wages with off-the-record payments. Divers recall arrangements giving up to NOK 3 500 in untaxed income.[35] This money could be collected in such places as New Jersey and brought back to Norway as cash in suitcases and pockets.

But the Norwegian divers naturally also assessed their pay in relation to what they knew the companies were willing to pay their foreign counterparts. Pay levels for American divers were already extremely high when North Sea diving began in the 1960s, primarily because there was a big shortage of people with experience in bell diving with helium. This type of expertise became particularly attractive in the USA after a number of oil installations in relatively deep water were destroyed by Hurricane Betsy, which ravaged the Gulf of Mexico in September 1965. The oil companies had also begun drilling in relatively deep water off Alaska. A diver could earn USD 3 750 per month there in 1965.[36] These were fantastic wages, even by American standards. At the time, it was the cost of a relatively expensive car. Three-four months would yield enough to buy a house. The first American divers in the North Sea are unlikely to have earned much less than they could get in Alaska. It would take a bit to tempt them from a booming market off California and in the Gulf of Mexico to the cold, rough North Sea. Straumøy earned NOK 2 500 per month when he joined *Ocean Viking* in 1968. His monthly pay then rose to USD 550 (about NOK 3 900),[37] which was very high by Norwegian standards in the late 1960s and far more than he had previously earned as a construction diver at Falken or Høvding Skipsopphugging. But it was also significantly less than the Americans received. The size of the supplement for diving in more than 80 feet of water gives an indication of the differential – an American diver received USD 1 per foot (about NOK 7), while the Norwegians got NOK 1 for the same distance.[38]

Diving remained a bottleneck for the oil industry in the 1970s. A growing group of more or less competent Norwegian divers helped to reduce the pay gap somewhat. Experienced Americans still led the pack, with considerably higher pay than they would get in the Gulf of Mexico. US diver Gerry Cronin, who worked on the NCS from the mid-1970s, notes that while the Americans could earn USD 60 per day in the USA at that time, the corresponding figure for the North Sea was USD 100.[39] In a 1975 newspaper report, 31-year-old diver Michael Marris said that he earned up to NOK 350 000 per year in the North Sea. That was three times as much as his Norwegian counterparts and more than six times greater than average pay in Norway. How could the differential have remained so big? Were American divers so much more able than the Norwegians?

In the mid-1970s, American and British divers with a naval background and many years of working on the bottom of the North Sea still generally possessed more expertise and experience that their Norwegian counterparts. Marris was trained in the US Navy and had worked for six years as a professional diver. As long as the majority of the diving contractors were US and British, those who spoke the language best had an advantage. Moreover, the diving industry was sufficiently small that a diver could benefit from knowing people in the company managements. Where the Norwegians were concerned, pay was a matter not only of what the companies were prepared to give but also what the divers were prepared to work for. As long as the Norwegian divers competed against each other, the companies were unwilling to pay more than they had to. This was precisely the circumstance that 3X and its Scandive successor exploited. When the foreign companies had too few personnel, they were willing to pay rates which corresponded to what an American diver might cost. That was enough for the Norwegian companies to make a solid profit while the divers were highly paid by Norwegian standards.

Norway's divers gained their best chance of catching up with US and British pay with the creation of Seaway. Ultra-modern equipment allowed it to become the first Norwegian company to win a long-term contract directly from an oil company. Since its management was Norwegian, operating with discriminatory pay levels was difficult – at least if these disadvantaged fellow nationals. Norwegian divers on Seaway's two DSVs were also able to secure big saturation supplements for the first time. Per Jacobsen, a former naval diver from Vestfold county, had a basic monthly pay of NOK 4 000 when he joined *Seaway Falcon* in 1975.[40] After a year, he was promoted to "leading diver" and his basic pay doubled. When the saturation supplements were fully adopted from 1977, he could earn NOK 198 000 per annum. That was almost three times the average annual wage in Norway. He earned no less than NOK 260 300 in 1979. Jacobsen joined 2W as a diving supervisor on Statfjord during the early 1980s. Since he no longer qualified for a saturation supplement, which totalled NOK 1 600 a day around 1980, his annual pay actually declined somewhat despite his promotion.

Norwegians and the other divers

No exact figures exist for the total number of dives conducted on the NCS, but the majority were clearly made by foreigners.[41] In addition to Americans, Britons and Frenchmen, the Norwegians regularly dived with Dutch, Italian, Swedish, Danish and Icelandic counterparts. Norway's offshore workforce in general had a similarly multinational composition until the end of the 1970s. It included skilled American and British workers with solid experience, who could be better paid than people from Norway, and low-cost unskilled labour on much worse terms than the Norwegians. A substantial part of the hook-up work on Ekofisk and Statfjord was carried out by Spanish-speakers on pay rates which lay far below what Norwegians got for the same work.[42] The Spanish proportion was reduced to almost zero overnight in 1978 when these workers secured Norwegian terms by going on strike. At that time, strong political demands were being made to "Norwegianise" the oil industry. Most of the foreign oil companies with operatorships on the NCS accordingly established Norwegian operating organisations. Drilling contractors and other parts of the supplies industry also implemented an extensive Norwegianisation of their workforces. However, the divers continued to form part of a broadly international pool of workers.

Many Norwegian divers report that they developed good relations with their counterparts from the US, the UK and elsewhere. A kind of diving community eventually developed, where you were a diver first and foremost and the most important consideration was your mastery of the profession. The nation you were from carried significantly less weight. But conflicts also occurred where nationality was an issue. Although the divers had much in common across their respective national affiliations, cultural differences did exist. The Norwegians found the Americans to be the most alien in this respect. While admiring US expertise, they could dislike the attitude of some American diving superintendents and get irritated about the big pay differentials. However, no particular "us and them" attitude appears to have developed as a source of conflict between Norwegians and Americans. Neither side saw the other as a threat. The high pay of Americans was, after all, a reflection of their preference for working in the Gulf of Mexico and off California.

To the extent that national groups formed, the conflicts lay between Norwegian and British divers. From the 1970s, the latter were by far the biggest group in all sectors of the North Sea where diving took place. However, the two sides learnt to respect each other's expertise, and relations were good in most day-to-day circumstances. Relationships between the two groups were affected for many years from the end of the 1970s by efforts to institute protectionist measures, which demanded greater use of local labour. While Norwegians generally earned less than Britons in the mid-1970s, pay rates began to equalise towards the end of that decade. That development partly reflected growing expertise – the group of experienced Norwegian divers expanded steadily. It was also a matter of economic trends. At one point, the number of divers and diving contractors was finally sufficient to satisfy demand. From then on, it only took a fluctuation in the level of exploration to create a surplus of divers. That became particularly difficult for the British divers, who were fearful of the consequences if they were una-

The American and British divers brought plenty of coarse expressions with them. These were not always seriously meant, but this diver has taken one of them literally. He remains anonymous.
Photo: Geir Ivar Jørgensen

ble to dive. While the UK experienced mass unemployment in the late 1970s and early 1980s, the economic position was far better in Norway.

Almost as many tales are told about the relations between Norwegian and British divers as there are people who did the diving. Most Norwegian divers can tell stories about both divers and diving supervisors who they liked a lot. One said that the conflicts could be at their worst during free time on land:

> It was OK when we were at work, and in the chamber. But fights could break out at the parties afterwards. The conflicts emerged then. A British supervisor told some Norwegians that he didn't like them ... he got beaten up.[43]

Another diver recalled what happened on occasions when the Norwegians were in the minority.

> You came out, after all, and were an unwanted Norwegian. You were a kind of pariah caste out there, and were picked on by both management and divers. Norwegian divers were picked on by everyone else. Our language was used against us ... The British were the worst – definitely. They were in the majority. When the British were in a minority, things went very well.[44]

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A third diver emphasised the good collaboration which developed between Norwegian and British divers on *Seaway Falcon*.

> A lot of differences existed to begin with. The British divers who remained on *Seaway Falcon* were fine types. They were able specialists and had in many ways the same attitudes as we did. Their attitude to the Norwegian system was actually positive.[45]

Care must be taken when generalising about relations between Norwegian and British divers based on retrospective reports. In so far as underlying animosities existed, these changed from period to period. As the examples quoted above also show, they could be experienced differently from diver to diver. Retrospective stories told by Norwegian divers may be coloured by the fact that British divers took over virtually all diving on the NCS from the 1990s. Episodes of fighting when out on the town do not need to have had anything to do with nationality and cultural differences. Divers who regarded diving as a temporary episode in their lives, and who lived in work camps or hotels far from home, occupied a very different social setting from those who returned to a family after an offshore tour and who regarded diving as a lifelong career.

Neither retrospective interviews nor contemporary journalistic accounts can provide an exact picture of the social life of divers. Nevertheless, a number of credible reports confirm that many divers did regard the extreme conditions in the North Sea as a temporary existence, where the aim was to earn as much as possible in the shortest possible time. US diver Marris, already cited above, told a journalist that he was thinking of retiring before the age of 35. Divers with such an attitude could be well aware that they were stretching the limits of what the tolerable. Many gave up almost all social life and sought to work as much as possible. The aim was to retire with solid savings. One British diver is said to have spent almost six months continuously in saturation.

> He was just skin and bone where he came out. His aim was to earn enough to buy a pub where he came from.[46]

Similar attitudes could also be found among Norwegian divers. Although pay rates were relatively high, only a handful achieved earnings which allowed them to retire after a few years. The same eventually applied to the British divers. Some were trapped in a position where they spent relatively freely during their time on land and felt they had to accept the conditions which prevailed in the diving business in order to maintain this level of consumption. Briton Philip Darcy provides an example of a diver who was clearly frustrated over his life but who nevertheless clung to the profession:

> I dive solely for money. I could never contemplate diving in my leisure time, and when I eventually stop diving professionally I'll never put on a breathing apparatus again.[47]

Darcy had nothing but contempt for the life he led on the platform, according to Norway's *A-magasinet* magazine:

> When on board he thinks exclusively of his free time on land – which he largely devotes to drinking fine whisky. Darcy got off to an unfortunate start. He came from the diver force in the British army and only had experience of air diving. The limit there is 60 metres. On his first day at work for a British contractor, he was literally sent to the bottom. Without knowing how to use gas mixture and only a brief verbal explanation of what goes on in a diving bell, he undertook a complicated bell dive in 160 metres. He was terrified, felt that every fibre in his body was stiff with fear, but managed both the job and the stresses and stayed in the business. For the money.[48]

Divers and the other offshore workers

The special background of the divers, with many of them having gone through a tough selection process in the navy and some able to flaunt money and status symbols on land, might suggest that they enjoyed a high status. The many newspaper reports on diving are clearly coloured by respect for the work they did. In the industrial society which gradually developed on the NCS, however, the reality was different. There the divers were almost at the bottom of the heap.

During the first exploration phase, as long as the diving spreads were placed out on the rigs, the divers were a physical part of the offshore work community. They flew to and from the rigs by helicopter along with all the others. But the diving companies were sub-contractors to the drilling contractors, who in turn delivered to the oil companies. Out on the rigs, the divers could wait for many days at a stretch with nothing to do. Even when they did work, the other offshore workers had no feel for what was going on. Darcy, who worked for Comex on the *Deep Sea Driller* rig, described the relationship with other offshore workers in *A-magasinet*:

> Social contact with the other crew on the platform is poor. The divers feel like outsiders, almost a pariah caste. The drilling crews, with 12-hour working days, look askance at the divers "who seldom do a stroke of work". For their part, the divers feel the dislike – and the contempt from the others.[49]

None of the divers on *Deep Sea Driller* were Norwegian. But many divers from Norway also confirm retrospectively that negative attitudes towards their profession existed among other offshore workers. "They could look down on us. If we occupied the front row in the cinema, people could express disgruntlement – those who 'didn't work' shouldn't take advantage of that to get the best seats."[50]

In the same way that they had to accept the worst seats in the cinema, the divers – as sub-contractors – had to rest content with the poorest quarters on the installations.

Many divers themselves cite the long periods of waiting offshore as one of the most frustrating aspects of their job in the early years. This changed significantly when the divers became involved in construction and most of the diving was transferred to large DSVs. These vessels, of course, could be quickly redeployed to wherever drivers were needed at any given time. But even on the DSVs, where diving was naturally the centre of attention all the time, the divers did not always feel that they were adequately valued. On the first DSVs, the divers always had to occupy cabins under the main deck.[51] Those above, which suffered much less noise, went to the seafarers.

Saturation diving also involved a lot of waiting. Those who had initially become divers from a sense of adventure and a desire for excitement increasingly experienced a different side of the job. In an interview with *Bergen Arbeiderblad* in 1975, Alf Schønhardt, Anton Smith, Bjørn-Aage Lassen and Ola Røseth observed that those who were driven by a desire for excitement were soon cured of that. "North Sea diving is hard work. Exciting perhaps for short periods. But also boring and monotonous. Think of all the time we spend in the decompression chamber. Day after day of doing nothing."[52]

Too much should not be read into the fact that a certain amount of carping occurred between divers and other groups of offshore workers. This was widespread between a great many of these groups during the 1970s.[53] Oil company employees could look down on contractor personnel. Certain process operatives regarded themselves not as offshore workers but as petroleum engineers, and were not happy to be lumped in with catering staff and the like. The oil sector was a new and expanding industry. Different groups defined their own position by setting boundaries with others. Similar antagonisms emerged during the growth of Norway's modern industrial society in the early 20th century.

A good deal of time could be spent waiting for special diving assignments or during exploration drilling. Conditions during such waits were seldom as attractive as this.
Photo: Torger Berge

The offshore workers who divers had the biggest dealings with were drilling personnel, and these two groups were also those who experienced the heaviest pressures at work. Once again, a large number of experienced Americans were responsible for most of the drilling in the early years. Drilling crews came from a part of the American workforce where trade unions and collective agreements and attitudes were virtually non-existent. This was a work culture remote from the regulated union-management-government collaboration which characterised Norwegian industry. The Norwegians who started at the bottom of the hierarchy had a tough fight to gain recognition. And, unlike diving, drilling was hard work virtually all the time. In circumstances where people felt under constant pressure from above, it could undoubtedly be tempting to carp about those beneath you in the hierarchy.

A lot changed, however, after the big wave of strikes which began at the very end of the 1970s and lasted well into the 1980s. Extensive union campaigns, where different groups supported each other, helped to create a stronger sense of solidarity between them. Many of these labour disputes were about pay, but by no means all. The first long sit-down strike on Ekofisk started after a British supervisor knocked down a Norwegian.[54] A fundamental change in the work culture of the foreign companies was the most important effect of the strikes. The latter were forced to adjust to the traditional collaborative regime which prevails in Norwegian working life. For their part, the offshore workers established themselves as a strong counterparty not only in top-level union-management negotiations but also locally out on the installations. A number of competing unions emerged. The largest were Nopef and the Federation of Oil Workers Trade Unions (OFS). Now the Norwegian Union of Energy Workers (Safe), the latter was originally independent and later joined the Confederation of Vocational Unions (YS). However, a common denominator for all the unions was the goal of organising all types of offshore workers.

When unrest among the offshore workforce first became really evident in the late 1970s, most diving activity had transferred to DSVs. Much of the physical contact with other groups of offshore workers was thereby coming to an end. Divers on a few of the DSVs still flew by helicopter with other offshore personnel to rigs and platforms. However, they were rapidly transferred to the DSVs via a basket. The biggest DSVs soon acquired their own helidecks. But the divers were by no means excluded from the general unrest among offshore workers on the NCS in the late 1970s.

Organising on *Seaway Falcon* and demands on the TV news

Only chance prevented a group of divers from being the first to stage an "illegal" (wildcat) strike on the NCS. A fax sent on 5 July 1977 from *Seaway Falcon* to Seaway's head office in Haugesund created a big stir.[55] All the company's divers offshore – 13 Norwegians and five Britons – had signed a declaration in which they called unanimously for a pay rise totalling 12 per cent. If the company refused to accede to this demand, the divers would down tools with effect from 12.00 on 7 July.[56] The 18 signatories had elected experienced diver Arne Jentoft as their spokesperson.

No strike occurred on *Seaway Falcon*. The management quickly realised that the divers were united and serious, and therefore opted to agree to the demand – initially by phone. But the divers insisted that the offer be put in writing, and this was done. The diving team on *Seaway Falcon* had presented a united front to the management and won. But they were aware of their vulnerability. They had put great emphasis on ensuring that a possible strike would happen before their replacements arrived on the DSV for a new tour. They knew that, if the initiative passed to divers who had not been geared up through discussions and

Dinner in the saturation habitat on *Semi II* on the Gyda field. From left: Max Osenan, Einar Andersen, Marvel Galloway, unknown and David Wound.
Photo: Einar Andersen

meetings in the febrile atmosphere on Ekofisk, they risked seeing their united front fall apart. Their demands were fronted by experienced and respected divers. It must have made an impression on the management ashore that the two Norwegian diving supervisors had signed along with the British divers.[57] At the same time, the activists had been in the diving business long enough to know that strike threats were not popular with the managements of the diving contractors, even when the company was Norwegian. Despite their success, they feared reprisals. So this action gave fresh impetus to a discussion which had been pursued between divers at regular intervals – the question of joining a trade union.

Although many of Norway's first North Sea divers devoted most of their energies to getting a Norwegian diving contractor up and running, they could not fail to observe that the Norwegian drilling crew on *Ocean Viking* and *Ocean Traveler* had joined the Norwegian Union of General Workers, which negotiated a pay deal with drilling contractor Odeco. Nor could the divers avoid noticing the considerable dissatisfaction which arose when the secretariat of the Norwegian Confederation of Trade Unions (LO) decided – against the wishes of its members offshore – that the Norwegian Seamen's Union should organise workers on the NCS. This played a part in the decision by the first operator employees at Phillips to establish a "house union" on Ekofisk – in line with practice in many US companies – rather than join the LO.

The question of unionising was also raised among the divers in the early 1970s. A couple of Comex divers had been members of the Norwegian Seamen's Union, but did not feel they received much support from it. Discussions among the Norwegian divers in 3X went so far that a meeting was called in 1973 at the Victoria Hotel in Stavanger.[58] Jentoft argued for a nationwide organisation and affiliation with the LO. However, a number of the divers had negative experience of the seamen's union and wanted, like the operator personnel on Ekofisk, to organise a house union. The meeting failed to reach any final conclusion, and the divers concerned were soon spread around the various diving contractors.

A new attempt to organise the 3X divers was made during the autumn of 1974.[59] At that point, the company had secured a substantial job related to construction of the concrete gravity base structure (GBS) for the Beryl A and Brent B platforms on the UKCS. This meant a concentration of divers in the same location. The prime mover on this occasion was Geir Jørgensen. There was never any question of affiliation with the LO. However, the divers progressed far enough to adopt a set of rules for a company union embracing everyone employed in 3X.[60] These gave great emphasis to measures for improving diver safety. Representatives of the union contacted the NLIA in the spring of 1975, which was working at the time to develop safety regulations. But this initiative soon collapsed.

Organisation of the *Seaway Falcon* divers began in a similar way. A company union was formed at the end of January 1977 among the Norwegian divers on the DSV. The divers held meetings after their shift ended, often in the mess. Among other actions, they elected a safety delegate – an important move for establishing some independence from the management. Mandated by the employees, the safety delegate could function as a union official. Discussions at several of the union's first meetings concentrated on working environment and safety-related problems.[61] In the spring of 1977, however, the main attention switched to various proposals from the management on holidays and pay. When the employees composed their first collective letter to the management, great emphasis was placed on avoiding an overly aggressive tone so that the management did not feel threatened and lost its room for manoeuvre in negotiations through an outright rejection.[62]

These cautious attempts to conduct talks with the management made no progress. When a pay increase which lay far below diver expectations was presented on a "take it or leave it" basis, emotions finally boiled over. By threatening a strike, the divers had adopted a confrontational approach. The risk was that management would later respond with reprisals. To defend their present victory, the divers needed more support than each other and the little union they had formed. One possibility was therefore to join the Ekofisk Committee, which organised operator employees in Phillips. Although originally a house union, this had acquired a more independent profile. However, the divers found that the operator employees had little interest in forming a united front with the divers.

The main proponent of getting in touch with the LO was once again Jentoft. Hailing from Bergen, he was a former naval diver and – like several of Seaway's most experienced personnel – had served with 3X. He had grown up in a family with close ties to the labour movement, so the LO seemed a natural option to him. The upshot was that he went ashore with a mandate to sign up everyone who had put their name to the threat of strike action with the LO. He went immediately to the LO office in Stavanger, which placed a call at once to the national secretariat in Oslo. A few minutes later, Lars A Myhre appeared. He had just been commissioned by the LO to form a separate union for offshore workers. The request from the divers was a little gift to the LO, which was struggling at the time to win support from workers on the NCS. When Nopef, the LO's offshore union, held its first national conference on the last weekend of October 1977, the divers were well represented. Their conditions also coloured press coverage of the conference. Jensen was interviewed by *Dagsrevyen*, the main TV news programme. Both he and Melvin Kvamme, a colleague from the same tour on *Seaway Falcon*, became members of the central committee.

To begin with, it was the divers involved in the little confrontation who joined Nopef. They were soon followed by the divers on the other tour. A number of the British divers also joined, along with a couple of divers from *Seaway Hawk* and *Seaway Eagle*. These were former supply ships which had been converted into small DSVs. Nopef thereby secured a solid foothold in the largest Norwegian-owned diving contractor.

Unionisation of the Seaway personnel was a breakthrough for the union movement among the divers in the sense that the latter had now secured a voice which could promote their interests more effectively with companies and government agencies. Although the dispute which had got the whole ball rolling was about pay, safety and working environment issues attracted the greatest attention during the period which followed. As we will see, the divers would continue to focus on safety-related issues. Where general union rights and safety were concerned, the unionised divers confined themselves to requests. Despite a contentious start, the divers remained the only occupational group on the NCS who did not back their demands with strike action. That was

Arne Jentoft played a crucial role when the divers on *Seaway Falcon* joined the Nopef union. He became known as a fearless spokesperson for the divers.
Photo: *Rogalands Avis*

not because the unionised divers were satisfied with their conditions. The option of downing tools was discussed on a number of occasions. But the prospects of winning a possible dispute depended to a great extent on the level of support from the membership.

After the breakthrough on *Seaway Falcon*, the diver activists in Nopef tried whatever they could to exploit their position in Seaway to recruit divers in other companies. Their success was minimal. Nopef had 97 diver members in 1981, all of whom worked for Seaway.[63] Although four years had passed since the first divers were recruited, the union had failed to gain a single member in the other diving contractors. Two years later, the hub of the unionised divers remained Seaway.[64] Four members in Comex and four in 2W were far from enough to make specific demands on these companies. Nopef even failed to secure a proper foothold in Scandive and Subsea Dolphin, which had their origins in the Norwegian community.

A theory on divers and unionisation

Readers of *Bergen Arbeiderblad* were confronted in 1982 with the following broadside from union official Trygve Gulliksen in Seaway:

> Offshore personnel in general have taken their organisational traditions with them from land, have quickly established proper unions, and with them as instruments have secured acceptable work and pay conditions. The divers, on the other hand, are not a homogenous group but have come drifting in – some from the armed forces, some from abroad – and some or most of them are boys in search of adventure without an earlier professional background. This conglomerate of divergent interests, the conservative, egotistical attitude of the divers, and their lack of union awareness have always made union collaboration difficult – if not impossible.[65]

This article was an attempt to answer the question of why the divers had failed to achieve the same rights as other offshore workers. As can be seen, Gulliksen does not blame opposition from the diving contractors or lack of government support, but the divers themselves. His starting point is precisely whether there was something special about the divers and if so, what it comprised. The article is not only a possible theory about why divers had problems establishing strong unions, but also a presentation of diver culture – from a diver in the heat of battle. However, most of the points made can be countered with other arguments.

People with a union background from manufacturing undoubtedly played an important role when the offshore workers took action.[66] Between 1978 and 1984, their strike rate was 26 times higher than the average for other occupational categories in Norway.[67] Like the divers, however, many groups of offshore workers were both young and came to the industry without strong union traditions. That applied to personnel on the drilling rigs, who unionised as early as the 1960s – but who in many cases quit the LO when they were compulsorily transferred from the general workers to the seamen's union. The question then is why the divers did not follow suit when the other categories of offshore workers unionised?

Although it does not appear in print that often, Gulliksen is not the only observer to suggest that a background in the armed forces and what he calls "conservative, egotistical attitudes" may have influenced diver attitudes to unionisation. Between the lines, it is possible to discern a view that the basic ideological assumptions of the armed forces about obedience, discipline and commitment to King and Fatherland ran counter to the equally fundamental union assumption of a conflict of interests between employer and employee. But this again becomes a question of what came first. As mentioned above, divers were not the only group affected by an attitude of "every man for himself". During the first few years, that applied to every category of offshore worker. It is only by organising a majority of the workforce and establishing a strong collective stance towards the employers that a union can fundamentally alter relationships between colleagues.

The divers were indeed special in many respects. However, nothing about the group which worked on *Seaway Falcon* suggested that they would be more positive towards unionisation than other Norwegian divers. *Seaway Falcon* was the one of the most modern DSVs, with prospects for paying the best rates – at least for divers from Norway. Seaway could thereby attract the most experienced of these. That undoubtedly gave the divers a certain self-confidence when they decided to threaten a stoppage. This meant at the same time that the proportion of people with a naval diving background in the team on *Seaway Falcon* was larger than the average for Norwegian divers. Nothing indicates that such a background produced particularly conservative attitudes. In any event, these attitudes did not prevent the relevant divers from joining the LO.

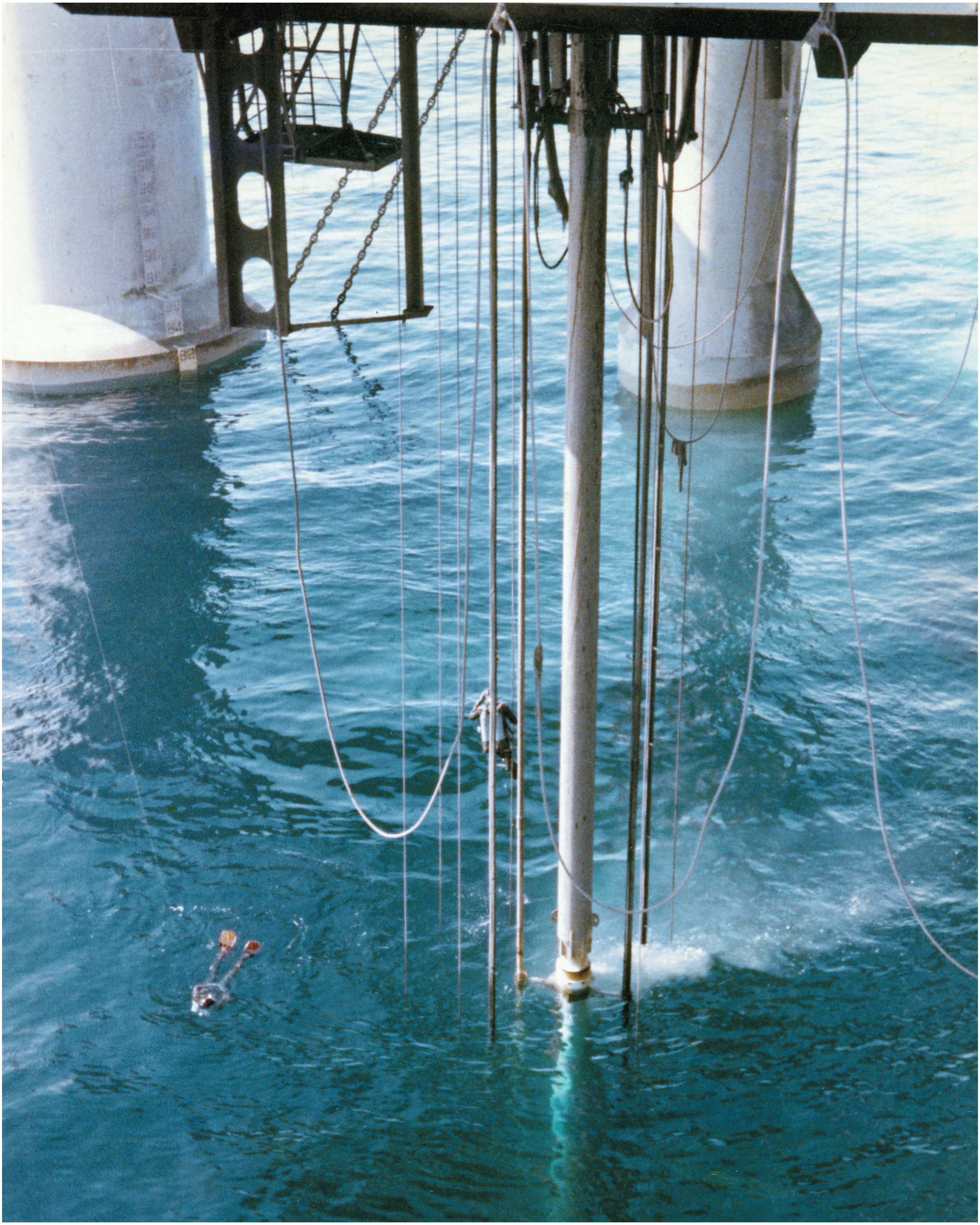
Nor did an affiliation with the navy, which was at least as strong for many US and British divers as it was in Norway, appear to have been crucial for the failure of these groups to establish strong unions. Swann describes how a number of attempts were made to unionise American divers. The Maritime Union came close to success in 1974.[68] At one point, a majority of divers in all the major diving contractors except Taylor Diving had petitioned for an internal vote on whether to unionise and demand collective pay agreements. The US system called for such signed petitions before a company could be unionised. Feeling themselves under threat, the diving companies hired a firm which specialised in union-busting. Tactics deployed included placing spies in the workplace. The union nevertheless succeeded in collecting signatures from more than 50 per cent of the divers in all 24 of the large diving contractors. After strong pressure from the management, however, the pro-union vote only achieved a majority in three of the biggest companies – S&H, McDermott and Ocean Systems. Although these were substantial enterprises, that was not enough for survival and the attempt at unionisation collapsed. Those divers who dared to declare personal membership of a trade union risked being fired.

The defeat of the unionised American divers also affected conditions on the NCS. Those US divers on the NCS who had been involved at one time or another in petitioning for union recognition at home were likely to be particularly reluctant to appear pro-union when operating under more uncertain terms in foreign waters. At the same time, the management and the supervisors, who had helped to win what one of the key leaders in the diving industry described as a "war", would be conscious of the need to counter similar attempts to unionise in other countries. If American unions had succeeded in organising the divers – something they came close to doing – both British and Norwegian divers would probably have unionised. It is worth noting that the American divers came closer to success in establishing strong unions than many other oil workers in a part of the USA where employer antipathy to such organisations was particularly strong.

As mentioned above, however, the union movement had success with other Norwegian offshore workers even though corresponding employee groups in the USA and to some extent in the UK failed to unionise. This may quite simply be down to a combination of individual efforts and chance. The small union protest action might not have led to membership of Nopef if Jentoft's father had not imprinted him with socialist ideas. Alternatives could have been that the divers failed to unionise at all, or joined one of the independent unions outside the LO. However, it is unlikely to be a coincidence that Seaway was where the divers unionised.

Unlike the exploration rigs, *Seaway Falcon* was a relatively large diver workplace. That made it easier for the divers there to define themselves as a group in relation to management. While discussions about strike action were under way out on the DSV, a substantial number of the divers were in saturation. The petition was passed to them in the chamber for their signatures. That would hardly have been possible if the relevant diving supervisors had not supported the protest. It is difficult to see how anyone could campaign against the wishes of the supervisors, given the dependent position people were in once they had entered a saturation spread. Unlike the other Norwegian diving contractors, Seaway had a long-term contract which involved year-round diving. Typically enough, the unionised divers had corresponding problems recruiting British divers on the converted supply ships *Seaway Hawk* and *Seaway Eagle*, even though these belonged to the same company.

As a group, the divers were in much better physical shape than the average Norwegian and the other groups of workers on the NCS. A substantial proportion of them had undergone a tough period of military training during an important period of their lives. In many cases, that may have contributed to a personal devotion to duty. But little suggests that their special background explains why the divers, unlike many other groups of Norwegian offshore workers, failed to establish a strong negotiating position versus the companies and the government. If divers as a group differed from other offshore workers, that seems primarily to reflect conditions external to the divers themselves. These relate to the work they did, the company structure they worked within, and the way the government got to grips with and regulated their complex working conditions.



Chapter 4

Accidents and regulations

Things went wrong several times on *Ocean Viking* in the spring of 1971, during preparations for test production on Ekofisk. A bolt failed just as a bell carrying two divers was being hoisted onto the deck.[1] The bell hit the water hard, but the divers incredibly enough escaped without serious physical injury. However, it took a long time to recover the bell and the lengthy period on the seabed meant that the divers had to spend a long time in the deck decompression chamber (DDC). But the accident had caused delays. The rig was about to leave the well. To avoid further hold-ups, Phillips asked diving contractor Comex to do the rest of the work with surface-oriented diving. So two men descended to a depth of about 70 metres without a bell, in normal frogman's gear. They could only stay down seven-eight minutes before having to ascend for decompression. The job remained unfinished. Another pair of divers was brought out at short notice. One was fetched from the Dickens bar in Stavanger, where divers and other offshore workers congregated at the time. The two – one Norwegian and one Briton – were sent down as soon as they arrived on the platform. Night had then fallen, and the water temperature was 5.9°C. After eight minutes on the bottom, they also had to decompress before they could leave the water. The ascent would take a total of 24 minutes with halts at 12 and then nine metres from the surface. Finally, they had to spend 12 minutes at three metres. However, the British diver went to the surface at once. He was feeling ill. His colleague, who was still at three metres, managed desperately to wave him back down again. After seven minutes, it was the Norwegian diver's turn to have problems. He was so chilled that he could not keep hold of the mouthpiece which supplied breathing gas to the two divers

A diver lies in the water, probably waiting to be retrieved. Another is being hoisted up in a basket. Such acrobatics in entering and leaving the workplace contravened the regulations, but continued to be practised until well into the 1970s.
Photo: Mike Lally

from the surface. He vomited and ascended to the surface five minutes too early. The British diver followed him up. The Norwegian was hoisted up first, but when the basket came down again for the Briton, he was dead and floating on his back. It was just after midnight on 9 March 1971. Attempts at resuscitation by *Ocean Viking*'s crew were unavailing.

Just a few months later, on 5 May 1971, the crew on *Ocean Viking* witnessed yet another tragic diving accident. A new suit and ventilation system were to be tested, a diving bell was sent to the bottom, and the diver left the bell. Nobody knows what happened then, but the diver clearly got too much air in his suit. Because the pressure steadily fell as he ascended, he rose faster and faster towards the surface like a balloon. The diving supervisor and the crew on deck tried to get hold of him with a basket, but to no avail. When the air was released, the diver sank like a stone. His body was found on the seabed beneath the rig the day after.

Dreams and reality under water

The accidents on *Ocean Viking* served as a concrete reminder that Norway's oil adventure would come at a price. Nevertheless, several years were to pass before society seriously woke up to this reality, at least where diving was concerned. The deaths warranted only brief mentions in the Norwegian press.[2] *Stavanger Aftenblad* was the only daily newspaper to devote some space to the first accident.[3] But even it, the largest paper in the new oil region, confined the second fatality to a brief single-column report.[4] The spirit of the times was coloured by dreams of all the benefits oil would bring. Cartoons of ordinary Norwegians dressed as rich oil sheikhs were carried in the media. At the same time, great political tensions prevailed. The non-socialist coalition headed by Per Borten resigned at the beginning of 1971. On the weekend after the first diving death, Trygve Bratteli began to construct a minority Labour government. By the time the second fatality occurred, the country was clearly heading for a referendum on joining the European Community (EC). Much was talked about oil during the subsequent “EC struggle”. But the broader issues dominated. How was Norway to ensure national control of its oil resources when production from Ekofisk and possible other discoveries in the North Sea began? What was the country to do with its future oil billions?

On the same day that the newspapers wrote about the second diving death, it was reported that Phillips was completing the installation work which might permit test production to begin from Ekofisk that week. A further four weeks was to pass before the field started producing from the converted *Gulftide* drilling rig. This event was covered in detail on the TV news. Bratteli declared it was a historic day for Norway. He did not mention the divers in his speech. Somebody had undoubtedly told him about the deaths which had just occurred. A story has long circulated in the diving community that the prime minister had a short impromptu meeting immediately after the inauguration ceremony with a group of divers who were present.[5] In this conversation, he is alleged to have said that they did a job of inestimable importance for Norway. The divers took note of these words. But had the oil industry itself and society at large adopted the necessary precautions which would ensure that this work was done in an acceptable manner? How much danger could a person be asked to face in the hunt for valuable oil? Or were the two divers who died in the hectic final preparations for test production from *Gulftide* to be regarded sacrifices – ones which nobody wanted, but which proved a price which had to be paid for venturing into the unknown?

A dangerous industry

People were well aware that this business could be dangerous. In 1966, when the Storting (parliament) was considering the royal decree which would serve in many respects as a "constitution" for the Norwegian oil industry, Edvard Hambro spelt out, as the rapporteur for the Conservative Party, the hazards involved in initiating oil activities in one of the world's roughest seas: "... one must not be too pessimistic or overdramatise, but we must be aware that accidents happen when drilling for oil and gas."[6] So it was no coincidence that safety occupied a central place in the Storting's sole – and very brief – political discussion ahead of the start to drilling on the NCS.

Hambro was to be proved right. The early years of Norway's oil history were coloured by many serious work accidents. Divers were not the only group affected. A month after the second diving fatality on *Ocean Viking*, a roughneck died on the same rig after several tonnes of equipment fell on him. The Ekofisk development alone yielded 45 registered deaths, including a helicopter crash which killed four people in 1973 and a fire with three dead two years later. However, most of the fatalities were work accidents – like the diver deaths on *Ocean Viking* – which only killed one person. Eighty-two people died up to 1978, when extensive work was also being done on Frigg and Statfjord. That was before the 1980 *Alexander L Kielland* disaster, when 123 people lost their lives. In retrospect, these accidents fall into a pattern which clearly indicates that extensive offshore operations had been launched in the North Sea without it being possible to deal with the associated safety challenges.

Divers were not the only group of offshore employees exposed to considerable risks in their daily work. The drillers on *Ocean Viking* experienced several serious accidents. Photo: *Stavanger Aftenblad*

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Divers were to remain over-represented in the accident statistics, even after the rest of the offshore industry became noticeably safer.

An obvious explanation for the large number of accidents and work-related injuries could be that diving was particularly hazardous. We have seen how the divers, compared with other groups of offshore workers, tended to be over-represented in jobs at the extreme limits of the technologically possible. At best, that explanation is inadequate. The potential for diving accidents was – and is – substantial. But the same holds true of other technologies, such as nuclear energy, rail transport and aviation, which nevertheless suffer fewer accidents. The question then is the extent to which companies, government and, of course, the divers themselves compensated for the risks by setting particularly stringent standards for the equipment, the way it was used and the conditions when dives could be made.

Diving regulation

The diving industry as such has always been concerned with safety, of course. Precisely because humans are not physically equipped to stay under water for long periods, this activity is in itself a matter of devising technical facilities and of training divers to handle techniques and procedures which minimise the risk. All basic diver training is thereby intrinsically safety education. At the same time, however, there seems to have been a tendency to introduce new hardware and methods with no reliable knowledge in advance about how they would affect safety and diver health. It also appears that new generations have started diving without any satisfactory training programmes in place. Moreover, the government was slow to establish effective regulatory systems for diving compared with many other industries and professions.

Although the use of diving for building quays, bridge foundations, dams and the like expanded greatly in Norway during the first decades after the Second World War, it took a long time for any form of regulation of this activity to emerge. As early as 1931, in the wake of a diving accident in the Hjelte Fjord, efforts were launched to develop regulations for diving. These proved fruitless.[7] Work resumed after a number of diving deaths during the war. At that time, draft regulations existed which called for a form of certification based on authorised training in diving work. However, these proposals remained on the shelf because no school of diving existed. Although Norway had 200-300 professional divers as early as the immediate post-war period, it remained the case in practice that anyone who wanted could undertake diving jobs.

Starting in the interwar years, the navy provided the only practical and theoretical education. Its diving regulations of 1915 were used as a

Hazardous work during the hectic development phase out in the North Sea some time in the mid-1970s – before an effective safety regime was established. All three people pictured are divers.
Photo: Børre Børretzen

"manual" by many divers right up to the end of the 1950s. These specified that a diver had to be able to swim and be "strongly built and appropriately sized for the regulation diving suits", and that divers should preferably be lean ("divers with a tendency to put on weight should be dismissed and must under no circumstances be used in greater depths").[8]

Torkell Tande from the Liberal Party asked during the Storting's question time in January 1959 why diving regulations had still not been put in place.[9] Andreas Cappelen, the local government minister of the day, replied that the relevant civil servants in the ministry had been occupied with other pressing work. In other words, diving did not have the highest priority. Nevertheless, the government adopted regulations for diving work with helmet and hose by royal decree two days later, on 30 January.[10] The text of the decree was very short. The age limits for commercial diving was set at 21-40, but with opportunities for exemptions. Furthermore, divers needed an approved licence issued by the Norwegian Labour Inspection Authority (NLIA). Apart from a requirement that a diver had to have a health certificate from a specially appointed doctor, the qualifications required to obtain a licence were not specified.

Diver training by the navy was significantly improved in the 1960s compared with the interwar years and the immediate postwar period. A number of private courses also existed. But no educational system was in place for the new challenges faced by divers in the North Sea.

A common feature of all the reports by Norwegian divers about their first encounter with working conditions offshore is that their existing training was inadequate, and that they needed in practice to be trained on the job. So it was an advantage for the first Norwegian North Sea divers that they met apparently experienced American and British counterparts. But too many of the Norwegians undoubtedly placed excessive reliance on their rather older British and American colleagues. As Jim Limbrick notes about his days in the UK's early offshore industry, no training for the type of diving done on the North Sea existed in Britain either.[11] "[W]e were inexperienced oilfield divers, but in the UK at that time there were no British oilfield divers, nor oilfield training to be had ..."[12] Christopher Swann, who details the meeting between the American divers and the North Sea, describes an industry and its practitioners similarly unprepared for the extreme challenges they faced.

Learning through trial and error and through social contacts between the divers was far from adequate in an industry which operated so close to the limits of the technologically feasible. During the 1960s and 1970s, the oil companies seldom interfered with the way diving contractors dealt with safety issues. The key questions when negotiating a contract were whether the company concerned could do the relevant job, at what price and – often most importantly – how quickly. This pressure on time found its best expression in the development of diving tables. The ability to perform an assignment depended in part on pure diving skills and the individual diver's ability to overcome all possible technical and practical challenges. But a crucial financial criterion for contractors competing with each other was how long they could allow a diver to work on the seabed and how much time he needed to decompress on the ascent.

The starting point for the diving contractors was the US Navy's diving tables. That was natural. These tables built on the most detailed research and the most extensive experience available there and then. But they were also based on military risk assessments and goals. For most naval divers, diving was primarily a way to travel from one place to another. The diving tables for deeper water were intended for possible evacuation from submarines in a crisis, not extensive subsea work over a number of years. Research done paid little attention to possible latent injuries caused by working under high pressure in deep water. The question was whether the same tables could be used by divers who dived day in and day out, some for a whole professional career. When the contractors eventually developed their own diving tables, the motive initially was not to identify the greatest safety margins. On the contrary, they were after the facts which allowed a dive to be completed as quickly as possible. The contractors also kept their tables secret from each other. Speedy ones were a competitive advantage. Since this was an expanding industry with a shortage of experienced divers, the contractors could be tempted to send novices down before they were adequately aware of the challenges they faced.

Green light for diving from *Ocean Traveler* and *Ocean Viking*

While motivated perhaps by curiosity rather than a sense of duty, there was certainly no shortage of interest among the Norwegian civil servants concerned with safety issues when *Ocean Traveler* first anchored in Stavanger during the summer of 1966. Certain American oilmen found their misgivings about Norway confirmed when representatives from no less than six government agencies – including the NLIA – arrived to inspect the rig.[13] The Norwegian inspectors drew up a list of 60 items which had to be improved before drilling could start.[14] None called for significant conversion work, but covered such points as improved radio communication, hand rails on dangerous companionways and "No smoking" signs in particularly vulnerable locations. The final item required that doors be fitted to the toilets. Most of these points were

Ragnar Winsnes was the principal person responsible for supervising diving at the Norwegian Labour Inspection Authority from the late 1960s until 1978. Educated as an engineer in Germany during the Second World War, he is said to have been part of the Norwegian XU intelligence organisation, which smuggled important technological information from Germany.
Photo: *Stavanger Aftenblad*

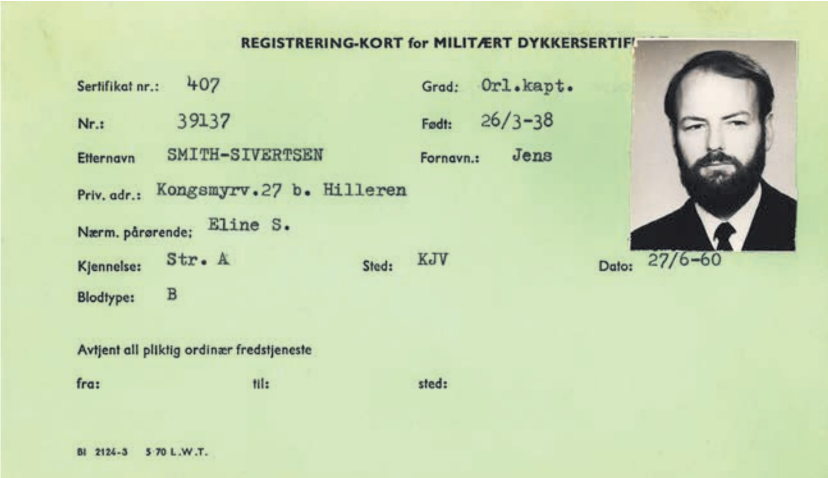
accepted by the company. Where the last item was concerned, it maintained that shower curtains were sufficient. Apart from a requirement for gas cylinders to be stored in an adequate manner on board, nothing on the list related to the rig's diving system.

On 1 July that year, however, the NLIA followed up with its own little inspection of Ocean Systems, which had the first diving contract on *Ocean Traveler*. This check was led by Ragnar Winsnes, who had studied engineering in Germany during the Second World War.[15] As an NLIA official, he had been responsible for professional inshore diving and had never dealt with the kind of diving which was now to be conducted in the North Sea.

The detailed report prepared by Winsnes after his meeting with Ocean Systems is coloured by the fact that the assignment in the new oil city of Stavanger had a certain exotic character.[16] The American diving experts clearly made a good impression on him. So did the equipment they could present. Dan Wilson, who headed the company's start-up on the NCS, emphasised that he would not leave Norway until he was certain that everything was going as it should. Lyle Kirling, his designated successor, would personally be taking part in the first dives before transferring to administrative duties. Wilson noted that Ocean Systems used the US Navy's diving tables, and also reported that it had improved these in certain areas on the basis of its own experience and research. Winsnes, whose only previous contacts had been with small Norwegian diving companies, was naturally impressed at meeting a contractor which conducted its own extensive research. "The preliminary report from this test dive runs to about 200 typewritten pages, which should provide an indication of the extensive scientific work carried out by the company to safeguard the divers in their work."[17]

Ocean Systems also explained that it was making provisions to use a number of Norwegian divers. Odd Berg from Nord-Norges Dykker- og Froskemannsservice was at the meeting and gave assurances that only divers trained by the navy would be employed. Wilson knew that the Norwegian divers would be under training for the first three-six months, working only as topside crew. Winsnes' conclusions were unreservedly positive:

> During my visit, I became fully confident that Messrs Wilson, Kirling, Gianotti and Berg had both the human and the technical knowledge required for this diving project. The equipment was designed by Ocean Systems itself, and seemed very solid and well conceived. It has also been tested in earlier dives. I have no safety-related concerns in connection with this project.[18]



REGISTRERING-KORT for MILITÆRT DYKKERSERTIF

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Nr.: 39137 Født: 26/3-38
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Priv. adr.: Kongsmyrv.27 b. Hilleren
Nærm. pårørende: Eline S.
Kjennelse: Str. A Sted: KJV Dato: 27/6-60
Blodtype: B

Avtjent all pliktig ordinær fredstjeneste
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Jens Smith-Sivertsen had recently been appointed medical officer for diving at the Haakonsvern naval base when he first became involved with this activity in the North Sea. He was long the Norwegian physician in whom the government placed the greatest reliance when questions were raised about diving health. He later became critical of the way companies and the government accepted an expansion in the limits of what was physically possible for a diver.
Source: Jens Smith-Sivertsen

The report from Winsnes was for internal use. In a letter to the Norwegian Petroleum Council in November that year, Esso noted that the company had gained the impression that Winsnes had given verbal approval of the relevant diving systems.[19] However, Esso lacked written evidence which could confirm this. The company wanted a minimum of Norwegian government interference in its operations. At the same time, it was worried that expensive safety-related requirements would be introduced at a later stage. It was accordingly necessary to get the government to confirm that they approved of the planned activities. Esso accordingly followed up by submitting copies of checklists and diving tables to be used by Ocean Systems.

In connection with a similar clearance of *Ocean Viking* that autumn, the NLIA was sent documents about the diving systems to be used by operator Phillips.[20] Diving from the rig was to be conducted by US contractor Sanford Brothers. Instead of assessing the information itself, the NLIA sent it to the naval diving and frogman school at Haakonsvern.[21] The case was given to Commander Jens Smith-Sivertsen, a young diving doctor. Since Norwegian knowledge of deep diving was so limited, it was entirely natural to draw on the navy's expertise. During the brief time he had been at Haakonsvern, Smith-Sivertsen had not only dealt with naval divers but also been used as an expert in serious cases of the bends among professional and recreational divers. Along with Winsnes, he was to be a recurring figure in government dealings related to North Sea diving during the years that followed.

The primary motive of the NLIA in sending the information to Haakonsvern on this occasion had been to obtain a medical assessment. Smith-Sivertsen's initial reaction was that it would be difficult to make any evaluation at all, since the material encompassed little more than a brief illustrated report and a list giving the background of the relevant divers. It contained no reference to safety regulations, plans for

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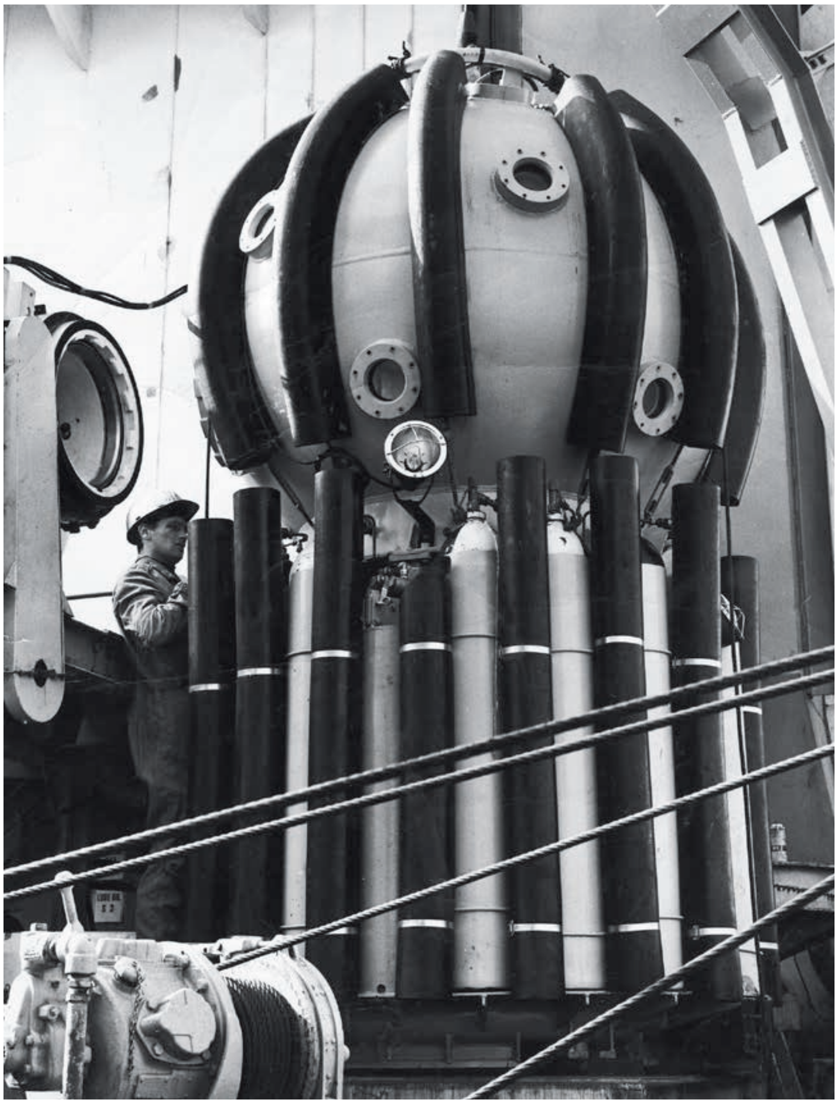
the actual diving or the decompression tables to be used. After obtaining more information and a conversation lasting two and a half hours at Bergen's Flesland airport with Jack Lahm, Sanford Brothers' representative in Norway, Smith-Sivertsen wrote a report for the ministry where, like Winsnes, he expressed a positive view of both the equipment and the planned diving.[22] He could note that he had seen a diving spread similar to the one which was now to be used during a visit to the US Navy a couple of years earlier. The US Navy diving tables used by Sanford Brothers were well known in the Norwegian navy, even though nobody actually had any experience with using them for hard work in deep water.

The correspondence on safety issues in connection with the start to diving on *Ocean Traveler* and *Ocean Viking* was clearly influenced by uncertainty over who had responsibility for what, and which legislation might apply. In its comment, the NLIA expressed reservations about whether Norway's Worker Protection Act also applied offshore. That question was never clarified. It was also unclear which government agency could issue approvals. The only area in which observations by the Norwegian authorities had any direct consequences for the first dives was the requirement for medical monitoring. A group of doctors was appointed under Smith-Sivertsen's leadership to approve divers for work offshore.[23] The companies followed up by hiring their own doctors.[24]

As long as no government agency intervened and declared that the planned diving was unacceptable, the companies could assume that they had the necessary approval. This meant in practice that the assessments made by Winsnes and Smith-Sivertsen were adopted. Neither of them possessed the necessary expertise to play that role at the time. But nor did anyone else in Norway. The need for more expertise on deep diving would be made clear a few months into *Ocean Viking*'s first drilling season.

Fatal "swell-up"

The 22-year-old British diver Roger John Lyons from Manchester was sent down to a depth of 67 metres from *Ocean Viking* on 3 October 1967, outfitted with helmet and hose but alone and without a bell.[25] He worked for Sanford Brothers. During the first stage of his ascent, Lyons told the surface team that he felt unwell. He allegedly reported that his condition improved somewhat on the way up. But something must have happened at some point or another. At an unknown depth, the diver "swelled up" and died as a result.



An Orion diving bell used by Ocean Systems, photographed in 1968. Mike Lally is on the left.
Photo: Mike Lally

This fatality was treated in the same way as other deaths at work in Norway by bringing in the police. The helmet equipment used during the dive was taken to Bergen. Because nobody was able to identify a fault, it was returned to the North Sea. Since no specific diving regulations existed, it was impossible to prove that the company or any individuals on board had done anything illegal. The only study which exists after the accident was carried out by Smith-Sivertsen. He knew that the victim had recently had a medical examination and accordingly concluded that the accident could not be health-related. The deceased was also regarded as an experienced diver. Smith-Sivertsen accordingly concluded that it was unlikely that Lyons had made a mistake, providing he was fully conscious, and speculated that the accident could have happened because a toxic gas mixture in the suit had been circulated. He referred to a case in Sweden where this had occurred.

A diver descending in a basket, with Frigg fully developed in the background. This means that the operation depicted here contravened the requirement that diving should use a bell when it was conducted from a "standing position" more than three metres above the sea surface.
Photo: Børre Børretzen

While Smith-Sivertsen's assessments appear sincere, he represents a problematic source in this case since he had vouched for both the equipment and Sanford Brothers' diving expertise only a few months earlier. When his study concluded that the dive, as conducted on the day of the accident, "cannot be characterised as directly unacceptable", he vouched once again for the company. According to Smith-Sivertsen, it was only beyond 200 feet (66 metres) that the depth alone called for the use of a diving bell.[26] Yet he notes that the accident could have been avoided if the dive had been conducted with a bell. Knowing the requirements subsequently established for diving safety and the sources available after the accident leaves one with more questions than answers.[27] *Ocean Viking* had a bell and a modern deck decompression chamber (DDC) on board. Why was this equipment not used for diving to 67 metres? Why was Lyons diving alone? Sanford Brothers must have been aware of the element of risk in such an operation in the North Sea.

Although Smith-Sivertsen neither referred to weaknesses in the equipment nor pointed to errors in the behaviour of the victim or the company, however, he said something indirectly about these aspects through a proposal for improvements in the wake of the accident. In his view, "the use of diving bell should become mandatory for safety reasons when diving in the open sea from a standing position which lies more than three metres above the surface of the sea when the dive requires decompression halts".[28] This recommendation was accepted by the Ministry of Industry. In a circular to all the oil companies operating on the NCS, it was repeated word for word but formulated as an order.[29]

The diving section

Although Hambro placed great emphasis on the many dangers which could arise in connection with offshore operations in the North Sea, he could reassure the Storting during its consideration of the oil issue in 1966 that the petroleum council under chair Jens Evensen was developing safety regulations.[30] On 25 August 1967, well into the second exploration season, an apparently detailed set of regulations was adopted as a royal decree.[31] When the *Ocean Viking* accident occurred five weeks later, an English translation of this code had still not been sent to the companies in printed form. But the oil companies, which had been actively involved in shaping the rules through their North Sea Operators Committee - Norway (NSOCN), knew what would be coming.

The oil companies had basically wanted an arrangement similar to the one adopted in the UK, where they were responsible for developing safety guidelines themselves through the Institute of Petroleum. However, Evensen insisted that Norway had to have official regulations. The companies were nevertheless satisfied with the Norwegian regime because it differed little in practice from that in the UK. L J Loeffler from Esso, who headed the company's lobbying ahead of the royal decree, took a sceptical view of government involvement in safety issues.[32] That was clearly demonstrated when the diving accident on *Ocean Viking* was discussed at a meeting of the NSOCN in November 1967.[33] Loeffler maintained that a competent commission of inquiry, with oil company representation, would come up with proposals "much more quickly, with significantly less publicity, at far lower cost" and with "exactly the same improvements" as the type of study conducted on behalf of the Norwegian government. However, he was corrected here by a Shell representative, who pointed out that most other countries would have conducted their own investigations in the event of serious accidents involving fatalities. A Phillips representative followed up by pointing out that the police investigation had been conducted fairly efficiently, without many formalities.

Norway's new offshore regulations differed from the UK regime particularly in their requirements for the maritime side of operating drilling rigs. The rest of the code was full of references to "best industry practice".[34] This formulation was not found in any other similar Norwegian regulations at the time. Diving was mentioned in just one section, number 123, which read as follows:

> The ministry or whom it may authorise must be presented in advance with a plan for approval concerning the way the diving is to be performed [and] which equipment is to be used, including the safety measures which will be adopted to protect the life and health of the divers. If the person who is to do the diving does not possess an approved diver certificate, consent must be obtained from the ministry or whom it may authorise before diving can begin. Diving work must be conducted in an acceptable manner and in accordance with the regulations applicable at any given time.[35]

This section was little more than a confirmation of the practice which had been established with regard to Ocean Systems and Sanford Brothers. In any event, the section would have no relevance unless separate diver regulations were adopted.

Foot-dragging follow-up

The letter from the Ministry of Industry which required the companies to use a diving bell "when diving in the open sea from a standing position which lies more than three metres above the surface of the sea" was in line with the diving section, even if it was not formulated as a regulation. Since the decks of the rigs which operated in the North Sea were far more than three metres above the sea surface, the letter could be interpreted to mean that a bell was mandatory for most types of relevant oil-related diving. Such an interpretation would represent a substantial intervention in diving contractor practice. However, the requirement was unclear because it did not mention any specific diving depth. It was also possible to avoid this provision by conducting deep diving without a bell from smaller craft. No amplification was subsequently provided about the meaning of the terminology in the letter. Nor did any government agency exist to check compliance in practice.

Safety follow-up for divers suffered the same fate as in other parts of the offshore sector. A number of government agencies took action on their own account right at the start. Once initial regulations were in place, however, the companies were left to themselves for a long time. To avoid the slightly chaotic conditions experienced when *Ocean Traveler* arrived, with a number of agencies virtually treading on each other's toes, the job of following up the regulations was assigned to the industry ministry's oil department. This small team had more than enough to do in dealing with more general issues of petroleum policy, and had virtually no resources to monitor what was going on out in the North Sea. The department could naturally draw on other relevant institutions, such as the NLIA, but the latter did not acquire any formal responsibility for following up North Sea diving until July 1969.[36]

Between the ministry's letter after the 1967 accident and the fatalities in 1971, the authorities conducted virtually no specific follow-up of diving. Nothing was done to develop concrete safety regulations. The fairly informal "approval" of the diving contractors and their equipment on *Ocean Traveler* and *Ocean Viking* by Winsnes and Smith-Sivertsen was not followed up in any way when the diving was under way.[37] In May 1968, the industry ministry did ask Smith-Sivertsen to inspect diving operations on *Ocean Viking* and *Orion*, which were drilling at the time for Phillips and Shell respectively.[38] However, Smith-Sivertsen cannot remember whether he carried out such an inspection.[39]

Asking him to carry out the inspection, rather than the NLIA, could reflect the industry ministry's opposition to extending the Worker Protection Act to the NCS. The NLIA, after all, had long experience of inspecting workplaces. Even though the diving contractors were not followed up after the initial approval, however, the first contacts did contribute to some build-up of relevant expertise on North Sea activities. Quite specifically, this meant that Winsnes gradually began to look at problems associated with more advanced diving operations in deeper water. Towards the end of the 1960s, he contacted a number of international deep-diving experts.[40] He also established some degree of contact with Smith-Sivertsen and others from the diving community at Haakonsvern.

This small group of Norwegian civil servants soon began to pose questions about the diving tables which the contractors brought with them. They wanted to know how the tables used would affect the divers under the special conditions prevailing in the North Sea. Reports they received supported a general perception that tables which called for longer decompression were generally better for diver health.[41] The impression given to Winsnes at his first meeting with Ocean Systems that the latter opted for safer tables than the US Navy did not entirely reflect the reality. The problem was that the companies actually tended to do the opposite. While they were both on a visit to Stockholm in January 1968, Winsnes and Smith-Sivertsen accordingly discussed the possibility of adjusting the tables for dives below 40 metres.[42] The matter was taken no further. The little Norwegian community was still nowhere near competent enough to propose alternative diving tables. However, the pair had raised an issue which was to dog Norwegian diving for several decades. It was only after the fatalities on Ekofisk in 1971 that the Norwegian government again got to grips with the challenges presented by North Sea diving.

After *Ocean Viking* in 1971

On 26 March 1971, little more than a fortnight after the first of the fatal diving accidents on *Ocean Viking*, the Directorate of Labour issued a circular to all the diving contractors operating on the NCS.[43] This referred to the order issued in the wake of the 1967 accident, and listed a number of new provisions.[44] Given the course of events during the accident, it was appropriate to issue a reminder about the requirement to use a diving bell imposed by the industry ministry on 11 January 1968. The demand that such equipment should be used for dives requiring decompression stops when diving from more than three metres above the surface, was – if possible – even more relevant for Comex working on Ekofisk at night in cold and turbulent seas than it had been for Ocean Systems on block 16/2 in October 1967. By sending four divers in scuba gear to a depth of 73 metres, with subsequent decompression stops, Comex had breached the 1968 provision. First came the problems posed by decompression in cold water. Second, the course of the accident had been marked by difficulties in servicing the two divers from the rig. In high seas, it was impossible to ensure that the divers were at the right depth during the uppermost decompression stops. The divers had to be hoisted up to the 11-metre-high rig deck by clinging to a kind of seat formed from a metal plate. That could in itself have contributed to the tragic outcome, since Mike Lally was alive when the first diver was being hauled up. In the wake of the accident, Winsnes discussed the problems of diving without a bell from the rig in the difficult conditions with representatives from Comex.[45]

However, he did not point out that the company had breached the applicable regulations before the accident, nor did others from the NLIA and the police.

The 1968 provision may have been unknown to Comex, which began diving on the NCS a little later than Ocean Systems. Since the industry ministry's circular was sent to the operators, the latter had a responsibility for passing it on. Possible unfamiliarity with the applicable regulations by Comex may also reflect the minimal follow-up received by the company from the NLIA and the industry ministry's oil department. That could be why the NLIA contented itself after the accident with referring to the 1968 provision instead of pointing out that it had been breached.

Once again, the provisions in the NLIA's 1971 circular did not represent an attempt to lay the basis for new diving regulations. They were an immediate response, clearly marked by a desire to indicate a willingness to act in the wake of a tragic accident. For precisely that reason, they can be read as an expression of what were perceived as significant factors which contributed to the accident. "Dives are not to be performed if the equipment is not in [a] satisfactory state",[46] one of the new provision specified. When a bolt could break so that a diving bell fell into the water with two divers inside, something was fundamentally wrong with the equipment. It was also unsatisfactory that the divers had to accept breathing air from hoses hanging down from the surface at their final decompression stage. Most of the 10 requirements concerned criteria to determine whether an individual diver should not dive for health reasons. These included the diver feeling unwell or suffering from seasickness, being under the influence of medicines or alcohol, or failing to eat enough.

These conditions were definitely relevant for the accident in question. Bjørn Lilleland, the Norwegian diver who participated in the fateful dive, reports:

> We were off duty in Stavanger when a message arrived that *Ocean Viking* had an acute need for divers. The bell had been damaged. Two French divers had carried out a dive in frogman's gear to 70 metres, but had not managed to complete the job. Mike [Lally] was fetched from a bar. Both of us were flown straight out. We didn't want to be worse than the Frenchmen, so we agreed. You didn't say no when you'd first been asked. Otherwise you ran the risk that there wouldn't be a second time. Mike was in such bad shape that he threw up just before he was due to descend. Everyone saw him. It was a cold dive. As 4.5-millimetre-thick wetsuit feels like newspaper 70 metres down. We had a helium mixture on our backs. During decompression, we breathed air from something most like a garden hose which hung down from the rig. My lips eventually became so numb that I ended up swallowing large quantities of seawater. With three-metre-high waves which pulled us up and down in the water during decompression, I became so seasick that I couldn't manage any more. I could barely grip the metal bar when I was hoisted up in the chair.[47]

Testimony from many divers who worked on the NCS in the 1970s confirms that they carried out very risky dives, partly from youthful determination and partly because of direct and indirect pressure from their supervisors. Regulations circulated by the NLIA were unlikely in themselves to produce any significant change in this. They contained, for example, no specification of how to establish that the diver's medical condition was satisfactory. Was this the diving contractor's responsibility? Should the responsibility be vested in the supervising medical personnel? If it was up to the diver, how should one ensure that the diver felt able to refuse a job without running the risk of being fired?

Requirements for a medical examination of divers became an issue in the wake of the *Ocean Viking* deaths. Immediately after the first accident, diving doctor Hans Benestad pointed out in a letter to the NLIA that the examinations of foreign North Sea divers he carried out regularly were far more extensive than those which qualified a Norwegian to dive.[48] According to a form from the NLIA, the requirements set for Norwegian divers were the same for all forms of diving. Benestad maintained that special standards should apply to deep diving. Smith-Sivertsen responded that he agreed with the call for a more extensive examination of deepwater divers.[49] At the same time, however, he expressed doubts over whether more examinations would reduce the number of accidents:

> I believe the benefit of making a big commitment to a broad medical examination of divers is limited to allowing the doctor to say with a better conscience that 'he, at least, did his best' to ensure that the diver did not have an accident. It seems far more important to me that the number of doctors approved to examine divers is reduced and that stricter requirements are set for such approval ... Preventing diving accidents is a very complex issue, where medical examinations of the diver play only a small part.[50]

Smith-Sivertsen had been a member of a medical commission which had considered the criteria for selecting diving doctors.[51] On the basis of its report, a scheme was introduce on 1 January 1972 which set stricter requirements for doctors entitled to issue medical certificates for divers.[52] However, the same scheme still applied to all forms of professional diving.

Another issue raised in the wake of the Ekofisk deaths was working hours for divers. In a letter to the industry ministry, the NLIA noted that it was unfortunate that these were unregulated. "Long continuous residence on the rig, with the limited mobility and closed community on board, is likely to have an unfavourable effect on the physical and mental condition of the divers."[53] The NLIA proposed that the same working time be set for divers as for other personnel on the rigs. The industry ministry responded swiftly. With direct reference to the two accidents, it specified that no diver could spend longer than one week on a rig.[54] Each week on board was to be followed by a week off on land.

The NLIA's tougher requirements for doctors issuing medical certificates for divers and the working time provisions were clear signs of a greater willingness to get to grips with the diving issue. But the first proposal to create comprehensive diving regulations came from neither the Norwegian diving community nor the NLIA, but from the UK.

John Prescott visits Oslo

During a visit to Oslo in the summer of 1971, young Labour MP John Prescott took the initiative for a meeting with Winsnes at the NLIA. He had worked on maritime safety regulations for Britain's National Union of Seamen before being elected to Parliament in 1970 (and later became a long-serving and controversial deputy prime minister to Tony Blair).[55] Prescott proposed that the UK and Norway should try to develop a common regulatory regime for North Sea diving.[56]

Winsnes was immediately positive to this suggestion. Although the grounds for it appeared sensible, however, it represented an unusual approach. No corresponding case existed of safety regulation for a Norwegian industry being initiated by the development of a joint international regime. Given that both the deceased on Ekofisk were British, as were a majority of divers on the NCS, it was not unnatural for a UK MP to be concerned with safety in these waters. There was every reason to suppose that diving would expand substantially with the major development plans for Ekofisk. Prescott was obviously genuinely interested in the divers' case. He handed over a report from Britain's Commander M B F Ranken, who had written immediately before the Ekofisk deaths that, without an improvement in safety, it was only a matter of time before serious tragedies occurred.[57] The report pointed out that diving was considered by some to be the world's most dangerous profession, and concluded that international safety regulations were required.


As a young Labour politician in the UK, John Prescott worked for the creation of a joint UK-Norwegian safety regime for diving. He later gained fame as a long-standing and controversial deputy prime minister to Tony Blair. Photo: Scanpix

But financial considerations could also have been behind Prescott's approach. He noted at his meeting with Winsnes that, since diving equipment was expensive, it would be unreasonable to require contractors to keep different sets of gear depending on whose waters they were in. Diving had become a substantial industry in the UK during the early 1970s, and the anticipated growth in activity on the NCS offered a major potential market. It would be an advantage for British companies if Norway could be persuaded not to establish distinctive rules which called for different technical solutions than those in the UK.

Prescott's meeting with Winsnes was private in the sense that the MP had no open, formal assignment on behalf of the government. The Conservatives had come to power the year before. But it was not unusual for Labour politicians to conduct industrial policy both privately and in more coordinated forms, even when the party was in opposition. In any event, Prescott had enough connections with the Department of Trade and Industry to be welcomed when he got in touch during the autumn of 1971. At that time, the British had already appointed a group to work on proposals for diving regulations. They took a positive view of modifying these rules so that they could also be applied in Norway. The British group circulated a draft from the end of February, and this also formed the basis for discussions in Norway.[58] A series of meetings was held in the spring and summer of 1972, many of them in Stavanger's Atlantic Hotel.[59] Representatives from the British and Norwegian industry ministries held a joint meeting in Oslo during June, where agreement on the existing draft was so great that both sides felt they had clarified most of the problematic issues of principle.[60] But the work ceased completely in the autumn of 1972.[61] When it resumed in the UK two years later, all plans for a shared regime with Norway had been dropped.

Winsnes and the diving company objections

Anyone who has been involved in developing regulations knows that this can be a very complicated process. First, it involves bureaucratic and legal aspects in the sense that new rules must be adapted to all other existing legislation and statutory regulations in a society. Looking just at safety, the legislative framework in Norway alone offers differing approaches and traditions which have big consequences for the way statutes and regulations are drafted. The NLIA, rooted in the Worker Protection Act, and the shipping industry with the Norwegian Maritime Directorate (NMD) and private classification society DNV are examples of institutions taking different approaches to safety which also played a role in the way regulations were drawn up. From a historical perspective, therefore, the unusual outcome would have been if the initiative taken by Prescott and Winsnes to develop a common regulatory regime for diving had succeeded rather than collapsing.

The discussions conducted in the belief that agreement could be reached indicate that the disagreements which arose did not primarily reflect a clear division between Norway and the UK. Rather, the work became too complicated when different interest groups in both countries were drawn into the process. A month after the joint meeting in Oslo, Winsnes discussed the draft regulations with representatives from Ocean Systems, Comex and 3X.[62] The contractors had so many objections that these can hardly be seen as anything but a frontal assault on the proposals. A few weeks later, Winsnes sent minutes from the meeting to the British negotiators in which he expressed himself in agreement with a number of the company objections.[63] That must clearly have been frustrating for those on the UK side who envisaged a quick solution after the meeting in Oslo. Among other observations, Winsnes expressed himself as if he agreed with the company objections to a proposal which would allow the divers to refuse to undertake jobs they regarded as hazardous.[64] Similarly, he appeared to agree with the contractors in opposing a requirement to obtain the permission of the rig manager before beginning a diving operation.

While Winsnes signalled a position which was more “company-friendly” than the British view on certain points, he wanted more radical action on others. Although he can be interpreted as believing that a diving supervisor should have unrestricted power over the actual operations, he insisted that it must be up to the individual diver to decide whether he felt fit enough to dive.[65] He referred to Norway’s Highway Code, where it is not the company for whom he might be working who decides whether a driver is fit to drive, but the driver himself. Winsnes also wanted the rules on drinking alcohol ahead of a dive to be far stricter than in the British draft. Both these views were clearly influenced by the experience gained from the Ekofisk deaths.

The disagreements raised in Winsnes’ letter to the British were so numerous and complicated that they could well have been enough in themselves to defeat the attempt to agree common regulations. Had Winsnes been the only problem, however, the British could have forged ahead with the completion of their own rules and ignored the Norwegian objections. The fact that efforts to develop rules stalled for a time on both sides of the North Sea primarily reflected a lack of political initiative.

The diving industry organises

The objections from the diving contractors are unlikely to have been unknown to the British civil servants. They were the same companies on both sides, of course. Unusually, however, the views of the companies were conveyed through a Norwegian civil servant, who they must basically have regarded as an ally. The new feature was that the diving contractors had now organised themselves for the first time and were thereby able to promote common views much more forcefully. But the starting point was not conditions on the NCS or the UKCS, but events in the USA – still the core country for the oil-related diving industry in 1971.

No coordination had existed between the diving contractors during the 1960s, either on safety standards or over other conditions. The companies were exclusively competitors. When the new US Occupational Safety and Health Administration (OSHA) sought to intervene in the diving industry towards the end of the 1960s, however, the companies were forced to think differently. In 1970, the dominant American firms founded the Association of Diving Contractors (AOD).[66] Their aims were clear. First, they wanted to defeat efforts by American unions to gain a foothold among the divers. Second, they sought to avoid government regulation by keeping the OSHA out of the industry. The management of companies such as Taylor Diving and Oceaneering regarded the OSHA as a Trojan Horse for the AFL-CIO trade union confederation. However, the companies would find it difficult to oppose government regulation unless they could show that they were tackling the safety challenges on their own account. Establishing "voluntary" safety standards called for a form of organisation in itself.

About the same time that Prescott was contacting Winsnes, representatives of the companies operating on the UKCS came together in 1971 to found the Association of Offshore Diving Contractors (AODC). The companies would doubtless have preferred to avoid government regulation in the North Sea too. After oil had been proven on both the NCS and the UKCS, however, it was difficult to see how some form of official regulation was to be avoided. The diving contractors also feared that their influence would be weakened if the safety regimes established were solely a matter between the oil companies and governments. They were worried, for instance, that the operators would secure disproportionate influence over when and how dives were to be conducted. The AODC accordingly represented a united front not only towards the authorities, but also against the powerful oil companies.

The organisation was given responsibility for coordinating operations on the NCS. From the perspective of the diving contractors, it must have seemed a decided advantage that they secured greater acceptance of their views from Winsnes in Norway than in the British government. The fact that consideration of the British draft also came to a standstill for a time did not mean that the AODC had won the argument and was ready to establish a self-regulation regime, but that the political will to push the proposal through was lacking in the Conservative government. Conditions changed when Harald Wilson resumed office at the head of a Labour government after a general election in February 1974, in the middle of the first oil crisis. The radical industry secretary, Tony Benn, wanted a quick solution.[67] However, Norway was now cut completely out of the process. The pressure for haste was not only a matter of political ideology. No less than nine British divers died in association with the offshore industry between 1972 and 1974, while the regulations were under consideration.[68] These diver fatalities attracted great attention in the UK press. The Offshore Installations (Diving Operations) Regulations came into force for the UKCS on 1 January 1975.[69]

Inspections

Nothing significant was done to complete similar regulations in Norway during the period from the 1972 collapse of negotiations with the UK on a joint regime until the British rules were adopted in 1975.[70] Since the UK-Norwegian talks on a joint regime were never formally broken off, Winsnes appears to have spent some time waiting for proposals from the other side of the North Sea. As the only person in the Norwegian government with a clear responsibility for following up diving, he was by no means idle. In addition to his work on North Sea activities, he was still responsible for supervising other diving operations in Norway. He was involved in a number of initiatives from the autumn of 1972 which aimed to develop a training system for deep divers and strengthen the general level of scientific diving expertise in Norway. Both were important for diver safety. The first meeting on establishing a Norwegian centre for underwater expertise took place in September 1972.[71] A working party concluded the following March that such a body should be established. Winsnes paid close attention to the work which led to the establishment of the Norwegian Underwater Institute (NUI). Given that he had to struggle on behalf to the government to gain access to relevant research abroad, the prospect of being able to develop domestic expertise in this field was clearly a major step forward.

Winsnes also monitored the efforts to develop various training systems inside the companies.[72] The activity which took most of his time in the following years was a series of inspections of diving installations. Most were conducted on land, but many took place out in the North Sea as well. Such workplace inspections were important in the supervisory philosophy which underlay Norway's worker protection legislation. A key consideration for the NLIA's inspectors was naturally that they had a set of regulations to enforce. These could take the form of either general provisions in the Worker Protection Act or special regulations developed for specific activities. An NLIA inspection could accordingly cover everything from checking that machinery and equipment complied with the regulations to looking at general tidiness in the workplace and whether the working time provisions were observed. Under the NLIA's supervisory responsibility, an inspection functioned as a regulatory intervention in itself since the inspectors could issue specific orders for improvements to the company concerned. An inspection thereby also served as a form of approval if the inspectors failed to find any faults.

Without specific diving regulations or any final clarification of the Worker Protection Act's status, and with an equal lack of clarity about how diving would be regulated following the adoption of the new Working Environment Act (WEA), Winsnes' authority was limited as he travelled around and inspected diving facilities in the North Sea.[73] Reports exist of inspections between the autumn of 1973 and the summer of 1974 at companies such as Comex, Subsea Oil Services and Oceaneering, and on rigs and DSVs like *Waage Drill I*, *Deep Sea Driller*, *Ocean Rover*, *Blue Water 3* and *West Venture*.[74] The last two were inspected while they operated off Shetland – in other words, on the UKCS.[75] The intention was to clear the diving spreads before they were taken into use on the NCS.

Many divers working in that period have reported that they can remember how Winsnes visited their installation and conscientiously checked most of the equipment in the company of the diving management. This is confirmed to some extent by the written reports of the inspections. At first, Winsnes placed great emphasis on familiarising himself with the functions of the equipment. He requested specifications of such aspects as how much pressure a bell could withstand, how much breathing resistance there was in a breathing set and so forth. But he also issued demands for improvements. When inspecting Comex on *Waage Drill I* in November 1973, he listed five points which had to be improved. The conclusion was nevertheless that the equipment looked suitable for its purpose. Winsnes allowed Comex to continue operating, but on condition that it corrected all the relevant points. In that way, he "approved" both the Comex equipment and its activities.

Virtually all the comments made by Winsnes in his inspections were technical in character. However, they continued to be couched in a cautious form and seldom required extensive and expenses interventions or conversions. A number of his comments have clearly helped to improve operational safety during diving, as when he could point out that it was a long time since the cylinders of breathing gas had been tested and when he noted on a number of occasions that baskets should be designed in such a way that a diver would find it easier to hold on.

Considering that he was employed by the NLIA, however, it is nevertheless unusual that Winsnes pays virtually no attention to operational aspects of the diving. That conditions could be different when a rig was in action was demonstrated to him during an inspection on *West Venture* off Shetland. When checking the same unit in Le Havre, he observed that the diving spread had been given a good and clear position on the rig.[76] In the meantime, winches had been installed in the same area which made it difficult to move between the diving equipment. The cautious request from Winsnes to the diving contractor and the rig company, in which he asked them to discuss whether this position could be improved, was typical of the tone he employed with the industry. During these inspections, however, he never raised such aspects as working hours, time spent in saturation and the offshore working environment. On a couple of occasions, it emerges that the diving superintendent concerned reported what kind of diving tables were used. But this was not a subject for discussion. One of the few occasions when Winsnes raised matters which related directly to the divers themselves occurred during an inspection of Comex on *Deep Sea Driller* while the rig was at the Bergens Mekaniske Verksted yard in 1974. Winsnes noted that the French divers, unlike the Norwegians, had a poor knowledge of English.

A spate of accidents

During the very hectic years when Norway had to build up an advanced petroleum administration from scratch, the government tended to make its strongest interventions where the most pressing challenges appeared to exist. So it was unlikely to have been entirely irrelevant for the pace of regulatory development that no new diving accidents occurred on the NCS between May 1971 and January 1974. Accidents on the UKCS during the same period were often reported in Norwegian newspapers, but they did not attract the same attention as a mishap which occurred in Norway. The government avoided all the formal processes, in the form of identifying causes and possible culpability, which followed an accident.

But another fatal diving accident struck the NCS on 16 January 1974, this time involving the *Drill Master* rig.[77] Two divers working for Ocean Systems, one British and the other Norwegian, were diving for Esso just north of Frigg when the brake for the ballast system (drop weights) on a bell failed. The bell was accordingly "blown up", killing the divers. This accident had a particularly tragic twist in that the Norwegian diver was Per Skipnes, one of the two divers rescued from the sunken bell on *Ocean Viking* in March 1971.[78] Skipnes stopped diving for a short time because he thought working in the North Sea had become too dangerous. But he was back again by 1974.

The *Drill Master* incident was unusual because the blame – unlike in earlier and many subsequent accidents – was pinned on the diving contractor. The bell involved had just been sent across from the USA. Parts of its equipment had been installed in France before it was dispatched for use on the NCS. The investigation established that the bell had been fitted with a new type of valve system which needed to be operated in a special way, but the correct instructions had not been sent with it.[79] The manual sent with the bell and in place on *Drill Mas-*

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ter belonged to a different system. It is unclear whether the divers sent down in the new unit had read the instructions. They were in any event wholly unprepared to operate the equipment properly. In a statement to Norway's public prosecutor, the NLIA recommended that Ocean Systems be fined.[80] Although the accident claimed two lives, however, it yet again failed to receive significant coverage in the media.[81]

This fatal accident near Frigg marked the start of a whole series. A 21-year-old British diver died on 27 August 1974 beside a pipeline close to Ekofisk.[82] He experienced problems with his gas supply and failed to get back to the bell in time. According to Stavanger's *Rogalands Avis* newspaper, two of his colleagues suffered from shock as a result of the incident – but were back at work two days later. Another British diver died on a helmet dive in February 1975 during construction work outside Stavanger.[83] The accident report noted that the diver lacked training. A Norwegian diver from 3X died on 22 March 1975 on the UKCS.[84] He was working in very cold water at a depth of 140 metres when his heating system failed. The autopsy report concluded that he died of overexertion. Just a few days later, a serious fire broke out in connection with the diving spread on *Arctic Surveyor*.[85] A gas control panel and part of the electrical system was destroyed while two diving teams were in saturation. A disaster was narrowly averted. In June 1975, a British diver died while doing air diving for Comex during pipelaying on the NCS.[86] The presumed cause of the accident was nitrogen narcosis.

Compared with what was to come, this long series of diving fatalities attracted little public attention. But they and a number of similar accidents affecting other categories of offshore workers helped to create a far more critical attitude about what was going on in the North Sea. On 28 September 1974, *Bergens Tidende* – the leading Bergen daily – ran a full-page story on the diving issue.[87] One of the headlines read: "The North Sea is being conquered with the lives of divers". An introduction continued:

> Five people have so far paid with their lives when diving on the NCS since [Norway's] Oil Age began ... Diving is the profession which has suffered the largest number of accidents in the work of bringing North Sea oil ashore. They carry out operations by which the whole oil exploration industry stands or falls, but have not so far been protected by fixed safety regulations.

Despite such apparently critical comments, the article is primarily a review of diving in its full breadth. No criticism is directed at either the diving contractors or the government. It concludes with an assurance from Winsnes that diving regulations will be ready immediately after the New Year – in other words, in the winter of 1975.

It is first in the latter year that a serious shift can be detected in newspaper coverage of oil issues related to unacceptable working conditions. In connection with discussions on extending the WEA to the NCS, the Ministry of Social Affairs presented a study in the summer of 1975 which was highly critical of the prevailing conditions.[88] After a cautious start-up, the NPD began to present a more independent face to the oil industry. But this agency still had no direct responsibility for diving issues. Established as recently as 1972, it was the prime mover behind a regulatory development which would soon overtake the virtually moribund work on diving regulations. The Vogt commission presented a proposal for safety regulations on fixed installations in June 1975. They were tailored to the fact that the new WEA would apply. With the clarification of legislation, statutory regulations and regulatory responsibility for fixed installations, the weakness of diver regulation became even clearer. An official inquiry in 1975 which looked at general supervision of both fisheries and petroleum activities made special mention of the urgent need for diving regulations.[89] This inquiry's report pointed out that the UK had adopted such rules. The NPD, which still had no formal responsibility for diving, also signalled that dedicated regulations for this activity were now a matter of urgency. In other words, the pressure to regulate diving came no longer only from frustrated divers but from parts of the civil service as well.

Diving in the crossfire between competing regulatory regimes

When Winsnes resumed serious work on the diving regulations in 1975, the job had become easier in the sense that he no longer had to take account of proposals from the British. One option was naturally to copy the UK regulations, which would mean achieving the goal of a common regime. The British regulations were influenced, after all, by earlier Norwegian proposals. Although Winsnes was more or less the only person involved with this work in Norway, it was by no means a lone effort on his part. The idea had solid support in the industry ministry, which wanted safety controls in the petroleum industry to be as independent as possible from other Norwegian safety regulations. The draft Norwegian rules prepared for consultation by Winsnes in November 1975 built to a significant extent on the British regime.[90] However, it soon became evident that regulations based on a British tradition could not simply be adapted to Norwegian practice. As a resolution approached, moreover, the diver issue found itself in the crossfire between competing Norwegian regulatory regimes. It now became clear that work on the diving regulations had been pursued in isolation from key events in the safety arena.

The 1970s were characterised in both Norway and the UK by the most extensive changes to the regulation of the working environment and safety in the entire 20th century. Because the offshore industry in the North Sea was of such economic significance and was pursued in an area without pre-existing regulations, it developed into a battleground where old and new safety philosophies and policy regimes clashed. Work on Norway's new WEA had only just begun when the diving regulations were under discussion in 1972.[91] The NLIA occupied a central position in the far-reaching process which followed. A draft was circulated for consultation in 1975. When the Act was finally passed in 1977, it represented a radical break with much of the thinking which had dominated safety work in Norway until then.[92] (See chapter 8.) The safety delegate system was introduced to ensure that all aspects of the Act were implemented in practice. Democratically elected, these representatives (also called delegates) were given a legal right to halt all hazardous activity. This represented a significant encroachment on the employer's right to manage.

However, work on safety legislation had progressed considerably further in the UK than in Norway when the discussions on common diver regulations were conducted in 1972. The British Health and Safety at Work Act was passed in 1974. Its extension to the North Sea was opposed by the oil companies to the bitter end. When it was finally applied offshore, exemptions had been granted on a number of important points.[93] The oil companies were not obliged to permit employees to elect safety delegates, and thereby also avoided the right of such elected officials to halt work. In Norway, too, the oil companies sought – with support from the industry ministry – to prevent the WEA being applied offshore.[94] Unlike the watered-down provisions adopted for the UKCS, however, a strengthened version was extended to the fixed installations in 1977. The Norwegian Act was a very important factor in the build-up of strong unions by many groups of offshore workers. However, it was not extended to mobile rigs and the many supply ships which worked closely with oil installations. These remained subject to the safety regime and philosophies which prevailed in the shipping sector. That proved a fateful decision for the Norwegian divers, since diving was conducted to a great extent from mobile rigs and special ships.

The draft diving regulations drawn up by Winsnes were very little affected by the changes taking place in the rest of the NLIA. When he supported the position of the companies during the discussions with the British and was sceptical about giving divers the right to refuse an order from a supervisor to do a job they personally regarded as dangerous, he also signalled his opposition to a principle which would gain a

Full concentration – the job must be done. But at what price?
Photo: Børre Børretzen

key place in the new WEA. Were the latter also to be extended to diving, the regulations would have to be significantly amended. That question was clarified when it became clear that the Act would apply only to fixed installations. Instead, the main issue came to be whether the NLIA should have the authority to formulate diving regulations at all.

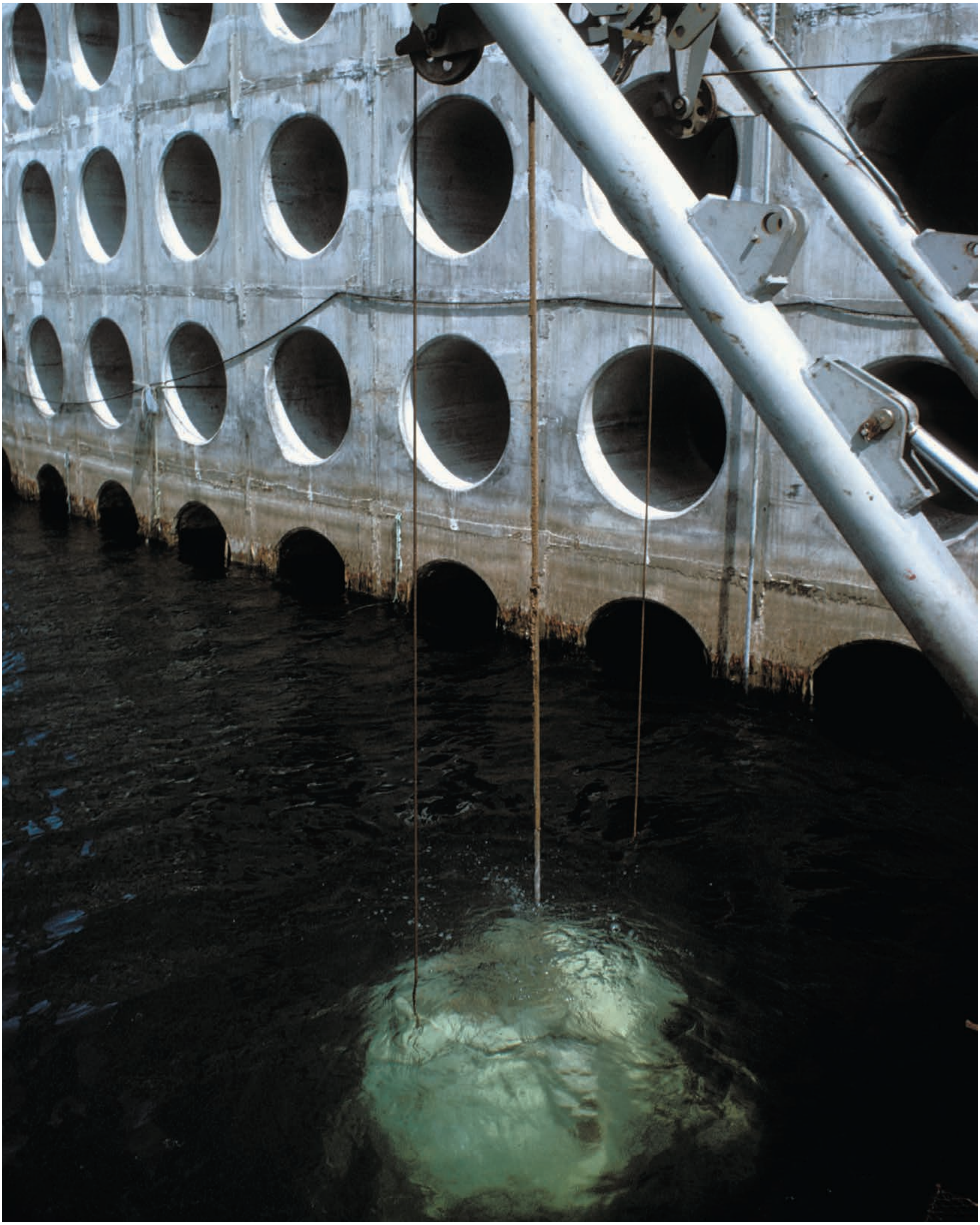
According to the NMD, excluding mobile rigs and supply ships from the WEA and subjecting them instead to Norway's maritime legislation meant that the same applied to diving. It would thereby be up to the NMD to draw up regulations. In line with the traditions which applied in shipping, this would mean in practice that the NMD left the job to DNV. Instead of developing regulations related to diving, this would subject the activity to a classification regime. The NMD's claims led to a lengthy round of discussions on where responsibility should lie. It became clear in the summer of 1977 that separate diving regulations were to be developed. A completed draft was supported by the board of the NLIA. At this point, however, the decision was taken to transfer responsibility for diving to the NPD. That meant a further delay. It was not until 1 July 1978, after the NPD had taken over responsibility for diving, that the divers on the NCS became subject to "preliminary" but nevertheless comprehensive regulations. By then, 12 years had passed since North Sea diving began and 11 since the first serious accident.

A political responsibility

In circumstances where the completion of an important set of regulations is hampered or blocked by various competing regulators, sorting matters out must necessarily be a political responsibility. Moreover, much would probably have looked different if the government had devoted more resources from the start to doing something about diving. Ignoring the question of overall responsibility and possible blame, and concentrating on discussing what actually happened and why, we cannot ignore the fact that government work on diving safety throughout the long period from the assignment of responsibility to the NLIA in 1969 until the regulations were ready in 1978 was confined in practice to a single person – Winsnes. While not referring to him by name, the Lossius commission makes it implicitly clear that he was not personally to blame for the slow pace of developing the regulations. Its basic view is that one man was not enough to deal with the big challenge represented by the diving issue. Both the records and most of the divers who met Winsnes during the relevant material confirm that he made an energetic commitment. But it is nevertheless the case that, as long as Winsnes was the only person who worked actively to secure an overall picture of the issue, both his professional orientation and his personal attitudes and assessments strongly influenced developments.

With his engineering background, Winsnes was a typical representative of a technical approach to safety which could be found in many industries – perhaps even more strongly in rail transport and aviation than in traditional manufacturing. The NLIA necessarily had to have a number of technical specialists. However, these were balanced by staff with a stronger orientation towards more operational and human relationships in a workplace. From that perspective, Winsnes was not a typical representative of the NLIA – which was, after all, the birthplace in the early 1970s of a WEA where the interaction between technical and human factors occupied a very central place.

Precisely because Winsnes was the civil servant who had the most to do with diving, one might have expected him to have argued that, since the safety challenges facing divers were particularly large, more resources were needed to get something done. But he did not. Winsnes was a "bureaucrat", without management responsibility. Norms exist in a bureaucracy against asking too many questions about political priorities and getting on instead with the job one has been given. However, the fact that Winsnes never complained about his working conditions might also reflect a belief on his part that the position of the divers was not particularly urgent, and a fairly high level of confidence in the safety work being done as a result of his many contacts with the companies. As we saw, the report he received from Prescott in 1971 concluded that diving could be the world's most dangerous profession. The large volume of written materials Winsnes has left contain no indications that he gave special weight to conveying such a view.



Chapter 5

Condeep diving

Work on casting the world's first concrete tank for offshore oil storage began in the summer of 1971. Its base was constructed in a dry dock at Jåttåvågen in Stavanger before being towed out into deep water in the adjacent Gands Fjord during February 1972, where the sides were raised using a technique known as slipforming. Once the work had moved into deep water, divers were naturally soon involved. They were a necessary part of the workforce, despite being less visible than the people erecting the formwork, tying the reinforcement bars (rebars) or pushing wheelbarrows full of concrete.

This structure was to be used for intermediate storage of oil on Ekofisk. The offshore loading system was vulnerable to strong winds and high waves, with tankers all too frequently having to disconnect from the buoys so that production was forced to cease. With a storage tank, oil could continue to flow uninterruptedly in all kinds of weather.

France's C G Doris was responsible for the tank's design, and it was built by Norwegian construction company Høyer-Ellefsen. Nine large storage cells were surrounded by a breakwater wall with big holes which allowed the waves to wash in and out. These openings were sealed with steel plates during the construction phase in order to provide enough buoyancy to get the tank out of the dry dock and into the open fjord. Once the tank was safely moored in deep water, one of the first jobs for the divers was to remove this steel cladding. Releasing and removing a thousand of these sheets was heavy work. One team worked outside and another inside. The latter unscrewed the bolts holding the plates in place, so that the external gang could remove them for hoisting to the surface.[1] While the divers mostly used commercial helmet diving gear, they were occasionally assisted by frogmen. This was a big job which took a long time.

Lowering a diving bell by the Ekofisk tank. Photo: ConocoPhillips/Norwegian Petroleum Museum

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Hoisting steel plates.
Photo: Leif-Tore Skjerven

The divers also installed many metres of cable down to the bottom of the tank, both inside and outside, for controlling its installation on the field. Since these cables needed protection against external loads, holes had to be drilled in the concrete to install expansion bolts for fastening protective steel covers over the cables. The work was done as bell diving by many French and Norwegian divers. Rolf Guttorm Engebretsen, who was then employed by 3X as a signalman and surface-oriented diver, says that the work also involved cleaning up the bottom between the external breakwater wall and the inner cells. Divers also installed distance meters on the edge of the wall as well as some under the actual tank. Many hours of bell diving were devoted to this task.[2]

By 24 June 1972, the structure had topped out. But much equipment still had to be loaded on before it was finished. The tank was designed to receive up to 350 000 barrels of crude per day. It was also decided to install oil and gas processing equipment on top of it. That job and the mechanical outfitting put towout of the tank 11 months behind schedule.[3] The last work the divers did was to sever the mooring chain with flame cutters. Doris had its own diving team with French personnel from Comex for this job. 3X was also hired to assist. While the French were supposed to cut two of the chains and the Norwegians one, the former ran into problems and 3X ended up dealing with all three. The Norwegian company had 20 permanent divers on its payroll at that time, and many took part in this job.

According to Karl Jørgensen, originally a fireman who had taken a helmet diving course at Haakonsvern, it was not that easy to stay in position when cutting the chains.[4] The latter were incorporated in the concrete, three-four metres above the bottom of the tank. This job was done in 65-70 metres of water as surface-oriented diving with a gas mixture, using oxy-arc cutters. Cutting progressed more quickly if the chain was clean than if it was covered with fouling (marine growth). However, working conditions were not ideal. There was nothing to sit on, and the diver had to maintain a grip on the chain while using the cutter. That was not straightforward, because the tugs keeping the tank in position generated currents in the sea. “The propellers created massive currents,” Jørgensen recalls. This was a particular problem when ascending. He passed the decompression straps through the openings in the tank wall and fastened himself in place. A multitude of sea cucumbers kept him company.

The time at working depth was just over 30 minutes. That meant many chilly hours decompressing in the sea while ascending to 12 metres. From there, the divers went straight up and into the deck decompression chamber (DDC) at a pressure corresponding to 12 metres down. It was only after several hours that they could emerge into the open air.

When the last chain was to be cut, there were not many divers left who had not recently dived. John Haugestad, who had taken the naval diver and frogman course at Haakonsvern, was one of them. He had been doing shallow helmet diving off a quay, and was called up in the afternoon. At 22.00, he entered the water and managed to "chew through" half the chain in the dive time he had available. Øistein Berge then descended and cut the last half of the chain link.[5] Since cutting the chain took longer than expected, the towout was delayed when it began early on 21 June 1973. However, the weather was ideal with a dead calm. Many people had lined up along the shore to view the event. Six tugs towed the 215 000-tonne structure from Stavanger to Ekofisk. *Stavanger Aftenblad* described it as a "world event".[6]

The tank reached the field on 1 July. It was installed by gradually pumping water into the tanks until the structure settled on the seabed. Bottom conditions had previously been investigated by the Norwegian Geotechnical Institute. DNV, responsible for approving the operation, feared that the seabed was too uneven to give the tank stable support. The placement was adjusted slightly at the last minute. This gave the Ekofisk centre its characteristic kink, instead of the installations running in a straight line from south to north. The tank was also provided

C G Doris' Ulis system was used for diving around the Ekofisk tank.
Photo: ConocoPhillips/Norwegian Petroleum Museum

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The first stage in building a Condeep GBS at the Norwegian Contractors dry dock in Stavanger. Casting these structures took place in Stavanger, Åndalsnes and Hanøytangen outside Bergen, while the Ekofisk tank's breakwater was cast in the Åls Fjord. Photo: Statoil

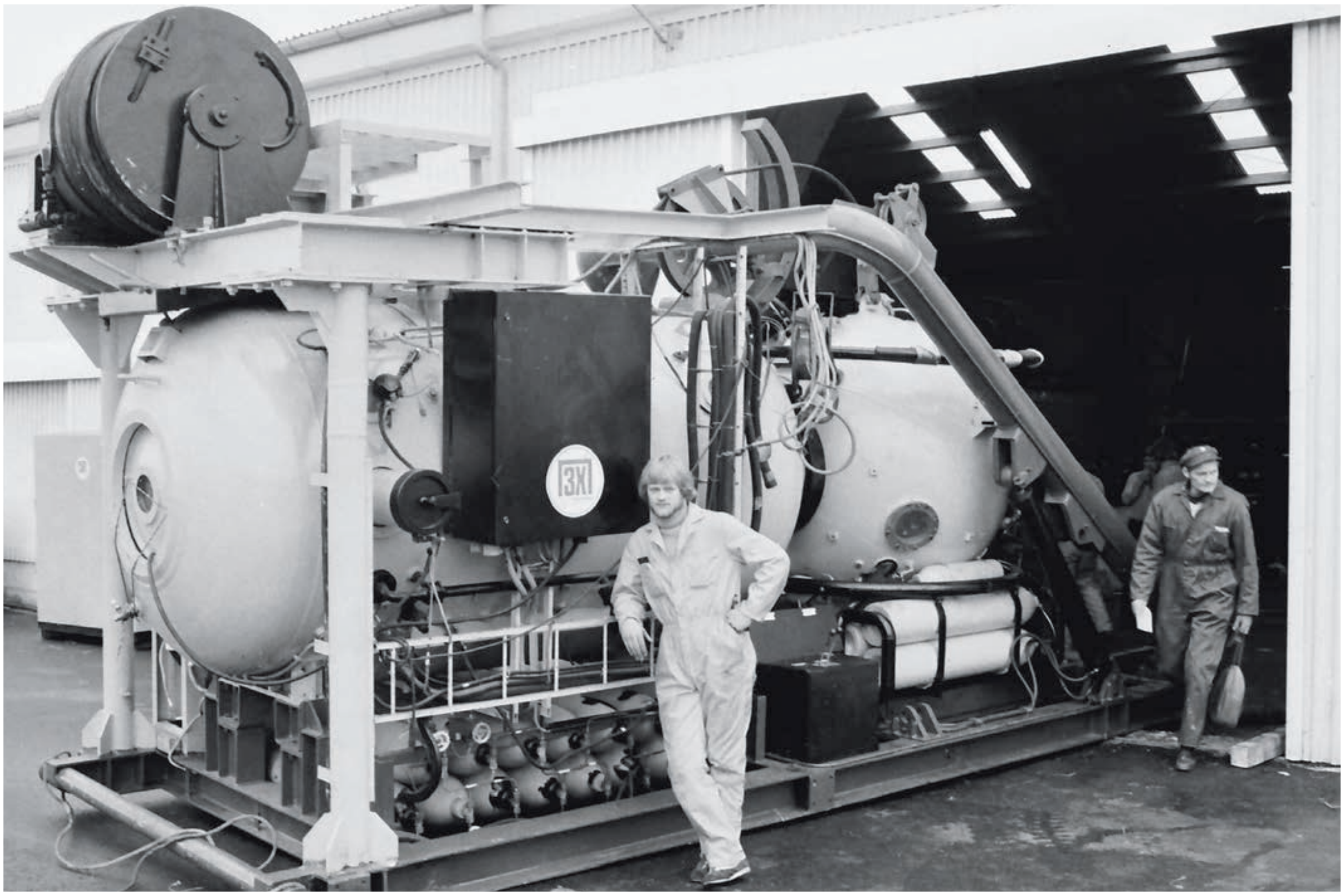
with a steel skirt which penetrated the seabed to prevent currents from undermining it and threatening its stability.

A Norwegian concept

Construction of the Ekofisk tank proved a success. It helped to shift the boundaries for what specialists thought was possible in the offshore industry. The world's first concrete tank at sea opened the way for the huge production platforms in the same material. Just a few weeks after the tank had been towed to Ekofisk, the first Concrete Deepwater Structure – Condeep – was ordered. Known as a gravity base structure (GBS) because it sits on the seabed by its own weight, this unit supports the steel topsides. The lower section comprises a set of cylindrical concrete cells which can be used for oil storage. One or more of these extend upwards as the hollow shafts on which the topsides sit. The shafts provide space for conductors, mechanical outfitting and so forth.[7] The Condeep design was developed by senior engineer Olav Moe at Høyer-Ellefsen. With its deep seas and rough climate, the NCS called for solutions other than the traditional steel jackets which could be used in depths up to 100 metres. The Condeeps could stand in substantially deeper water.

The first client was Mobil, which needed a production platform for its Beryl field on the UKCS. Norwegian Contractors (NC) began constructing this GBS in the summer of 1973. Shell followed immediately afterwards with an order for a similar installation on its Brent field. Mobil Brent A and Shell Brent B represented the definitive breakthrough for concrete technology in the North Sea. By the end of 1974, NC had no less than six Condeeps under construction in the Jåttåvågen dry dock and the Gands Fjord.

These Norwegian structures attracted international attention, and the design won the prize for technological innovation at the Offshore Technology Conference (OTC) in Houston. Globally, the Condeep became the very symbol of oil operations in the North Sea and can stand as Norway's most important independent contribution to the offshore business. It was a Norwegian industrial adventure of great significance for value creation and employment in Norway. A thousand people or more were employed on each project, a small proportion of whom were divers performing necessary underwater work. After the Ekofisk tank, Condeeps were produced one after another in Stavanger. The last was completed in 1995. Two of the Norwegian concrete GBSs were built at Åndalsnes further north. Completion of the platforms, with the mating of GBS and topside, took place at Vats north of Stavanger and Stord Verft closer to Bergen.



The Ulis diving spread is readied by Rolf Guttorm Engebretsen (left) and his father Rolf Egil – a frogman and helmet diver.
Photo: Geir Ivar Jørgensen

Inshore oil diving

Beryl A, the first Condeep GBS to be built, involved a wide range of diving work. Construction went on continuously throughout the week, including Saturdays and Sundays. In periods with a lot of diving, three vessels with full diving teams could be engaged simultaneously. Ninety per cent of the work on all the Condeeps was conducted as surface-oriented diving. Cutting of mooring chains, which occurred in deeper water 70-80 metres down, required bell dives.

A special diving job on Beryl A was the installation of risers from the bottom to the top of the oil storage cells. These pipes continued up the outside of the tall shafts. To attach them, the divers first had to install robust double-sided steel brackets up the concrete walls to hold the risers. On later Condeeps, the risers were installed dry inside the shafts.

More varied diving work was carried out underneath the GBS, such as measuring, piping inspection and plugging, and installing anodes on the bottom skirts.[8] Divers also tested nozzles installed low on the outside of the ballast tanks to spray water under high pressure towards the seabed during installation. These jets ensured that the mud swirled up

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Geir Ivar Jørgensen (foreground) was one of the divers who worked both on Condeeps and offshore.
Photo: Geir Ivar Jørgensen

so that the GBS got a good grip on the bottom. Before towout, all aids used during the construction period had to be removed. That gave the divers a lot to do removing the underwater crane supports.[9] A more unusual job was to hunt for possible cracks if casting errors were suspected or signs of leaks detected. Divers were then sent down to seek out and seal the weak spots with a kind of epoxy. In addition, they sometimes had to look for equipment which had been left behind or lost at the bottom of the GBS.

Geir Ivar Jørgensen recalls that a good deal of work cutting mooring chains was always involved when a Condeep came to be towed out. The links were huge and had to be severed with flame cutters. That required skill, and only the best people were given that job. Starting the tow at the right time was important. Any delay could be very expensive for the client. Jørgensen relates:

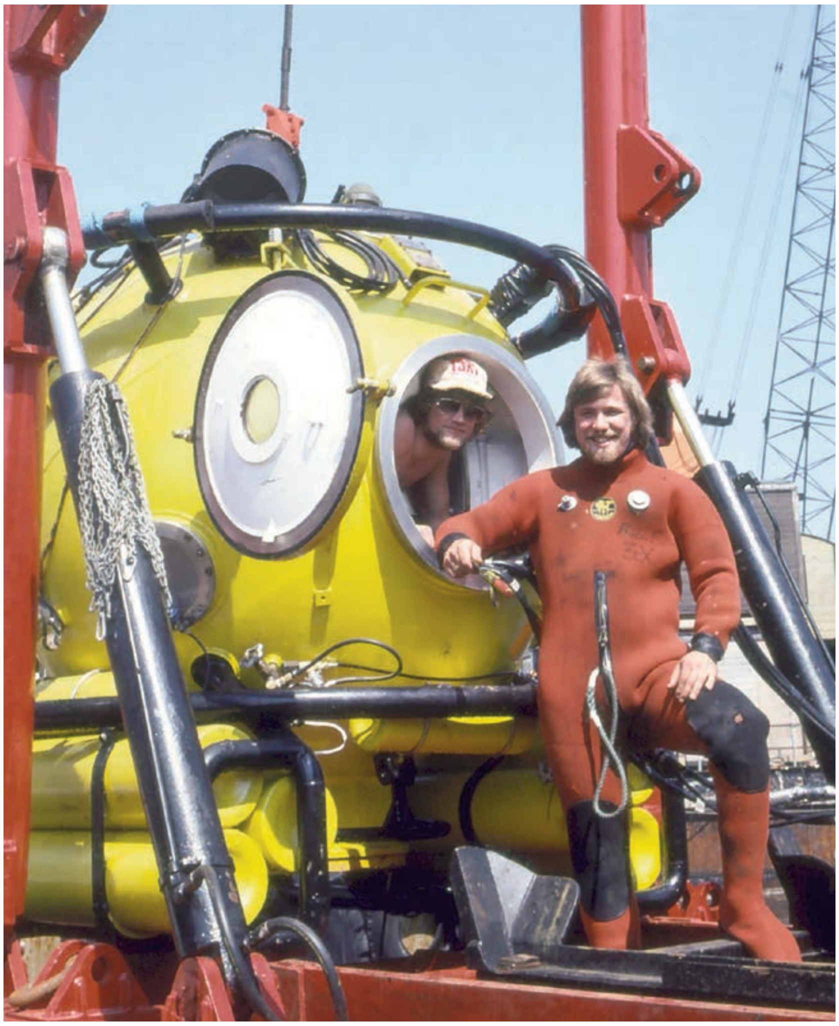
> Time was of the essence. Cutting through these thick chains was pretty dangerous ... You had to burn cleanly, so that the slag was blown through. Inaccurate burning caused cavities to form where oxy-hydrogen gas collected. That caused some real explosions. Several of us were knocked silly and suffered burst eardrums from such blasts. I eventually developed my own technique. This involved hanging under the chain with my legs wrapped round it so that I could burn upwards and take advantage of the buoyancy of the water. Burning in that direction gave me full visibility because the bubbles rose. I also got a longer jet from the cutter. The disadvantage was that the red-hot slag ran down onto me. It hit me in the middle of the stomach and flowed down both sides of my diving suit. To start with, I tried to avoid it, but I soon noticed that it did no harm because a kind of steam coating formed around the molten steel. A few zips were undoubtedly destroyed by the slag, but that was all. It looked a little dangerous, of course, so I think I was the only one to use this technique. It allowed me to cut a chain with a single rod – in other words, two-three minutes. Others might take 30 minutes or more on the same job because they had to change a lot of rods as they chewed their way through with many small cuts. I always held the record. That meant I was in demand for such work, which was seen as a prime job.[10]

Cutting mooring chains on the Condeeps was both exciting and challenging. The chain was tensioned to more than 700 tonnes, and the divers had to cut against that. When half the link had been cut, the rest broke free of its own accord. Big forces were involved.

Condeep divers and diving vessels

Spissøy moored alongside a Condeep GBS at Stord.
Photo: Børre Børretzen

3X was one of the leaders for Condeep diving. In 1973, the company became affiliated to the Aker group's oil division. Fred Olsen then registered it as Sub Sea Dolphin and allowed this name to exist alongside 3X.[11] The company used *Spissøy*, a 60-foot former fishing boat, as a diving base during the early years. This was outfitted solely for surface-oriented diving. Conditions were fairly primitive, with a DDC installed in the cargo hold and a home-made control panel for air and gas diving from the surface.[12] As time passed, more supply ships and barges were utilised as diving vessels.[13] When Fred Olsen and the Aker group became involved, funds were provided which permitted the purchase of new equipment. That included the acquisition of three new saturation diving spreads from Italy and a former car ferry for use offshore. The latter was also used as a mother ship for manned submersibles, which carried out such work as pipeline inspection.



At work on Statfjord A in the Digernes Sound off Stord in 1976. Rolf Guttorm Engebretsen is in the hatch and Rolf Buer in the diving suit. A diving team normally comprised five people, who took it in turn to do the jobs. Everyone dived during a shift. Diving normally took place in daylight, but there could also be periods when it continued with several shifts around the clock.
Photo: Geir Ivar Jørgensen

Another step forward for 3X was the *Buldra* barge, which replaced *Spissøy* in 1977. Many divers developed a special relationship with this vessel because it was later used for many years by the National Diving School (NDS) to train saturation divers. *Buldra* was specially tailored for use with Condeep diving.

A lot more divers than before were needed during the early years of Condeep diving. The supply of personnel with a naval background was insufficient to meet demand. Many people then entered the business by chance and without much in the way of training. One example was Tor Jan Wiik, who was a mechanic when he joined 3X in April 1975. He secured his first job as a diver at Stord that July, and took the recreational diving certificate later. After four years, he was promoted to supervisor. Another was Johan Otto Johansen, who was a sales driver before being tempted by his diver brother to try his luck in the profession. All he had was a recreational diving certificate. Jørgensen was a driving instructor, and had only borrowed his brother's diving gear on the sly before

The diving control room on a Condeep dive in Åndalsnes. At the top of the photo are the two depth meters, one for each diver. Outside to the left is the winch for raising and lowering the umbilical which supplied the diver with breathing gas, hot water and communication. Photo: Ulf Lars Ola Fredriksson

starting his career as a diver in 1973. None of these three, who did a lot of Condeep diving, even knew how to use the valves on their diving suits to regulate the air pressure when they entered the water for the first time. But they bluffed their way through and learnt quickly from experience. Others came from such trades as loggers, plumbers, bakers, goldsmiths or butchers. The prospect of better pay could have been one attraction, but another was acquaintanceships and friendships. According to Wiik, it would be fair to describe the way they worked as "professional amateurs".[14] The impression that many people without diver training were recruited during the busy Condeep period is confirmed by Leif-Tore Skjerven, who was part of the 3X management:

> We needed divers. We'd actually used up the resource bank represented by those we knew in the navy. Our target group now was skilled workers. Pettersen was a sheet metal worker from Rosenberg, Henning Christensen an electrician/engineer, Bjørn Vik and Gudmestad electricians, and Bue a plumber. We were looking for people who could provide different trades. I got the impression that they were

Norwegian experiment abroad

3X became the first Norwegian company to conduct a series of test dives at the Tarrytown laboratory north of New York during 1975 in order to develop its own bounce diving tables.[17] The lab had experience in developing tables for both the US Navy and Ocean Systems. A series of deep bounce dives was conducted to 188-235 metres of water using trimix. This blend includes a certain proportion of nitrogen alongside helium and oxygen. In addition to being speedy, with decompression from 188 metres taking less than 18 hours, the table was intended to save money by reducing the consumption of helium –an expensive gas, while nitrogen is free. In addition, a possible thermal benefit was expected for the diver since nitrogen is regarded as a "warm" gas.

Geir Ivar Jørgensen, Arne Jentoft and Odd Pedersen participated in the six-strong team together with three Britons and Americans. They dived together in pairs. These were the first tests of this type performed at the Tarrytown lab with people. Pigs had been used earlier.

"The blowdown speed was extremely high," recalls Jørgensen. "That caused strong trembling when we passed the 120-metre area. These shakes declined at the target depth. Everything we did at the working depth was designed to measure how much of our capacity for work had been affected by HPNS and the dense breathing gas. We managed the tasks almost as well at the working depth as when we did them on the surface. But we were unable to carry out a single dive in this series without serious symptoms of the bends. None of the decompressions got us back to the surface without repeated halts and recompression to a greater depth before we could continue."

Briton Clem Turner became seriously ill during one of the dives and threw up a number of times. The doctor outside the chamber ordered Jentoft to inject Turner, even though he had never given injections before. Pedersen became paralysed from the small of his back and down (spinal bends). Treatment consisted of pills and red wine in addition to recompression. The divers had to be transferred to saturation tables because no bounce tables were available for such long periods of treatment. On the basis of this series of dives, a table for 188 metres was adjusted by the Tarrytown lab and subsequently approved without further tests. But it was little used. Saturation diving took over more and more from the bounce method in the mid-1970s.[18]

> serviceable in the water. Odd took them out to *Spissøy*, where Gunnar was the supervisor, and he saw how they conducted themselves.[15]

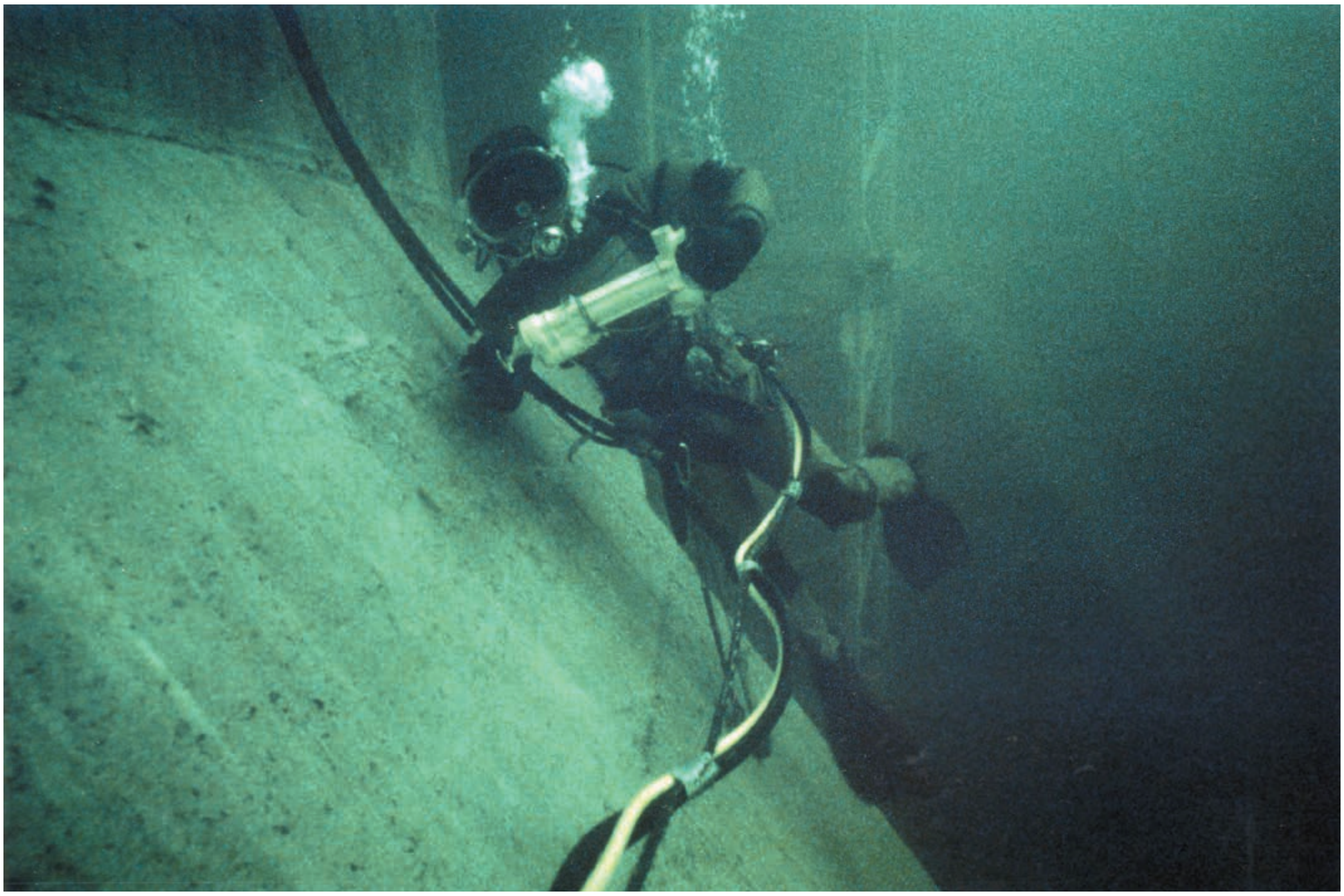
Most of the divers worked permanently offshore in the summer season, since all installation and maintenance work took place then. During their free time on land between tours, they took jobs on the many concrete installations then under construction. But winter work was confined to Condeep diving, since few assignments were then available offshore. Casting and completing concrete GBSs went on continuously throughout the year in sheltered fjords. Condeep diving could represent an estimated 60-70 per cent of the total work available. The divers seldom worked permanently in only one place. They were nomads who moved to where the jobs were. Although the companies which won the contracts in the Gands Fjord or at Stord, Vats or Åndalsnes differed, the same divers recurred.[16]

Accidents in the Gands Fjord

Condeep diving experienced a busy year in 1975. Several platforms were to be completed simultaneously. Brent B, Beryl A and Statfjord A were all due to be taken offshore. That put great pressure on the divers.

A fatal accident occurred on 6 February of that year during diving on Brent B in the Gands Fjord. A 30-year-old British diver was out on one of his first jobs on the GBS, which involved measurement work about 50 metres down. He signalled to the other divers that something was wrong, but failed to appear when they hauled up the umbilical.[19] He had broken free and sunk to the bottom of the fjord in 250 metres of water, and was never found. This accident was caused either by a fault in the diving gear or because the diver had mistakenly released the umbilical.

Another accident occurred in the late autumn. A 20-year-old Norwegian, Øyvind Kristiansen, who had taken the navy's diving course and worked for 3X, was helping to ready Statfjord A in the Gands Fjord. The diving team to which he belonged had worked without a break for a long period and was tired. Although this was inshore diving, working time was governed by the petroleum regulations – in other words, a 12-hour daily shift for 14 days including Saturdays and Sundays. The team was due to have the weekend off, but the job needed to be finished as a matter of urgency. The diving supervisor refused to take the job, but another person with less experience was persuaded to accept it. Kristiansen was to dive inside one of the "star cells" between the storage cylinders, accompanied by a standby diver in a steel basket suspended at the water surface. The basket hung from one of the cranes



Underwater work on a Condeep.
Photo: Geir Ivar Jørgensen

on the GBS. The cell could be accessed from the top, with a clearance of 40 metres to the water – which was 25 metres deep. Kristiansen was cutting off 16 bolts on a pipe flange at the bottom of the cell, and has described what happened:

> I cut off the bolt, but the flange wouldn't come loose. So I needed something to break it free. I was in a bit of a hurry. If the dive lasted too long, I'd need a decompression stop at three or possibly six metres. It was already late in the day, and it'd be good to finish early so I could get the weekend off. I reported that I needed something to free the flange with, and went to the surface to get it. I thought that a crowbar or something would be lowered to the surface, and that the easiest thing was to get it there. Then I was going to descend again to break free the flange within the deadline. While I lay at the surface, I held onto the cutter hose. Up top, a crowbar was attached to the cutter hose by a noose. With no communication between me and the supervisor, I hadn't grasped how the crowbar was to be lowered to me. It came sliding down the hose in free fall. It hit me in the chest a little up on the right-hand side and stuck out of my back ... At the

> time, we didn't know how bad the injury was. Gunnar Flaten pulled out the bar. It was a bit difficult communicating with the people on top of the cell. We got the steel basket lowered, but it vanished into the water. When it came up again, Flaten was outside it. So the basket had to be lowered afresh. Things went better then. We were hoisted to the top of the cell and transferred to *Spissøy*, which was the vessel we were working from. I was quickly sent to Stavanger Hospital. Flaten came with me in the ambulance. At the hospital, they quickly got ready to operate. My right lung had been punctured in the accident. The operation itself went well. I was hospitalised for several weeks.[20]

The report from the NLIA found that the way the crowbar had been sent down into the cell, with the cutter hose as the guy line, was a grave error. The supervisor was held responsible,[21] and fined for breaching procedures. That the accident occurred at the end of a shift just before the diving team was due to take the weekend off was not considered an extenuating circumstance. Nobody investigated how pressured the work had been before the accident. Nor was anyone in the diving company management held responsible for requiring the team to dive when they should actually have begun their weekend off.

Kristiansen recovered after a few weeks of operations and convalescence. Because of the damage to his lung, he was banned from diving for life. 3X had promised him further training as a diving supervisor, but that never happened. After a few years as a warehouse worker in the company, he became fed up and quit. He became partially disabled and later suffered other health problems which left him on a full disability pension.

Condeeps hang in the balance

The Stord Verft yard had built one supertanker after another until the shipping crisis of the mid-1970s, when most of its newbuilding contracts were cancelled. Conveniently enough, it landed its first offshore contract in 1975 from Mobil for the Statfjord A topsides. It was then decided to establish a deepwater base in the nearby Digernes Sound, where the topside structure could be mated with the GBS. This facility, which was sheltered from wind and weather, soon became a competitive advantage in the offshore market. Stord Verft quickly secured another three contracts from Shell for platform matings. The first was Dunlin A, which had been built in Rotterdam. That was followed by two big structures built in Scotland, Cormorant A and Brent C.[22]

A series of accidents occurred in connection with testing the platforms, when divers were among those who had to go into action. In

A diver on the diving vessel for Statfjord A at Stord.
Photo: Geir Ivar Jørgensen

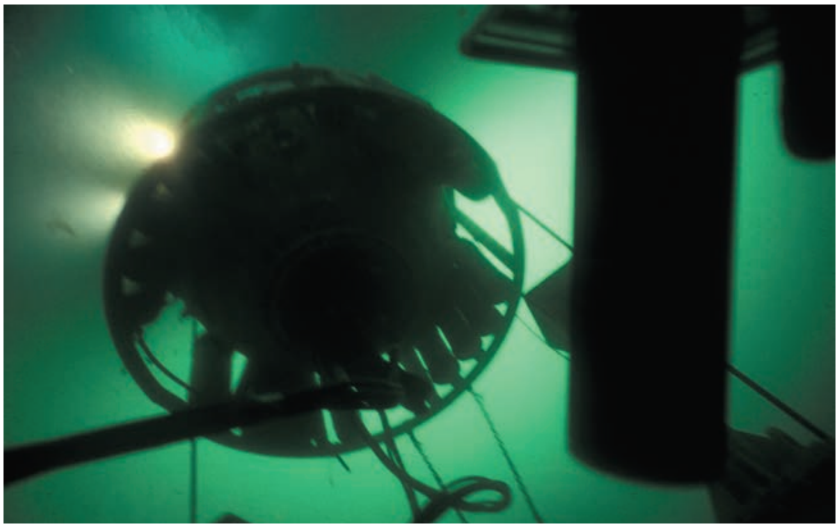
mid-December 1976, Dunlin A developed a list. An airbag under one of the cells failed during testing of the piping system on the platform. One shaft sank more than a metre before the platform came to rest with a list of one-two degrees. Personnel on board were evacuated in the course of 30 minutes. A reassuring tone was adopted in external information. *Stavanger Aftenblad* reported that the structure was never in any danger of sinking. Its design and buoyancy were such that even if the airbags failed under all the cells, the platform would remain afloat. The list was corrected and work continued as normal.[23] A leak also occurred on the platform in March 1977, but this was solved fairly quickly with the aid of a wooden plug.[24]

Statfjord A developed a serious list on 20 April 1977 during testing of the ballast system. Through human error, a valve was mistakenly opened so that the water level in the various cells became virtually the same. The weight of the topside was unevenly distributed – with the living quarters placed on one edge, for instance – so the platform tilted. Spotting immediately what had happened, the duty officer in the control room sounded the alarm. Evacuation of the 200-strong afternoon shift began at once. The list was three degrees, which meant that one edge of the topsides sank by eight-nine metres. Since the list happened so quickly, a number of the people on board panicked and problems developed in getting the whole shift down to the boats. The access stairs had been partly removed ahead of the towout.[25] Those who failed to get down quickly enough jumped into the sea, but nothing of that was reported in the press. Maintaining an orderly impression of the construction projects was important for the operators.[26]

The third platform, Cormorant A, also suffered mishaps after arriving from Ardyne Point in Scotland during July 1977. Weaknesses were revealed when pressure-testing the piping system. A number of pipes were removed in October and returned to the UK to be given a new PVC coating.[27] The piping system was completed during November, and the platform was ready for its first deballasting test down to seven metres. Minor leaks were then discovered in some piping penetrations, which had to be sealed before deballasting could continue.[28] A few days later, more leaks were discovered between the GBS cells and further lowering was postponed. Mating with the topsides was delayed until after the New Year.[29] Information emerged later about yet another accident on Cormorant A, when the platform allegedly listed following a leak during Christmas 1977. Whether this incident actually happened is a matter of dispute.[30]

Problems were also experienced by a number of divers working on Statfjord B at Stord in 1978. A big leak once again occurred here and the platform had to be evacuated while it was being repaired. Geir Ivar Jørgensen, a diver in this operation, recalls:

> There was something special about being the only people on the platform after the rest had been evacuated. The repair job was done as bell diving with a Ulis system, rather than in saturation. Because it was urgent, a number of divers were involved and a lot of dives were made one after another. There was a crack in one of the star cells – in other words, the three-sided spaces between the cylindrical storage cells. This crack was 17 metres long and a couple of inches wide. Many divers had to mobilise for this job. The first team opened the manhole leading down to the star cell. It was followed by a gang which tried to seal the crack with epoxy, but that was just sucked



A diving bell descends to the work site.
Photo: Øistein Berge

right through. Sawdust and wooden wedges were then used, a good old-fashioned sailing ship technique. Wedges were packed tightly together along the crack, with a mix of sawdust and epoxy between them. That held.

Diving in the star cells was hazardous. For the dive to go ahead, the bell was sunk as close as possible to the top of the Condeep dome. But it nevertheless remained a long way from the cell. The umbilical proved too short, and two had to be spliced together – contrary to the regulations. Another danger was that, because the bell was outside the cell, the bellman would be unable to pull the diver out through the narrow manhole and back to the bell should anything happen to him. Several of the divers actually experienced difficulties with their gas supply and fainted inside the cell, which meant they had to be brought out by other divers. Jørgensen believes that the gas supply problems arose because the work site was too deep in relation to the bell. While the bell had to be on a level with the top of the star cell, the diver had to swim many metres down. Pressure at the work site was thereby higher, and gas delivery force became too low.[31]

Johansen experienced precisely the same problems of gas supply while down filling cracks on Statfjord B. He fainted in the water several times, but managed to get back to the bell under his own steam. Neither the bellman nor the surface control room understood what had happened, and Johansen was told by the supervisor on returning to the surface that he was useless as a gas diver. He did not learn until many years later that a number of others had passed out in a similar way on this type of job.[32]

A dangerous position also arose when Statfjord B was to be cut free from its mooring chains. The bell was lowered from the diving vessel to a depth of about 80 metres. In the meantime, the tugs were waiting with their engines going to start the tow as soon as the chains were gone. Jørgensen had just left the bell when he discovered that, as soon as the massive chains were cut, they would fall down on the concrete casing of the GBS and damage it. He reported this to the surface, whereupon it was decided to rotate the GBS a little to avoid the problem. The tugs started moving, and the current increased. Meanwhile, Jørgensen had ascended to the top of the bell. He held fast with one arm and clutched the cutting equipment with the other. While this was happening, the hawser holding the diving vessel in place broke. Jørgensen discovered with a shock that the chain they were to cut was suddenly over the bell. The position was critical. With the diving vessel adrift, the bell would soon get caught in the chain. The steel cable holding it would be torn off, leaving bell and divers to disappear in the depths. Their chances of survival would be slim. Jørgensen knew he was in mortal danger but, instead of panicking, he became icily calm. He contacted the supervisor, but had no time to explain the position. As clearly and as calmly as possible, he said: "Come down with the bell. Come down with the bell". This was an unusual order and matters would have gone badly if the person running the bell winch had not immediately done what he was asked. Fortunately, supervisor Byron Tate was an experienced diver who understood that this was serious and did what Jørgensen commanded. The position was brought under control and the divers survived on this occasion, too. In the meantime, the surface crew replaced the hawser, got the vessel back under control and returned it to its original position. Although Jørgensen was deeply shaken, he completed the cutting job before ascending. Once back on deck, he saw that the boom holding the bell was bent. The bell had been close to tearing loose. However, bellman Kjell Lindgaard was unaware of the drama. He had (fortunately) been unable to hear the conversation in the bell.

If it works, it works

"GSG" – short for *går det, så går det*, which can be translated as "if it works, it works" – was an established expression in the Norwegian diving community. It conveyed a kind of fatalism. The divers were willing to try to overcome difficulties. If it worked, it became a good diving story. They appreciated that their job was risky, and a great many of them can relate incidents when their own lives were in danger. But these incidents were seldom or never reported.[33]

The number of risky episodes recalled from the 1970s reflects the fact that some diving jobs on the Condeeps were not as carefully planned as others. Unforeseen problems often cropped up. People who

Øistein Berge monitors the depth of the bell – about 200 metres.
Photo: Øistein Berge

liked excitement and demanding jobs which put creativity, courage and endurance to the test enjoyed the work. Diving was well rewarded as long as the divers were paid per dive. The disadvantage was the heavy pressure which prevailed during the construction period for a Condeep. It was essential to complete these installations so that they could be towed out at the right time and the field could start production. Big money was at stake. This pressure passed down through the organisation to the individual contractor and employee. Divers were used to the limit. The Condeep jobs were a very intensive form of diving. Dives were made every day, sometimes twice a day if each did not last long. It was difficult for the divers to refuse a job if they wanted to continue working. They were conditioned at an early stage to conform to the system. As freelancers, they had little or no job security. When the divers failed to take time off, the work put a big strain on their bodies. People knew little at the time about the possible long-term consequences. The divers did the work they were given to the best of their ability, and were trained to obey orders. Getting the job done and the Condeeps ready on time was the top priority at every level. Consideration for people, such as a diver who found himself in danger, took second place.

As the worst construction pressure eased, Condeep diving was put on a more ordered footing. The creation of the NDS in 1979 improved training for new divers, and fewer accidents were reported in the 1980s. Conservative diving tables were introduced, eventually also dive-free days. Condeep diving then came to function for many divers as a school where they were able to practise a multitude of different jobs which might also crop up in offshore work.

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Chapter 6

In deeper waters

The huge concrete oil installations will probably remain standing as a monumental expression of Norwegian history from the late 1970s to the mid-1990s. Each larger than the one before, they were towed offshore by a fleet of tugs which became pygmies against the colossi they surrounded. Their groundbreaking qualities were symbolised by the height of the concrete GBSs – the higher they were, the deeper the water in which they could be installed to produce oil and gas. As always in the history of offshore oil, however, it was not only a case of getting this valuable energy source up from the sub-surface. Production also had to be brought to refineries and markets on land. Diving was essential for all these aspects.

If people had not expected to earn big money once production started, the massive technological commitment would never have been made. In other words, forcing the pace of change had a strong underlying financial motive. But developments were also driven by powerful political forces. Some of these originated abroad. After the 1973 oil crisis, Norway and the UK were urged to step up the pace of North Sea development in order to safeguard strategic energy deliveries to the west at a time of radicalisation and unrest in other key oil regions. During the 1980s, under President Reagan, the Americans brought pressure to bear on the Norwegians to speed up gas deliveries from the Troll field to avoid Europe becoming over-reliant on Soviet supplies.[1] However, neither Middle East unrest nor the final throes of the Cold War were responsible for pushing diving operations into ever deeper waters during the late 1970s and early 1980s. This primarily reflected a domestic political motive. There was a strong Norwegian desire for the country's oil and gas to be processed on land in Norway. That depended on being able to surmount the biggest challenge of all – the Norwegian Trench.

After the installation of Statfjord A, one concrete colossus after another – each larger than its predecessor – was towed out to ever deeper water. The tallest of them all is Troll A, installed in 303 metres of water. It stands 472 metres high from the seabed to its topmost point.
Photo: Statoil

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By pipeline to Norway

This feature is a submarine valley which separates the relatively shallow waters in the middle of the North Sea, where the first petroleum fields were found, from the Norwegian coast. Before the last ice age, the area embracing most of today's oil fields was dry land where Stone Age humans lived alongside mammoths and sabre-toothed tigers. Only the Trench separated these flat plains from the Norwegian coast. It extends from the outermost part of the Oslo Fjord, around the southern and western coasts of Norway, and opens like a funnel towards Greenland and the Arctic Ocean. At its deepest point off southern Norway, the bottom of the Trench lies 700 metres down. This rises to 280-300 metres off the west Norwegian coast. The Trench was regarded as a challenge as far back as the early 1960s, when Norway was positioning itself for negotiations with the UK and Denmark on North Sea boundaries.[2] The Geneva convention on the law of the sea, which governed the determination of boundaries in coastal and sea areas, defined a continental shelf as extending out to a depth of 200 metres or as far out as the water depth permitted the exploitation of natural resources.

The strong Norwegian desire to ensure that possible deposits would be landed in Norway had already been incorporated in the royal decree of 9 April 1965, which formed the legal basis for the first licence awards on the NCS: "If the King finds that the national interest requires it, he may decide that produced petroleum products can be landed wholly or partly in Norway."[3] Immediately after the Cod discovery in 1968, a committee was appointed to assess the possibility of piping the oil to the mainland.[4] Discovered by Phillips, Cod initially proved too small to justify commercial production. However, Phillips is unlikely to have been surprised when the question of landing by pipeline to the Norwegian coast was raised immediately after the Ekofisk discovery.

As operator and dominant licensee, Phillips not unnaturally wanted the pipeline to go where its markets lay – either the UK or continental Europe. Ekofisk lay in the middle of the North Sea. Why take an expensive diversion via Norway? The problems of crossing the Trench were crucial in allowing Phillips to win acceptance for its position. A pipeline running directly from Ekofisk to the Norwegian coast would descend to 372 metres at its deepest.[5] That was deeper than any similar pipelaying project in the world. Phillips claimed it to be impossible with the technology of the day.

The Norwegian government also had an interest in ensuring that development costs did not become excessive. The question was whether it could trust Phillips when the company claimed that a landfall was technologically impossible. After all, it had a clear financial interest in landing abroad. A committee appointed by the industry ministry in August

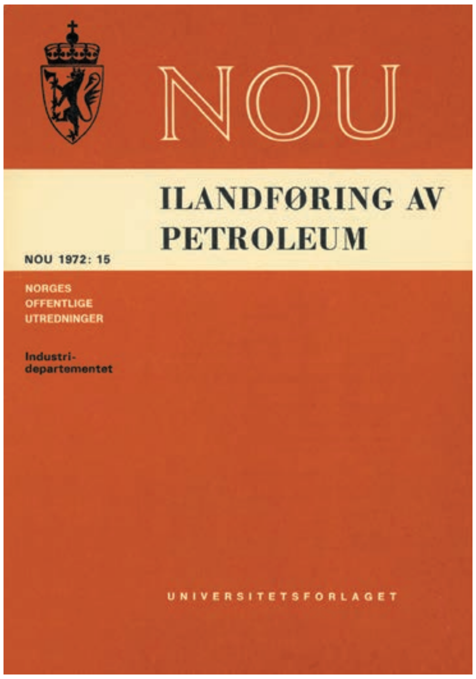
1970 was charged in practice with checking the conclusions reached by Phillips.[6] In January 1972, this "Ekofisk committee" found – contrary to the oil company claims – that it would be technically possible to cross the Trench. But this called for a great deal of research and investigative work, which would involve a two-year delay in starting regular production from Ekofisk. Since both the field licensees and the government wanted revenues to flow as soon as possible, an oil pipeline to the UK represented the only realistic option.

Politicians in deep water

The Ekofisk committee's report was clearly influenced by the position Norway found itself in during the first phase of its oil age. Its government might make political demands but, as long as no independent Norwegian technological expertise existed which could vouch for and execute what was wanted, had to accept the solutions proposed by the foreign companies. In retrospect, the committee can be seen to have made poorly founded claims. That applies not least to its superficial treatment of diving. The committee was fully aware that pipelaying across the Trench would depend on divers being able to descend to all the relevant depths.[7] Reference was made to long saturation dives having been made in depths of 87-117 metres while the report was being written. The committee assumed that the depths for working dives would almost certainly soon be extended to 135-150 metres. Even deeper dives were a matter of further research.

Assuming that working dives would soon be made in depths down to 150 metres was fairly realistic. Around 1973-74, diving was conducted in 150 metres during exploration operations on Britain's Brent field and Statfjord on the NCS. But the Trench was more than twice as deep. On the other hand, the idea that research would provide the necessary technology to master such depth within two years – that is to say, by 1974 – was more or less fanciful. It was probably coloured by a need to promote a national alternative in negotiations with Phillips.[8]

The question of a pipeline to mainland Norway came up again in connection with the development of Frigg. On this occasion, the line would carry gas. The underlying clash of interests was the same. Dominated by French companies, the Petronord group wanted the fastest possible development aimed at the markets, using proven pipeline technology in waters where diver assistance was available. Many Norwegian politicians pressed for a pipeline to mainland Norway. A relevant route would go down to about 280 metres. That was considerably deeper than 150 metres, which was the greatest depth in which pipelines had been laid until then. Yet again, a commission of inquiry was appointed to



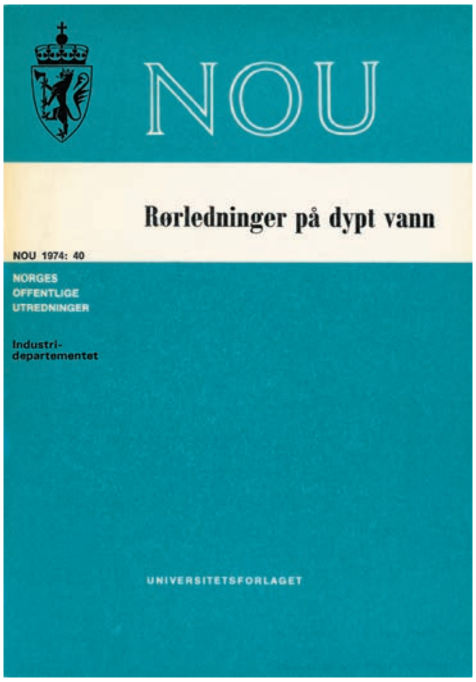
The cover of the Norwegian official report (NOU) from the "Ekofisk committee" on landing petroleum. This body's Norwegian experts were generally more optimistic than the foreign oil companies about the prospects for crossing the Norwegian Trench with a pipeline in the near future.
Source: NOU 1972:15

assess opportunities for crossing the Trench with a pipeline.[9] On this occasion, however, no time was taken to wait for a conclusion. Some 30-50 per cent of Frigg was thought to lie on the UKCS, and the British had already decided to lay a pipeline to Britain for their part of the field. Norway ran the risk of the UK building a platform on its side of Frigg and, in the worst case, taking out Norwegian gas. The solution was a joint development, with all the gas being piped to St Fergus in Scotland. A unanimous recommendation was produced by the Storting's standing committee on industry. Nevertheless, committee chair Reidar T Larsen from the Socialist Left Party (SV) expressed deep dismay over the constraints Norway faced. He called on the government to commit sufficient funds "to secure as quickly as possible the technological and practical instruments required for landing [petroleum] in Norway".[10]

The DWP commission

Neither Larsen nor other Storting representatives made any special mention of diving during the debate in June 1973 which buried the Frigg landfall project. On the other hand, the commission of inquiry which had been mandated to assess the "technical, financial and safety" challenges related to deepwater pipelines gave greater attention to diving than the earlier committees. In the spirit of the times, it was given the English nickname of the Deep Water Pipeline (DWP) commission. This body was again forced to conclude that the necessary technological obstacles to laying and operating a pipeline in 280 metres of water had still to be surmounted. At the same time, however, it maintained that such a project would be technologically possible "in the near future". Although "the near future" is a flexible concept, it was a formulation which gave hope to everyone pressing for the pipelines from the next development project to be laid to the Norwegian coast.

Like most other Norwegian institutions and initiatives which got to grips with the practical aspects of the oil industry in the early years, the DWP commission was dominated by engineers. With a budget of NOK 5 million, to be spent in little more than a year, it could afford a very hectic programme of travel and meetings. As long as the commission was at work, it became an important arena for network-building related to subsea technology on the NCS. The commission concluded that pipelines could not be laid across the Trench unless divers were able to descend to the relevant depths. It pointed out that diving was essential for repairing damage to a line during laying, assisting the positioning of possible trenching equipment, and repairs during operation. Although diving was seen as a bottleneck for crossing the Trench, other technological areas nevertheless received more attention. During its work, the



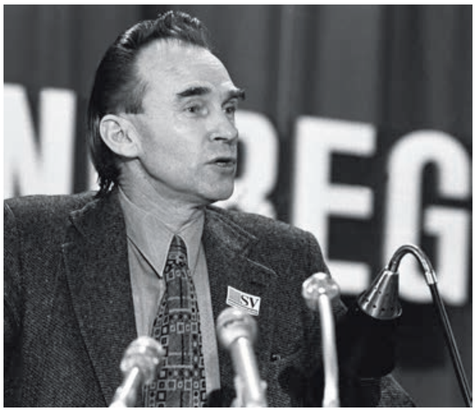
The cover of the other major Norwegian official report on the pipelaying issue. It was produced by the "DWP commission", which had a sub-committee on diving.
Source: NOU 1974:40

commission made it clear that its greatest emphasis was on "pipeline protection/burial".[11] That view also made its mark on the final report, where a chapter on diving came at the very end after a much more detailed consideration of various pipeline types, pipelay vessels and methods, and so forth. Of the 25 appendices, only one related directly to diving.[12]

Diving-related issues were addressed in a separate sub-committee chaired by Per Laheld, an engineer who was also a member of the DWP commission's secretariat. This sub-committee comprised representatives from the two Norwegian diving companies, Seaway and 3X, as well as DNV and the navy. Naval medical officer Jens Smith-Sivertsen was the only Norwegian physician involved in the study.[13] Work in the diving sub-committee was also characterised by a good deal of travel. That was natural, given the lack of any advanced diving technology community in Norway. Like most of the approaches to diving at that time, however, the sub-committee was primarily concerned with overcoming new obstacles to deepwater work, and with how far Norwegians could be involved in such efforts.

Both the Norwegian companies represented on the sub-committee saw this as an opportunity to secure a large share of a future market for diving contracts in deep water. They accordingly had no interest in highlighting problems which could lead to regulations and thereby hamper their future growth. At that time, neither 3X nor Seaway possessed diving tables for deep water. Both accordingly sought to exploit their membership of the sub-committee to secure access to such tables. That included efforts to acquire tables developed by Professor Bühlmann at a university clinic in Zurich. He was described as the only independent "supplier" of diving tables. The problem was that the professor, as a university employee, could not sell his tables commercially just like that.[14] A solution was negotiated whereby a one-off Norwegian grant would be made for general research at the clinic in exchange for representatives from the two Norwegian companies working in Zurich for a time. The NPD expressed its willingness to fund a substantial one-off payment.[15] This scheme collapsed after 3X refused to pay a share of the cost.

The latter, which had just been acquired by the Aker group, presented at about the same time an "offer" to carry out repair work down towards 300 metres.[16] This was pretty audacious for a company which lacked experience, equipment or suitable diving tables. The offer depended from the start on political and financial support. At the initiative of the DWP commission, a meeting was held with the industry ministry to present the proposal to director-general Odd Gøthe. The ministry emphasised that it saw the value of a Norwegian company being prepared to undertake such an assignment, but politely refused to take part in the financing. It pointed instead to the appropriation



Reidar Larsen, a former Communist Party leader and a Storting representative for the Socialist Left Party (SV), was a driving force for many years in efforts to ensure national control over oil operations in the North Sea. Photo: Scanpix

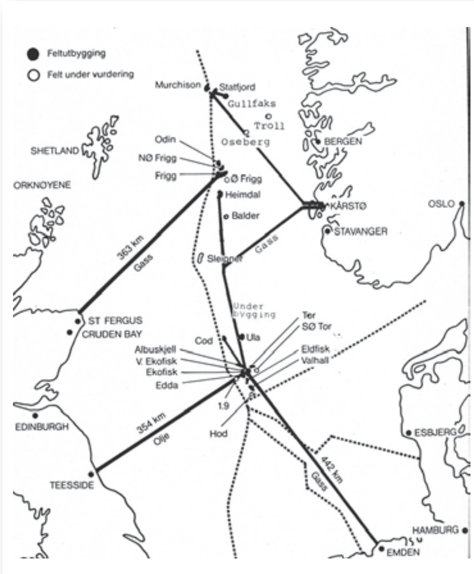
which had already been made for the DWP commission. Since the civil engineers within the commission had already secured the bulk of that money, the 3X proposal also failed.

With the politicians on the one hand wanting the quickest possible confirmation that a pipeline over the Trench was actually feasible, and Norwegian companies on the other concerned to secure the strongest possible position for potential future pipeline projects, little scope for critical comment existed in the sub-committee. At this time, Smith-Sivertsen was developing a more critical stance to what was going on. But he had little to contribute when all the foreign diving specialists met by the sub-committee's representatives on their travels maintained that it was possible to come up with gas mixtures and decompression tables which would make it possible to work at the depths involved.[17] Even though the commission's conclusions provided an opening for the speed-up in activity which most people wanted, a number of the formulations in the chapter on diving were ambiguous and clearly influenced by the increased disquiet felt by Smith-Sivertsen. For instance, the report describes the mental challenges facing a diver in deep water:

> The diver knows that he is completely dependent in this alien element on the equipment he uses being fault-free, and that there is little chance of receiving assistance if he loses control of the circumstances. He also knows that a rapid retreat to the surface is impossible because of decompression. He is often alone in the water, and cold, darkness and poor communication with the outside world will reinforce his sense of isolation. Responsibility for and the degree of difficulty of the job to be done, as well as the limited time available to him, could also help to increase mental strain during the dive.[18]

The report notes that "a certain lack of clarity prevails" about the depth at which practical diving work can be done.[19] The commission nevertheless presumed that a practical limit for simpler operations in 1974 was 300-350 metres of water.[20] It pointed in that connection to the existence of satisfactory diving equipment for such depths, with the reservation that systems for heating suits and breathing gas could be improved.[21] According to the report, resistance in the diver's breathing equipment would particularly reduce work capacity at depths beyond 300 metres. It makes no unambiguous recommendation about the advisability of diving at such depths. On the one hand, the report refers to "specially trained divers" being able to perform inspection and simple tasks. On the other, it notes that divers at these depths would face such major mental and medical problems that going beyond 350 metres had to be regarded as risky.[22]

The equivocation in the commission's attitude emerges most clearly from its discussion on the use of decompression tables in deep water. It states: "although the problems are by no means overcome, however, this area is not where progress in deep diving is being slowed up at the moment. The navies of a number of countries have developed decompression tables intended to be available for diving down to about 300 metres … Decompression sickness … does not appear to constrain diving in deeper water at present, as long as the decompression periods are sufficiently long".[23] In the same discussion, the report notes that the diving companies want shorter decompression times and have accordingly funded the development of their own tables – without the commission expressing what it thinks of that.

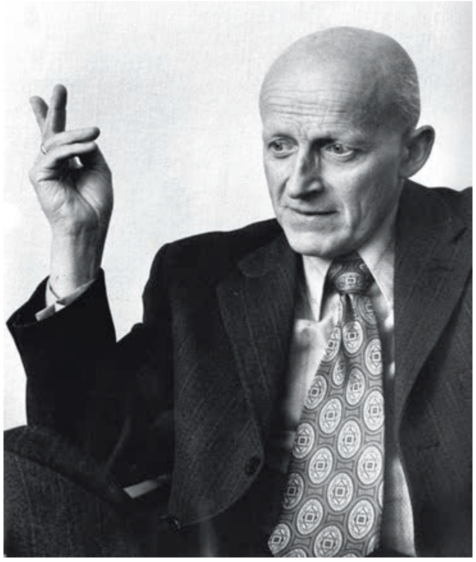


The pipeline network as it looked in 1983 after a tough struggle between the companies and the Norwegian government.
Map: *Facts*, Ministry of Petroleum and Energy, 1983

The Statfjord pipeline issue

Landing oil in Norway was first discussed as a serious option in connection with the development of Statfjord. Published in April 1976, White Paper no 90 represented the fourth major public discussion of the problems associated with laying a pipeline across the Trench.[24] The time required for developing satisfactory equipment and necessary diving techniques was now reduced to about a year. Work diving at about 330 metres was regarded as the limit of the possible. To go any deeper, it would be necessary to develop systems for laying and maintaining pipelines without diver assistance.[25] A depth of 330 metres corresponded exactly with a possible pipeline route from Statfjord to Norway.

When the White Paper was discussed that June, the political landscape had altered from earlier years. Larsen and the SV had changed their position from being a driving force for the quickest possible crossing of the Trench to supporting a solution based on offshore loading. Larsen feared that the government's desire for a pipeline to land would contribute to an excessive speed-up in the pace of oil production, which could be negative for safety and the environment.[26] The most enthusiastic backers of a rapid crossing of the Trench were now powerful industry interests in the Labour Party. Rolf Hellem, a member of that party and the Storting representative who provided the most detailed description of the problems of diving when the pipeline issues had last been debated, admitted that a pipeline from Statfjord would represent a major technical challenge.[27] But precisely such a challenge could help Norwegian industry to acquire groundbreaking experience. Hellem pointed out that about 35 per cent of the world's oil and gas reserves were thought to lie in more than 200 metres of water. By being an early bird, therefore, Norwegian industry could gain experience in an impor-



Rolf Hellem, a Labour Party representative in the Storting, played a key role for many years in the parliamentary consideration of oil-related issues.
Photo: *Stavanger Aftenblad*

tant growth sector. On this occasion, neither Hellem nor other Storting representatives raised the position of the divers in the brief debate.

A final decision was postponed until proper preliminary engineering had been completed. Development and operation of Statfjord was initially assigned to Mobil. Unlike Ekofisk and Frigg, the government held a dominant licensee position on this field through Statoil. That ensured substantially greater Norwegian influence. Moreover, a condition of Mobil's operatorship was that Statoil should take over this role after serving an apprenticeship. The first substantial independent operative assignment which Statoil undertook in relation to the Statfjord development was precisely to study opportunities for laying an oil pipeline across the Trench.[28] Up to February 1979, the company awarded contracts worth more than NOK 100 million to sub-contractors for investigating various aspects of such a project. In other words, this was no longer just a matter of committee work and travel but a proper preliminary engineering project. A pipeline nevertheless failed to be built because the construction of Statfjord A had proved more expensive than expected, while estimates of the field's producibility had been downgraded. Now it was the politicians, against Statoil's wishes, who put their foot down. Many of them still had a strong desire to see the resources landed in Norway, but it was too expensive on this occasion – and some of the uncertainty remained.

When the Storting came in 1981 to clarify what was to be done with the gas from Statfjord, conditions had changed once again. A tripling in oil prices after the Iranian revolution in 1979 had a positive effect on financial margins. Nobody doubted any more that Statfjord would operate at a profit. But there were fears that the British might acquire a monopolistic position in relation to Norwegian gas. By landing this resource in Norway for processing, it could be piped back over the Trench further south and connected to the gas pipeline network on Ekofisk. From there, the gas could be sent on to Emden in Germany. Statoil's studies now came into their own. The work of crossing the Trench began in 1983. A separate company, Statpipe, was established to own and operate the pipeline. The receiving terminal in Norway was located at Kårstø north of Stavanger. But had the diving challenges been overcome?

Towards greater depths

The studies on landing petroleum across the Trench were generally over-optimistic compared with actual developments. They can be interpreted in that light as evidence of the way studies, expertise and research can, under specified conditions, have a tendency to come up

Bad weather on Statfjord A.
Photo: Leif Berge/Statoil

with the answers and conclusions people want. The Ekofisk committee thought that the necessary technology to permit practical work diving in more than 300 metres would be available as early as 1974. That was not the case. Even when the laying of Statpipe began a decade later, no extensive practical experience had actually been acquired with diving in depths corresponding to the deepest sections of the line. The fact that the studies nevertheless became gradually more realistic reflected a fairly substantial strengthening of international and Norwegian expertise in this area during the same period. Where Norway was concerned, the creation of the Norwegian Underwater Institute (NUI) played a significant role by providing the country with a genuine centre of expertise in diving research (see chapter 9). It was also important that the Norwegian diving companies developed the expertise to undertake major contracts on their own account rather than merely supplying divers to the foreign contractors.

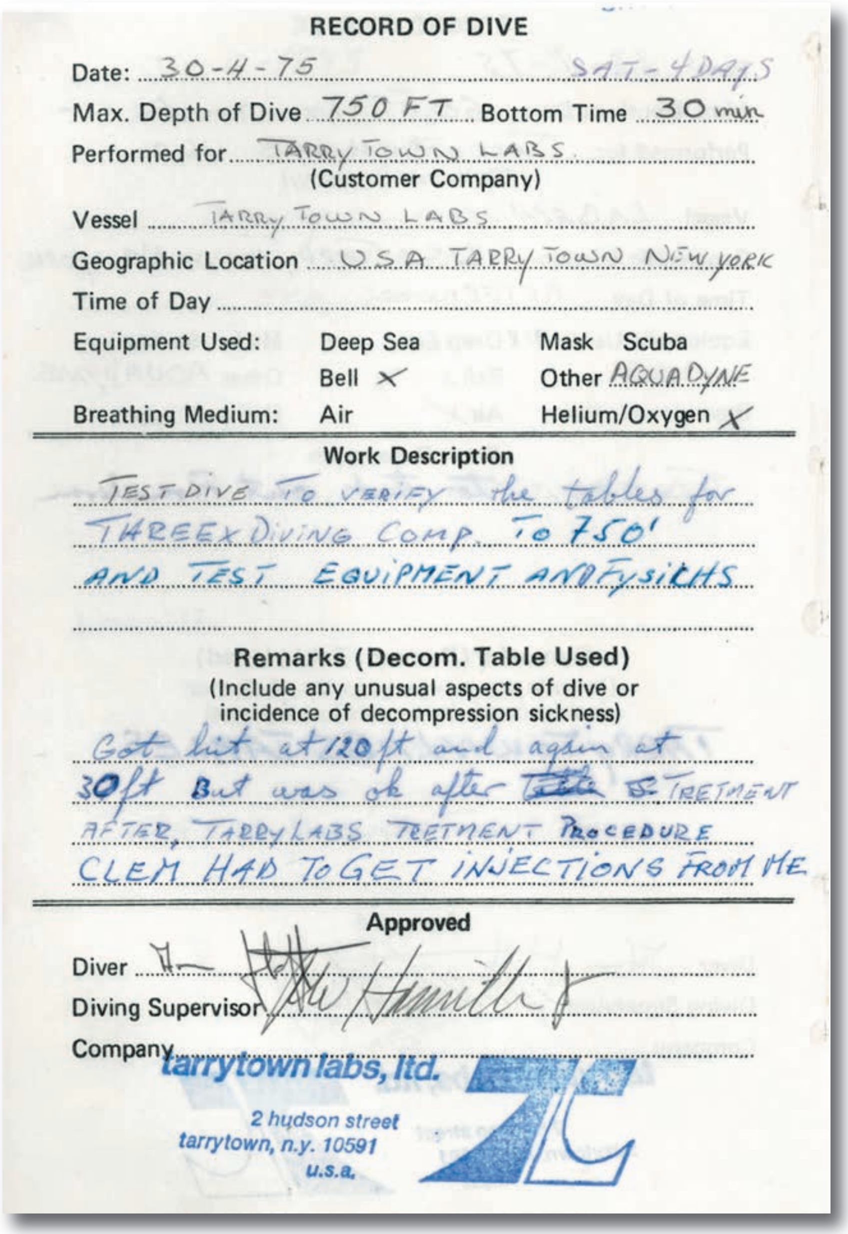
So strong was the Norwegian political pressure to cross the Trench that it became an important driving force in pushing the international diving industry into deeper water. Deep diving on the NCS was regarded as a major future market. The oil companies were fully aware that the trend was towards greater depths, regardless of Norway's pipeline choices. This gave the research institutes working to overcome "decompression issues" substantial elbow room. From the late 1960s and well into the 1970s, a number of experimental dives were conducted in deep water in the USA, the UK, France, Switzerland and West Germany. Britain's Royal Naval Physiological Laboratory (RNPL) and the research lab at Duke University Medical Centre in North Carolina were originally developed for military purposes. Now, however, developments were driven forward by the oil and gas companies.[29] Comex had its own research centre in Marseilles, which also received extensive support from a French government which regarded securing national participation in an expanding international market for subsea technology as an important strategic goal.

Until the early 1970s, most of the research into deep diving was based on bounce technology – in other words, a relatively rapid descent, a correspondingly short period of work under water, and then decompression. Helium played a key role. But experiments were also conducted with varying dosages of nitrogen and oxygen. With the breakthrough of saturation diving, however, the research efforts also changed their focus of attention. When the Norwegian representatives from the DWP commission travelled around in 1973-74, the most prominent scientists they met were working almost exclusively on saturation diving. Physiologist Peter Bennett, who the Norwegian delegation met at Duke University, had taken divers down to 1 500 feet – roughly 500 metres – during a 1970 experiment.[30] When the Norwegians met

Construction of Statfjord A was a difficult period. Much of the work had to be done after the platform arrived on the field. Life for those involved could shift between waiting and hectic work. The same applied under water. Photo: Leif Berge/Statoil

him, he claimed to have developed tables and gas mixtures which could reduce the effect of high pressure nervous syndrome (HPNS), which often occurs at depths below 180 metres. A number of the French experiments were led by Xavier Fructus, the man who met Winsnes in the wake of the 1971 accidents on *Ocean Viking*. In the Sagittaire IV dive carried out by Comex in 1974, two divers stayed at 2 001 feet (610 metres) for 50 hours. Like most of the experimental dives that followed, it was conducted in saturation. Another key researcher encountered by the Norwegians was Briton David Elliott.

However, there was a big difference between experiments under more or less controlled conditions at research institutes and actual op-


RECORD OF DIVE

Date: 30-4-75 SAT-4 DAYS

Max. Depth of Dive 750 FT Bottom Time 30 min

Performed for TARRY TOWN LABS
(Customer Company)

Vessel TARRY TOWN LABS

Geographic Location U.S.A TARRY TOWN NEW YORK

Time of Day

Equipment Used: Deep Sea Mask Scuba
Bell X Other AQUA DYNE

Breathing Medium: Air Helium/Oxygen X

Work Description

TEST DIVE TO VERIFY the tables for
THREEX DIVING COMP. TO 750'
AND TEST EQUIPMENT AND FYSICHS

Remarks (Decom. Table Used)
(Include any unusual aspects of dive or incidence of decompression sickness)

Got hit at 120 ft and again at
30 ft But was ok after ~~Table~~ 5 TREETMENT
AFTER TARRY LABS TREETMENT PROCEDURE
CLEM HAD TO GET INJECTIONS FROM ME.

Approved

Diver

Diving Supervisor

Company tarrytown labs, ltd.
2 hudson street
tarrytown, n.y. 10591
u.s.a.

3X became the first Norwegian company to conduct a series of test dives at the Tarrytown laboratory north of New York during 1975 in order to develop its own bounce diving tables. As this log shows, all the divers suffered serious cases of the bends.

erational dives conducted by diving contractors in the sea. After the initial exploration wells on the NCS had helped to make dives in around 70 metres routine, there was a period when the US and UK continental shelves were breaking the largest number of barriers. California-based Cal Dive had dived to around 600 feet (180 metres) during 1968 in the Santa Barbara Channel. Cal Dive was acquired by Oceaneering the following year, and divers from the latter went even deeper in the same area during the 1970s. However, this still involved bounce diving with relatively brief periods in the water. Even though the company did what it could, with the aid of the research by Bennett and others, to come up with tables and gas mixtures which reduced decompression times as

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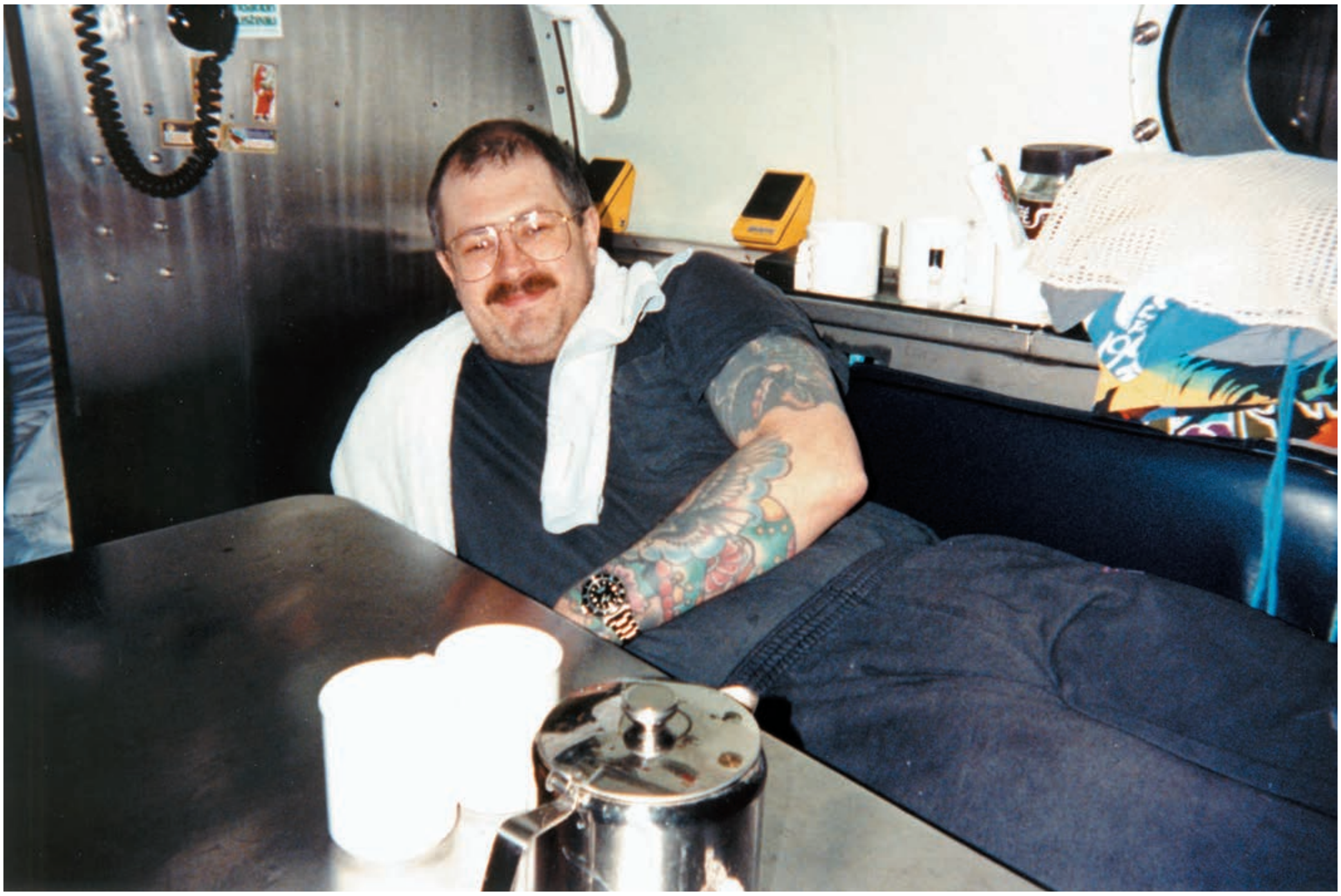
much as possible, the cost per actual hours worked became very high. Bounce diving could be suitable for short jobs related to exploration drilling, but the saturation method was soon the only option for underwater work on platforms and pipelines.

Just as Ocean Systems became successful as the first company to industrialise diving with the aid of bells and decompression chambers, Taylor Diving led the introduction of the saturation method. Links to Halliburton and Brown & Root on the owner side meant it was well positioned to win major construction-related assignments. When BP began production drilling and installation work on Britain's Forties field in the mid-1970s, however, the diving contract went to the much smaller Sub Sea International – even though Brown & Root was the main development contractor. With work in depths from 110 to about 145 metres, Forties was the most extensive diving project worldwide before activities on Statfjord got fully under way. From the award of the Forties contracts until the early 1990s, however, no similar oil-producing region could match the contribution of the NCS to pushing the diving business into ever deeper water.

Saturation becomes dominant

Most of the offshore diver's work has been carried out on the seabed in both exploration and production phases. The NPD's statistics for the average water depth of drilling on the NCS thereby also provide a good indication of how deep the diving was at any given time. Logically enough, diving on fields brought into production was largely conducted at the same depths as exploration drilling. In the late 1960s and early 1970s, the average depth was 70-80 metres.[31] By the late 1970s, drilling in 140 metres around Statfjord helped to raise the average to just over 100 metres. From 1983, the average drilling depth was more than 200 metres. However, this figure was boosted by operations on Troll, where drilling took place without diver assistance for the first time on the NCS. Somewhat later, however, diving was carried out for exploration drilling and installation of production facilities on Gullfaks. Parts of this field lie as deep as Statfjord. Its third platform, Gullfaks C, stands in no less than 216 metres of water.

Underwater diving work during exploration drilling was the same in the early 1980s as it had been in the 1960s and 1970s. As drilling moved into ever deep water and the demands on decompression chambers, habitats and other equipment increased, much exploration-related diving was conducted in saturation. Transferring divers to specially designed DSVs meant that a diving team in saturation could theoretically carry out work for several drilling rigs simultaneously. With dynamic



Life in saturation was never luxurious for the divers. The new habitats introduced in the late 1970s were nevertheless more comfortable than the original equipment used earlier in the decade. Mike Noel in saturation on *Ametyst* at some time in the 1980s. Photo: Einar Andersen

positioning and arrangements for lowering the bell through a moonpool, DSVs such as *Arctic Surveyor* and *Seaway Falcon* could move close to the drilling rig. More than anything else, however, it was the explosive expansion in diving on the major producing fields and for pipelaying in deep water which changed the character of the business. It was also here that a series of new DSVs came into their own.

A good deal of surface-oriented diving with cylinders or traditional helmet diving with hose still went on in connection with special assignments and for a good deal of maintenance work, even on the fixed installations. From 1979 until the late 1980s, the number of registered surface-oriented dives remained relatively stable at around 2 000 per year.[32] The DSVs primarily conducted saturation diving, and such dives in deep water thereby became the norm for an ever growing group of divers. Their scope reached a peak in 1984, with an annual total of 384 136 working hours in saturation.[33] That represented more than a doubling from the level in the late 1970s to 1980, which was around 145 000 hours.[34]

Diving on Statfjord

After saturation diving had been introduced on Ekofisk and Frigg (chapter 2), Statfjord more than any other development became the proving ground for modern diving methods in deep water. From the discovery of this field in 1974, exploration activity became at times intensive. Comex, which won the first major diving contracts related to exploration operations on Statfjord, conducted all its deep dives using the saturation method. Bounce diving with a bell, of the kind carried out by the company from *Ocean Viking* and other drilling rigs in the Ekofisk area, became both uneconomic and hazardous at a depth of about 150 metres.

As soon as Statfjord was found, intensive production drilling began in the area. Diving became a really large-scale activity when Statfjord A (1977), Statfjord B (1982) and Statfjord C (1985) were installed.[35] With three apparently similar concrete behemoths spaced more or less evenly apart, this field could seem better ordered than Ekofisk. But the Statfjord development also had a chaotic character. Technological barriers constantly needed to be breached, both above and below the waves. As with Ekofisk, getting production going was a matter of urgency. In many respects, in fact, it was even more urgent. The huge investment in oil had created Norway's biggest-ever trade deficit of NOK 20.5 billion in 1977.[36] This corresponded to about 11 per cent of that year's gross domestic product. The country's foreign debt was rising year on year, and the government budget was also in deficit. Welfare provisions had been introduced in anticipation of expected offshore revenues. Statfjord held so much oil that both deficits would be eliminated if only production could start. But disquiet began to spread for a while during the late 1970s. Would Statfjord's costs become so high that the project nevertheless became unprofitable? Accidents, strikes, delays, budget overruns – the newspapers were full of reports which painted a picture of chaos.

All the occupational groups who worked to complete the platforms offshore were under great pressure. The overriding priority was clear. It was essential to meet the schedule, make sure that production started as soon as possible, and ensure that the oil and gas could be transported to market. Statfjord A remained far from finished when it was towed out to the field in 1977. The next two platforms could build on experience from the first, but were also characterised by incomplete drawings, hasty planning and poor design, and occasionally by solutions which were far too complicated. Many of the weaknesses were below water. That meant it was the divers who had to carry out difficult

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repairs and improvement work. Without an intensive commitment by this group, the platform would never have produced oil.

Particularly big problems were created on Statfjord A by the loading buoy installed alongside it. The effort to pipe the oil ashore had been dropped in favour of loading into tankers on the field. Although this was simpler than laying a pipeline over the Trench, it presented difficulties enough. Vessels of 150 000 deadweight tonnes lay in high seas and strong currents and tugged on the buoy. The latter was attached to a swivel on the seabed which allowed it to oscillate a little in response to pressure from the tanker. As so many times both before and since in the Norwegian oil industry, however, what might seem a simple solution on an engineer's drawing board did not behave as intended once it was exposed to ungovernable natural forces and required to function together with other complicated technological systems. So the divers had to set to work. They first had to go down to survey the problem. Repairs could then begin. These included having to weld on a wedge system – work of kind which not even the most advanced submersibles could perform. In such circumstances, a diver could undoubtedly feel at times like a remotely controlled machine. The work was monitored on cameras from surface. Not a few, often contradictory, orders could flow from the diving leadership and the contractor responsible for the construction work. The result therefore depended crucially on the assessments and actions of the diver on the spot. In such cases, what mattered was his ability not only to operate under water but also and equally to improvise and act as a practical problem-solver.

Even though friction could arise between the divers on the seabed and the person leading the operation, however, both sides were trained to understand each other. The position most divers feared above all was having to follow decisions made by the operational management on the production platforms. On drilling rigs, the rig manager, drilling personnel and maritime crew were people the divers could relate to on a day-to-day basis. Work acquired a routine character as the rig moved from well to well. Operating large platforms also became routine – as the years passed. But much more complex technological systems were involved. A number of functions which on land would have been located in separate factories were concentrated in one and the same place.

Many people with experience of "high-tech" seminar rooms have surely seen how a rather clumsy speaker or willing assistants can become completely confused by a control panel designed for easy use – so that Venetian blinds go up and down, screens suddenly appear and the lights brighten rather than dim. When something like that happened at the start of the diver lawsuit in the Oslo District Court during 2007, one of the divers in the audience cried out spontaneously: "That's just the way it was for us in the water in the North Sea". Everyone understood

**When the Storting dropped the proposal to pipe Statfjord oil across the Norwegian Trench, it was decided to load this output into tankers via buoys on the field. Divers had to make extensive subsea modifications before the system functioned.
Photo: Henning Christensen**

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at once what he meant. It took time for the platform management and process operators to learn all the practical consequences of the technical control mechanisms on board. Moreover, they often knew little about the conditions faced by a submerged diver. Since most diving was now done from DSVs, direct day-to-day contact between divers and other personnel on the platforms had been lost. The bell was also lowered through the DSV's hull, so that observers on a platform could not even see whether divers were in the water.

From a diver perspective, the big production platforms presented a number of dangers. Several submerged intakes might be present, drawing in cold seawater to cool down machinery on board. These were activated without regard for possible divers in the vicinity. Other types of pipe sticking out from a platform could be equally hazardous. A common potential trap for divers was the blind flanges closing off pipes which might be required for later connections. Divers assigned to remove these covers depended on the platform management having the pressure under control. That was not always the case. An episode in 1984 can serve as an example. A diver was told that it would be safe to enter a pipeline for inspection. While he was inside, a valve was opened and the diver was blasted out into the sea like a bullet from a gun.[37] The dive was being conducted with an umbilical in 30 metres of water. Both mask and equipment were blown off. The diver had to ascend rapidly and enter saturation treatment. He survived. However, a diving superintendent recalls having to pluck pieces from destroyed equipment out of the diver's skin.

A substantial part of the diving on Statfjord was conducted to install a complex system of flowlines between the various platforms. Unlike the gathering lines from Ekofisk and Frigg, and the later gas pipeline from Statfjord, these infield flowlines were welded together by divers on the seabed. For simple jobs, this could be done directly in the water. Although it might be thought that such surroundings would extinguish any flame, the heat generated by a welding torch is so great that it will also work on the seabed. Unless additional aids are deployed, however, subsea welding creates a brittle weld which will be too weak in most contexts – not least for flowlines required to carry large volumes of oil and gas without leaking. As a result, most of the seabed welding on Statfjord was conducted in the dry using a hyperbaric chamber similar to the system first adopted on Frigg. After welding, the flowlines were buried by a specially designed trenching machine. Given all the activity which took place in the waters around the platforms, the risk that flowlines lying uncovered on the seabed would be damaged was particularly high. But the divers were responsible for ensuring that the job was done properly. Moreover, they were not infrequently required to help lay sandbags. Handling such loads under saturation in a depth of 150 metres for four hours or more at a stretch and for many days in succession was hard work.

The companies

Never before or since have so many divers worked in one and the same place off Norway as during the Statfjord development. During a single season, six-seven DSVs could be at work in connection with the field. In addition to its maritime crew, such a vessel employed about 30 people on the diving side. So 200-300 people could have been involved in underwater work during the peak period. Since their time was split roughly 50-50 between ship and shore, a total of 500 diving-related personnel could have been involved with Statfjord at peak.

The diving companies competed vigorously for a long-term main diving contract on Statfjord when it was put out to tender in 1979. Possessing experience, sufficient suitable equipment, and a staff of experienced divers and diving supervisors was naturally essential for a contractor. But it was still the case that the most important competitive advantage over rival companies was how fast a specific job could be done and at what price. The crucial consideration in that context was the kind of diving tables used.

Mobil was operator for Statfjord and thereby primarily responsible for awarding contracts. But Statoil, with 42.7 per cent of the unitised field and ambitions to take over the operatorship, also influenced the choice. Many people in the Norwegian diving community accordingly expressed disappointment when the contract went to Britain's Wharton Williams (2W) and not one of the domestic companies.[38] Wharton Williams had been founded in 1976 when the leaders of Comex's UK arm broke with their French management and formed a branch of Taylor Diving.[39] Comex, which had clearly wanted the big Statfjord contract, found its award to the breakaway team a bitter pill to swallow. Taylor Diving's decision to concentrate on a UK branch partly reflected the fact that British divers had by then become at least as competent as the much more expensive Americans. Moreover, the US company expected growing protectionism to make it harder for Americans to win work on the UKCS.

The late 1970s were also characterised by increasing protectionism in Norway. With support from key politicians and the government, Statoil actively applied pressure to ensure greater Norwegian success in winning contracts. In this case, the state oil company supported Mobil's choice of a foreign diving contractor. A diving superintendent in Haugesund-based Seaway Diving told Oslo tabloid *VG* that unionised Norwegian companies could not compete with foreign contractors which operated with contract divers and their own working-time rules. "Even though Norwegian companies have cut [costs] to the bone in their tender, 'WW' has always underbid them," he claimed.[40] This was an issue which would come up again and again in the following years.

Although 2W was a foreign company, however, the first long-term diving contract on Statfjord nevertheless represented a certain degree of Norwegianisation. It worked from DSV *Tender Comet*, owned by Norway's Anders Wilhelmsen. The company also undertook to use Norwegian divers as far as possible. Since this was a long-term assignment, that was in many respects advantageous for the British company – providing the Norwegians had the necessary expertise. After all, divers had to be flown in and out of the Statfjord area from heliports in Norway. Over time, it was therefore beneficial that they lived nearby. The first North Sea divers were used to moving from one company to another, and many found a long-term job on Statfjord attractive. So 2W had no difficulty recruiting Norwegian personnel. During the 1980s, close to 70 per cent of its divers hailed from Norway.

Nor was 2W by any means the only company to secure work on Statfjord. The scale of diving operations was so great that both Comex and Seaway Diving – which had now changed its name to Stolt-Nielsen Seaway (SNS) – won contracts for short-term work relating to various special assignments. Precisely because these were short jobs, the companies relied heavily on contract divers. The proportion of Norwegian divers employed by SNS was smaller at times than in 2W's operations on the NCS. That was something of a paradox, given that a SNS representative had complained about 2W not being Norwegian.

Diving on Statpipe

Statoil's first chief executive, Arve Johnsen, was asked in connection with the company's 20th anniversary in 1992 to name the most important event during his 15 years at the helm. He responded that it was the Storting's decision in 1981 which led in part to the Statpipe development:

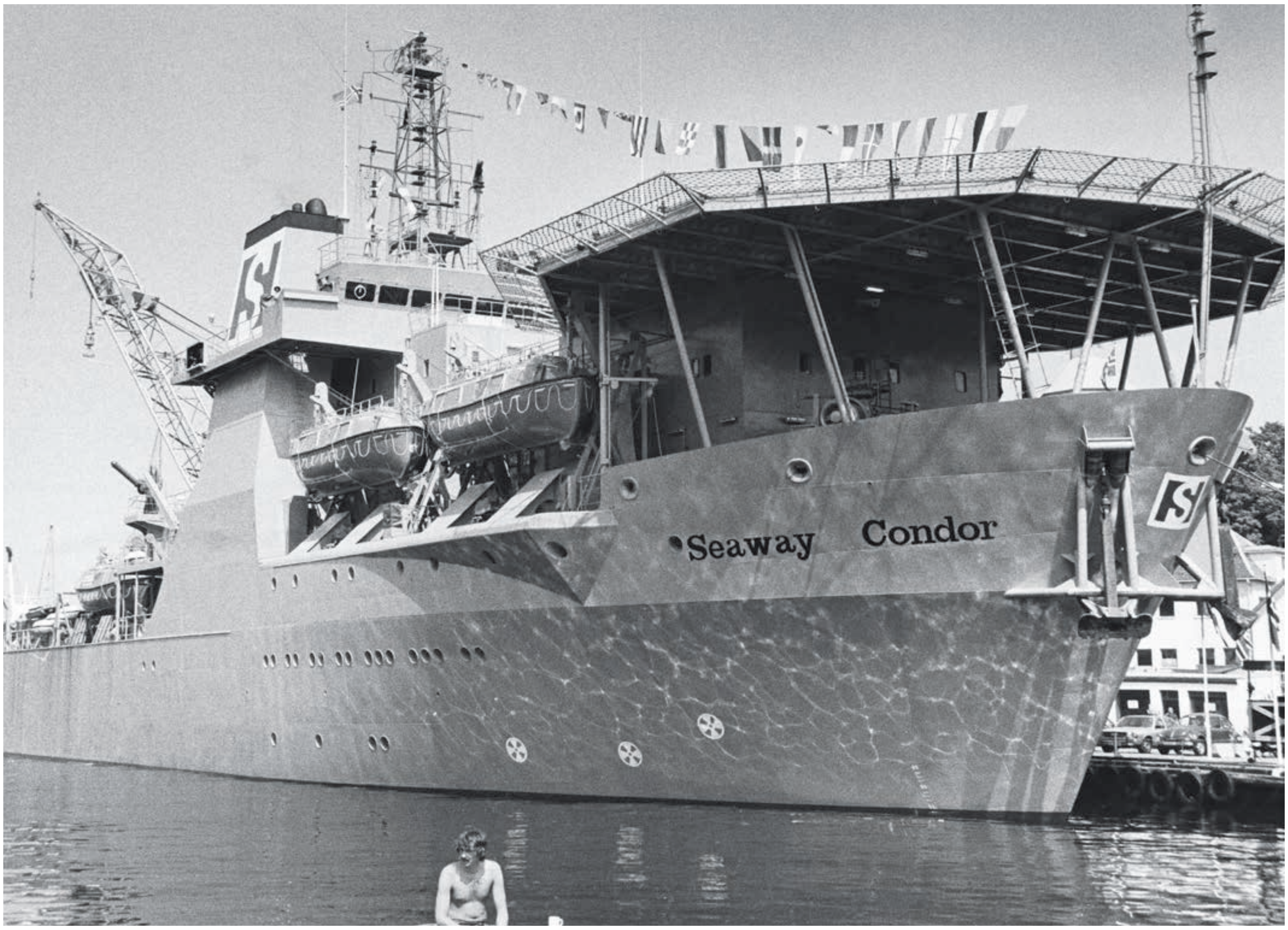
> The Statpipe project was special because we did something everybody else thought would be extremely difficult – laying a pipeline across the Norwegian Trench in 380 metres of water. We also laid the basis for an infrastructure of gas pipelines from the NCS, which will have enormous significance for Norway and Statoil ...[41]

Johnsen exaggerated a little when he added 80 metres to the actual depth of the Statpipe line. This was nevertheless a technical achievement, where Statoil itself, the pipelaying contractors and not least the divers and the diving companies all breached barriers.

Since Statpipe lies under water, no visual expression of the scale of the achievement exists to compare with the huge concrete platforms it was tied into. A total length of 850 kilometres meant that this system nevertheless ranked as the biggest project of its kind in the North Sea at that time. Unlike the pipelines from Ekofisk and Frigg, which ran directly over a relatively shallow and flat submarine plain to the British, Danish and German sectors, every kilometre of Statpipe was laid on the NCS. The challenge was not only the depth but also stretches of very broken seabed terrain. Statpipe's first leg ran from Statfjord to Kårstø, where the natural gas liquids (NGL) were separated out. The dry gas was sent back across the Trench to the Draupner S riser platform, where a spur from Heimdal to the north brought additional gas. Statpipe then continued to Ekofisk. It is no coincidence that the record for total hours spent by divers in saturation on the NCS was set in 1983-85, when work on the pipeline was at its most intensive. This Statpipe diving came in addition to the extensive underwater work being done on Statfjord at the same time.

Despite Statoil being the operator, the many major studies conducted in advance and the pipeline's status as a national prestige project, most of the contracts went to foreign companies.[42] The huge laybarges attracted the greatest media attention, with McDermott's *LB 200* as the most impressive. But a DSV was always to be found just behind – and occasionally ahead – of these vessels. The diving contract was awarded to SNS. That represented a solid consolation prize for losing out on the main Statfjord assignment. For two years, the company's DSV *Seaway Condor* shadowed the pipelaying process. Diving on Stat-

Line pipe number 14 260 leaves the *LB 200* lay-barge. Laying Statpipe was rightly regarded a major engineering triumph. However, only the deepest sections were laid without diver assistance.
Photo: Leif Berge/Statoil



Seaway Condor in 1985. A substantial part of the underwater work involved in laying Statpipe was conducted from this diving support vessel (DSV).
Photo: Norwegian Petroleum Museum

pipe was so extensive that other contractors were also drawn in. The semi-submersible DSV *Uncle John*, built for Comex by Norway's Aker group, participated both indirectly via research and verification dives at the Norwegian Underwater Technology Centre (Nutec) and directly in the actual pipelaying. Nevertheless, no single company before or since has been responsible for as many continuous days in saturation on the NCS as SNS during the Statpipe project.

Seaway Condor had 80-90 people on board at any given time, of whom 35-45 were saturation divers.[43] As a rule, 15 men were in saturation at all times during the work on Statpipe. Inspection accounted for a substantial part of the work. Most diver time in the water was devoted to building up the seabed under and around the pipeline at vulnerable points. Sandbags had to be hauled in some places, while cement was applied elsewhere. A great deal of the diving took place in 190-200 metres of water, which meant that the divers spent up to nine days in decompression. The deepest operational work dive took place in 245 metres on the edge of the Trench off the island of Utsira. This involved measuring the length of a free span, a job which ROVs were still unable to do. Although most of the line pipes were welded together up on the laybarges and laid out in full length, a good deal of welding was required on the seabed.[44] Since sections of the pipeline were laid by different barges from various starting points, they had necessarily to be welded together where their ends met. Steps were naturally taken to avoid such a meeting point at the bottom of the Trench. With much thicker pipes and higher pressure in the welding habitat, this work was even more demanding than on Statfjord.

With such a large number of divers involved and an average saturation time of around 25 days per dive, Statpipe diving made big demands on both the equipment and the personal qualities of each diver. Conditions in the diving spread on *Seaway Condor* were much improved from the habitats used for the first saturation dives on Ekofisk and Frigg. When Norwegian companies such as SNS and Scandive bought systems for their DSVs, they occasionally combined components from manufacturers in different countries. Divers in Norway viewed systems from Germany's Dräger as the best, with Italian and British products regarded as of poorer quality. *Arctic Surveyor* used a Dräger spread with two chambers.[45] Diver comfort on *Seaway Falcon* improved markedly when it acquired a separate toilet chamber. But this was very expensive to operate because there were entrances from both habitat and decompression chamber.[46] Every time a diver in decompression needed to use the facility, it had to be blown down from the working pressure to the relevant decompression depth. Large quantities of expensive helium could disappear in such a process. The decompression chamber was provided with its own toilet during a conversion in 1979.

Seaway Condor had four pressure chambers. Of the 15 men usually in saturation, two-three were generally involved in bell-related work and six were under decompression. The remainder were sleeping or relaxing. All the "rooms" or chambers could be sealed off from each other, with separate pressurisation. Divers were usually "blown down" in the toilet chamber, which was also used to enter or leave the bell with various items of equipment. The divers had two chambers at their disposal when they were not down in the bell. One was used for sleeping and the other for recreation and eating. These two chambers were normally pressurised to the same depth, so that the divers could move freely between them. However, the decompression chamber was always separate and only opened when a new team was to start being decompressed. A separate toilet for this chamber avoided the problems which had arisen during the first phase on *Seaway Falcon*.

Even though the habitat on *Seaway Condor* was larger and better than earlier diving spreads, however, life in saturation was never luxurious. To start with, the diving companies used the extra space to increase the

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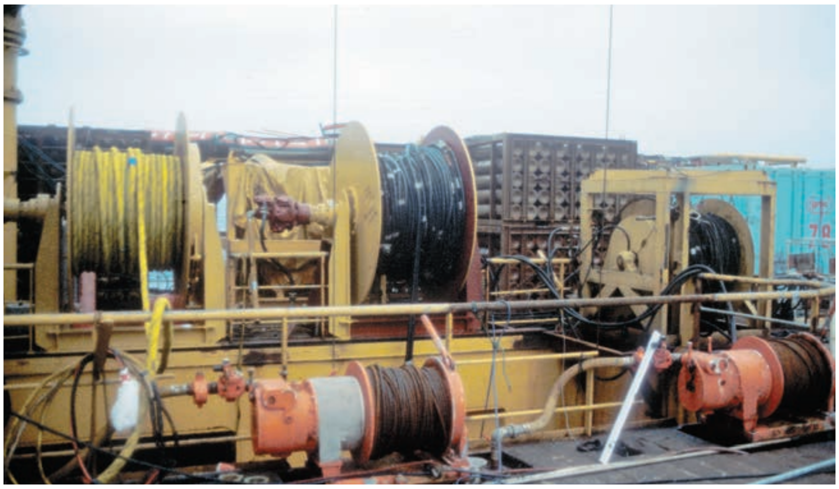
A welding habitat on land. The structures required to weld in dry conditions under water were large and complex.
Photo: Tor Jan Wiik

number of divers. At the same time, pressurisation in itself imposed a burden on the body. Never before had so many divers spent so long at such depths as they did on Statpipe. Many had big problems sleeping, and a lot also found it difficult to read. One diver reports that he had taken the same book with him from the time he started saturation diving on Statfjord in 1986 until he left in 1992, without succeeding in finishing it. Divers with ambitions of using their "free time" to take various courses or for academic study often gave up. Light reading was the usual choice. Apart from the stress of the actual working conditions, being packed closely together with a lot of other people and without opportunities to escape could be a source of mental strain.

The most important requirement for a pressure chamber was naturally that it did not leak. Second, the quality of the life support system was crucial for diver comfort and safety. This kept chambers and bell supplied at all times with the right gas mixture and ensured the correct pressure. In addition, it functioned as a form of air conditioning as well as ensuring the appropriate internal temperature and humidity. Striking the right balance between the last two conditions was difficult but also very important for the divers. Particularly when breathing helium gas, it took very little before they began to feel cold. In this area, too, *Seaway Condor* could avail itself of better and more thoroughly tested technology than the first saturation systems. However, the number of chambers involved and the constant opening and closing of hatches between them made the actual operation of the system more complicated. The large number of hardworking divers also contributed to high levels of humidity. At its worst, these could create a greenhouse for various types of bacteria.

The control room for the diving spread on *Seaway Condor* around 1985.
Photo: Bjørn Wilhelm Kahrs

Operating the diving systems during the Statpipe operation was further complicated by the fact that dive depths could vary substantially. That had been a problem even during stationary diving on Statfjord, where saturation habitats on the surface could be set to 138 metres while the actual work was done 10 metres further down. Dynamic positioning allowed the DSVs to maintain position. Since the waves could be very high at times, the bell had to be positioned a good bit above the seabed to avoid hitting the bottom every time the DSV found itself in the trough of a wave. A diver who worked for four hours or more 10 metres below the pressure he was saturated for needed a certain amount of decompression when his stint was over. The people on the surface who regulated the pressure and calculated this could find it hard to make the right adjustments. During diving on Statpipe, a work team could often be moved to another point along the line at a completely different depth during one and the same saturation period. In some places, moreover, the seabed terrain could be so steep that the divers depended on changing depth in order to do simple jobs. They called this “yo-yo” diving. No tables existed which could give an exact answer to how they should be decompressed in such cases.



Extensive diving called for large quantities of equipment – breathing gas and drums holding umbilicals, hoses and wire cables.
Photo: Bjørn Wilhelm Kahrs

Diving on a large scale was also needed where the pipeline came ashore at Kalstø. Norwegian construction contractor Selmer had the contract to build a 600-metre concrete culvert which would protect the pipeline in the rough landfall zone. This was constructed in five sections measuring 80-140 metres long, which were towed to Kalstø.[47] Divers helped to position them. That job was not straightforward, since the underwater terrain at the landfall is uneven. The culvert was accordingly laid on six pillars installed on the seabed. These supports were built by the divers. A big initial job was to clear the seabed with the aid of high-pressure water jets and the like. Their next step was to drill into the bedrock to fix the rebars securely. They then erected the formwork so that the concrete columns could be cast.[48]

Many divers were engaged in this work during 1982-83. The market was more or less swept clean. In many cases, offshore divers took a subsidiary job at Kalstø while on land between tours. During the final phase, the pipeline was pulled through the concrete culvert before being extended to Kårstø. The pipeline became operational on 25 March 1985, when the flare at the processing plant could be lit.

Milestone with a sour taste

The opening of Statpipe in 1985 was a milestone in Norway's oil history. An important technological barrier had been breached. The Trench had been conquered. This had also represented an important political and financial constraint for Norway. Greater direct national control over the petroleum sector had now been secured, while conditions for industrial development based on these reserves improved substantially. At about the same time as gas started to flow through Statpipe, Norsk Hydro began planning a similar oil pipeline between the Oseberg field and Sture

Diving on Oseberg. Diver Børre Børretzen has had a newspaper sent into the saturation habitat, probably together with food. Many divers had problems reading when they were under high pressure.
Photo: Børre Børretzen

near Bergen. Oseberg itself lay in 100 metres of water, but was right on the edge of the Trench, so that an oil pipeline would rapidly descend towards 300 metres. Its deepest point would be 360 metres down – in other words, considerably deeper than Statpipe. After competitive tendering, Comex secured a long-term contract for diving both during the construction phase on Oseberg and in the pipelaying to Sture. During the relevant period, about 20 people worked on diving-related issues at Hydro.[49] When the actual laying was conducted during the summer of 1987, the work was accompanied by Norcem Comex's DSV *Seaway Osprey*. However, the scale of diving was smaller on this occasion. The job was executed without welding in deep water. By surveying the relevant

route carefully in advance with the aid of ROVs, it proved possible to find a track without excessively long free spans.

Although practical working dives never took place deeper than 248 metres, both Statoil and Hydro were dependent on it being possible to carry out repairs with diver assistance right down to the deepest point on the pipelines if something went wrong. The fact that no divers had come near the deepest sections of Statpipe meant that the extent of inspection and possible adjustment to special seabed formations were not as good as on other parts of the pipeline. The line broke in May 1984 while it was being laid. Fortunately, this only happened once and in 110 metres of water along the spur to Heimdal. The laybarge initially aban-

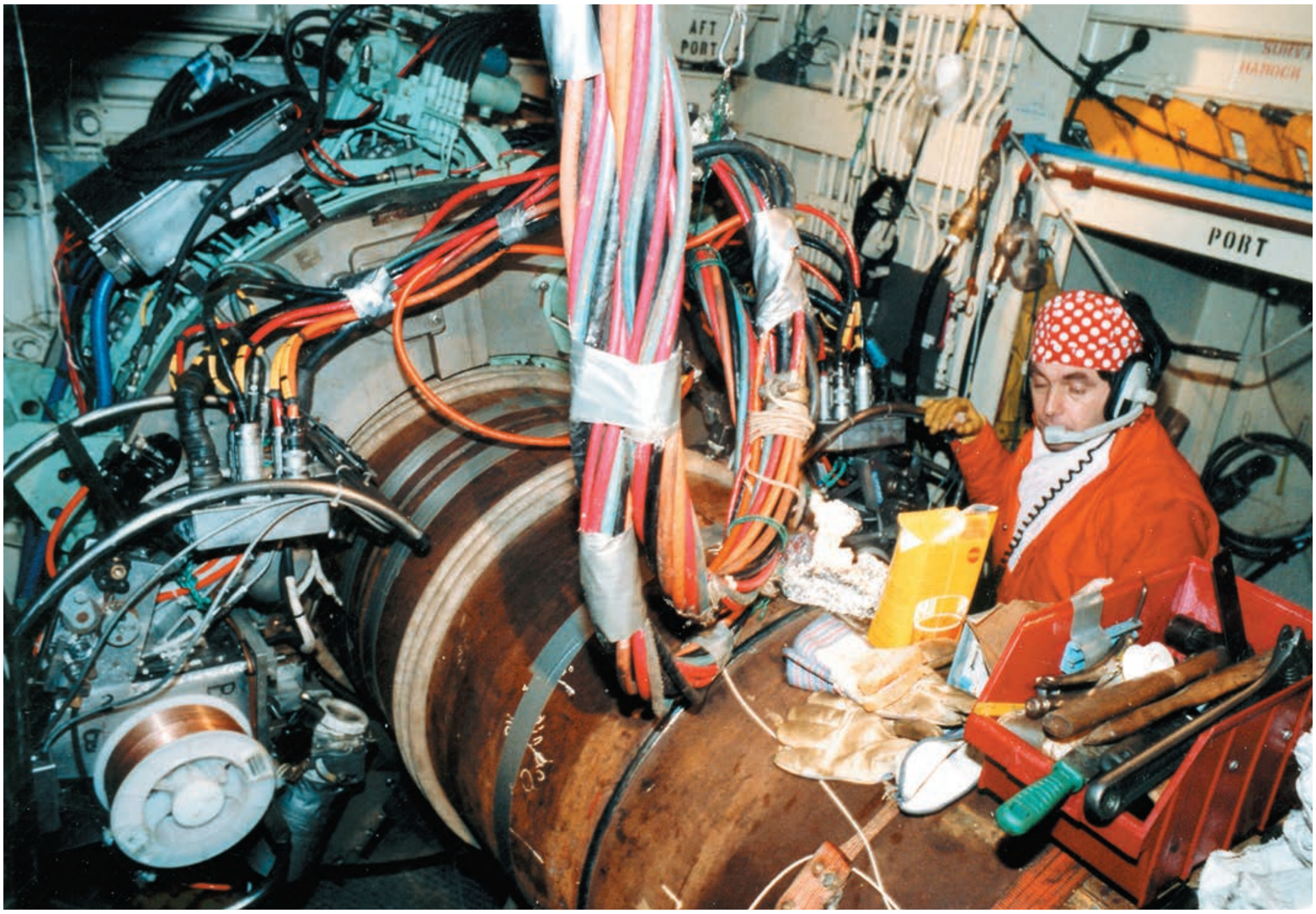
The Statfjord area witnessed intensive diving activity during its development. Photo: Harald Pettersen/Statoil

doned the broken pipeline to resume laying from another direction. When these sections eventually met, however, divers had to go down to clean up and weld. Moreover, the whole pipelaying job halted at Easter 1984 when an ROV discovered an old mine at a depth of 298 metres in the middle of the route.[50] This proved to be part of an unmarked minefield laid against German submarines towards the end of the First World War. Each containing 120 kilograms of TNT, these mines would undoubtedly cause major damage if they went off. They were removed with the aid of trawlers before any harm was done, so no diving was required. But the episode was a reminder of the need to be prepared for all eventualities.

Both Statoil and Hydro were told by the Storting that they remained subject to its old requirement that the companies had to be able to make repairs quickly with the aid of divers should the pipelines leak for any reason. As long as the gas did not ignite, leaks from Statpipe posed no immediate threat to those working at sea. An oil leak, on the other hand, would cause substantial marine pollution. Since the Trench was much closer to the coast than the offshore platforms, moreover, there was a big danger of such pollution reaching land. Where both Statfjord gas and Oseberg oil were concerned, the financial consequences were undoubtedly at least as important as safety and environmental considerations in demanding that Statoil and Hydro had to document the feasibility of making advanced operational dives down to 300 and 360 metres respectively. A full halt to oil deliveries while Oseberg was producing at its plateau rate would represent about one per cent of global output. When planning the Troll gas development, operator Shell faced a similar requirement.

Without divers, neither gas from Statfjord nor oil from Oseberg could have been piped to Norway. Extensive saturation diving from large DSVs was a step forward for the divers in the sense that many conditions became more orderly than in the period when bounce diving was the dominant method. Diving had become a fully industrialised activity. The equipment was more robust. Diving bells lowered and raised amidships in a controlled manner made it possible to avoid the type of hazardous conditions which had prevailed when divers and then bells were hoisted up and down from drilling rigs in high seas. But the safety challenges associated with diving had by no means been overcome. Diving in ever deeper water was steadily stretching the limits of the human body's tolerance without anyone knowing for certain what the consequences might be for the individual.

Fortunately, no serious accidents have occurred since these important pipelines became operational. Divers have thereby never been sent down to do heavy work at the very greatest depths. In order to satisfy the Storting's requirements, however, Statoil, Hydro and Shell



launched extensive programmes of experimental dives. Many of these were conducted at the NUI, others were done abroad. These experiments would themselves prove hazardous for the many divers who took part (see chapter 9). From that perspective, conquering the Trench was a breakthrough which left a sour taste.

Lunch on the seabed under high pressure, inside a welding habitat near Oseberg in 1986. Georg Geoff is wearing a headset to communicate with the diving control room on the DSV. Photo: Einar Andersen

Chapter 7

The *Alexander L Kielland* disaster

The first Mayday call from *Alexander L Kielland* was received at 18.30 on Thursday 27 March 1980. This flotel (accommodation rig) was listing dangerously. A fatigue fracture in a weld on a brace had led to one of the five support columns being ripped off, and the rig was accordingly unstable. The Mayday was picked up at the Ekofisk centre and by a supply ship located two nautical miles to the north. The joint rescue coordination centre was immediately notified and a rescue operation at once launched. A converted drilling rig, *Alexander L Kielland* was providing accommodation for the Edda platform a couple of nautical miles southwest of the Ekofisk centre when the accident happened. The gangway to Edda had been raised because of bad weather and could not be used for evacuation. Panic broke out. Some managed to get into lifeboats, others jumped into the sea. Not everyone donned a lifejacket, and only a few got survival suits on. The list happened so suddenly that many failed to get out on deck and accompanied the rig into the depths when it overturned after 20 minutes.[1]

Efforts to rescue the survivors were hampered by the gathering darkness and gale-force winds. The waves were six-eight metres high, and the current strong. Temperatures were 7°C in the air and 4°C in the water. So only the first vessels to reach the accident scene had any chance of rescuing survivors from the sea and the liferafts. In addition to supply ships and DSVs working in the North Sea, naval and civilian vessels from all over the North Sea responded along with aircraft and helicopters from Norway, Denmark, West Germany and the UK. But it was impossible to survive for long in the icy water. Only a small part of the big rescue force was on the scene during the first critical period

After it had capsized, all that was visible of *Alexander L Kielland* on the surface was the four remaining pontoons. DSVs *Seaway Falcon*, *Seaway Eagle* and *Tender Power* searched the area. The Edda platform is in the background. Photo: Børre Børretzen

after the accident. They saved 89 people, while 123 died in the biggest industrial accident in Norwegian history.

Diving work after the disaster

By the morning after the accident, the weather had improved and the sea was calm. It seemed almost unreal that the dramatic incident had occurred. Rescue work was now primarily conducted by DSVs. The divers were given the job of going down to find and retrieve the dead as well as securing loose objects around the wreck.

Tender Power began immediately to secure the torn-off support column. *Seaway Falcon*, which was permanently stationed on Ekofisk, arrived at 11.24 and began to secure the wreck. Air divers from both ships went systematically over the rig columns in search of sounds from possible survivors. Three hawsers were attached to the rig to prevent it drifting about freely. More DSVs arrived, and various jobs were allocated. *Seaway Falcon* continued search and rescue work. *Seaway Eagle* checked the Edda platform for possible damage. *Wildrake* searched for and retrieved equipment. The latter had a team of divers already in saturation when the accident occurred, and they set to work immediately to secure objects in deep water. *Seaway Hawk* also joined the fleet on 31 March. Once the platform inspection was complete, all the vessels were assigned to search for bodies.[2] The seabed beneath the Edda installation and *Alexander L Kielland*'s original position, as well as a wide area around Edda, was fine-combed. A total of 47 corpses were found and retrieved.[3]

Locating and bringing up dead bodies was a grievous job for the divers. Some had done similar work before, but not others. Arne Jentoft, one of the divers who took part, relates that they found several bodies on the seabed with lifejackets on. They had clearly been dragged down with the rig when it capsized. The divers were personally acquainted with some of the dead. "We found five or six in a lifeboat which lay on the seabed," Jentoft says. "It was a terribly difficult job, but somebody had to do it."[4] While they were at work, Phillips resumed mud circulation in the Edda well for safety reasons, in order to maintain pressure in the borehole and so forth. On 5 April, the NPD consented to the resumption of drilling. During that operation, 85 barrels of drilling mud were dumped in the sea contrary to the regulations. The divers taking part in the search reacted to this insensitive behaviour. They submitted a written complaint which noted that the mud, chemicals and similar substances discharged from the platform reduced visibility for the divers to a minimum and made it difficult to conduct an effective search. The discharges also presented additional risks for the divers, who crit-

A pensive diver views the wreck. Photo: Børre Børretzen

Preparing to tow *Alexander L Kielland* to land. *Seaway Falcon* is in the background. Photo: Børre Børretzen

icised Phillips for behaving in an unworthy manner and showing little respect for the dead and their families.[5] Phillips subsequently apologised.[6]

The divers differed in how tough they found the salvage work after the disaster. *Wildrake* had a surface-oriented diving team as well as the one in saturation, with the first of these searching for bodies in the quarters module and under the rig deck. The weather was fine and the job was not difficult in purely diving terms, but it was special in that many dead were discovered. One relatively straightforward job was to attach steel cables to the rig and the torn-off column to prepare them

Diving during the operation to right *Alexander L Kielland*.
Photo: Jan-Egil Pettersen

for towing. The divers dived once a day, with about 45 minutes of bottom time, and the work continued right until *Alexander L Kielland* was towed to land.[7]

For the divers in saturation, who were given the job of securing technical facilities, the operation was perceived as more chaotic. Geir Ivar Jørgensen was among those who took part in this work. When the accident occurred, he had been involved in a training dive from *Wildrake* with another experienced diver and four beginners at the Dusavik base outside Stavanger. Since they were already in saturation, they were called out to field and reached the accident site quickly. They were ready to join the rescue operation, but were told on arrival to wait for a clarification of who would foot the bill. While this was being decided, the DSV lay idle. The divers were motivated to search for possible survivors in air pockets within the rig, but were not allowed to do so because it was regarded as too dangerous. Instead, they were ordered to ensure that no damage occurred to nearby flowlines and the telephone cable to Scotland. This did not feel so meaningful, and was also hazardous.

Steel cables hung from the wrecked rig like a spider's web. Derrick and cranes went so far down that they literally scraped the seabed. The crane boom had broken off and was being dragged along the bottom by cables attached to the rig. One of the dangers of the diving work was that the bell could get caught up in the tangle. Items constantly fell from the rig. Because of the poor visibility, the divers could only glimpse dark objects tumbling down. Large sheets, probably steel plates, knifed through the water at high speed. In the worst case, the diver or the umbilical supplying his breathing gas, hot water and communication link could be hit – with fatal consequences. The rig's helideck had landed upside down on seabed together with a heap of other wreckage. Some survival suits also lay on the bottom. They looked like people and could give the diver a nasty turn.

Jørgensen, who was good at oxy-arc flame cutting, was given the job of cutting steel cables. The strong current meant that these were under great tension, making the work particularly demanding. Jørgensen had to calculate carefully where to cut and the direction the cable would take when parted, so that it would not hit the umbilical, the bell or himself. Some of the mooring cables on the rig had snapped, but others remained and had to be cut. These heavy steel hawsers comprised many thinner wires twined together. During cutting, one wire after another parted and flicked sharply around and to the side. Because they were under tension, the wires parted abruptly and made the work unpredictable. It was perceived as a hellish business.

This dive became Jørgensen's last in saturation. It imposed a far greater mental burden than he realised. It was stressful to see corpses floating beneath the rig after being ordered to leave them until the work of securing the wreck was over. As a result, many of the dead vanished into the sea and were never found. That conflicted with Jørgensen's personal view of what was morally right. At great risk to themselves and their colleagues, the divers had to give priority to saving technical material. This made Jørgensen angry.

Just after completing decompression from this saturation session, he collapsed and lost consciousness. He was taken to the Central Hospital and then to *Wildrake* for treatment in the decompression chamber. That turned dramatic when he suffered cramps and breathing difficulties during recompression. He was treated in accordance with the standard procedure for the bends, but believes he was probably suffering from serious oxygen poisoning, to which the divers were exposed in the habitat during the *Alexander L Kielland* operation.[8]

In the wake of the accident, rescue personnel – including the divers – were surveyed about their experience of the operation. Of the 15 divers who responded to the questionnaire, 11 had taken part in rescue work a few times before while four had not. When asked to compare the personal strain with previous incidents, 65 per cent of the respondents said it had been worse than the worst they had previously experienced. About half the divers said they were upset by their own mental reactions during the rescue work. This was a much higher proportion than in the other occupational groups. Two of the divers reported that their physical and mental health was still reduced nine months after the accident. Divers, maritime crew and rig personnel were over-represented among those who suffered such afflictions.[9]

First attempt at righting

Scott Cobus monitored the first attempt to right *Alexander L Kielland* in the Gands Fjord from a raft under the Norwegian and British flags.
Photo: Børre Børretzen

The government appointed a commission of inquiry into the *Alexander L Kielland* disaster on 28 March 1980, chaired by district recorder Thor Næsheim from Sandnes south of Stavanger. Roughly two weeks later, the wrecked flotel was towed in from the field and moored for closer inspection. The torn-off column lay at Linesund in the Åmøy Fjord, while the rest of the rig was positioned off Kårstø. Divers were sent down to film the fractures and other sites on the structure as part of efforts to identify the cause of the accident. They could not penetrate the quarters sections to any great extent. Moving about inside the wreck was both difficult and dangerous. Possible corpses could not be removed until the rig had been turned right way up. The investigations were conducted on behalf of the rig's builder. Both survey company Bloms Oppmåling and the police were involved, and the divers pledged to keep the dives confidential.[10]

At the end of August, the rig was towed to the Gands Fjord for the planned righting operation. A consortium comprising Sweden's Nicoverken and Britain's Structural Dynamics was given the job. Work began in October under the direction of Scott Cobus, who monitored the whole operation from a scaffold on a raft in the fjord. No less than 150 people took part. Dolphin was responsible for the diving work. Three diving stations were involved, with about 40 divers in all working in shifts. Diving was conducted from the *Sirafjord* and *Lunde Senior* vessels and a converted ferry.

Børre Børretzen from Dacon was among those stationed on *Sirafjord*. He reports that efforts were made to enter the rig, but it was impossible for the divers to penetrate more than eight to 10 metres inside. The rig was accordingly not fully explored. One body was found in this attempt.

The concept used in attempting to right the rig utilised the existing ballast tanks on the rig columns together with some large lifting balloons and airbags. Pumping air into the tanks and balloons would provide the necessary buoyancy, while water and cement provided weight

The first attempt to right *Alexander L Kielland* in the Gands Fjord, with diving vessel *Lunde Senior* in the background.
Photo: Einar Andersen

at the right points so that the rig would fall back into its proper position. A large array of compressors supplied air and water. Before the work could begin, the practical job of establishing the external ballast system was carried out by divers. This involved shooting holes through the steel rig columns with a bolt gun to install valves for connecting hoses to supply air and water and to pump in cement. The divers also fitted lines used to guide hoses to valves on the platform column. Børretzen filmed the submarine work. Because it was autumn, the water was as clear as glass.[11]

A political hot potato

However, the method chosen proved to be less than effective. The righting operation had to be halted on 12 November because of technical problems. These included accidents with the balloons and airbags. When the rig turned over from its upside-down position and almost reached an even keel, it rolled on and punctured a number of the balloons. A series of changes to the turning procedure failed to produce the desired result. This all created an unfortunate picture in the me-

The second attempt to turn the wreck of *Alexander L Kielland* right-way-up succeeded. Source: Norwegian Petroleum Museum

dia, and the Labour government under premier Odvar Nordli began to get cold feet. It resolved to intervene on 28 November, and the operation was stopped. This decision was justified on the grounds that the government did not want to take a chance that something might go wrong. It would be very unfortunate if the rig were further damaged or if members of the turning team suffered an accident or injury, and this could strengthen criticism of the government's oil policy.

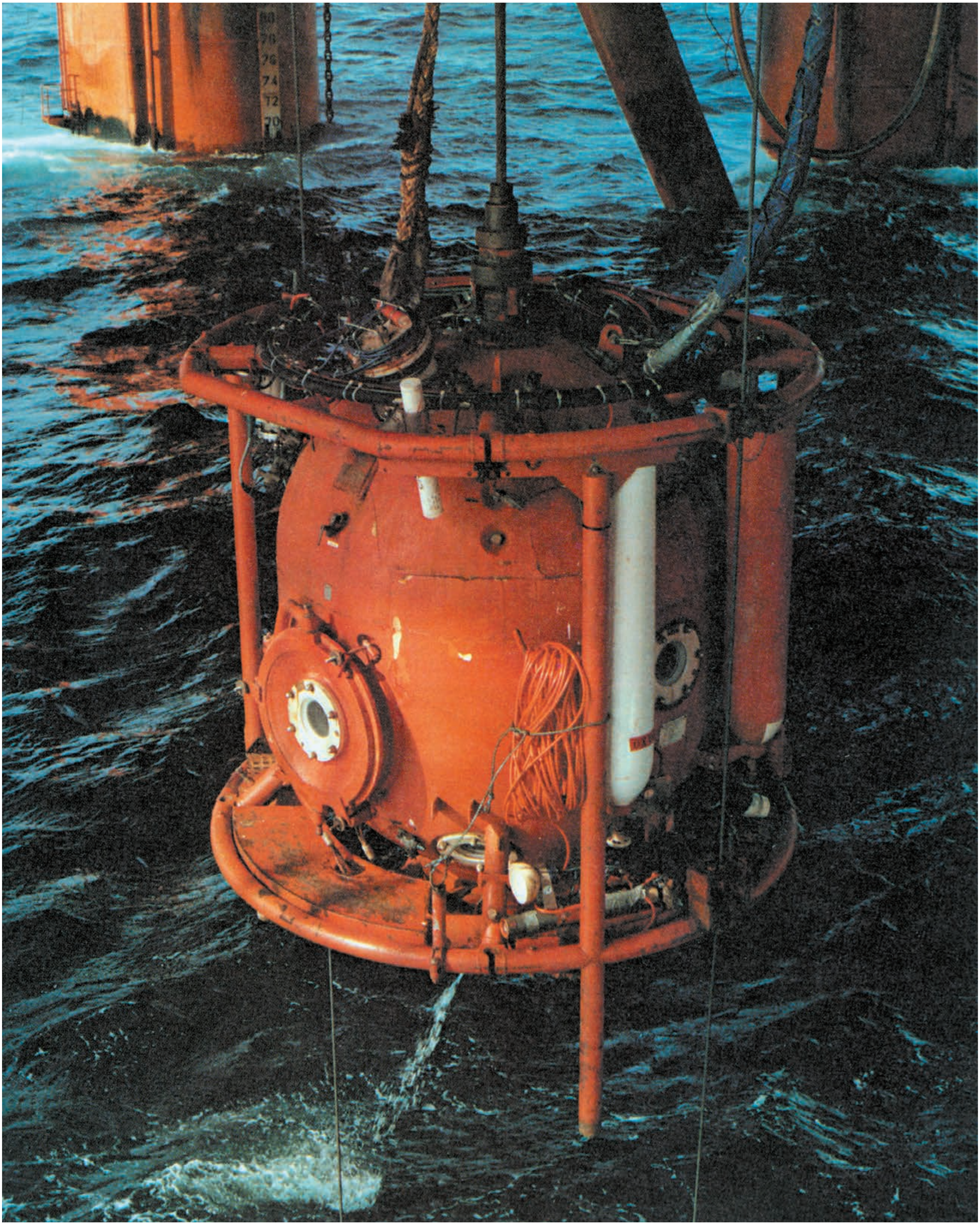
In the eyes of many Norwegians, the *Alexander L Kielland* disaster symbolised the failure of a policy based on forcing the pace of oil production, and thereby the flow of revenues into the government's coffers, without paying adequate attention to safety. It was not worth taking the chance that another accident could occur. To avoid any false steps, a committee was appointed to assess the rig's ultimate fate. This work dragged on. Nordli resigned as prime minister in February 1981, but the new Labour government under Gro Harlem Brundtland launched no fresh initiatives either. The Conservative administration which took office under Kåre Willoch after the 1981 general election also adopted a wait-and-see position. It could point to the committee's conclusion that no new righting operation should be attempted, in part from concern for worker safety. However, the families of the missing would not give up and still had the support of public opinion. They organised a Kielland Fund, which conducted intensive lobbying in the Storting. In May 1982, they succeeded in securing a parliamentary vote in favour of turning the rig against the votes of the Conservatives and the right-wing Progress Party. The cost of a righting operation proved higher than expected, but the issue was finally resolved when the Storting voted extra money in April 1983.[12]

Kværner Engineering was commissioned to plan and lead the job, and a new attempt began in September 1983. Stolt Seaway Contracting handled the actual work, which employed a new method. Robust pontoons were attached to the rig columns to provide additional assurance that the rig would stay afloat once it had been turned upright. A total of 1 200 dives amounting to 2 200 hours investigated the rig, attached hoses and valves, installed pontoons, ran cables to winches on land and so forth.[13] One job given to the divers was to attach special strong stays from the deck to the quarters module in order to reinforce the latter and prevent it falling off while the rig was being righted. The divers cut holes to attach the stays and secured them with big shackles and stay tighteners. Two diving stations were used on this occasion, and work continued around the clock. The actual operation succeeded in the end.

A human cost as well

A total of six bodies were found in the wreck. This small number was undoubtedly a disappointment for many of the bereaved. Nevertheless, everyone was assured that all which could be done to find those missing had been done. As a final closure, a memorial service was held in Stavanger Cathedral, and wreaths were thrown on the sea in memory of the dead. After a detailed examination, the rig was finally sunk in 700 metres of water in the Nedstrands Fjord north of Stavanger. That marked the conclusion of an affair which had been not only a tragedy but also a hot potato for the main political parties. For more than three and a half years, the wrecked rig had served as a visible symbol that the oil industry had a human cost as well.

Along with the Ekofisk Bravo blowout in 1977, the *Alexander L Kielland* accident ranks as the event which has attracted the greatest attention in Norway's oil history. It is perhaps the incident which has made the strongest impression on everyone involved with the petroleum sector, reminding workers, companies and the responsible authorities that safety needs to be taken seriously. Respect for safety issues was difficult to avoid after that accident. Specific measures included making it mandatory as early as the autumn of 1980 for all personnel on offshore facilities to have survival suits. On the regulatory side, this disaster prompted the adoption of the principles of self-regulation and internal control.[14] As we will see in the next chapter, that came to influence thinking on safety issues in the diving industry as well during the years which followed.



Chapter 8

Safety and responsibility

Norwegian newspapers were full of reports in early February 1978 about what was seen as a technological and human achievement. A dive was to be conducted in the Skånevik Fjord north of Stavanger with the goal of welding two pipes together in 320 metres of water. If this succeeded, it would be a world record. Nobody had previously carried out extensive work at corresponding depths. Many newspapers conveyed the impression that Statoil and Hydro were behind the dive.[1] In reality, a number of foreign oil companies accounted for the bulk of the financing. The budget was put at roughly NOK 40 million, with Hydro as the responsible operator. The actual dive would be conducted by America's Taylor Diving. It was compared on the front page of Stavanger daily *Rogalands Avis* with a space mission.[2] According to the press, everything was in safe hands. The dive had been approved by the NLIA, which would have representatives present along with personnel from DNV and the NPD.

It was no accident that the contract for the experiment had gone to Taylor Diving. After the creation of its UK subsidiary 2W in 1976, where Taylor Diving owner Brown & Root had a controlling interest, the US company had cut back its direct presence in the North Sea. In the late 1970s, nevertheless, it was still regard as the world's largest and most experienced saturation diving specialist.[3] It was also the most expensive. The dive in the Skånevik Fjord was a prestige project. If the Trench were to be crossed with a pipeline, the ability to do complex jobs in depths down to 360 metres would be essential. The divers who were due to take part in the experiment had been trained by the US Navy. Many of them also had long experience from the North Sea. Hiring

The diving bell used on the *Byford Dolphin* drilling rig.
Source: NOU 1984:11

NorthSeaDivers_indhold.indd 203 11/03/14 11.34


VESTLANDET

Skånevik-dykkingen ikke avbrutt etter dødsfallet

Det er foreløpig ikke tatt noe standpunkt til om ...eiseforsøket i Skånevikfjorden skal avbrytes etter ... den 28 år gamle amerikanske dykkeren, David ...ower, omkom tirsdag kveld under arbeid på 320 ...eters dyp. Mobil/Statoil og Frigg-gruppen som står ...k prosjektet ønsker mer tid til å klarlegge hendelsesforløpet før ulykken inntraff. I tilfelle de går til det drastiske skritt å avbryte forsøket med å reparere rørledninger på så store havdyp, kan det føre til at en eventuell ilandføring av olje og gass til Sotra blir utsatt med flere år.

Erfaren

Press coverage in the wake of the Skånevik accident was extensive and critical. The headline reads "Skånevik dive not terminated after fatality".
Source: *Bergens Tidende*, 9 February 1978

Taylor Diving indicated that the choice had fallen on the toughest and the most experienced of them all.

Things nevertheless went wrong. American diver David Hoover died at a depth of 320 metres in the late evening of 7 February. Together with Mike Cooke and John Kohl, he was in the first team sent down in the bell to the working depth. Hoover and Kohl went out into the water and began the work of connecting the two pipe ends. The welding was to be carried out in a dry habitat. Kohl entered the latter, leaving Hoover to do a number of jobs outside. Halfway through the dive, the control room lost contact with Hoover. When Kohl emerged from the welding habitat, he found Hoover lying lifeless.[4] After a struggle, Kohl and Cooke managed to get Hoover into the bell. They immediately tried to resuscitate him, without success. Two attempts to close the hatch in order to pressurise the bell failed because hoses had got struck in the hatchway. When the bell could finally be pressurised, it took about 20 minutes to retrieve it to the surface. In the meantime, the necessary medical equipment had been passed through the airlock into the saturation habitat. When Cooke and Kohl came up, they continued their resuscitation efforts together with the other divers in saturation – but to no avail.[5] All attempts to revive Hoover were abandoned at 23.45.

Although many journalists were present to cover the Skånevik dive, the accident did not become public knowledge until the following morning. While the first police inquiries were taking place, residents in western Norway awoke to headlines announcing that all was well with the divers.[6] When the accident became known, even more journalists arrived. Everyone who wrote about the affair was aware of the possible political consequences of a failed dive. However, a number of journalists complained that it was difficult to obtain information about what had happened. Some attempted to get close to the diving barge in boats, but were turned away. A seaplane which landed on the water was also shooed away by the guard boats.

Work on the seabed was naturally suspended immediately following the accident. After two days, a formal temporary ban on further diving was issued by the NLIA.[7] One obvious option was to begin decompression immediately and halt all further diving because the uncertainty was too great. But the divers already in saturation remained there under a pressure of 324 bar in anticipation of a resumption of diving. If the whole operation was to be cancelled, it would not only represent a loss of prestige but a big setback for everyone who wanted a speedy crossing of the Trench.

Hydro finally opted for an intermediate solution. The actual welding was abandoned, but a diving team would be sent down to retrieve the equipment which lay on the seabed. Two physicians who had been hired by the operational leadership outlined to the NLIA how such a dive would be conducted.[8] It would comprise only a few simple jobs. Two divers would always be in the water together during the dive, in constant visual contact with each other. The NLIA responded swiftly and issued a new permit. Around 01.00 on 14 January, three divers again descended to 320 metres. During the morning hours of the following day, the welding habitat was retrieved to the surface. Seven days after the accident occurred, the divers who had been so closely involved with it were able to begin decompression.

In terms of prestige, it was clearly fortunate that the operation to retrieve the habitat went well. It had thereby also been demonstrated that it was possible to perform simple jobs in 320 metres of water if something were to go wrong at a corresponding depth in the Trench. Just a few days after the accident, moreover, Hydro's press spokesperson claimed that the fatal dive itself had not been completely unsuccessful in purely technical terms.[9] He pointed out that the divers had already completed the most physically testing operations when the accident occurred. What remained was welding in a habitat. Despite the tragic accident, the dive was to be used subsequently as evidence that working dives could be made in depths down to 320 metres.

Question without answers

As with so many earlier diving accidents, however, it proved impossible after the Skånevik accident to determine with complete certainty what had gone wrong. This was despite the fact that no previous dive in Norwegian waters had been monitored so closely. The doctors who conducted the forensic autopsy of Hoover found no indication of drowning, but an excess of carbon dioxide in his body. That supported a hypothesis that carbon dioxide poisoning was the direct cause of death. In practice, this meant that Hoover could have over-exerted himself. He had become so breathless that he poisoned himself, probably with respiratory failure and loss of consciousness as the result.[10] This was a disturbing conclusion if the goal was to lay the basis for working in extreme water depths. However, the doctors were unable to establish anything with certainty. It was difficult to interpret findings from a diver who had been subjected to a pressure of no less than 324 bar.

The initial investigation was headed by Olav Hermansen, district police chief for Etne. He had been informed of the accident at 02.00 on the night it occurred, and was in place to conduct interviews two hours later, at 04.00. The value of these interviews has subsequently been questioned in view of Hermansen's limited command of English and lack of diving knowledge. Since the divers at that time were still breathing a gas mix containing helium, too, their voices were distorted. Nevertheless, the written record of the interview with Kohl, in particular, gives a detailed and credible impression.[11] Kohl described an extremely difficult dive beset by a number of technical and practical problems.

After having worked for a while in the water, both Hoover and Kohl found that the hot water in their suits had been lost (with a water temperature close to 4°C, helium as a component in the breathing gas and a pressure of 324 bar, the heat loss was acute). Both were therefore ordered into the bell. When the heat was restored after a few minutes, they returned to the water to speed up the work. It transpired that the valve used to blow gas into the seabed habitat was broken. After replacing it, Hoover was told to leave the habitat while Kohl remained to check that everything worked during pressurisation. At that point, the heat supply failed again. The divers were again ordered to return to the bell.

When Kohl tried to leave the habitat, however, he found himself entangled in the hose intended to pump in gas. At that point, the heat was being restored. Kohl felt under such stress that he sought permission to cut the hose in order to get back into the bell in any event. That request was turned down by the surface team. After a further attempt to extricate himself, Kohl again asked to be allowed to cut the hose and was again refused. While trying to get free, he felt his supply of breathing gas fail. He stopped his efforts in order to breathe calmly, but felt that he was not getting sufficient air. He then raised himself so that his head was in the part of the habitat being filled with gas, and took off his mask to breathe. (That is confirmed by the dive log.) He was immediately ordered by the control room to put his mask back on, which he did after taking a couple of gulps of air. When he resumed the mask, the breathing gas supply was clearly functioning again. Kohl managed soon afterwards to free himself from the hoses. On exiting, he again became entangled in a hose, which proved to be Hoover's. When Kohl finally got out of the habitat, he found his colleague lifeless.

Kohl's dramatic account supports the assumptions made by the doctors in the sense that the dive must have been extremely stressful, both physically and mentally. But it can also be interpreted as serious criticism of the way the dive was managed from the surface. If Kohl's statement that the breathing gas supply failed at one point is true, it could be sufficient in itself to explain Hoover's death. After all, he did not have the same opportunity as Kohl to breath in the habitat. Kohl's decision to tear off his mask because of breathing problems may naturally have reflected his sense of panic. However, this does not preclude a failure in the gas supply at that point or Hoover experiencing the same. In that case, the accident resulted from a failure in the equipment or in the way it was operated from the surface. The failure of the heat supply on two

occasions also makes it natural to ask whether this was a contributory factor.

An immediate problem for the investigation was that no recording existed of the radio traffic in the 10 minutes before the accident. The explanation given for this was that the person responsible had forgotten to insert a new tape when the one being used to record was full. But Ragnar Winsnes, who took over the technical side of the investigation on behalf of the NLIA from the police on the following day, never took charge of the recordings which actually did exist. This was unusual, given that the sequence of events up to 10 minutes before the accident should have been of interest. In retrospect, it also appears unusual that

Ready for the investigation after the accident. Ragnar Winsnes from the Norwegian Labour Inspection Authority is in the centre, dressed in black. From left: Bjørn Weibye from Norsk Hydro, police constable Ole Matre and district police chief Olav Hermansen. Photo: *Stavanger Aftenblad*

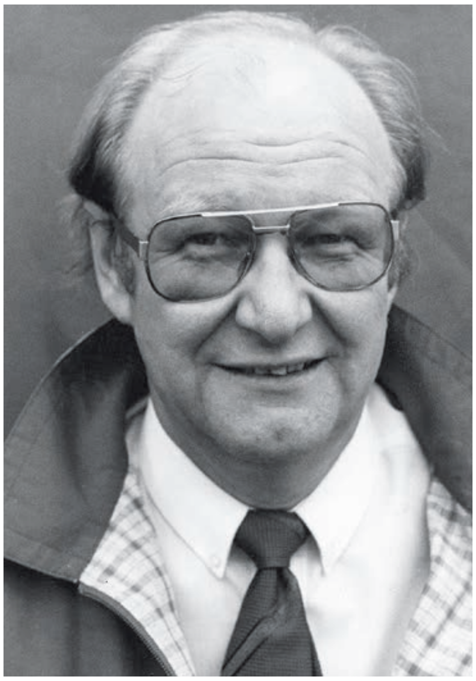
Winsnes – who had personally played a key part in preparations for the experimental dive – acquired such a prominent role in the first critical phase of the investigation.

The Skånevik affair was investigated as a possible crime. Despite its complexity, this inquiry was shelved as early as the autumn of 1978. At that point, the cause of the diver's death had still not been established with certainty. The crucial consideration for the police was that they could not find any relevant legislation or regulations which had been breached in connection with the accident. A report in which the NLIA vouched for Taylor Diving's operations is likely to have weighed heavily in reaching that conclusion.[12] According to a report written by Winsnes, no unacceptable conditions existed which could form the basis for criminal responsibility. Winsnes rejected Kohl's account of a possible failure in the supply of breathing gas as the cause of the accident. The police investigation had established that Taylor Diving breached a number of their internal safety instructions. However, the NLIA maintained that none of the relevant rules were part of any official regulation. It also asserted that none of the breaches in the internal safety instructions were relevant for the accident.

It is reasonable to ask why the police, as the representatives of the public prosecutor, did not get more strongly to grips with this affair. A number of the questionable conditions mentioned above emerged as early as a press conference two days after the accident.[13] Although errors had been made, it must have been a difficult case to handle from the perspective of a public prosecutor. Who was responsible for what, and who was going to charge whom? It was said that the divers involved were more than willing to make the dive, even though they were experienced enough to be aware of the potential dangers. All the institutions with any form of safety responsibility were involved ahead of or during the actual dive.[14] That included the NMD as well as the NPD, which was soon to take over responsibility for regulating the diving business. However, the NLIA had the closest involvement. Winsnes had attended meetings with Taylor Diving in Rotterdam during December 1977, when all aspects of the dive were discussed.[15] He had been shown a detailed procedure for the operation. The NLIA also had a representative on the diving barge during the dive. However, this was a new employee with no particular experience of diving.

The NLIA and Winsnes maintained that responsibility for implementing the dive rested with the employers. In practice, it would unquestionably have been difficult for a representative of the regulator to intervene once the dive was under way. When the NLIA imposed a temporary diving ban immediately after the accident, and then gave "permission" to retrieve the equipment from the seabed, it confirmed its authority as far as it went. That was not the same as the NLIA being responsible for everything which occurred during the actual dive. A basic lack of legal clarity in the government's approach to safety was exposed here. That was because, regardless of whether the NLIA could be accused of anything, the many bodies which represented the government ahead of the dive contributed to a pulverisation of responsibility. When something went wrong, it was unquestionably advantageous for the oil companies and diving contractors that the regulators had approved the relevant procedures and were present during the actual dive.

Given the coverage received by the Skånevik dive in the media both before and after the dive, political disquiet might perhaps have been expected when things went wrong. The most critical voice in the days immediately after the incident belonged to Nopef leader Lars A Myhre, who questioned whether it was right to experiment with human lives.[16] But he moderated his criticism by noting that the divers he was in contact with "were not directly worried about depths of this nature". The Skånevik accident happened only a few months after the Seaway Diving divers had joined the LO. Although the recently unionised divers were concerned about safety issues, it is probably true that a number of them would also have been willing to participate in the experiment had they been given the chance. The two-sided nature of Myhre's comment also reflects the LO's conflicting interests in this case. On the one hand, it wanted to protect the safety of its members. On the other, scarcely any other Norwegian organisation had a greater self-interest in the Trench being crossed. That was crucial for a number of oil-related jobs along the Norwegian coast. To begin with, almost no critical comments about the way the dive was conducted came from the politicians.



Lars A Myhre, who led the LO's Nopef union from its creation, was known for having good networks with political institutions where decisions were made. He was a member of the Labour Party's executive committee for many years. Despite numerous attempts, however, it took many years before the government acceded to the divers' most important demand – extending the WEA to cover diving. Photo: *Stavanger Aftenblad*

Two comments

The only person connected with Norway's professional diving community who openly criticised the experimental dives in the Skånevik Fjord was Jens Smith-Sivertsen. At that time, he was still a diving medical officer at Haakonsvern. Immediately after the accident, he wrote a comment piece in daily paper *Bergens Tidende* which many people noted.[17] He was one of the few members of Norway's small professional diving community who had not been involved in the dive preparations.[18] Despite its careful wording, his criticism addressed a fundamental point: "I have a feeling that financial and technological considerations have shoved safety into the background in this case". Smith-Sivertsen's main objection was that far too little was known about the medical consequences of extreme loads on the human body. "We must on no account allow our lack of expertise in this field to mean that we allow ourselves to be governed by financial interests or be steamrollered by technological enthusiasm." Smith-Sivertsen's conclusion on the Trench was clear – pipelines at depths beyond 200 metres were inadvisable as long as they depended on diver assistance.

His article attracted no response from the many who were involved in the Skånevik dive.[19] However, it was picked up by Arne Skouen, a well-known Norwegian film director and contributor to *Dagbladet*.[20] In his regular column for this Oslo daily, he used the Skånevik accident and the diving business to illustrate what the recently-passed Working Environment Act (WEA) was about "in the widest sense". Norwegian divers were an example of the kind of working conditions which the Act was intended to eliminate.

> One's thoughts revert to the WEA and its long-term mission when the Norwegian expert describes what happens to the diver in 320 metres of water, under 33 times atmospheric pressure. Inside his suit, he breathes the light gas helium, but the atmospheric pressure 'makes the gas tough to breath in'. So he must use most of his physical capacity to 'maintain his breathing'. That leaves little for manual labour, and 'in these conditions, it is easy for the diver to overestimate his ability'. Then he is dragged dead into the bell down in the depths.[21]

The most striking aspect for Skouen was the way the other divers, immediately after the accident, were nevertheless willing to continue the experiment.

> [We] get another demonstration of a working environment where the tradition places a low value on human life. NOK 40 million has been invested in an experiment with divers as the guinea pigs. The worker's self-image is also an important element in the oil industry, with demands for toughness encouraged by the buyer of labour. A life for heroes, not for weaklings. A primitive working environment where rumours of the dangers are a bonus on the wages.[22]

Diving becomes a public "issue"

While diving accidents in the early 1970s had earned no more than brief reports in the press, the many hazards of North Sea diving became a major issue in all the national media during 1978. It was no longer a case of simply referring to information from the police and the diving companies. Many journalists began to dig deeper on their own. The new, far more critical attitude to the negative aspects of the oil industry was not confined to diving. Completion of Statfjord A acquired a chaotic look, with big cost overruns and a number of serious accidents.

Discontent among other offshore workers found expression during the spring of 1978 in a series of "illegal" (wildcat) strikes.

The person who dug most deeply and critically into the diving story was Bjørn Nilsen, a journalist with the Norwegian Broadcasting Corporation (NRK). He had led the Norwegian Authors Union during its most radical period in the 1970s. In 1978, he was working on a TV series about labour conditions in the North Sea. As early as June that year, *VG* – which clearly had good sources – could report that the programmes would let off enough dynamite to create tremors deep within the ranks of those responsible.[23] The series thereby became a subject of debate even before it was broadcast. In an article in *Dagbladet* during August, Nilsen said that he had talked with many offshore workers who could relate stories about "breaches of the regulations, reckless behaviour, and contempt for the life and health of the workers".[24] At the same time, he pointed out that it was difficult to get employees to speak on the record because many had seen people dismissed after making demands or complaining about unreasonable treatment.

A story in Trondheim daily *Adresseavisen*, under the headline "Professionals await oil programme with concern and apprehension", quoted Dag Meier-Hansen, head of the NPD's safety department. He questioned whether Nilsen's comments conflicted with the NRK's guidelines in the sense that the latter had formed an opinion even before he had made a programme.[25] *Dagbladet* followed up with a story which asked whether the NPD wanted to censor the series in advance.[26] This was denied by Meier-Hansen. The relevant producer at the NRK stated that the requirements for documentation would be same as for all other programmes produced by the corporation. With such advance publicity, most of those involved in the oil industry were full of suspense before the first in a series of six episodes aired on what was then Norway's only TV channel at 20.00 on Thursday 4 January 1979.[27] The reactions to the first programme were fairly positive, but nobody "was particularly enthusiastic", as *Rogalands Avis* put it.[28] General agreement prevailed in the initial reviews that Nilsen had done his homework well. But the treatment of diving in later episodes created reactions. Nilsen painted a critical picture of the general working conditions for divers. Special attention was paid to the Skånevik accident. Most of the information Nilsen presented had been reported in the press immediately after the incident. But the way it was put together, particularly about the NLIA's role in the inquiry and the shelving of the police investigation, sparked renewed debate.

In an interview with business daily *Norges Handels- og Sjøfartstidende*, Meier-Hansen used terms such as subjective and one-sided to describe Nilsen's series. He did not deny any of the information presented, but claimed that the journalist's aim was to paint a bleak picture. He re-

NRK journalist Bjørn Nilsen contributed through a TV series and several books to putting working conditions for offshore workers on the public agenda. He was particularly concerned about the position for the divers. Photo: Scanpix

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ferred in particular to the programmes on diving, and maintained that a number of conditions had improved in terms of both safety and equipment.[29] In a report in *Stavanger Aftenblad*, diving medical officer Svein Eidsvik at Haakonsvern also said that the negative picture of the industry painted by the programme was far too one-sided.[30] Eidsvik, who had been involved in the Skånevik dive, argued that the experiment was not a complete fiasco and that the negative reports in the mass media would frighten Norwegian expertise away from such advanced projects and instead "heave all the jobs into the hands of foreign firms".

But a number of people also asked whether the Skånevik accident should be investigated anew. The public prosecutor for Bergen and Hordaland county, which embraced the dive site, took an open attitude on claims that the investigation had been conducted in an unsatisfactory manner.[31] He pointed out that the police had been dependent on the technical assessments made by the NLIA. It seems likely that the extensive advance publicity had nevertheless helped to moderate Nilsen's TV series. Two months after it ended, however, he emerged as the co-author of a polemical book with a much sharper tone. *Det brutale oljeeventyret* (The Brutal Oil Adventure) addressed all sides of the industry but, like the TV series, paid particular attention to the working conditions of divers.[32] He gave special emphasis to the length of time it had taken to develop regulations, and also came close to accusing the NLIA of trivialising the mistakes made in connection with the Skånevik accident and thereby contributing to the shelving of the case.[33] By the time the book appeared, however, public interest in the accident had subsided.

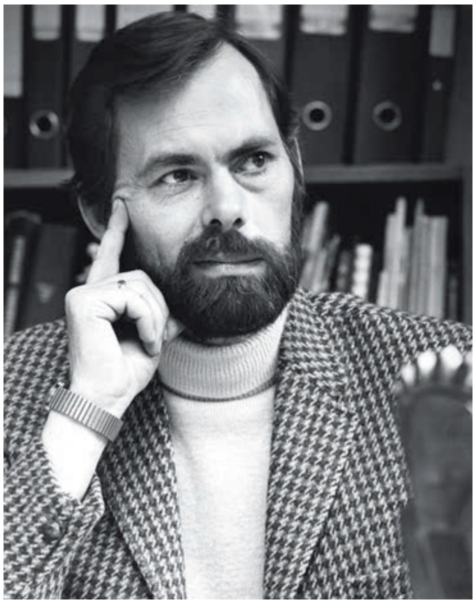
The NPD takes over

The Skånevik accident illustrated the core of the safety challenges constantly faced by the diving industry in the North Sea. What could be achieved with new technology? How much could the human body cope with under water? It might seem that the dead diver had reached the limits of the physiologically possible. But was there any limit to the size of risk one could take? Could a regulatory regime be established which would function as an effective counterbalance to big financial interests and what Smith-Sivertsen has described as blind "technological enthusiasm"?

This incident marked the end of an era in the sense that it was the last in which the NLIA and Winsnes were principally responsible for diving regulation. The NPD took over responsibility for regulating offshore diving operations three months after the accident. From that perspective, neither the directorate nor Meier-Hansen had any reason to feel directly affected by the criticism of the diving sector in Nilsen's TV series. Many divers had great expectations that the transfer of regulation from the NLIA to the new oil regulator would speed up the formulation of safety regulations and – equally important – their enforcement in practice. The diving business would now be regulated by an institution which was focused exclusively on the oil industry and, with its location in Stavanger, was close to the challenges faced.

The NPD immediately established a separate section for diving supervision, with a staff of five. That represented a fivefold increase from the time the NLIA was responsible. The new section was headed by Per Rosengren. Another of its new personnel was none other than Smith-Sivertsen. The others were engineers, like almost all the 85 people who worked in the NPD's supervision department at that time. Completion of the first preliminary diving regulations was based on preparatory work done by Winsnes at the NLIA.[34] The latter also came across to Stavanger to support the new section in its initial phase. Many people nevertheless felt that a framework had finally been created for an effective, conscientious regulation of offshore diving operations. However, the new regulations were not directed in any way at the safety challenges posed by experimental diving. Since such dives were conducted on land or in coastal waters, they remained the NLIA's responsibility. The large new diver section at the NPD and the new regulations undoubtedly contributed to the lack of further follow-up of the Skånevik accident. An impression was created that substantial improvements were in hand. The Liberal Party's Odd Einar Dørum, who raised the accident in the Storting's question time, was satisfied that local government minister Arne Nilsen would ensure future compliance with the Norwegian diving regulations.[35]

Compared with the era under the NLIA, the fact that they could now contact an institution where five staff had diving issues as their main concern was unquestionably a step forward for the divers. Although it was pay claims which had first prompted the Seaway Diving personnel to unionise, safety and working environment issues would dominate union work by the divers in subsequent years. This found clear expression as early as Nopef's national conference in the autumn of 1977, when the offshore divers got a set of demands adopted under five headings: 1. a maximum of five hours of diving work, 2. a lower retirement age, 3. the introduction of a retreat scheme, 4. diving certificates to be mandatory, 5. emergency preparedness and evacuation. Norwegian company Seaway Diving, where virtually all the unionised divers worked, could hardly satisfy these demands on its own. From the start, therefore, a significant part of the work of the unionised divers was directed at the government.



Dag Meier-Hansen was the first head of the NPD's safety department. He was in charge when the directorate fired off its notorious "expensive" letter, which refused to allow the installation of quarters modules on production installations. This ban was moderated, but operator Mobil still had to demonstrate substantial safety improvements. Photo: Norwegian Petroleum Museum

Despite the great initial expectations, a certain disappointment soon spread among the unionised divers – both over the NPD and its new diver section and over the government's approach to diving in general. The first disappointment arose as early as the work on finalising the preliminary diving regulations. Winsnes' earlier draft had included a provision which limited a bell run to eight hours.[36] When the regulations came into force, all references to working time had been removed. This was justified on the grounds that provisions on working hours would require additional rounds of consultation and further delay completion of the regulations.[37] The NPD's unwillingness to adopt a provision on this point reflected the decision that diving, even after the latest transfer of regulatory responsibility, was not to be brought under the WEA. It would remain subject to legislation for the maritime sector. As a result, a good deal of ambiguity persisted about who was responsible for what among government agencies. Remaining outside the WEA was the biggest disappointment suffered by the divers.

Diving and the WEA

The following petition was sent in May 1978 to the Ministry of Petroleum and Energy, the NPD and the prime minister by Arne Jentoft on behalf of the divers organised in Nopef:

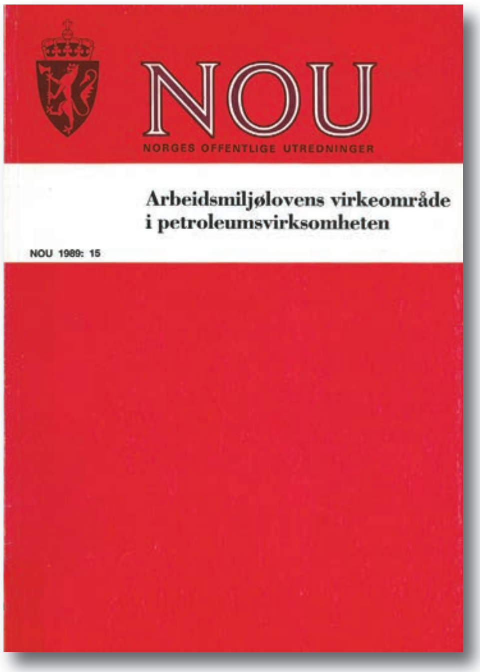
> The divers will no longer accept being discriminated against as an occupational group. It is the divers who indisputably run the greatest risk and have the most hazardous workplace in the North Sea. Nevertheless, this occupational group is not covered by the WEA. Nothing is said about divers, as far as I am aware, in [Norway's] maritime legislation. We will no longer accept being looked upon and treated as a inferior occupational group which the individual diving company or operator company can treat as disposable … Diving is incomparably the heaviest and most demanding occupation on the NCS, and must on that basis acquire its own working-time provision. The divers out on the NCS cannot understand how, and what, the government was thinking when it excluded this occupational group from the WEA. The divers must now suffer the consequences of this [decision] – when, for example, as one of several occupational groups on a DSV, barge, drilling rig or the like, they always receive the worst living quarters. On DSVs, the divers are without exception allocated the cabins which lie closest to the bottom of these vessels and where the occupant is most exposed to noise from the engines, dynamic positioning, anchor winches and so forth. They also get the cabins with the most berths. On top of that, the divers are required to be

> ready to dive at all times. With the noise and discomfort experienced in a number of the cabins where the divers are required to live, many sleep badly and one can imagine how a person who has not slept enough feels about starting an arduous job and possibly having to dive in deep water.[38]

Jentoft's initiative was supported by Myhre as head of Nopef, who repeatedly demanded on behalf of the union that either the WEA had to apply or rules and regulations had to be adopted which gave the divers the same protection as other occupational groups.[39] Nopef's demands were followed up by the Federation of Norwegian Oil and Energy Workers (Noemfo), part of the YS.[40] However, the strong political appeal to the Labour government was not enough to succeed.

The unionised divers had good reason for giving such high priority to getting the WEA extended to them. Like the earlier Worker Protection Act it replaced, this statute built on an underlying understanding that a conflict existed between workers and general social interests on the one hand and economic demands on the other. This was enough *in itself* for the foreign oil industry, which would have preferred a self-regulation regime, to regard the Act with suspicion. The new statute also ensured substantially more co-determination for workers. Democratic elections for safety representatives and the creation of working environment committees became mandatory at workplaces above a specified size.[41] Safety representatives were given greater rights to intervene in the work process, including the power to halt activities with immediate effect if the representatives found them to be hazardous. That represented a major intrusion in the employer's right to manage. The Act contained a number of provisions which directly and indirectly supported the right to unionise.[42]

Even before the Norwegian safety regime came into force, substantial differences could exist between working conditions for permanent offshore employees in an operator company on fixed installations, drill floor personnel on a rig, and divers. Oil company employees have generally been best placed. But elements of a "get it done" mentality, where safety and basic worker rights were little valued, could be found in both oil companies and contractors.[43] Demonstrating that you were up to the job, even when it was clearly dangerous, was the essential requirement. If you questioned a supervisor's order, you risked being sent home on the next helicopter. It must be said that there were also Norwegians who found themselves at home in the foreign companies. Many were keen to show that they mastered the job for reasons of not only personal but also national pride. But most Norwegian offshore workers, not least those with a manufacturing background, reacted against what they perceived as an alien work culture which clashed with the norms



Work on the diving regulations was pursued while the discussion on new worker protection and working environment legislation for Norway was in full swing. How far the Working Environment Act should apply offshore was addressed in an official report entitled *The ambit of the WEA in the petroleum activity* (cover, above).
Source: NOU 1977

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Aftenposten Lørdag 29. oktober 1977

Nordsjø-oljen tok 34 dykker-liv:

— Harde arbeidsforhold for norske dypdykkere

Aftenpostens medarbeider OLAV STEIMLER

Bryne, 28. oktober.

Siden starten på oljevirksomheten og frem til 1976 er det omkommet 34 dykkere i Nordsjøen. I tillegg til dette har det vært et utall varige skader blant dykkerne. Årsaken til dette har vært at norske off-shore dykkere sammen med utenlandske dykkere har måttet arbeide med lite utprøvet utstyr. Oljearbeidene i Nordsjøen krevde en form for dykking som var lite utviklet med hensyn til teknisk utstyr og dykkertabeller. Det var dykkeren Arne Jentoft som orienterte landsmøtet i Norsk Olje- og Petrokjemiforbund om de rystende arbeidsforhold norske dykkere har i Nordsjøen. Opplysningene som Arne Jentoft kom med til NOPEF's medlemmer, vakte åpenbar oppsikt.

Kontrollen av dem som dykker off-shore er mangelfull, og papirene de besitter kan utstedes av nær sagt hvem som helst. Det har vært eksempler på at personer er blitt ansatt som dykkere og dykkeledere, uten at de har kunnet de mest elementære dykkerregler. Dermed har de påført mange dykkere unødvendige problemer.

påstå at en 55 år gammel off-shore dykker vil ha meget vanskelig med å utføre sitt arbeide. Pensjonsalderen er idag 67 år for off-shore dykkere, og med de krav som stilles til en dykker idag, må denne alder ansees for å være alt for høy, sa Jentoft.

— Dykkerne i Nordsjøen har et spesielt og krevende yrke med en

utbildning, forlis eller lignende er minimale. For oss dykkere eksisterer det ingen overtidsbetaling eller kompensasjon i fritid, sa Jentoft. På bakgrunn av dette mener vi oss berettiget til å få innført 36 timers uke for off-shore dykkere efter den nye Arbeidsmiljøvernloven på like linje med andre oljearbeidere.

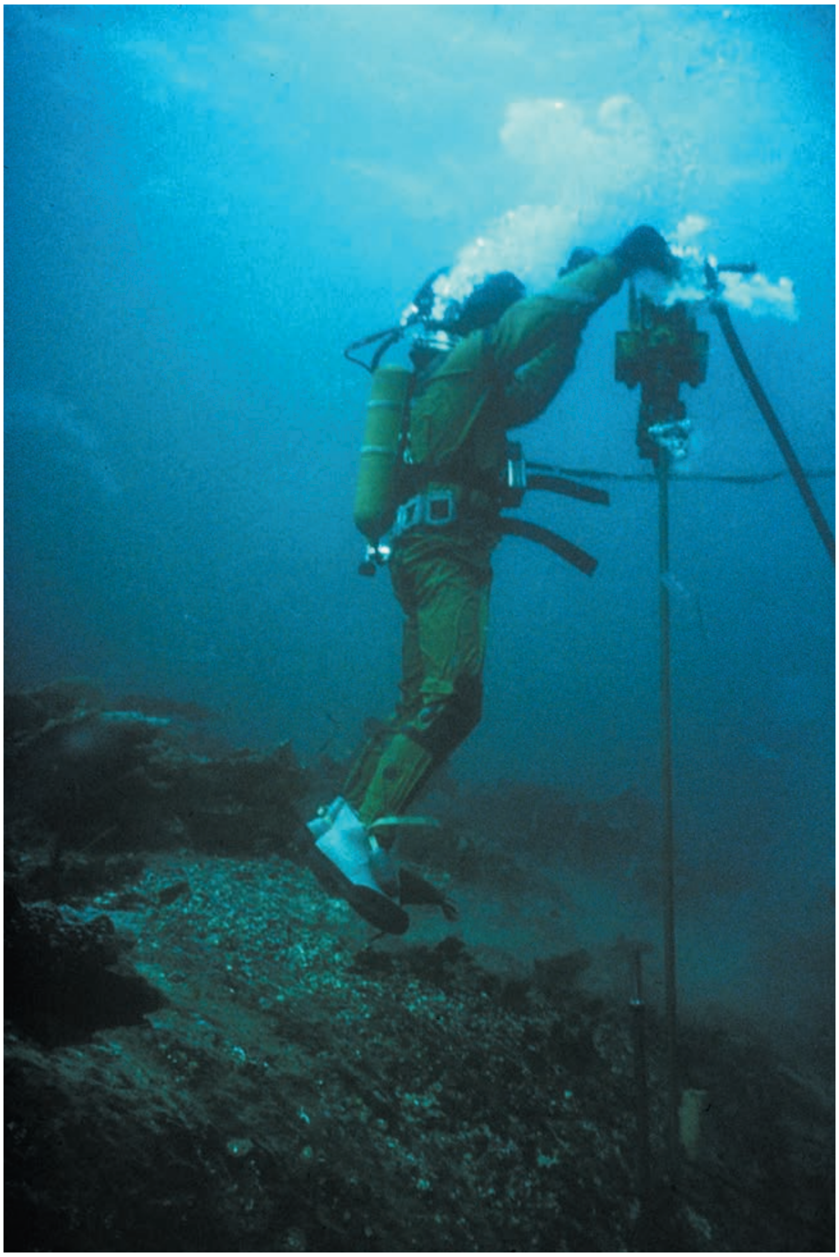
Safety and working environment issues topped the agenda from the word go for the divers who chose to unionise. The headline reads: "Tough working conditions for Norwegian deep divers".
Source: *Aftenposten*, 29 October 1977

of Norwegian working life. The NPD's intervention in the oil industry thereby acquired an element of national self-assertion.

Backed by the WEA, the NPD's mandate was not confined to improving safety. The young directorate had an informal political mandate which involved Norwegianising the actual culture which prevailed in the oil industry. When Meier-Hansen from the NPD's safety department came across as a little hurt by the criticism in Nilsen's TV series, one reason was undoubtedly that he felt the NPD had got to grips with the challenges and confronted the oil industry in many areas.

Although the WEA had only been extended in the first instance to the fixed installations, few government agencies did more than the NPD to develop the statute's underlying ideas. The Act represented a further extension of the "tripartite" collaboration between employers, employees and government which had characterised Norwegian working life throughout the post-1945 period. Strong unions were a precondition for such a system. These necessarily had to be established by the employees themselves, which was particularly difficult in an industry where the employers actively obstructed unionisation. During the extensive wave of strikes which began in the spring of 1978, many offshore workers made active use of the WEA to strengthen their position. Charged with ensuring that the Act was implemented, the NPD often came across as an indirect supporter of the unions. Clear boundaries seldom existed between what related to safety, to the working environment and solely to pay and working conditions.

The unionised divers saw how other offshore workers exploited the WEA to achieve more co-determination and to strengthen their own unions. Given their extreme working conditions, however, other aspects of the Act were even more appealing. Somewhat simplified, it can be said that, while the earlier starting point for safety work had been to adapt people to the prevailing technology, the aim now was to adapt technology to people. This intention finds expression in a number of the WEA's sections. The very first sub-section in the Act's first section stated that its purpose was "to secure a working environment which affords the worker full safety from harmful physical and mental influences and which has a standard of technical safety, occupational hygiene and welfare which is consistent at all times with the level of technological and social development of society".[44] Section 8, sub-section 1 of the Act specified that a workplace "must be organised in such a way that the working environment is fully acceptable with regard to the worker's safety, health and working environment".[45] In cases where uncertainty prevailed about whether an exposure to chemicals or the like might be hazardous, the burden of proof lay with the employer. In other words, the employee did not have to prove that something was hazardous – the employer had to prove that it was not. The Act was moreover based on



Hard work under water.
Photo: Børre Børretzen

Maslow's hierarchy of needs.[46] A workplace was to be a place not only where work was done without danger to the worker, but also where the worker could develop themselves further as a person.

An ocean of difference literally separated the general intentions of the WEA and the reality facing North Sea divers in their daily work. Extending its goals to the divers would undoubtedly have carried a cost. If all the Act's provisions were to be taken seriously, it would have been an open question whether diving was possible at all – at least in the deep waters the industry was thought to be moving towards. However, the immediate reason why diving remained uncovered by the Act was not financial considerations but disputes over jurisdiction between government regulators in partial competition with each other.

Leaving rigs, support ships and diving subject to maritime legislation substantially reduced the NPD's influence over key aspects of the oil industry. Neither the Ministry of Trade nor the NMD, which were struggling with a shipping industry in crisis, showed any inclination to relinquish the foothold they had gained in the lucrative oil industry. At the same time, the regulatory regime in the maritime sector was based on a model in which a significant role in both formulating and enforcing regulations had been ceded to private classification societies. In Norway's case, that was primarily DNV. The latter was by no means satisfied with the compromise solution which had been adopted. In the late 1970s and early 1980s, DNV head Egil Abrahamsen worked actively to secure an even more central position for the society on the fixed installations as well.[47]

Regulation of the rigs was shared. The NPD was responsible for the actual drilling facilities and processes, while all maritime functions related to operating the vessel were subject to the NMD. Since this activity was also excluded from the WEA, drilling personnel had to obey the working time provisions in Norway's maritime legislation. Although many people regarded this separation as problematic, a fairly clear division existed between a drilling operation and the job of moving a rig from one location to another – which was a maritime activity. However, the division of regulatory authority became much more of a problem for the divers. The actual diving – in other words, how dives would be conducted in practice, the diver's personal equipment, hoses and so forth – was a matter for the NPD. The NMD was responsible for the diving systems, such as bells, decompression chambers and control rooms, on rigs and DSVs. For a diver, however, every aspect related to technical equipment in the control room, decompression chambers/habitats, bells, breathing gas and suits, procedures for using this equipment and the actual diving all formed part of an indivisible process. That was the case as much for surface-oriented diving with a gas cylinder as for advanced saturation diving in deep water. To a far greater extent than with other occupational groups, moreover, diver working time was not only a working environment issue but also a safety challenge.

In line with its customary practice, the NMD delegated most of its duties to DNV, which undertook both classification and inspection of diving systems. Given the public attention being devoted to diving, it was impossible to avoid issuing specific official regulations for such facilities. The problem was that the NMD not only had little experience of formulating regulations but also did not know all that much about diving. That was illustrated by the fact that members of the NPD's diver section had to assist in drawing up both the first set of regulations, issued in 1980, and a revised edition in 1984.[48]

Diver working time

Like the WEA, Norway's maritime legislation contained provisions on working time. Viewed from a diver perspective, the WEA again provided the best terms. When the NPD's revised – but still preliminary – safety regulations were issued in 1980, a number of safety-related working-time provisions had been incorporated.[49] The unionised divers regarded this as a step forward. At the same time, however, the work of improving these provisions became more complicated. The divers continued to press for the extension of the WEA. As long as they remained unsuccessful in this, they had to work with the NMD and the trade ministry on general working-time rules and with the NPD and the local government ministry on safety-related provisions.

With the increased use of saturation diving, the working-time issue for divers acquired four aspects. The first concerned how long a diver could work in the water. Then came the question of how much time should pass from the moment a diver sat fully equipped in a bell which had been released from the habitat until the bell had returned and the diver could remove his equipment (bell run). The third issue was how long a diver could spend in saturation per session. Finally came the question of how long a diver should spend offshore on each tour.

It was actually difficult to compare working time for divers with that of other offshore workers because of the extreme loads the former were subject to. Out on the drilling rigs in the late 1960s and early 1970s, long periods of waiting could be followed by intensive spells of work. With DSVs and saturation diving, the working-time issue acquired a completely different significance. While other offshore personnel worked a 12-hour shift during each North Sea tour, many divers were in continuous saturation or decompression for most of the time they were out. Personnel on *Seaway Falcon*, which had the best-regulated working conditions for divers on the NCS in the late 1970s, the tour cycle consisted of 14 days at work in the North Sea and 14 of free time on land. Most offshore days were spent in saturation. Assuming that the divers spent all or much of a tour in saturation, and that time in saturation was also work, they averaged no less than 84 working hours per week. Even if saturation as such is not defined as work, the figure came to 42 hours – longer than was acceptable under the WEA.[50] The unionised divers maintained that these long working hours represented a safety risk and were unreasonable. They argued that the special loads they had to

The standard of the mess on a new DSV like *Stad Flex* was often good. Divers in saturation ate few meals here.
Photo: Norwegian Petroleum Museum

bear in their job should actually mean far fewer working hours than for other offshore personnel.

It is worth noting that, although the NPD was meant to be concerned solely with diver safety, the question of regulating their working hours became a negotiating issue from the moment the new diver section was established in 1978. Although the NPD did not include working hours in the first preliminary regulations, a working group was established where representatives from the divers and the companies would try to reach agreement on a proposal.[51] This group was chaired by Smith-Sivertsen. It soon emerged that disagreement between the two sides was too great, and the group was wound up.

The NPD nevertheless incorporated working-time provisions in the regulations of April 1980, without the sides having reached a consensus.[52] According to the new rules, a spell in saturation should not normally exceed 16 days and should be separated from the next session by at least the same length of time. Total time spent in the bell or the water was not to exceed eight hours in any 24. Water time should not exceed four hours without the diver having an opportunity to rest and to consume food and drink. But exemptions were permitted to the provisions on time in saturation, the length of intervening periods and the duration of a bell run. These exemptions required the consent of elected diver officials and the NPD. The regulations did not specify which conditions would justify a possible exemption. However, the implication was that these involved a pressing need to complete a job. Instead of reaching a generally accepted consensus, in other words, the NPD had made working hours subject in practice to negotiation between the individual diver and his supervisors offshore.

Although the adoption of the first genuine restrictions on diver working hours represented progress, the divers in Nopef were disappointed. The hope that the NPD's diver section would be a source of support was changing into general mistrust. Nevertheless, while other offshore workers were in widespread turmoil during 1980-81, with one group after another staging lengthy and often illegal strikes, the divers continued to appeal to the authorities. Immediately before the summer holidays in 1981, it seemed that this would finally yield results. The breakthrough looked like coming in the area regulated by maritime legislation. On 26 June, the Labour government issued a special royal decree on working time for divers on Norwegian vessels, drilling rigs and other mobile units.[53] This provision marked a step forward for the divers directly affected, since it permitted a transition from an average working week of 42 hours to one of 36. The divers could thereby convert to a tour cycle of two weeks offshore and three on land, which was then becoming normal for other North Sea workers.

But the new working-time arrangement had a serious drawback. Precisely because the breakthrough occurred under the maritime regime, it was also subject to the "flag state" principle. This is an international legal regime in the shipping sector which seeks to ensure that vessels can sail across national boundaries without having to relate to different sets of regulations – they only have to observe the rules of the state in which they are registered. This meant in practice that foreign companies operating on the NCS could observe the provisions which applied in the country whose flag their vessel was flying. American, French and particularly British DSVs could accordingly operate on the NCS with working-time agreements which were much worse than those applied to Norwegian-registered ships by the royal decree. Because these differences had major financial consequences, companies with Norwegian working-time provisions risked being out-competed.

More than six months passed from the adoption of the royal decree before Seaway Diving had put a new tour cycle in place.[54] As long as the ships were subject to the flag state principle, however, this represented at best only a partial victory for the divers. They were fully aware of this in advance, and had won a certain amount of support for this objection. The Storting's standing committee of shipping and fisheries had asked the government to work for the application of similar working time provisions to foreign companies as well.[55] The Labour government justified its attitude on the grounds that it had opted for "a cautious approach to deviating from the flag state principle in questions relating to the working environment on such vessels".[56]

Nothing prevented the government from deciding that the same working time regulations should also apply on foreign DSVs. However, it feared that such action by Norway might rebound if the big Norwegian merchant fleet were subject to similar interventions in other parts of the world. The trade ministry's arguments had carried the day. In a letter to Nopef immediately after the decisions, Kåre Halden in the local government ministry said that the Norwegian government would confine any regulation of foreign vessels to safety conditions.[57] A statement from the NPD had tipped the balance here. On behalf of the directorate, Rosengren had vouchsafed that "it is not considered necessary for safety reasons to regulate working hours or time offshore for divers on foreign vessels".

Divers in both Nopef and Noemfo were bitter about the NPD's role in the discussions on the flag state principle.[58] The diver section in the NPD could defend itself by arguing that, to the extent that working-time issues were relevant for safety, they were covered by the provisions in this area in the revised regulations of 1980.[59] The length of a bell run and working time in the water were definitely more relevant for diver safety than the relationship between total work and leisure hours, which could be regarded to a great extent as a welfare issue. At

Fredrik Hagemann served as the first director-general of the Norwegian Petroleum Directorate (NPD) from 1972 to 1996. Photo: Fredrik Refvem/*Stavanger Aftenblad*

the same time, the divers could argue with greater justification than many other groups that the opportunity to rest between periods of work was also a safety matter. As with aircraft pilots, professional drivers and similar professions, it was important that divers were rested and concentrated when doing their work. In addition came the prevailing uncertainty about the body's ability to recover from a long period in saturation.

The fact that the NPD's formulation of the safety regulations had made time in the water, the bell and saturation into negotiating issues confirmed that the distinction between safety and welfare was unclear. In practice, the diving regulations were tailored to the tour cycle which was normal until the early 1980s, but with substantial opportunities for "overtime". The working-time scheme adopted by Seaway Diving after the royal decree of 1981 in reality redefined a number of the provisions in the safety regulations. Within a 14-day tour cycle, it was not possible to operate a saturation period longer than 16 days as allowed for by the rules. At the same time, the three weeks on land which the divers gained under the new scheme provided a longer period for restitution between each saturation session. In that way, working-time provisions and safety regulations were intertwined – but only on Norwegian vessels.

The differences between requirements which governed diving by Norwegian-registered and foreign contractors remained an unresolved problem. This was why the unionised divers complained that the big Statfjord diving contract went to Britain's 2W (see chapter 6). The latter had to comply with the NPD's safety regulations, but not the working-time provisions. A possible strategy for Nopef and Noemfo was to organise employees in the relevant foreign companies and then demand "Norwegian" agreements on working conditions. However, the differences which had been created definitely made it no easier to organise either Norwegian or non-Norwegian divers in the foreign contractors working on the NCS. Nopef had 96 divers among its members in 1981, all of whom worked for Seaway Diving.[60] Although four years had passed since the first divers were recruited, in other words, Nopef had not succeeded in signing up a single member in the other diving companies. Under the leadership of Jan Christian Warloe, the competing Noemfo union succeeded in organising a majority of the divers on DSV *Sedco Phillips SS*.[61] However, the unionisation of divers in Noemfo collapsed when the union ran into major financial problems and went bankrupt. In the years which followed, Seaway Diving remained the centre of gravity for unionised divers.[62] In 1983, Nopef had four members in Comex and four in 2W. That was nowhere near enough either to secure agreements with the companies or to put weight behind demands to the government.

NPD – supporter or opponent?

A widespread feeling existed among the divers in the early 1980s that the NPD's diver section was on the side of the diving companies in important disputes. That view was expressed not only by members of Nopef and Noemfo, but also by some non-unionised personnel.[63] Did this attitude reflect unrealistically high expectations among the divers about how a supposedly neutral government regulator would behave? And did these expectations thereby overshadow the improvements which actually occurred? Or was it true that the diver section acted differently towards its area of regulatory responsibility than other similar sections of the NPD?

In purely formal terms, the NPD – like other government agencies – was meant to be neutral and to work within parameters determined by the politicians. Initially, it was subordinated to the industry ministry. Its safety department became responsible to the local government ministry from 1 January 1979 in order to strengthen its neutrality even further in relation to industry interests.[64] In practice, however, the NPD enjoyed considerable autonomy. That included the ability to formulate regulations, an area in which the ministry seldom intervened. Like other institutions, the NPD's staff were able to influence the direction of its work through the priorities they set for their day-to-day work. That might concern such issues as when and where to carry out inspections, the attitude taken to applications for exemptions, and the signals conveyed during conflicts. When all is said and done, the experience and attitudes of the NPD's staff played a certain role. Diver mistrust was long focused first and foremost on Rosengren as head of the diver section.[65]

He held this post from its creation until 1989. Educated as a naval officer, he had also received diver training at Haakonsvern.[66] In 1974, he was offered a job with Comex in Marseilles, where his work included testing and further developing safety equipment as well as analysing accidents. He was also involved as a diver in an experimental descent to 320 metres with just three days of decompression on the ascent. Upon returning to Norway, he acted for a time as operations manager for Comex's Norwegian branch before returning to the navy. The latter was considering at the time whether to install systems for deep diving on its own vessels. During his final term with the navy, Rosengren assisted Winsnes on a number of occasions with the inspection of diving systems in the North Sea.[67] For the same reason, he had been involved in preparing the experimental dive in the Skånevik Fjord. This broad background put him in a strong position when he applied for the job as head of the diver section at the NPD.

Per Rosengren headed the NPD's diver section from its creation in 1978 to 1989. Before joining the directorate, he had worked for France's Comex.
Photo: Scanpix

Although Rosengren took his previous experience with him into his new post, it cannot in itself be taken as evidence that the diver section was employer-friendly in practice. With Meier-Hansen and later Magne Ognedal as his superior, Rosengren and his section belonged to an organisation which both defined general goals and in some cases also intervened in current issues. With the great attention being given by the media to diving in the wake of the Skånevik accident and Nilsen's TV series, it was impossible for the section to operate in complete isolation from the NPD's other units. Nor were the new section's early years characterised solely by conflict. It involved itself in a number of issues in a manner which benefited all divers.

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The section initially devoted a great deal of work to speeding up the creation of a long-desired diving school. Preparations were made in collaboration with the NUI. Plans were presented in the autumn of 1978 for courses which could provide training for most of the relevant diving jobs in the North Sea.[68] The National Diving School (NDS) was formally established and began teaching, but lacked both premises and equipment to operate properly during its first few years. The Ministry of Finance's rejection of an application for funds to acquire a new building and equipment caused great disappointment. However, this reflected a lack of political willingness rather than insufficient commitment by the NPD. The latter was a prime mover in efforts to ensure satisfactory diver training. While awaiting a suitable education system, moreover, the diver section launched an extensive effort to issue bell diving certificates. A total of 1 340 of these had been awarded by 31 December 1980. From that date, nobody would be allowed to dive in the North Sea without such certification.[69] Certificates were issued to both Norwegian and foreign divers. The criterion was sufficient relevant work experience. This meant that divers who had secured a job in the North Sea without any relevant experience could now secure documentation that they were trained. Securing a certificate was not difficult. Only about 10 per cent of applicants were rejected. This nevertheless represented progress from the years when no proper control existed over who could qualify as a diver. It was now also possible to make an adequate formal education mandatory for newcomers.

With five staff working solely on diving, the government had an organisation to follow up the regulations adopted. During 1980 alone, the NPD carried out 50 inspections of diving systems. Some of these were outside the NCS when the inspectors arrived. Purely technological aspects continued to attract the most attention. But the NPD now had the resources to ensure compliance with its own orders. Despite disputes over where regulatory authority was to lie, the NPD inspectors were also vigilant in checking compliance with the NMD's diving system regulations.

Like Winsnes and the NLIA, however, the staff of the NPD's diver section were not particularly strict about enforcing rules related to working time and other operational conditions. This found specific expression through extensive use of exemptions from those parts of the regulations which came closest to the working-time provisions of the WEA. The diving regulations allowed a saturation period to be extended from 16 to 24 days – exceptionally 36 – if agreement had been reached between the company and a union official. Such exemptions could only be given for a job which was best completed by the diving team already in saturation. Both Nopef and Noemfo complained that so many exemptions were granted that the 16-day rule had no significance.

Diver education

Training of both civilian and military divers in Norway had traditionally been provided by the navy, but this education was unsuited to the oil industry's requirements. During the pioneering years, many Norwegian divers were trained either on the job by serving first as a tender for an experienced man or – in the best case – being sent on a course abroad.

Some of the diving companies also organised courses in Norway, with Seaway Diving staging the first in 1973. 3X gave one for DNV engineers in 1974, and Comex ran programmes for its own employees in some years after 1975. Otherwise, the divers usually took brief courses on such topics as helmet diving and work diving which led to various certificates. This training could be arbitrary in nature, with possibly unfortunate effects for safety.

When the NPD acquired responsibility for diving, attention was given to the question of a proper diver education. The result was the formal establishment of the National Diving School (after an interim period) in Bergen during 1980, on the basis of a decision by the Ministry of Education and Church Affairs. The NDS has subsequently offered a number of courses aimed at training professional divers and support personnel. It obtained permanent premises during 1990 in Skålevik, 15 kilometres from central Bergen and close to other important permanent institutions such as the NUI/Nutec and the Haakonsvern naval base.

Basic training for divers has been provided by the NDS. Valid certificates from the Directorate for Labour Inspection and the NPD (later the Petroleum Safety Authority Norway – PSA) have been required since 1980 to pursue professional diving. In addition, the diver must meet health standards set by these regulators. The basic course for occupational diving has qualified graduates as class I divers – in other words, diving with surface-oriented equipment down to 50 metres. Currently qualifying students for the certificate issued by the PSA, the bell diving course provides the knowledge needed to dive from a bell and in saturation. This course was first offered in 1979. Diving took place in most years from the *Buldra* barge, but DSVs have also been used. The NDS failed to secure sufficient government funds to continue the bell diving course after 1996. Training of saturation divers in Norway accordingly ceased until the spring of 2008, when the course resumed.

A one-year technical college course for professional divers was launched by the NDS for the first time in the autumn of 2004. This was the first course approved at technical college level by the Norwegian Agency for Quality Assurance in Education (Nokut). The NDS merged on 1 January 2005 with Bergen University College and is now a department of the latter.

Similarly, exemptions were given for the duration of both bell runs and the individual diver's water time. Although the diver unions could theoretically help to prevent such exemptions through their local officials, this was found to be difficult in practice. When a job urgently needed to be done, the individual diver could find it difficult to refuse – not least at times when competition over new contracts was tough. The saturation supplements were moreover so high that many divers preferred to spend as long as possible in the habitat, even if this was felt to be a strain. In such circumstances, it was hard for elected union officials to say no. That became clear not least during diving on Statpipe. In order for divers on *Seaway Condor* to spend no less than 25 days in saturation, this had to be agreed both by their union officials and by the NPD. After an application from SNS, the NPD agreed to an exemption. The company was also permitted to breach the working-time provisions regulated by the NMD. SNS's motive was clearly financial. With the lengthy decompression required by the divers after working 220 metres down, not much time was left to work in the water if the safety regulations and working-time provisions were to be observed. When even the union officials for the most unionised of the Norwegian divers gave way during the biggest operational diving project on the NCS, the working time restrictions were not worth much in practice. For the divers on Statpipe, who were responsible for the most intensive deep diving ever on the NCS, the exception became the rule.

Another area where extensive use of exemptions from the safety regulations became an issue was the provision (section 3.3.2) that diving from a bell was prohibited if the umbilical to the diver in the water was longer than 29 metres. The divers knew perfectly well, of course, that the further they went from the bell the further they were from help if anything went wrong. And the longer an umbilical, the more likely it was to get entangled and stuck. The Skånevik dive had illustrated how hazardous this could be. The companies often maintained that it could be more dangerous to dive from a vessel which lay close to a platform with its positioning thrusters in action than to send off a diver with a long umbilical from a point further away. At the same time, of course, the longer the umbilical the more flexible and thereby economically efficient a diver could be. In other words, the companies had an opportunity to use safety arguments to justify an exemption when the motive was actually financial. The unionised divers questioned the point of the regulations when the NPD gave an exemption so systematically every time a company requested one. Many union officials regarded this practice as further evidence that the NPD's diver section tailored its interpretation of the regulations to suit the needs of the companies rather than the divers.

The NPD's good years

Despite its demarcation dispute with the maritime agencies and the increased dissatisfaction among the divers, the 1980s were good years for the NPD. It could point to a noticeable improvement in safety within its area of responsibility. Eighty-two offshore workers died from the start of operations on the NCS in 1966 until 1978. The *Alexander L Kielland* accident on 27 March 1980 claimed 123 lives. From then until 1990, only 13 deaths were recorded among offshore workers – and this during a time when the number of working hours was four times higher than in the period until 1978. Nor were these improvements noticed only in Norway. Following the Piper Alpha platform explosion on the UKCS in 1988, safety work by the NPD was referred to as a shining example.[70] This attention focused first and foremost on the directorate's new philosophy of *internal control*.

The development of this concept has rightly been associated with Ognedal, who became head of the NPD's safety department in 1980. It emerged from the very special challenges faced in regulating such a complex activity as the oil industry. How could an industry be regulated when it changed faster than any regulator could follow up with effective regulations, and when responsibility dissipated easily in a warren of complex company relationships? There were the licence groups, which had the rights to the fields, the operators which ran them, and various types of contractors and sub-contractors. The diving companies were to be found far down the pyramid. While nothing was said in any study, the Skånevik accident was a clear example of the way a complex interaction between a multitude of public and private players contributed to a diffusion of responsibility. Even though attention in the wake of the accident focused primarily on the authorities and the diving companies, it was the oil companies with Hydro in the lead who were responsible for the financing, most of the planning, the overall leadership and the flow of information to the outside world. A key element in the internal control principle was precisely to make it unambiguously clear that overall responsibility for safety always lay with whoever was the operator of an activity at any given time. Concepts such as *performance management* and *functional requirements* were introduced. Operators were responsible for developing their own safety systems to ensure than accidents did not occur. If something went wrong, they could not hide behind claims that all applicable regulations had been observed. The regulator's role would be more to supervise that the companies had established their own functioning safety systems than to draw up detailed regulations itself. The new principle was first designated "self-regulation" in 1979.[71] "Internal control" was introduced as a term in a 1981 regulation.[72] The principle was incorporated in the Petroleum Activities Act in 1985 and thereby extended to all operations on the NCS.

However, internal control was not the only factor which contributed to improvements on the NCS in the 1980s. In the wake of the *Alexander L Kielland* disaster, all demands for better safety acquired a moral dimension. With the WEA and an extensive wave of strikes as their

Magne Ognedal became head of the NPD's safety department in 1980. After it was separated off from the NPD in 2003, he continued as director general of the Petroleum Safety Authority Norway (PSA). Ognedal is well known in the international safety community, partly because of the substantial improvements achieved on the NCS during the 1980s and partly for his role in developing the internal control concept. He retired in 2013. Photo: *Stavanger Aftenblad*

base, the offshore workforce established a strong and committed layer of elected union officials who put safety requirements high up the agenda. Norwegian oil companies and suppliers, who wanted a key place in the lucrative petroleum sector, placed great emphasis on presenting themselves as better at safety and the working environment than their foreign competitors. In turn, the latter feared that their future position would be weakened if they failed to improve. It is worth noting at the same time that divers accounted for 10 of the 82 offshore fatalities up to 1978, and no less than seven of the 13 after *Alexander L Kielland*.

Oil company acceptance of greater overall responsibility for safety developments also benefited diver safety. One of the main problems in the diving sector nevertheless remained the disputes over where regulatory responsibility should lie. Yet again, serious accidents were needed before further progress could be made. Two such incidents occurred in 1983. The first hit the unionised Norwegian divers on *Seaway Falcon*.[73] A number of those involved had been at a union meeting on board that day. Together with operator Phillips, the company had signalled a desire to introduce a tour cycle whereby the divers would be continuously at work for 24 days. This created a rebellious mood in the workforce. The accident happened on the afternoon of 16 March.[74] Seaway Diving had been instructed to work on mooring attachments on the north side of the Ekofisk tank. *Seaway Falcon* had problems mooring close to the work site. The diver thereby had to swim some distance. During the work, fears arose that the diver had been drawn into the suction from the propellers. These were turned off. A standby diver quickly entered the water when contact with the diver was lost. It proved to be too late.[75] The dead man was found the following day.

A complex sequence of events led up to this accident. These involved several unfortunate factors which collectively influenced the tragic outcome. No individuals were blamed for operational errors, and the accident accordingly had no legal aftermath. One issue naturally raised was precisely the length of the umbilical. Seven months later, an accident occurred which attracted far greater public attention.

Byford Dolphin

Five divers died at 04.00 on 5 November 1983 on the *Byford Dolphin* drilling rig.[76] This was the most serious diving accident ever on the NCS. It differed from other incidents in this sector by taking place when a bell was to be disconnected from a saturation habitat on the surface after the diving team had apparently entered the habitat safely. This was a routine operation which took place several times a day in diving spreads across the whole North Sea. Comex was the diving contractor on *Byford Dolphin*, and the spread was a two-chamber system. A two-man work team had just returned to the surface. After pressure had been equalised between bell and habitat, this pair left the bell for a connecting tunnel where they removed their wet equipment. They then entered the actual saturation habitat, where two other divers were still resting on their bunks. Outside the habitat, a diver began to unscrew the mechanism connecting the bell and the connecting tunnel while the hatch into the habitat was still open. This caused an immediate and explosive drop in pressure. The four divers inside the habitat – two Norwegians and two Britons – were killed instantly. The diver who had released the locking mechanism, also a Briton, was thrown backwards and died later of his injuries. Another diver on deck was badly injured.

Both the police report and the commission of inquiry appointed after the accident concluded that it had been caused by "human error". No sign of any technical fault was found in the locking ring between bell and habitat. The surviving diver on deck said that he was on his way back from turning off the heating in the bell when he saw his colleague release the locking mechanism. According to procedure, this should not be done until the go-ahead had been given by the diving supervisor in the adjacent control room.

The latter claimed in his statement that he had not given any signal to open the locking ring.[77] The procedure stated that he should have received a green light from the divers in the habitat that the door to the connecting tunnel was closed and have reduced pressure in the tunnel before giving a go-ahead. Why the diver had nevertheless started opening the locking ring therefore remained a mystery. He was experienced, dived regularly with the same spread, and was fully aware of the fatal consequences of a sudden pressure drop. Since no sound recording or log was available for events in the relevant minutes, it remained unclear what signals have been given by the divers in the habitat. Interviews immediately after the accident nevertheless revealed that a lot of informal chat passed over the loudspeakers used for communication between the supervisor and the deck workers. At one point, the supervisor was alleged to have concluded a conversation with a comment along the lines of "get on with your work, you have job to do".

No active discussion of the course of events prior to the accident was pursued by the inquiry commission. It confined itself to observing that a number of possible courses existed between the extremes of "1. The supervisor ordered that the connecting lock should be released, even though the tunnel was under pressure, 2. The operative by the connecting lock opened it without having received orders to do so".[78]

On the basis of the specific information from the investigation and witness statements, the police found no basis for bringing criminal charges against the supervisor or any of the other survivors on duty at

The ***Byford Dolphin*** **drilling rig, where a serious diving accident occurred on 5 November 1983.**
Photo: Bob Fleumer

the time of the accident. A proposal in the wake of the accident that all conversations in a control room should be taped was intended not only to have a preventive effect on procedural breaches, but also to avoid anyone falling under unresolved suspicion through no fault of their own.[79] Under the prevailing diving regulations, such recording was only mandatory while divers were in the water. Although no formal charges were ever brought or blame allocated, the incident was a serious burden for everyone involved.

Investigation of the *Byford Dolphin* accident was unusual in that the police were responsible for clarifying the actual course of events, while a government-appointed commission concentrated on the possible underlying causes and on proposing measures which could prevent similar incidents. This division of labour partly reflected a demarcation dispute between the prosecuting authorities and the NPD, and partly questions raised about the commission's composition.[80] In the mandate from the Ministry of Justice, the commission was required to collaborate with the police. However, this was prevented when the public prosecutor for Rogaland county (which includes Stavanger) intervened to ban the provision of interviews and witness statements to the commission with reference to "elementary principles of due process". This objection had little practical effect on the information available to the commission. Rosengren, one of its members on behalf of the NPD, had by virtue of his position in the directorate rushed off and participated in questioning with the police immediately after the accident occurred. But his and the NPD's participation in the commission may have precisely contributed to the public prosecutor's action.[81] Could the commission be neutral when one of the parties was an active participant? On the basis of the general mistrust of the NPD's diver section, Nopef protested about the commission's composition. Rosengren responded by offering to withdraw.[82] However, he was urged to remain by the local government ministry. The latter felt that the NPD's status as a party to the case was counterbalanced by the presence of Nopef representative Melvin Kvamme.

The commission of inquiry

Ever since Norway's criminal law first included sections which make employers and employees responsible for the safety of others, all accidents with a fatal outcome have been a matter for the police. The shipping industry, where insurance companies have also been a key party in relation to wrecks, has had maritime accident inquiries at which those involved are questioned in public. A common feature of both police investigations and the maritime inquiry institution has been a one-sided concentration on clarifying responsibility, ideally to establish whether those involved have broken possible laws or regulations. At the same time, the idea has been that such processes will have a preventive function by giving everyone responsible for the safety of others a reminder of the need to take their work seriously. However, many people have felt that neither traditional police investigations nor maritime accident inquiries are appropriate approaches if the aim is to identify important causal relationships underlying accidents, which must be understood in order to prevent repetitions. The practice of appointing independent government commissions after major accidents with a mandate to view the incident in a broader context therefore became established in the mid-1970s. In many ways, the inquiry into the Bravo blowout provided a coordinated review of deficiencies in offshore safety work.[83] Similarly,

The report produced by the official commission of inquiry into the *Byford Dolphin* accident identified many weaknesses in safety work by the diving sector.
Source: NOU 1984:11

the commissions appointed after the 1986 Vassdalen and 2000 Åsta accidents investigated key aspects of the safety system in the armed forces and the railways respectively.[84]

The *Byford Dolphin* incident was the first involving divers to be the subject of an official inquiry. Its failure to deliver a coordinated critical review of the safety system in the diving business partly reflected the commission's mandate, which was more or less unilaterally concerned with conditions specific to the actual accident. It was also emphasised by the local government ministry that the report should be completed as soon as possible. Moreover, appointing the person with the greatest personal responsibility for regulation of the diving business to the commission ensured that no critical review of the government's role was carried out. Published on 22 February 1984, the relatively limited report nevertheless identified a number of conditions of great general significance for diving safety.

As a result of the flag state principle, diving on *Byford Dolphin* was exempted from the new working-time provisions in Norway's maritime legislation. But those specified in the NPD's safety regulations did apply. The deck personnel involved in the accident had been working overtime. According to the commission, this was within the parameters set by the regulations. However, it transpired that overtime working which clearly breached the safety rules took place on the two preceding tours. A review of a three-month period ahead of the accident revealed that no less than 38 per cent of all bell runs had exceeded the maximum period of eight hours. This reflected systematic breaches of a clear safety-related rule. Nor did any shift plan exist for the divers, making it difficult to determine how long an individual had been working. The divers on *Byford Dolphin* had clearly been subjected to considerable pressure of work.

Neither the commission's review of the accident nor its summary conclusions found the breaches in the working-time provisions to be a direct or underlying cause. Its criticism of the companies was general. The question of whether fatigue among those involved was a possible underlying cause was left to the reader. Nor did the report discuss how far the breaches were an expression of a general trend. Nevertheless, the unionised divers regarded the report as a confirmation that extensive breaches of the working-time rules were taking place in the foreign companies. A common allegation was that the latter evaded these regulations by transferring personnel back and forth across the continental shelf boundaries.[85]

The commission's most important proposal for preventing similar accidents in the future was a call for the introduction of technical solutions which made it impossible to disconnect bell and habitat while the connecting tunnel was pressurised.[86] It also proposed the adoption of

mechanisms which ensured that the hatches in a habitat closed automatically in the event of a sudden pressure drop. Technology which allowed this was already available at a reasonable cost. DNV, which certified diving spreads on behalf of the NMD, had been fully aware of the danger presented by disconnecting diving bells, and had made such security mechanisms mandatory in 1982 – in other words, a year before the accident. Comex was also fully aware of the dangers presented by the type of diving spread it used on *Byford Dolphin*. It was even possible to read about the threat of such an accident in the company's own manual for diving on the rig.[87] This stated that factors such as pressure of work and routines which reduced attention could enhance the risk of an accident related to hazardous disconnection.

A core issue which almost always arises when dealing with causes, responsibility and liability related to accidents is raised by the course of events which led to the *Byford Dolphin* accident. How far can one actually expect humans to act without error in a day-to-day work process? Can a company be blamed when a worker makes a fatal mistake like unscrewing the locking ring on a diving spread without being certain that the pressure has first been equalised? What responsibility does

Safety work on the NCS in the 1980s was characterised by demands that oil companies and contractors should operate with equipment which tolerated human error. The clearly laid-out diving spread on one of Seaway's DSVs gives a much more "robust" overview than corresponding equipment from the 1970s. Photo: Bjørn Wilhelm Kahrs

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the company bear when it is aware of the risk in advance while also knowing that technology exists which will almost entirely eliminate the hazard?

The *Byford Dolphin* commission's report revealed that Comex's safety systems had definite scope for improvement. It proposed the introduction of special procedures which ensured that greater attention was paid precisely to transfers from bell to habitat. During inspections on the rig, moreover, Comex was found to have breached one of its own safety manuals by operating with two separate control panels for pressurising the tunnel between bell and habitat – one in the control room for the bell and the other in the habitat control room. The company's safety manual specified that only one panel should be used to avoid misunderstandings.

A clear conclusion by the commission was that the accident would have been avoided if the available safety technology had been adopted. On the other hand, it gave no clear answer to the question of how far anyone in the companies and the safety institutions concerned could be blamed for what had happened. In a concluding summary, the commission wrote:

> The strong warnings given in the Comex manual about the dangers of transfer under pressure, combined with fact that DNV decided about two years before the accident to tighten requirements for locking systems in its rules, indicate that the locking systems on *Byford Dolphin* were insufficiently safe. It emerges from the NPD's explanation that the directorate had already incorporated similar rules in the draft for the revised edition of its regulations before DNV tightened its rules. In the wake of the accident, it is easy to see that the above-mentioned indications should have led to a safer locking system. Reaching a firm opinion on how far the responsible instances can be criticised that this did not happen is more difficult.[88]

Given the commission's mandate and composition, more than such a vague conclusion on the question of the responsibility and liability of the institutions involved should not perhaps be expected. The commission took the unusual division of responsibility between the NPD and the NMD as given, for example, without discussing how far the lack of clarity at the interfaces between them contributed to delays in establishing rules which could have prevented the accident. Nor did it discuss the problems related to the competing regulatory regimes created by the flag state principle. Even before the commission's report was published, however, DNV and the NMD ensured that new certification rules requiring automatic locking mechanisms would now also apply to existing installations. However, the flag state system meant that DNV did not cover all vessels with diving spreads. A number of DSVs and rigs were classed by foreign classification societies which operated with different rules from those adopted by DNV.

The WEA again

The consequences of applying the flag state principle to DSVs was at least as unfortunate for the unionised divers as they had expected. To be sure, Seaway Diving retained its long-term contract on Ekofisk. It was also very important for the Norwegian diving community that this company won the prestigious Statpipe job. Both assignments were to a certain extent politically determined. Struggling with its image in the wake of the Bravo blowout and the *Alexander L Kielland* accident, Phillips wanted to come across as a company willing to adapt to Norwegian conditions. Statpipe was a national prestige project, where a key concern for Statoil was to show that Norwegian companies could overcome major technological challenges. Unions and Norwegian working-time regulations were thereby part of the package.

It was equally the case that the special working-time rules from 1981 helped to make Norwegian diving contractors more expensive than their foreign rivals. While the former had to apply a working-time scheme which gave workers three weeks on land for two weeks offshore, the norm in foreign companies on long contracts was a cycle where the divers spent up to four weeks on the field and a corresponding period on land. The practice revealed in Comex after the *Byford Dolphin* accident moreover showed that the working-time restrictions incorporated in the NPD's regulations, and which applied to both Norwegian and foreign companies, were extensively flouted. Such breaches would probably have been easier to identify if the company had possessed a strong Norwegian union. The Norwegian divers who changed employer in this period experienced clear differences in working culture between Norwegian and foreign contractors. While conditions had improved in Seaway Diving, most of the other diving companies retained the working culture which had applied in the late 1960s and early 1970s. A Norwegian diver who worked for a British diving contractor for a time in the early 1980s reports:

> The British supervisors who had previously been officers were the worst. They hounded people in a military fashion. We had to greet them almost in a military manner. I was once commanded to sit without eating while waiting for the supervisor himself to finish. I could hate those British supervisors.[89]

Regjeringen går inn for tvungen lønnsnemnd i oppgjøret for de 2300 operatøransatte. Partene var hos kommunal- og arbeidsminister Arne Rettedal i går kveld. Statsråden foreslo frivillig voldgift, men partene avslo.

Endrede arbeidstidsordninger for oljeproduksjonsarbeiderne. Kravet ble reist ved de to foregående oppgjør uten at nemnda tok stilling til det.

Arbeidstiden

Det som nær hadde stanset all norsk olje- og gassproduksjon til en daglig verdi av over 200 millioner kroner, var en setning i riksmeklingsmannens forslag til hvordan arbeidstidsordningene i Nordsjøen kunne utredes.

OAF ville ha en bundet utredning som skulle slå fast at overtid som i dag blant annet går med til å dekke andres sykefravær, pålagte kurser, øvelser osv, skal inn i de normale skiftplenene. Riksmeklingsmannen foreslo at bedriftene i prinsippet skulle stå fritt i forhold til resultatet av en slik utredning, men at partene på den enkelte bedrift skulle komme sammen for å drøfte arbeidstidsordningen og eventuelt gjøre noe med dem. Dette ble for svakt for OAF, som hevder at arbeidstidsordningen et utredet tilstrekkelig, og at de i dag er i strid med arbeidsmiljøloven. Arbeidsgiverne derimot godtok meklerens formuleringer om arbeidstidsutredningen.

For øvrig var det enighet mellom OAF og arbeidsgiverne i Norske Operatørselskapers Arbeidsgiverforening om alle detaljer i en skisse som ville løst oppgjøret innenfor en økonomisk ramme på 5.9 prosent. Men spørsmålet om arbeidstid veltet lasset over til Rikslønnsnemnda.

Rettedal med pisken

En storkonflikt i oljesektoren ble avverget da partene sent tirsdag kveld fikk beskjed om at kommunal- og arbeidsministeren allerede onsdag formiddag vil foreslå tvungen lønnsnemnd i lønnsoppgjøret mellom Operatøransattes Forbund (OAF) og Norske Operatørselskapers Arbeidsgiverforening (NOAF).

Statsråd Arne Rettedal måtte konstatere at enda en meklingsrunde ville være nytteløs, og at begge parter avviste hans forlag om frivillig voldgift. NOAF etterkom Rettedals henstilling om ikke å sette i verk en lockout, mens OAF ville vurdere streikespørsmålet nærmere i sitt forhandlingsutvalg.

Formannen i OAF, Eivind Lønningen, sa etter møtet hos kommunalministeren at når OAF-oppgjøret nå igjen går til tvungen lønnsnemnd, betyr det at forhandlingsviljen og forhandlingsretten til partene undergraves. – Det blir mindre muligheter for at parten kan nå fram til enighet i framtida og vår motpart spiller helt bevisst på bruk av tvungen lønnsnemnd, sa Lønningen.

Direktør Halvor Vaage i NOAF avviste at arbeidsgiverne har spekulert i tvungen lønnsnemnd og viste til at det var arbeidstakerpartene som hadde brutt forhandlingene og som allerede hadde streiket siden før påske.

Kommunalminister Arne Rettedal benektet at det nå var etablert en fast praksis med at OAF-oppgjøret automatisk går til lønnsnemnd. – Det har pågått en streik siden før påske, men når konflikten så står i fare for å bli utvidet, har det samfunnsmessige konsekvenser som Regjeringen ikke kan ta ansvaret for, sa Rettedal, som la til at han hadde ventet at partene denne gang ville nå fram til enighet. (NTB)

Union and employer representatives met Arne Rettedal, minister of local government and labour, before the government imposed compulsory arbitration to halt an offshore strike in 1984. The headline reads: "Rettedal swings his whip". Photo: *Stavanger Aftenblad*

With Norwegians experiencing these and similar conditions, and with the *Byford Dolphin* accident fresh in people's minds, the divers in Nopef decided that the time was ripe for a new drive to get the WEA extended to all divers and to establish an integrated safety regime on both Norwegian and foreign vessels. A Nopef delegation met director-generals Per Holm and Halden, from the justice and local government ministries respectively, on 18 January 1984.[90] According to the union, experience showed that safety was "very seriously threatened" by the unfortunate division of responsibility adopted in 1981. Myhre could report that the Norwegian Seamen's Union had no objections in principle to the WEA's working time provisions being extended to foreign rigs and ships operating on the NCS. The position of the seafarers was not unimportant for this issue.

Arne Rettedal was minister of local government and labour in 1984. Despite being a Conservative, he was by no means hostile to Nopef. Quite the contrary – when he took over the ministry in the autumn of 1981, and in complete contradiction with his party's rhetoric during the general election, he had taken the initiative to force foreign oil companies into the traditional Norwegian tripartite model.[91] In his view, the foreign companies contributed to creating turmoil and strikes through their negative attitudes towards unionised Norwegian labour. At the same time, they created differentials by paying some people extremely well. Another problem was the militant unions outside the LO, which were also unwilling to adapt to the government's income policy framework. So Rettedal considered it advantageous that a more responsible LO strengthened its position among offshore workers. As a former mayor of Stavanger, who turned an obedient ear to those calling for local industrial development, he was also no opponent of solutions which promoted the position of Norwegian companies. However, none of these considerations were strong enough for the divers to succeed in their campaign. The real barrier remained the trade ministry and Norwegian shipping interests. Nor did a Conservative Party which basically opposed many aspects of the WEA want to override the traditionally powerful shipping sector.

But Nopef did not give up. In 1985, LO legal officer Karl Nadrup Dahl was commissioned to write an opinion on the possibility of extending the WEA to diving. He concluded that no international legal provisions prevented this.[92] Nopef promoted its views at every opportunity. When the non-socialist coalition under Kaare Willoch resigned in the spring of 1986 after a lockout by the employers, the unionised divers saw a fresh chance to secure a final clarification.

Leif Haraldseth, a long-serving LO functionary and its acting deputy leader, was appointed local government and labour minister in Brundtland's second Labour administration. At a meeting in the ministry on 3 October 1986, Nopef's representatives again presented the whole of their case.[93] The union earnestly requested that steps be taken to ensure that the whole diving sector was regulated in the same way as fixed installations on the NCS. In a written summation of the arguments presented at the meeting, deputy Nopef head Leif Sande noted that the Norwegian diving industry had been established to serve activity on the NCS and therefore did not have the same need for protection abroad as traditional shipping services. Like many divers before him, he said that diving had nothing to do with the maritime sector:

> Divers ... work on fixed installations or pipelines connected to them. Whether you inspect the fixed platform structures above the sea surface or do the same work a few metres beneath it, it must surely be

Melvin Kvamme was a key official in Nopef's diver section for a number of years. He sat on many official committees which investigated diver-related issues.
Photo: *Stavanger Aftenblad*

> possible to regulate this without dragging in the flag state principle. The ship functions for divers as quarters and a means of transport for personnel and equipment from one work site to another.[94]

Nor was the change of government the only reason for greater optimism among the divers. In early February 1987, Melvin Kvamme, then chair of Nopef's diving committee, received verbal signals that the NPD was working for the divers' cause.[95] This was soon confirmed officially.[96] The NPD made it clear to the local government ministry that, from an overall safety perspective, conducting effective supervision of the diving business was difficult unless the WEA was applied to the whole sector.

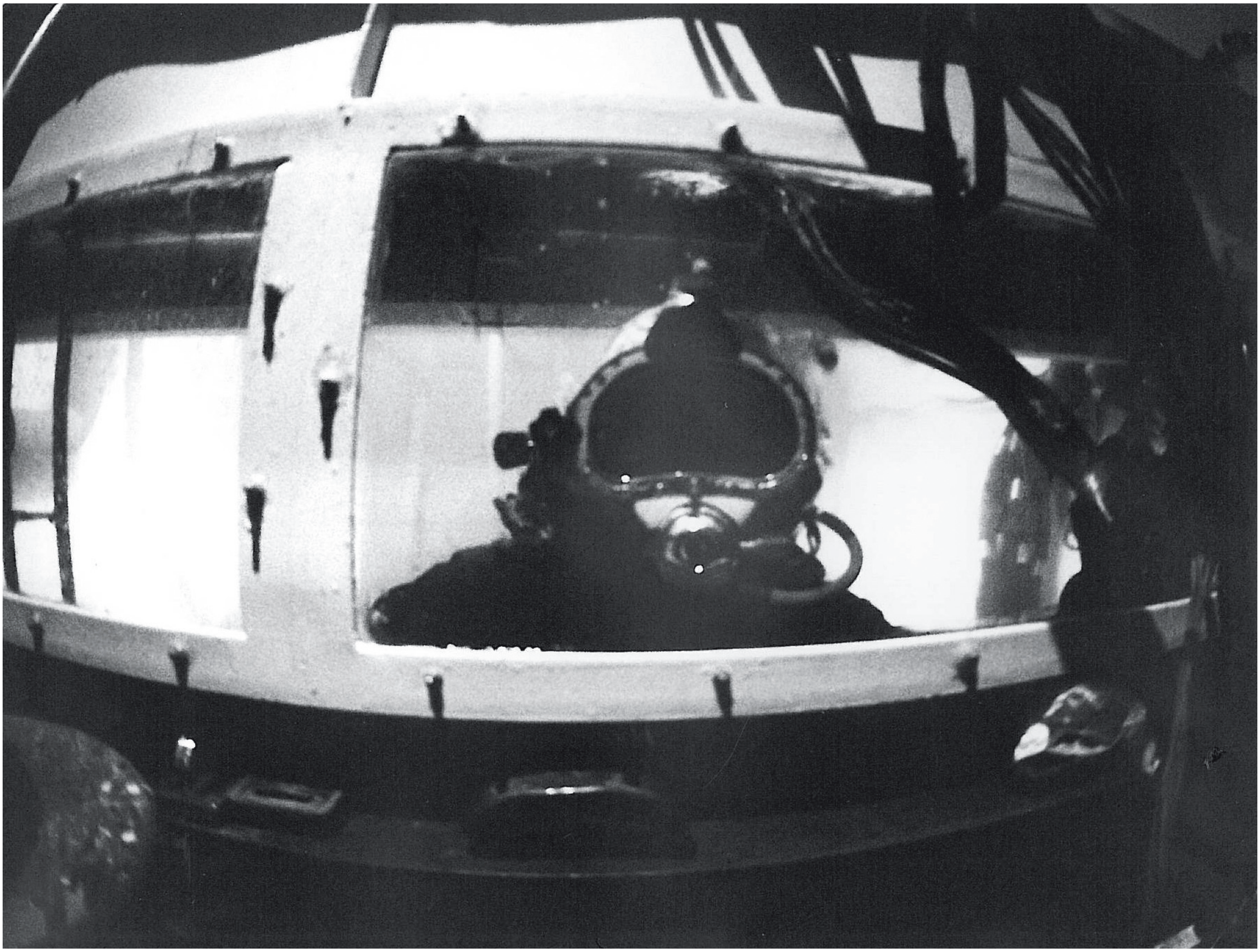
The NPD refrained from commenting on its own role in the discussion on the WEA in 1981 when, as mentioned above, its argument was that exemption from the Act and a division of responsibility would have no direct impact on safety. It now reached the opposite conclusion, for reasons very similar to those cited by many divers when foreign vessels had been exempted from the Act on diver working time six years earlier. The NPD also noted that Norwegian employers and employees in the diving sector were now united in their desire for a common legal regime:

> Employees and companies in Norway's diving industry agree that the business should be conducted in accordance with Norwegian requirements and that these represent a minimum standard for acceptable operation. The provisions of the Act nevertheless mean that company operations become more expensive compared with diving work conducted from units or vessels under foreign flags, which observe their own legislation. This means that Norwegian diving companies/vessel owners lose out in competition both on the NCS and on the continental shelves of foreign states.[97]

With the expression "Norwegian diving companies/vessel owners", the NPD was referring principally to SNS Diving. The way might now have seemed open for a swift clarification. But that was not the case. A committee had first to be appointed to assess all aspects of the matter. The diving issue was drawn into a broader assessment which also discussed whether other activities on floating units should be subject to the WEA.[98] This "Bull committee" reported in 1989, and its conclusions were positive for the divers. But it all took time, a long time. Through regulations issued on 27 November 1992, the WEA was extended to subsea operations "from vessels or installations, in so far as special rules do not apply".[99] That little subordinate clause was enough to maintain some lack of clarity over whether the Act actually applied. It was not established that all the provisions of the WEA applied to diving on the NCS until the NPD issued its regulations on systematic follow-up of the working environment (SAM) in 1995.[100] By then, subsea work had changed fundamentally since the first demands for the WEA to be applied to divers were made.

A different section?

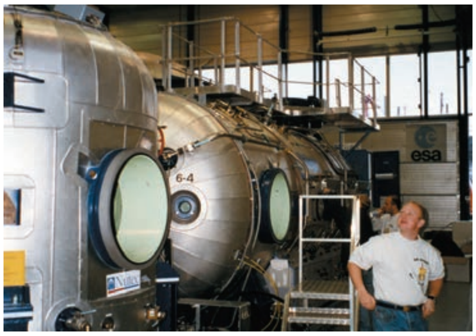
The NPD's diver section was regarded with great scepticism by the divers. Rosengren's background probably helped to give him a particularly good understanding of the views of the diving companies in many of the circumstances where conflict arose. As we will see, however, relations between the unionised divers and the NPD section remained difficult long after Rosengren had ceased to head the latter. This unit came across as different from other NPD sections primarily because the divers faced a completely different legal regime than most other offshore workers, and because the sharing of responsibility with the NMD had a particularly unfortunate effect. Diving on the NCS would undoubtedly have looked very different if the WEA had been extended to it as early as 1977, and the NPD's approach to the divers would also have been different. The reason oil activities were excluded from the WEA primarily reflected forces outside the diving business. The most important hurdle was represented by the trade ministry, which was motivated by general shipping interests. As long as no politicians intervened, the ministry could continue to block a final clarification. Only political intervention from a higher level could have yielded a different result.



Chapter 9

Controversial research dives

Diving research has been pursued in Norway at the Norwegian Underwater Institute (NUI), later renamed the Norwegian Underwater Technology Centre (Nutec). The initiative to establish the NUI came from the DNV research department in 1971. Two diving accidents on Ekofisk and the attention they attracted probably helped to hatch out the concept of an underwater centre.



The training facility at Gravdal. Photo: Bjørn Wilhelm Kahrs

Diving research on the starting blocks

A preliminary study for the NUI was presented in the autumn of 1973 by a group drawn from Norsk Hydro, the Norwegian navy and the Norwegian Council for Scientific and Industrial Research (NTNF). Its goals were ambitious. The idea was to establish a facility to conduct research on the physiological and medical aspects of diving and to test equipment. It would also draw up safety regulations and develop certification schemes. A key requirement for all these activities was the acquisition of a pressure chamber system. It was also proposed to procure a floating test platform. The study envisaged that the NUI would be run as a foundation, with financing both from the government and from a number of private interests.

The Ministry of Industry signalled that the plans were too comprehensive, and should be confined to a land-based facility with a pressure chamber. A new proposal presented in 1974 was well received, and the decision to establish the NUI was taken in principle. The idea of the new institution drawing up regulations had been dropped. That would

A Deep Ex dive at the NUI. Diving in water inside the pressure chamber. Photo: Hans Claesson

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BERGENS TIDENDE TIRSDAG 30. JANUAR 1979

Dykker-kammerne ved Norsk Undervannsinstitutt er klare for oppdrag fra oljeindustrien på norsk kontinentalsokkel.

Undervannsinstituttet er klart for oppdrag

NUI — Norsk Undervannsinstitutt — på Laksevåg ved Bergen har i disse dager startet opp med dykkerforsøk i sitt hovedlaboratorium.

Instituttet ble offisielt åpnet 30. mars 1978, og tiden siden er gått med til justering og kontroll av de enkelte laboratorieenhetene.

— fortrinnsvis operatører på den norske kontinentalsokkelen.

Norsk Undervannsinstitutts hovedformål er å bygge ut kunnskapsgrunnlaget for undervannsaktiviteter og dermed øke sikkerheten ved undervannsoperasjoner.

get slik at dykkere skal kunne oppholde seg «neddykket» over meget lange perioder. Likeledes kan man, i det største kammeret, foreta testing av mindre undervannsfartøyer, såkalte miniubåter.

From *Bergens Tidende*, 30 January 1979. The headline reads “Underwater institute ready for assignments”.

remain a government preserve. The research ambitions were also somewhat moderated. On the other hand, “securing, maintaining and operating facilities for a diving school” was formulated as a goal for the institute.

Despite the start-up decision, several years were to pass before the new institution was ready to play its intended role. The first step was to secure a suitable location. In this case, no competition arose between local authorities on the scale which occurred from time to time during this period in connection with major investment projects and other oil-related institutions. The choice fell on Hestviken in Gravdal, a few kilometres south of Bergen, where the adjacent waters were up to 360 metres deep. That corresponded to the deepest parts of the Norwegian Trench where pipelaying was envisaged. Depths down to 650 metres were available just off nearby Salhus, within Bergen’s city limits. The most important reason for establishing the NUI near Bergen was the naval base at Haakonsvern, which had Norway’s most experienced diver specialists. However, the community in Bergen was small compared with the NUI’s ambitions. It was not easy to secure enough competent people. The monitoring staff consisted partly of people with diving expertise and partly of technicians and medical personnel. Many of these recruits were sent on courses in the USA, and an affiliation to US underwater research teams remained strong at the NUI.

A joint venture to own the NUI was created in 1976 by DNV and the NTNF. It turned out that the first of these was the only private enterprise in Norway willing to invest capital in the project. Problems related to DNV's dominant ownership position increased as the NUI developed its own role and identity in practice. At one point, DNV moved into a vacant section of the NUI's premises. The classification society wanted at the time to expand its role as a consultant, certification authority and research institution related to subsea technology. As a result, DNV found itself competing with the NUI in certain contexts. The outcome was that DNV withdrew from the NUI's premises and eventually also from the position of dominant owner. This became difficult in the initial phase, since the NUI had problems securing sufficient capital. However, the goal was to make it self-financing through assignments from the industry and the government. That all depended on establishing a suitable pressure chamber spread.

In line with the ambitions to develop Norwegian expertise, the job of designing the latter facility was awarded to Kværner Brug in Oslo, which was to build on licence from Germany's Drägerwerk. The NUI was able to hold the official inauguration of a new building in the spring of 1978. This contained a laboratory with top-quality pressure chambers and monitoring centre. Its first assignment was to conduct tests on dogs to determine how anaesthetics functioned under high pressure. This was not an insignificant issue for divers. What if one of them needed a serious operation while under saturation? The first jobs involving human subjects were carried out in 1979, and a continuous flow of work then followed.[1]

Given that extensive diving operations had been conducted on the NCS for more than a decade, it had taken time to establish a dedicated Norwegian underwater institute. It was more the product of enthusiasts than of strong government action. Nevertheless, establishing the NUI faced no kind of opposition from the politicians. On the contrary, it accorded with the goals reiterated countless times in various official reports for securing the expertise required to cross the Norwegian Trench with pipelines (see chapter 6). By facilitating the project, the government demonstrated that Norwegian society wanted greater insight into the many challenges presented by diving.

The NUI's role in international diving research

When the decision in principle on creating a Norwegian underwater institute was taken, groundbreaking research on saturation diving was under way in other countries. The world record set in March 1970 by two British divers to a depth of 457 metres at the Royal Navy's Alverstoke laboratory near Portsmouth was shattered.[2] Divers conducted a rapid dive to 609 metres in 1974 at the Comex laboratory in Marseilles.

That same year, the French company sought permission from the Ministry of Foreign Affairs to conduct an underwater experiment in a Norwegian fjord.[3] The third trial in the Janus series, this involved welding in 400 metres of water under normal atmospheric pressure in a habitat.

The application was sent to the DWP commission's sub-committee for diving, then in the process of completing its study of the possibilities for laying pipelines across the Trench. Although several members of the committee would have preferred to see the Norwegian diving community playing a larger role in such research, the request was naturally received positively. At that point, divers had done work down to about 180 metres on the NCS. If the Comex experiment could extend the limits for realistic working dives, it would bring the government closer to its goal of landing oil and gas in Norway. That represented a significant element in Norwegian oil policy, but depended on the feasibility of laying oil and gas pipelines across the Trench. Accomplishing such a landfall was conditional on the ability to repair a damaged pipeline on the seabed. Documenting diver ability to work at such depths was unquestionably a requirement.[4]

Comex wanted to conduct an experiment in a Norwegian fjord in part because the conditions there were more like those in the North Sea than in the Mediterranean, for instance. At the same time, the company had commercial interests in possible future deepwater diving activity on the NCS. Both considerations could be exploited by the Norwegian government to set terms which also ensured that the domestic diving community gained access to the result. This related not least to the possible creation of an underwater institute in Norway. To strengthen national involvement in the experiment, it was proposed that a professionally qualified observer group be appointed from the navy, the NLIA, the industry ministry and the NPD. This team would have access to all information of a technical and medical nature during preparation, execution and processing of data from the experiment. It would be authorised to postpone or halt the trial if Comex was felt to be failing to comply with the conditions.[5] However, the experiment called for lengthy preparations and was not ready to be carried out in the Er Fjord until 1978. The NLIA was continuously informed about and involved in the project.[6]

In the meantime, Comex had set new records for work dives off France in the Mediterranean. Six French divers conducted a six-day experimental programme called Janus IV, with two spending 20 minutes at a depth of 501 metres and two others carrying out a good deal of the work required to connect two sections of an oil pipeline on the seabed in 460 metres of water.[7]

Diving research was also being pursued in the USA. A record was set at the University of Pennsylvania during Predictive Studies IV, with

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Tense minutes before the divers reach 500 metres. From left: Ragnar Værnes, Stein Tøn-jum, Steve Porter and Peter Bennett follow developments.
Photo: Anders Lindahl

a wet dive to 490 metres in 1975. Duke University achieved a world record with a simulated dry dive in 1981 to 686 metres.[8] Taylor Diving carried out four simulated work dives to 320 metres at its own research facility in New Orleans during 1977. This was part of the preparations for the Skånevik Fjord trial in February 1978 with Hydro as the responsible operator. Statoil and Hydro initiated a research collaboration on hyperbaric welding in deep water in 1977. The Sintef research foundation in Trondheim also participated, and the welding procedures were approved by DNV. During the Skånevik trial, Taylor Diving was responsible for the underwater work while Brown & Root was the main contractor. As recounted in chapter 8, this experiment had to be terminated after the death of a diver. Statoil and Hydro pulled out, but Taylor Diving and Brown & Root wanted to continue. Divers and equipment were transferred to Scotland, where the trial was conducted as planned. The divers spent 44 days in saturation, which was an unusually long time. The diving physician in attendance had no objections, and maintained that the divers were in good shape when the experiment ended. Pipeline connections were welded in a habitat 320 metres down, and the actual welding experiment yielded a satisfactory result.[9] A film was made of the dive for use in marketing to government agencies.

It was in this climate, characterised by technological optimism and opportunities to break new ground in both human and diving technology terms, that the NUI began regular operation in 1979. The aim of the major international projects was to demonstrate the safety of deepwater diving. The depth record at the NUI was set as early as 1981 with a 504-metre dive known as Deep Ex II. It has not been broken since. In 1981, the NUI was converted into an independent foundation called the Norwegian Underwater Technology Centre (Nutec). DNV and the NTNF were joined as owners by the three Norwegian oil companies – Statoil, Hydro and Saga Petroleum. This trio was also responsible for future pipelaying activities and pipeline operation across the Trench. They were now co-owners of Nutec and helped to finance research programmes on deepwater diving. That position eventually raised a number of problems related to research ethics.

This chapter will look more closely at some of the experimental dives carried out between 1980 and 1990. These include the Deep Ex series in 1980 and 1981, the Troll dive in 1985 and the OTS dives in 1986. Their common denominator was that they were conducted to test equipment and procedures in deep water.

Issues addressed here include which experiments were conducted, what results they had and how the divers experienced them. Finally, the reasons why several of the dives have been controversial are considered.

The table opposite provides an overview of the most important dives conducted at the NUI/Nutec in 1979-2002.[10]

Bård Holand gets into shape.
Photo: Anders Lindahl

The Deep Ex dives

The first major diving programme conducted at the NUI was the Deep Ex series in 1980-81. It was led by US physiologist Russell E Peterson from the University of Pennsylvania, which had one of the world's most reputable specialist teams for deep diving. The ethics committee, which was brought in because the trials involved experiments with humans, demanded that the programme should also have a Norwegian leader. This role was assigned to diving physician Stein Tønjum.[11] The dives were financed by a broad range of players. A/S Norske Shell, which had discovered the Troll field in 300 metres of water the year before, accounted for the largest share. Other contributors were Statoil, Hydro, BP, DNV and the NTNF. The diving companies also participated, with personnel rather than cash.[12]

YEAR	GREATEST DEPTH, MSW*	NO OF DIVERS	DURATION (DAYS)	NAME/PROJECT, PURPOSE, ETC
1979	9	3	1.5	Air saturation: debugging dive
1979	9	3	1.5	Air saturation: debugging dive
1979	70	3	1.5	Heliox-bounce: debugging dive
1979	150	2	1.5	Heliox-bounce: work capacity
1979	150	3	1.5	Heliox-bounce: work capacity with oxygen hit
1979	50	6	14	Air saturation: work capacity
1979	50	6	14	Air saturation: work capacity
1980	150	4	3	Polar Bear I: survival test
1980	100	2	1.5	Preparatory dive for Deep Ex
1980	150	2	1.5	Preparatory dive for Deep Ex
1980	300	6	19	Deep Ex with wet dive
1981	504	6	34	Deep Ex with wet dive and welding
1981	150	2	3	Polar Bear III: survival test
1982	100	4	1.5	Helium communication project
1983	350	6	17	Statpipe (3DP-Seaway) with wet dive
1983	350	6	24	Statpipe (3DP-Comex) with wet dive
1984	150	8	13	Welding qualification for Seaway
1985	450	6	30	Troll (Shell/Seaway) with wet dive
1986	360	6	18	OTS I (Oseberg) with Royal Navy
1986	360	6	25	OTS II (Oseberg) with welding
1986	360	6	27	OTS III (Oseberg) with wet dive
1989	220	3	14	OBS UBA-250 with wet dive
1990	5	6	28	Iseemsi – astronaut insulation for the ESA
1991	15	8	28	Oxygen dive – long-term effects
1994	10	8	2	Medical dive with medical/technical equipment
1996	5	8	2	Excursion bubble study
1998	111	8	10	100-metre dive
2000	111	8	13	DY2K
2002	250	8	21	250-metre dive

*metres of seawater.

Deep Ex, short for "deep excursions", tested the way pressure changes affected the human body when the work depth was significantly different from the habitat depth in very deep water. The programme covered two dives, one of 300 metres in 1980 and one of 500 metres the following year. The dives were made in the NUI's pressure chamber complex on land.

Medical research involving trials with humans is subject to special rules. Ethical guidelines for this type of work were adopted by the

A rather uncomfortable bath.
Photo: Anders Lindahl

World Medical Association in the 1964 Helsinki Declaration. Providing guidance to physicians and others conducting medical research, this specifies that "the subject's welfare must always take precedence over the interests of science and society" and that participation in research projects must always be voluntary. All research related to the Deep Ex dives accorded with these international ethical guidelines. Before each dive, all subsidiary goals, methods and risks in the project were reviewed. The research subjects signed a contract which allowed them to withdraw from the experiment at any time. In theory, the subject would then be transferred to a separate chamber where decompression could begin, and a possible assistant could be pressurised and introduced to the chamber. The research and dive plans for each operation were submitted to an ethical committee for approval.[13]

The programme for the two dives embraced a number of research projects, which included testing the way various gas mixtures affected the symptoms of *high-pressure nervous syndrome* (HPNS). This is a condition first described in 1969 during dives to 300 and 365 metres. It takes the form of trembling in the hands and arms, decreased mental performance, dizziness, nausea and vomiting. Early studies indicated that the symptoms of HPNS became more pronounced with increasing depth and/or rapid compression.[14] Another Deep Ex experiment was the "freeze test". Several accidents had occurred where the diving bell was torn free of the DSV and fell to the seabed. The danger of freezing to death before the bell could be recovered was fairly high if its heat insulation was inadequate. To find satisfactory solutions to this challenge, a survival suit was to be tested under high pressure while the divers breathed heliox. One test sought to establish how heat loss affected the diver's mental performance when their body temperature approached 35.5°C. Thirdly, the Doppler technique – a form of ultrasonic investigation of the bloodstream in important veins and arteries – was to be tried out as a method for measuring the formation of gas bubbles in the blood, particularly in connection with pressure changes. Other tests covered breathing apparatus and the use of tools such as welding gear under high pressure.[15] Six divers participated in each dive, with the necessary support personnel outside the saturation spread.[16]

All the subjects were highly motivated and open to exploring the unknown. It was a feather in their cap to be selected from as many as 100 divers. They were to test the limits of human endurance under high pressure, which can be considered in many ways as demanding an activity as being an astronaut. It was the first time a trial of this kind had been staged in Norway, and everyone taking part wanted to show they could do a good job. Good money was also to be made. The preparations began a month beforehand with daily training on an ergonometric bicycle so that the subjects were in peak physical condition when the dive began on 6 November 1980.[17]

Anders Lindahl, who hailed from Gothenburg, was one of the test subjects. He found this dive to be a completely new experience:

> The deepest I'd been earlier was a bounce dive to 160 metres. It was very different to be pressurised for one hour 26 minutes to a depth of 250 metres and for four hours 44 minutes to 300 metres. My whole chest and throat were somehow anaesthetised by nitrogen [trimix]. I found the pressurisation tough. During the whole process, we answered various status questions both individually and as a group. We were supposed to live at 250 metres and make excursions to 300 metres. In reality, however, the opposite happened – we lived at 300 metres and made excursions to 250 metres. An excursion from 300 to 250 metres took five minutes while an ultrasonic investigation was made of the diver's carotid artery.

The excursion experiment was intended to verify the US Navy's diving tables, which had not originally been developed for commercial diving.[18] According to these tables, a diver could leave deep water – such as 300 metres – and reduce depth by 50 metres without requiring decompression. Jan Onarheim, a physiologist who participated in the dive, was responsible for operating the Doppler equipment with his team. After reaching 250 metres, he amused himself by listening to the carotid artery and – to his great surprise – received a strong signal which indicated gas bubbles in this blood vessel. Alf Otto Brubakk, who was responsible for the Doppler study, was contacted and systematic measurements were made and recorded. In the worst case, gas bubbles in the carotid artery can cause blood clots and tissue changes in the brain.[19] This meant that the table being tested was unusable.

Two divers, including Lindahl, were selected for the freeze test at 300 metres. They were to remain at 4°C for 11 hours. The pair wore thin wetsuits next to the skin and a specially made undersuit in the sleeping bag. They wore masks and breathed in a Sodasorb box which contained lime to keep the breathing gas free of carbon dioxide. The test proved a tough experience. After only a few hours, Lindahl felt very cold and began to have problems with his feet. The thermometers were attached to his body and in his rectum. After about five hours, the unit in his rectum ceased to function and had to be replaced. One of the other divers entered wearing Arctic clothing and a breathing mask, opened the sleeping bag and pulled down the zip of the wetsuit, but could not get at the thermometer under the tight clothes. He left to fetch a pair of scissors, leaving Lindahl feeling indescribably cold. He recalls:

> He comes in again and cuts open my wetsuit at the groin. But getting in the thermometer was difficult. He tells the diving control room 'The Swede is quite impossible and damn me if he doesn't even have a hole either'. He puts the cable and the thermometer on my stomach, zips up the wetsuit and the sleeping bag and leaves the chamber. It took me a long, long time to get it in position in my rectum.

The other diver taking part asked to be released from the freeze test before it had finished, and was told he was a poor team player. He decided to continue, but lay crying for the last two hours of the experiment. Once it was over, he could not stand and had to be carried from the chamber. Following the dive, Lindahl's colleague was mentally broken and spent more than nine months on sick leave.[20]

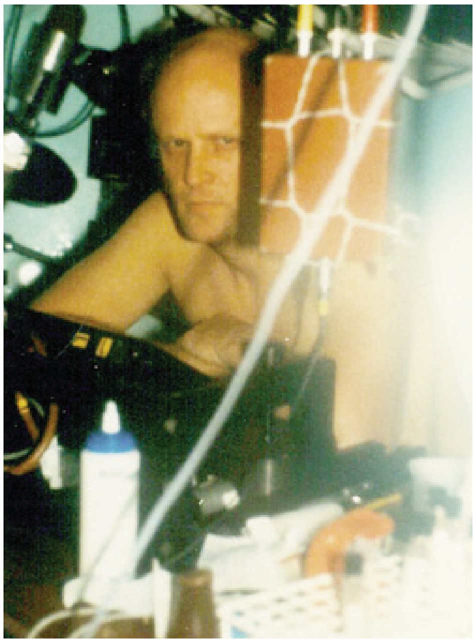
When decompression began, it continued at a steady upward pace of 30 metres per minute, but without the halt for sleeping to which the divers were accustomed. At 125 metres, the divers were told that a trial was to be staged with speeded-up emergency decompression from

125 to 104 metres in the space of two minutes. A normal decompression at this depth differential was supposed to take more than 11 hours. This experiment was Peterson's idea. He had a project under way which sought to establish how quickly divers could be decompressed without killing them. Such emergency procedures could be relevant in connection with the sinking of a DSV.[21] This experiment had been discussed, but not cleared with the divers in advance. The latter felt they could not refuse to participate. "With all the pressure from the assembled doctors and with an eye to all the work in the future, we were compelled to collaborate," reports Lindahl. "When we reached 106 metres, I suffered intense pain in every joint. I cried out 'stop completely'. We were supposed to have the right to break off, but nobody listened. 'The Swede's getting the bends,' the others in the chamber shouted." Despite the protests, decompression continued to 104 metres. Lindahl was very frightened and in great pain, and begged to be blown down again. Two of the Norwegians were now also experiencing problems. Before the pressure could be raised again, however, Doppler tests of the carotid artery were to be taken. It took 10-12 minutes before everything was ready, and that was a difficult time. Testing showed massive bubble formation in tissues and blood vessels. The divers were finally returned to 130 metres and treated with increased oxygen partial pressure in the gas mix, which reduced their pain. Decompression could continue at the normal pace. Back at atmospheric pressure, the divers felt fine and the dive was declared a success. But the failure to clear the emergency procedure test with the divers, and continuing it when the divers demanded an immediate halt, represented breaches of the ethical guidelines.

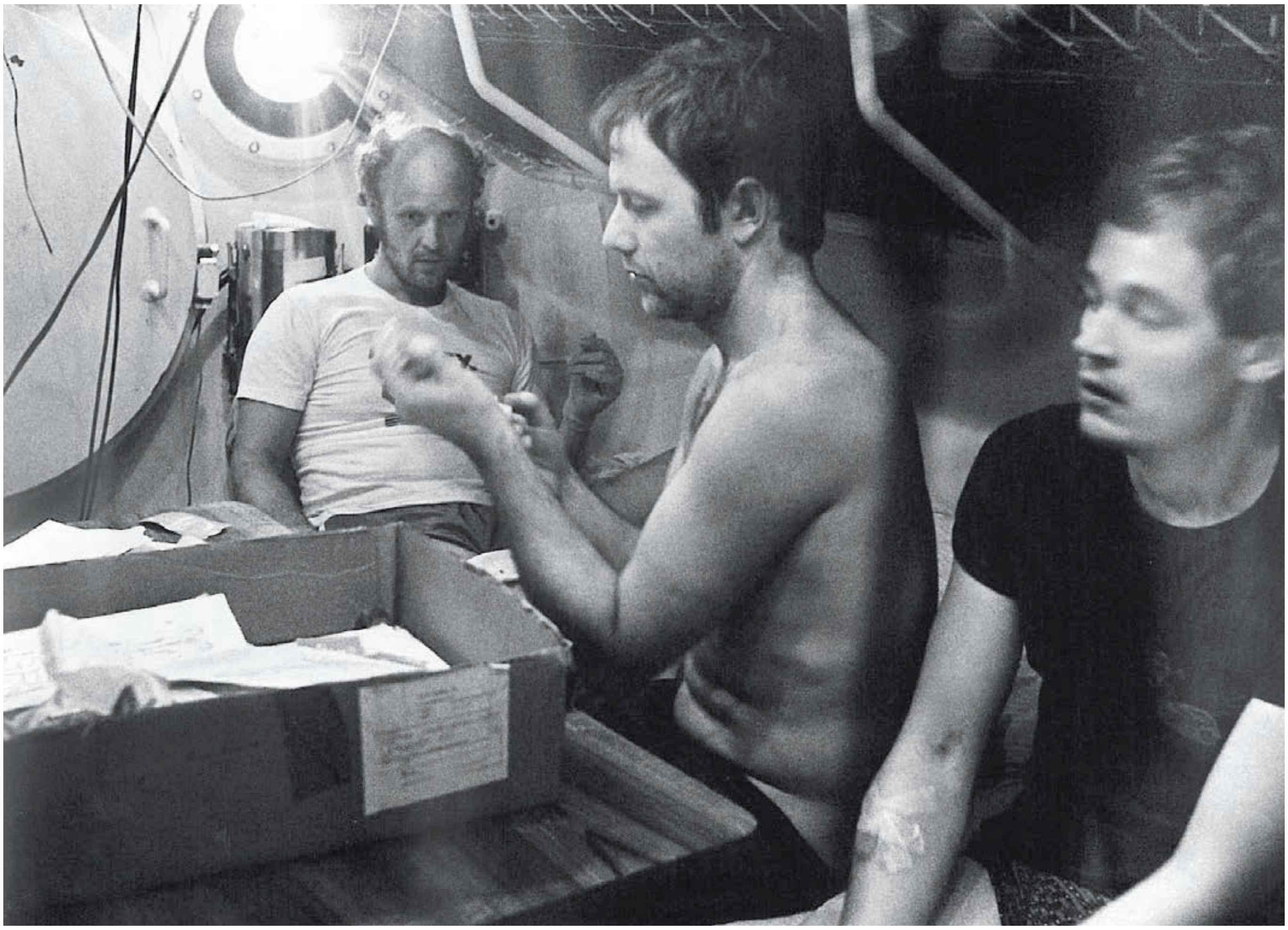
Bård Holand undergoes Doppler measurements at a depth of 500 metres to check whether gas bubbles have formed in his blood. Photo: Anders Lindahl

Norway's deepest dive – 504 metres

The second dive in the series – Deep Ex II – took place in 1981 and ranks as the deepest simulated dive ever conducted in Norway.[22] No less than 14 medical and technical investigations were included in the programme. Opportunities for reducing HPNS occupied centre stage on the medical side. The NUI researchers wanted to investigate whether a trimix blend of helium, nitrogen and oxygen had a different effect on HPNS than the heliox mix of helium and oxygen which was normally used. So the divers were divided into two teams, each compressed to saturation depth with one of these two options. The freeze test was also continued, and trials were conducted with pressure variations, work performance restrictions, and ear and balance function. On the technical side, tests were conducted with breathing equipment communication and welding. The dive lasted for 34 days.[23]



Anders Lindahl takes a blood sample during the Deep Ex II dive. Photo: Anders Lindahl



The divers are not in peak physical condition under 504 metres of pressure as they take blood samples from each other. From left: Anders Lindahl, Bård Holand and Wigulf Schøll Larsen.
Photo: Anders Lindahl

Expertise was recruited for the experiment on HPNS down to 500 metres from such sources as Duke University, which had launched a dive series called Atlantis. This sought to determine whether HPNS could be reduced by using different compression profiles and trimix blends down to depths corresponding to 460 metres. No HPNS was reported from a 650-metre dive (Atlantis II) in April 1980 using trimix. It was not clear whether this reflected nitrogen narcosis, which was countered in its turn by the hydrostatic pressure.[24] The NUI now wanted to test this further with a diving gas mix containing 10 per cent hydrogen at 500 metres. Of the six divers in saturation, three breathed this trimix blend. One of the divers in the heliox team developed HPNS at 300 metres, so that he was unable to stand upright. Problems also occurred in the trimix team, but the researchers wanted to continue investigating this at 500 metres because they still hoped that the 10 per cent nitrogen in the mix would reduce the HPNS symptoms. At 500 metres, however, the divers in the trimix team were so heavily affected by narcosis that the dive management had no option but to remove the nitrogen from the breathing gas. This was a planned operation, but was not meant to give the divers strong withdrawal systems involving anxiety, cramp and hallucinations. The experiment thereby demonstrated that nitrogen could *not* be used to suppress HPNS symptoms. Although all six of the divers continued on the heliox mix, only one of them managed to function. According to diving physician Tønjum, the other five ranged from miserable to unusable. One was unconscious for about an hour at a certain depth, and another suffered substantial weight loss. Problems also persisted after the dive. One diver felt depressed for months, while another suffered trembling for almost a year.[25]

Lindahl, who had also taken part in Deep Ex I, believed there was a huge difference between diving to 500 metres and to 300 metres. The latter was demanding, but the greater depth was much worse. Simply moving a hand rapidly through the air encountered so much resistance at 500 metres that it felt like pushing through water.[26]

Bård Holand, who dived on trimix, was the one who fainted from HPNS under compression. He described the dive as dramatic. At 250 metres, he began to feel that his brain was swelling inside his skull. He suffered from tunnel vision, and also experienced a time lag between seeing his hand doing something and feeling that he did it. He trembled more than usual as well as feeling nauseous:

> A growing feeling of general illness soon made it impossible to sit up. I had to lie down and simultaneously felt terribly tired. I closed my eyes in an attempt to sleep, but experienced what both I and others have suffered under similar circumstances – the world rotates when you close your eyes and have nothing to focus your gaze on. However, the need and desire to escape the 'misery' through sleep took over and the last thought I can recall before 'blacking out' was: 'Christ, they're continuing the compression'.

When Holand fainted between 250 and 300 metres, he was unable to demand a halt to the experiment even if he had wanted to. He only recovered consciousness when compression ceased at 470 metres, but when they reached 500 metres both he and the others felt nauseous and wretched.[27]

The divers were due to carry out work in the water breathing trimix. By the time they reached 504 metres, however, only Wigulf Schøll Larsen and Lindahl were ready to dive. Lindahl was in the best shape, so he dived first. But when he came out of the water (into the habitat), his body developed an odd reaction. One leg stuck out to the side and trembled. Larsen lay more or less ill on the edge of the pool and watched. The physical reaction meant that he did not dive. So Lindahl is the only person in the world to have made a wet dive to 504 metres on trimix.

28

Dykkerne er på vei «opp» for å feire suksess

TEKST: OLAV STEMLER, FOTO KNUT STRAND

Guinness' rekordbok betyr ingenting for dem som i disse dager er på vei til overflaten etter å ha satt verdensrekord i dypdykking ved Norsk Undervannsteknologisk Senter i Gravdal. Rekorden er kanskje det minst interessante ved prosjektet. Det er ikke derfor seks dyp-dykkere sitter innesperret i et trykk-kammersystem i mer enn en måned. De driver vitenskapelig arbeid og er viktigste ledd i dykker-forskning. En forskning vi må drive i Norge for å kunne ha glede av de store petroleumsforekomster som vi vet skjuler seg under store havdyp på kontinentalsokkelen.

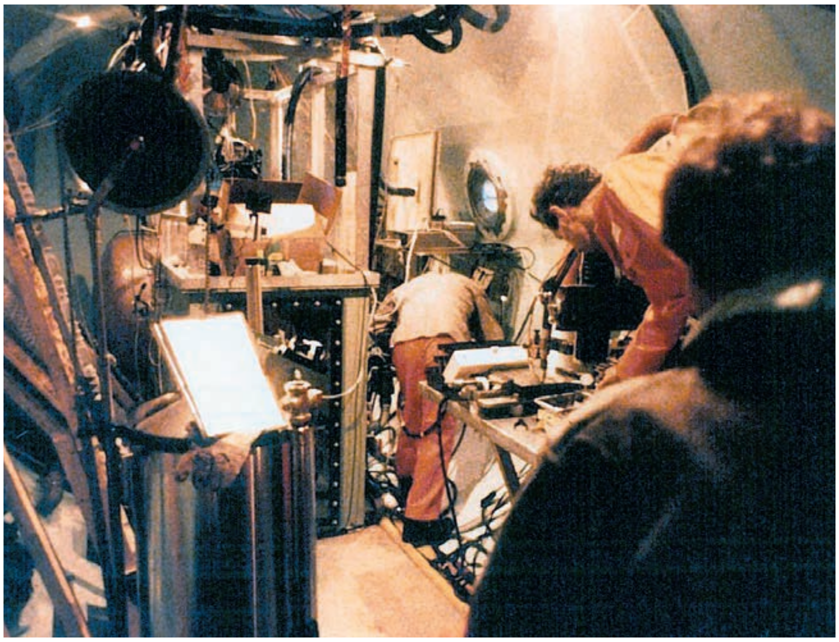
I denne reportasjen bringer Bergens Tidende bilder som verden knapt har sett maken til. Vår fotograf har vært til stede ved rekorddykket som pågår ved undervannssenteret. Ved å «sluse» sitt kamera inn i trykk-kammerne til dykkerne, har han klart å få bilder av de operasjoner og de prøver som pågår på 500 meters «dyp». Andre bilder er tatt gjennom de tykke glassvinduene i trykk-kammerne.

***Bergens Tidende*, 14 November 1981. The headline reads: Divers on the way "up" to celebrate success.**

Thanks to the trimix blend, the divers were actually heavily intoxicated. They were happy regardless and failed to react adequately. In line with the programme, the nitrogen was washed out of the breathing gas and the divers returned to heliox. But that caused a strong reaction. They first developed stomach pains, and then experienced withdrawal symptoms like those which can follow getting stoned on drugs. Their brains failed to function normally, which was frightening. Lindahl suddenly thought he saw a vulture on Larsen's pillow, and the latter also saw birds, snakes and worms. They heard music – Elvis Presley and Christmas carols – and colours changed. In other words, they hallucinated.[28] These reactions disappeared after they had breathed heliox for a while.

The ascent to surface pressure became literally an uplift. At 400 metres, Holand felt like a new person. "It was as if something had been lifted off me, both mentally and physically," he recalls. At a later stage in the decompression, he experienced pricking in his knees – a form of bends. Afterwards, it took a month before the muscular spasms he acquired when the gas mix changed had disappeared. He also became short of breath more quickly than before. Lindahl reports a substantial under-reporting of his own physical and mental symptoms. He was so exhausted, for example, that it took him a whole day to pack his bag before leaving the NUI. During the days following the dive, he experienced an episode of tunnel vision while walking in the open. He also suffered feelings of remoteness afterwards. No long-term follow-up was conducted with the divers to pick up such after-effects, and Lindahl kept his reactions to himself. Reporting them was a "sissy" thing to do, and both he and fellow divers were a little afraid to talk of their suspicions about injuries for fear of losing future work. One of the divers suffered great mental problems after the dive. Their causes might be complex, and naturally might not relate to the dive, but the sad fact is that he ended up a few years later in the statistics over former divers who chose to kill themselves.

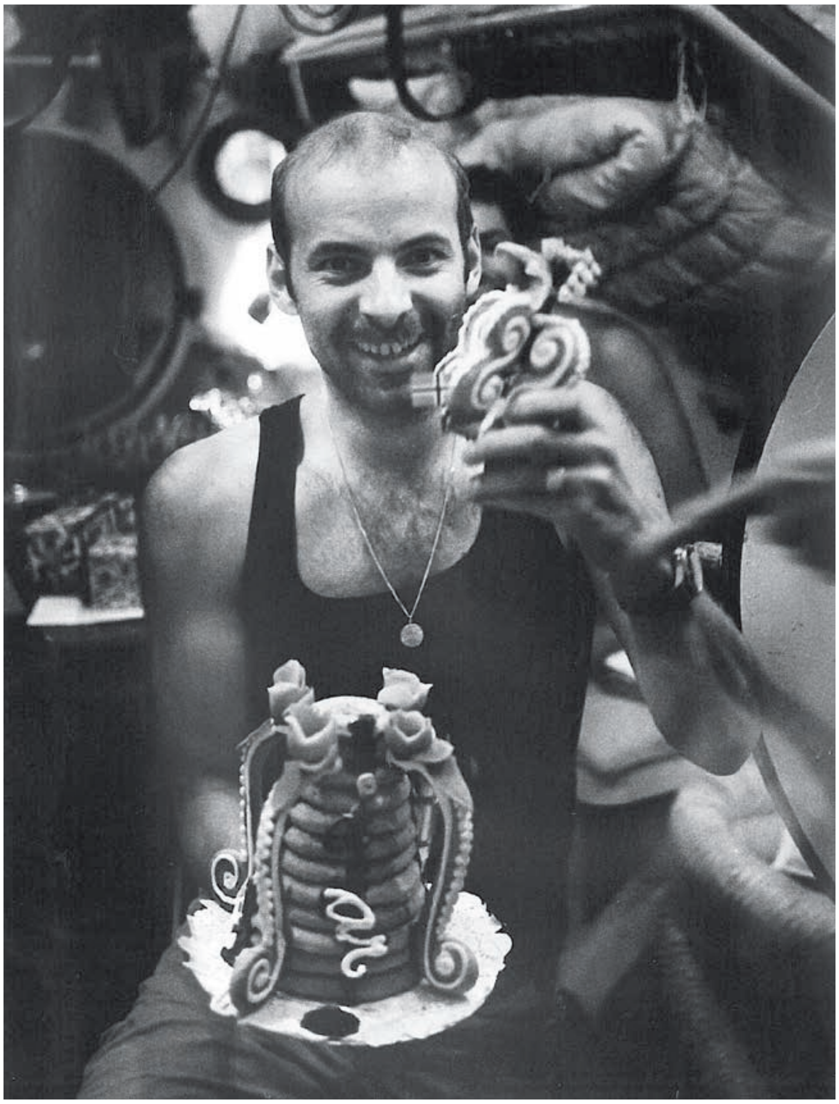
Immediately after it was over, this Deep Ex dive was presented as another success. That was important for Nutec, which needed recognition from its clients to secure more research projects. Several records were set, including diving in cold water at 504 metres. A dive lasting 182 consecutive minutes had been conducted in water under extreme pressure with heliox as the breathing gas. Manual welding (both tungsten inert gas – TIG – and electrode) had been done at a pressure corresponding to 500 metres of water.[29] This dive broke new ground and attracted international attention, but the conclusion was that more tests were still needed with both technical equipment and the effects of deep diving on humans before it could be stated with certainty that diving to such depths was practical and safe.



Getting ready for a welding test at 500 metres. Richard Dawson and Anders Lindahl undertook a number of these tests at this depth, with successful results.
Photo: Anders Lindahl

A closer analysis of the results a couple of years later yielded more judicious conclusions. A Nutec report published in 1983 concluded that "the experiments identified significant medical and psychological changes in the test subjects and showed that the equipment needed improvements."[30] Comments on the technical aspects included the need for better camera monitoring, while the breathing equipment required upgrading to achieve acceptable reparatory resistance, heating and gas humidity. Nor was communication good enough at such great depths. Even with the use of speech converters, only 30 per cent of the words spoken were comprehensible at 200 metres. That fell to 22 per cent at 300 metres and a mere 10 per cent at 500 metres. To communicate, better and more reliable microphones had to be installed in the diving masks. These matters called for improvements.

The medical problems related in part to the occurrence of the bends, with gas bubbles forming in body tissues, particularly during "deep excursions". Although the trial was conducted well within the US Navy's diving tables, gas bubbles were detected in the carotid artery of one diver during an ultrasound investigation, and this part of the experiment was immediately cancelled. A reduction in red blood cells was also identified in the divers after the dive, which showed that they had been subject to major stress. Third, it transpired that the divers tired more rapidly with increasing depth, which boosted the danger level. Muscle strength was nevertheless the same as on the surface. Fourth, diver appetite declined and they lost up to 10 kilograms in weight. Fifth, the subjects coped less well with temperature changes as the depth in-



Stein Rygland celebrates his 30th birthday with an almond cake under high pressure. Photo: Anders Lindahl

creased. Neither breathing gas nor diving suit heating were satisfactory.[31]

Jens Smith-Sivertsen, then a diving medical officer at Haakonsvern, felt compelled in August 1982 to warn director general Torbjørn Mork at the Norwegian Directorate of Health against giving the NPD a green light for diving to 300 metres:

> Experience from the Deep Ex dives at Nutec gives grounds for concern … The risk of serious health damage in connection with this diving indicates that the Directorate of Health should take the initiative to get the plans assessed by a neutral and competent specialist in diver medicine. Technical/financial interests and specialist knowledge could otherwise easily push health considerations aside.[32]

This letter was copied to the NPD. The question had now been raised about how much control was being exercised over the health risks of diving to 300 metres. The NPD had been warned against approving diving to this depth. In addition, the impartiality of research at Nutec had been questioned.

An article by Tønjum, who headed the diving section at Nutec, appeared in less than a week later in Norwegian technical weekly *Teknisk Ukeblad*. This concluded that all diving beyond 200-240 metres had still to be regarded as experimenting with humans. Tønjum emphasised that research dives should occur in the university system or the navy, where stringent ethical guidelines had to be observed for experiments involving people. The problem was that most diving research and development was conducted by the industry itself. A common denominator of dives conducted to 300 metres or beyond by Comex, Taylor Diving and Salvage Co, Wharton Williams and others was that the results were carefully guarded company secrets and not publicly available. According to Tønjum, this was unacceptable and hampered efforts to find solutions to a number of important questions which needed to be clarified if deep diving was to be permitted on a regular basis. The effect of HPNS on people immediately and in the long term was unknown, for example. Nor was it known what impact repeated pressurisations had on the human body. The boundary which separated "shallow" and deep dives had still not been determined. No rules existed for how thoroughly deep divers should be tested before being allowed to work. Another question was the advisability of allowing deep divers to remain in saturation beyond 16 days, which the industry wanted for commercial reasons. Technical specifications for DSVs and the equipment they carried had not been developed at the time. Deep diving would need the best breathing equipment and heat protection available on the market. Tønjum concluded that more research was required, and that deep diving still had to be regarded as experimental. Planned activities had to be clarified ethically and be subject to medical supervision.[33]

Tønjum was not alone in such criticism. A report from Nutec researcher Erik Jacobsen, dated June 1983, was critical of the pressure in the diving industry. He maintained:

> The tempo of future oil and gas production in deep water (beyond 200 metres) on the NCS would depend on the available underwater technology. This technology should be effective, reliable and secure with regard to the work which is to be conducted below water. The technology currently available is not satisfactory. It will not be easy to meet this challenge, since the necessary technology will be very complex.[34]

Problems with deep diving had been identified on the medical, technical and organisational sides. The NPD had not least been warned. But what was done about the weaknesses exposed? Did these results have any effect on Nutec's continued research activity?

Stronger industrial control

The criticism from the medical experts was undoubtedly hard to swallow for some in the Nutec system, which was under pressure from several quarters. Critical articles in the media were not what a company which lived from contract work most needed. It was one thing to point out that research by the diving industry itself failed to meet a sufficiently high ethical standard because the results were treated as commercial secrets. It was an entirely different matter to question how far Nutec's research findings should be treated as public property. According to Jan A Andersen, who headed the centre, the issue of unrestricted and open use of medical-physiological and psychological data versus the desire of clients for some degree of exclusive rights to the results was a recurring topic in discussions by the Nutec board. Research findings made publicly available became headline news in the media, and the industry felt that the resulting "clamour" did not serve its interests. Demands for further research could help to delay the approval of new development projects.

Andersen, who was himself a researcher, was shoved out of the system and into a job with Statoil in February 1984. He was replaced by Thorvald Mellingen, who had been head of the underwater department at Nutec and served before that with Saga. A majority on the board wanted somebody who could provide firmer leadership and tighter financial management. Nutec was facing a financial crisis, partly as a result of heavy investment in the *Nutec Fjordbase* research vessel and new quay facilities. Another consideration was that the organisation had expanded from 40 to 70 employees within a few years and had high payroll costs. The centre lacked stable operating revenues and was very reliant on contract work.

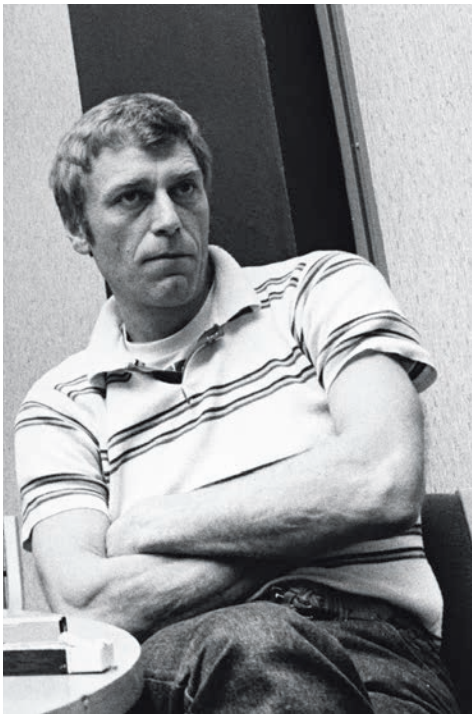
To escape from this financial predicament, the decision was finally taken to wind up the Nutec foundation and to refinance and reorganise it as a limited company owned 60 per cent by Statoil, 30 per cent by Hydro and 10 per cent by Saga from 1 January 1985.[35] DNV and the NTNF ceased to have any equity interest, which made the centre even more dependent on the oil industry. Thorleif Enger represented Hydro on the new board, along with Jon Huslid from Statoil and Bo Brennstrøm from Saga.

The new chief executive had a good grasp of the industry's requirements, and was concerned to adapt the organisation better to the market. A good reputation among potential clients was important. The goal was to win work for Nutec, and the conditions which created controversy were played down – including the dispute over ethical clearance. But those responsible for the medical side persuaded the board to resolve that the Helsinki Declaration was to be observed in all research dives at Nutec. This decision was made in December 1984, just before the change in ownership. An adjustment to the market in connection with that restructuring can be seen in the amendment made to Nutec's business purpose clause. From being a national centre of expertise in the fields of diving technology and hyperbaric medicine/physiology, as the previous clause stated, Nutec was now merely to offer services in diving technology and hyperbaric medicine/physiology.

Diving department head Tønjum, as the person who had most prominently maintained that diving research must be pursued in accordance with strict ethical guidelines and who had noted that deep diving was a long way from practical application, felt under pressure in a number of cases.[36] This all came to a head when the board appointed Tom Getz as the new head of the diving department in the spring of 1985. He had a naval education and experience from offshore operations.[37] Tønjum thereby lost his job as head of the diving department, and was offered an alternative post as the medical officer at Nutec. This meant in reality that the centre opted to depart from a professional medical leadership model. Tønjum's response was to resign. He was followed by Arvid Påsche, a physiologist who had been assistant head of the diving department. The trade unions protested, and the whole workforce in the department complained directly to the board over what had happened. But it was too late. There was no way back. The medical expertise and leadership had clearly been pushed aside after the oil companies took over as owners.

Tønjum went public and criticised the board for wanting to conduct experiments on humans without having a physician as the responsible specialist, which did not accord with the Helsinki Declaration.[38] The NPD expressed concern, too. "We risk losing the expertise which has taken years to build up in Norway."[39] The scientific community at Nutec was also weakened. All in all, 20 highly qualified staff left over a short period after the oil companies took over. This indicated a deep-seated lack of confidence in the senior management and the chair.

External criticism was also voiced. Jan Jacobsen in the Energy Divers and Service Association (EDS) was sharply critical of what had happened:



Physician Stein Tønjum headed the diver department at Nutec.
Photo: Scanpix

> It represents a disaster for diver health and safety when Nutec, as our only research centre in these fields, is in danger of losing its position as a free and independent brake on the companies' drive towards using divers in ever deeper water. Hyperbaric medical research has only been able to show that damage occurs in key areas. The reasons are still not known, and it could take a long time before all the factors have been clarified and we can stand on a solid foundation. The government must now see what might happen and ensure that hyperbaric medical research is put on an acceptable footing before it is too late.[40]

The bulk of international diving research was conducted by private companies. But neither reports nor other documentation was available from these commercial dives. This meant that researchers and other relevant specialists could not utilise the information to improve diver safety in greater depths.[41] That made it all the more important for diving research in Norway to be conducted in open forms and to be checkable. However, the question now being raised both among employees and in public was whether Nutec had sufficient independence to safeguard the ethical and moral aspects of the research. In many respects, it was Nutec which – through its research – could give Norway the key to recovering more oil and gas from fields in even deeper water and bring it ashore in the country. The reorganisation meant that DNV and the NTNF were no longer represented on the board. Statoil, Hydro and Saga controlled this body. Although these companies were Norwegian and two of them were wholly or partly owned by the state, they behaved in many respects like other international players in the oil sector.

The next experiment, the Troll dive, was imminent. Developing Troll would require the approval of dives down to 300-400 metres. Major assets were at stake. Was this why it seemed timely to tone down critical voices within Nutec's organisation?

Troll and ethics

Troll is the biggest gas discovery in the North Sea and contains 60 per cent of the total gas reserves on the NCS. It was initially proven in block 31/2 during 1979. Since both Shell and Statoil were licensees in the field, it was agreed that the former would serve as development operator with the latter taking over when production began. Negotiations began in 1985 to sell the gas. The huge reservoirs were expected to produce for 70 years. Gas from Troll also represented a stable alternative to Russian supplies in a political and security perspective – not least during the Cold War. US president Ronald Reagan applied pressure for

Troll A being towed out to the field. This was in many ways a prestige project. The platform was the tallest structure ever moved over the Earth's surface, measuring 472 metres from its concrete "skirt" to the top of the flare boom.
Photo: Statoil

an agreement to be reached. The gas sales deal was worth NOK 800 billion when entered into in 1986, and ranked then as the world's largest energy contract.[42] It took 10 years from the signing of this deal until production could begin on 1 October 1996. So even though the development decision was taken in a political climate influenced by the Cold War, the Berlin Wall had long since fallen and East-West relations had normalised when exports began from Troll.

Rich gas from Troll was piped to a receiving terminal at Kollsnes in Øygarden near Bergen, where it was separated and the dry gas sent on by pipeline to markets in continental Europe. This solution called for

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the Trench to be crossed on the way to Kollsnes. The Troll project accordingly depended on a research dive at Nutec being approved before the development could get the go-ahead.

As development operator, Shell primarily wanted the actual installation of the massive concrete platform to be done without divers. Remotely operated subsea technology was constantly advancing, and Troll lay on the boundary for work dives. Diver-free solutions depended on the development of subsea production equipment which could be replaced, repaired and maintained from the surface or from a subsea operating system which did not expose humans to the pressure found at 300-400 metres. Since such equipment had not been fully developed, Shell felt compelled to use diving to some extent in combination with ROVs and modularised equipment.

To secure permission for the necessary diving, Shell and contractor Seaway planned in 1985 to conduct a research dive to 450 metres at Nutec. Six people would participate, and the dive would last for 30 days. Before this plan was approved, however, disagreement arose about its ethical clearance. Shell maintained that the dive was less a question of research than of verifying that the company had full control over what was to happen on the field when development began. Since the company had been responsible for a number of previous dives to 300 metres, ethical clearance was unnecessary. Shell argued that it only leased equipment from Nutec and had the medical expertise to interpret the health data itself.[43] According to Tønjum, the oil company did not understand Norwegian culture and the ethical attitudes which prevailed among Nutec staff. Shell was used to being able to do what it liked around the world.[44] All dives in Nutec's diving spread had been cleared from the start by an ethics committee, and the board decision of December 1984 on compliance with the Helsinki Declaration meant that no grounds existed for departing from this practice. The signals from Nutec's management were unclear, however, and the turbulence in its organisation continued through the summer of 1985. Operations manager Cato Hordnes resigned in protest only a few weeks before the Troll dive was to begin.[45] But planning for the dive continued.

The complicated division of regulatory authority for offshore diving between the NPD and the NMD also helped to create a lack of clarity over the experimental dives. The NLIA was responsible for supervising all inshore diving, including dives in Nutec's land-based spread. However, checks by the NLIA were confined to investigating the formal aspects of the dive, such as working-time provisions for technicians and so forth, and to granting the necessary exemptions so that the work could continue around the clock. The authority exercised no supervision of the medical experiments. Responsibility for that rested with the diving physicians at Nutec and the Directorate of Health.[46]

In purely formal terms, the NPD was merely an observer during the research dives.[47] This was a strange arrangement, given that all the experiments were intended to acquire knowledge of relevance for offshore diving. As a result, the NPD was the regulator with the greatest expertise – at least compared with the NLIA. The latter accordingly used the former as a technical consultant. As soon as the trials were over, the oil companies and diving contractors turned primarily to the NPD – including for the interpretation of the results. In cases where disagreements existed and things went wrong, such conditions could easily lead to a fragmentation of authority.

Both the Directorate of Health and the NLIA gave their consent to the dive.[48] But it also had to be approved by an ethics committee. The first meeting of the regional committee for research ethics in health region 3 (western Norway) was planned for 4 September – the same day as the original starting date for the Troll dive. The latter accordingly had to be postponed. Physician and professor Bo Anesjø chaired the committee. Its other members were philosophy professor Gunnar Skirbekk, law professor Nils Nygaard and representatives from the health service.[49] The outcome was that the ethics committee also approved the dive. This decision reflected a view that it was a research dive, since little experience existed at these depths. Only 79 divers worldwide had descended to the kind of depth involved here. Although various health problems had arisen during the dives, none of the divers were known to have suffered permanent health deterioration or had died. The committee was aware that the dive presented a clear health risk for the six divers, but took the view that it did not conflict with medical norms for research ethics. Emphasis was given to the right of the divers to withdraw at any time, and to a good health insurance plan in the event of possible accidents. The committee requested that the medical investigations after the dive be extended so that more could be learnt about long-term effects. Since this was a research dive, the medical conditions had to be fully public. No part of the result could be kept confidential.[50]

But the report from the dive, dated 24 October 1985, was classified "Investigation for client, carried out according to client's specification. No distribution outside Nutec without permission from client". How transparent was that?[51]

One Irish, one Icelandic and four Norwegian divers took part in the Troll dive, which was carried out in September-October 1985. Compression took two days. The divers then spent 11 days in saturation under a pressure corresponding to 450 metres, followed by 17 days of decompression. They did jobs in a chamber with water at the bottom depth, and then worked three-hour shifts. Their assignments included manual work, heavy lifts, and motor and cognitive tests.[52] Neurophysiological and neuropsychological tests were conducted during the compression stage, at 450 metres and in the decompression phase. Four of the divers developed HPNS during this dive. Although they reported dizziness, nausea, tiredness and difficulties concentrating, however, this had no effect on their work performance. Most of the symptoms occurred around 200-300 metres. All functions returned to normal during decompression, and the divers all reportedly felt fine when they returned to the surface. It was concluded that the divers were healthy at all depths when decompression was conducted at a continuously slower speed and with a number of stops on the way.[53] Performing maintenance work at 350-400 metres had now come close to being found acceptable.

However, the assessment of the dive by the divers themselves once again diverged clearly from the official reports. One participant, Larsen, who had previously taken part in the Deep Ex dive, characterised the Troll test as "indefensible, unacceptable. We had great problems in completing the experiment. Afterwards, we were completely exhausted."[54] Sigurdur Hafsteinsson, Bjørn Gjerde and Ole Molvær have written memos about their experiences. They all recall that problems were encountered in maintaining a stable temperature in the habitat – they either sweated or shivered. It was difficult to sleep, and they had strange dreams. The worst part, according to Hafsteinsson, was the breathing difficulties they faced at 450 metres. The gas seemed much too dense, and he thought he was going choke. But there was no point in panicking when you were 17 days from the surface, and the choking feeling eventually disappeared. The Icelander said nothing to his fellow divers at the time. Strangely enough, however, when he told the others about it a few days later, they all reported similar experiences. Nobody had spoken up because they did not want to complain. Molvær reports that even something as simple as eating was a challenge. The density of the gas made it impossible to breath through the nose. Trying to breath through the mouth when it was full of food being chewed posed problems. To overcome these, the routine became food in, chew, breath, chew, breath and so on until you were ready to swallow.

A few days after decompression started, one of the divers became ill. He collapsed during a meal and only a quick reaction by Hafsteinsson cleared his respiratory passage so that he could breathe. He regained consciousness after 10 minutes of mouth-to-mouth resuscitation, but had great difficulties breathing. He suffered major problems for the rest of the dive with itching all over his body and difficulties sleeping.

The bottom phase was to be concluded with a rescue exercise. The divers were to cut part of an umbilical and swim with a dummy dressed as a diver to the dry part of the chamber. They were equipped with standard Heliox 18 respirators with an Ultraflow regulator. The latter failed to supply sufficient gas, and cutting the umbilical proved more difficult than anticipated. Hafsteinsson tried for as long as he could,

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and probably went too far because he was on the verge of collapse. He had to abandon the rest of the test and needed a long time to regain sufficient energy to get into the dry section. He lost 10 kilograms during the dive. It was highly stressful.[55] The same applied to Molvær, who got pains in his lower back and numbness in his legs during his first night in a hotel after the dive. He was carried back to the chamber for treatment with pressurisation and oxygen breathing.[56]

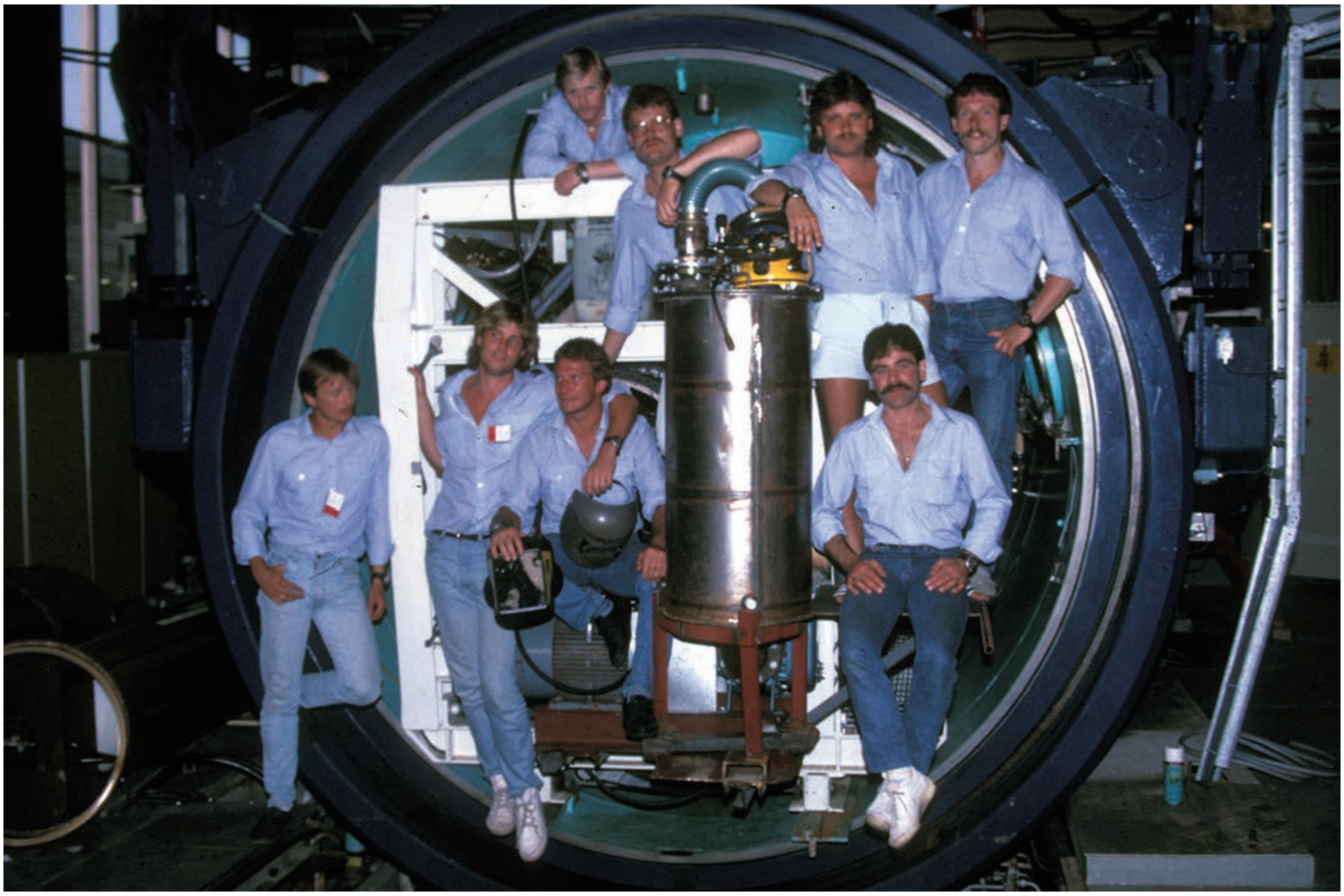
That the dive was particularly tough was supported by clinical findings. Diver physician Alf Otto Brubakk, medical director for the dive, warned the NLIA and the ethics committee that five of the six divers showed signs of focal central nervous system dysfunction immediately after the dive. Although the symptoms were only transitory, this was very disturbing. It had been assumed that diving conducted in accordance with accepted procedures and without accidents involved no threat to health. Another assumption was that diving deeper than about 180 metres which produced a number of central nervous system symptoms would not have any long-term effects and that the decompression procedures used were acceptable providing no serious clinical symptoms were encountered. These assumptions could no longer be regarded as valid, Brubakk maintained. He argued that more findings were probably made on this occasion than before because the neurological examinations had been more detailed. It was accordingly important to improve medical monitoring of the divers, particularly for damage to the central nervous system. Brubakk called for research to continue in order to establish where the boundaries lay in purely medical terms.[57] The diver who lost consciousness and broke out in a rash also experienced pains when he approached the surface. He was monitored medically for three years after the dive.[58]

This experiment cost Shell almost NOK 20 million. Nutec's total contract for leasing its premises was worth NOK 4-5 million.[59] The special feature was that the oil company itself interpreted the health data. Nutec simply printed out the matrices and handed them over.[60] The dive took place while the big Troll gas sales agreement was being negotiated with European buyers. Whether that put any additional pressure on the dive is difficult to determine, but it was unquestionably very important that the operation was declared a success and that no delays occurred. Statoil's agreement with the German buyers of the Troll gas was signed on 31 May the following year. The cost of the experimental dive represented a microscopic part of the total development bill. By 31 December 2007, NOK 58.8 billion (in 2008 value) had been invested in Troll Gas. The value of the field to Norwegian society is shown by the fact that it originally contained 1 331 billion standard cubic metres of gas, 25.7 million tonnes of NGL and 1.6 million standard cubic metres of condensate (light oil).

The Oseberg field centre.
Photo: Terje S Knudsen

Medical practice and responsibility during the OTS dives

Although not all discoveries were as significant as Troll, every field development involved major capital spending and substantial profits. That also applied to Oseberg, an oil field 130 kilometres north-west of Bergen and a little south of Troll. The pipeline planned to carry oil and condensate from Oseberg to a receiving terminal at Sture in Øygarden would cross the Trench in 350 metres of water. As with all the major pipelaying operations, this project would call for extensive and technically demanding diving work. Several laybarges would be involved, each laying different parts of the line so that the pipe ends overlapped. Divers were used to connect these sections. They first cut the overlapping pipes to the right length, and then joined them up with hyperbaric welding in watertight habitats on the seabed. These connections were made on opposite sides of the Trench. Diving in the depths of the latter would only be necessary if a later accident to the line called for a repair. To have such an emergency response in place, a series of three test dives



A team picture from the OTS dives to 360 metres. Front row from left: Rune Sundsdal, Tord Solberg, Ove Stiansen and Max Ouzeane. Back row from left: Trond Hansson, Harald Klinge, Tomas Bauer and Askil Moe.
Photo: Trond Hansson

to 360 metres – known as the Oseberg Transport System (OTS) dives – were planned for 1986.

With the equipment available at that time, the NPD could approve diving operations to 300 metres. But the technology would have to be further developed before it could be sanctioned for use down to 350 metres. In connection with the preparation of a White Paper on the development issue, the NPD assured the Ministry of Local Government and Labour that it was fully possible to devise equipment which permitted diving to 350 metres with acceptable safety. This statement shows that the NPD was playing various roles, both as resource manager and safety regulator. Was it certain that both concerns were given equal weight? This was apparently the case, given that the licensees, with Hydro as operator, were required by the ministry to devote the necessary resources to developing the equipment required.[61] The OTS dives were planned in part to satisfy this requirement.

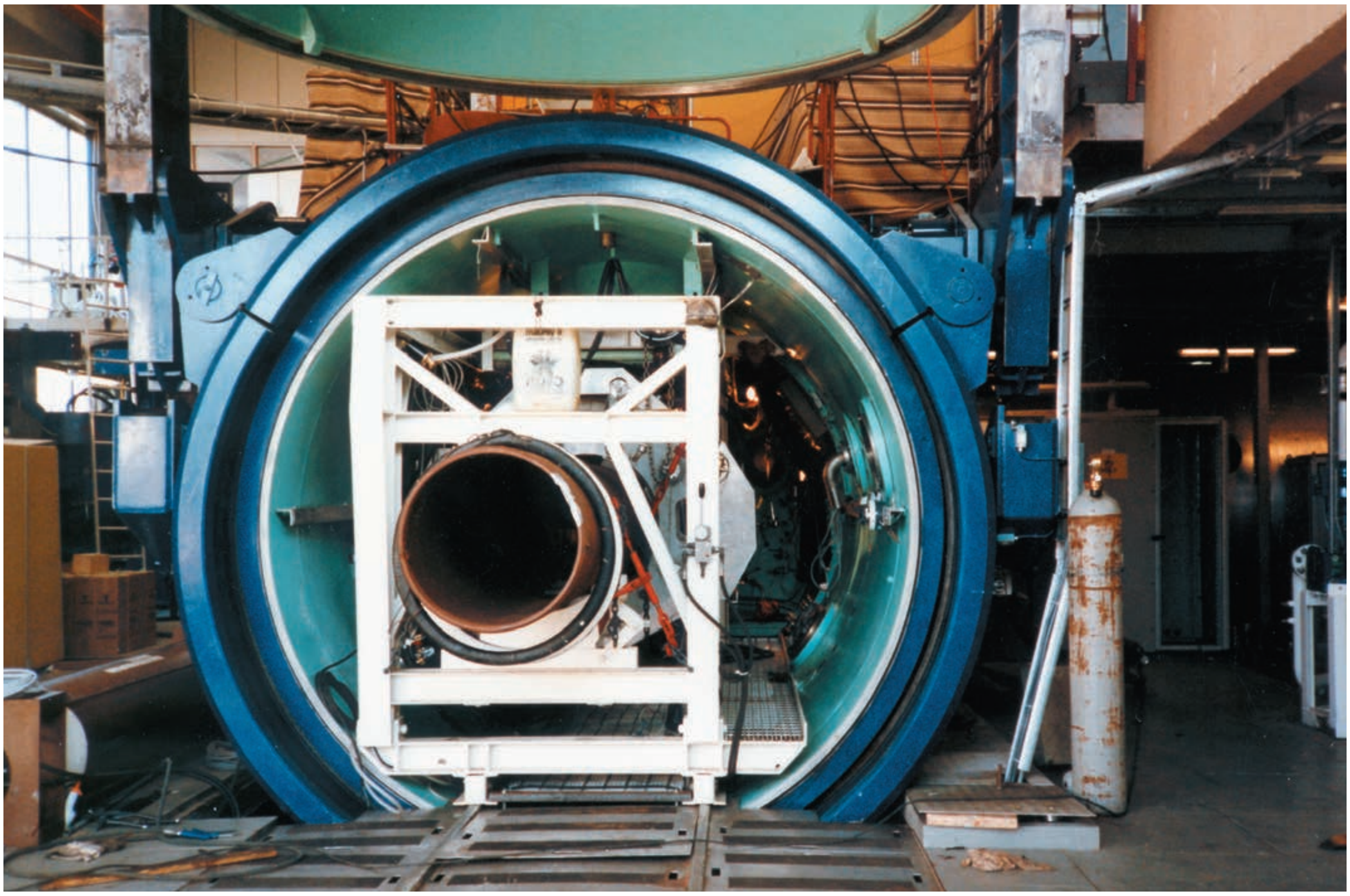
In going down to 360 metres, this series was 90 metres "shallower" than the Troll dive. Given the results of the latter, the licensees did not consider it necessary to conduct research dives deeper than was

Residents in chamber 2 during the OTS II dive to 360 metres. From left: Harald Klinge, Askil Moe (top bunk) and Tomas Bauer.
Photo: Trond Hansson

required for crossing the Trench. The first dive took two days to reach full depth, with a halt every 80 metres for tests to be carried out. Six British naval divers took part. One of their jobs was to try out emergency breathing sets. When this equipment failed, however, the dive had to be halted earlier than planned.

Divers competed to take part in the series, with 12 coming forward for the second dive. Six of these were selected – five Norwegian and one French. The selection process was very thorough, with tests lasting no less than seven days. Since earlier research dives had shown stresses on the brain and central nervous system, all 12 candidates were subjected to X-ray magnetic resonance imaging (MRI) to acquire cross-sections of their brains. Four divers were eliminated as a result of this examination.

The second OTS dive also failed to proceed entirely as intended. Thomas Shields, the medical director for the dive, travelled to Aberdeen the day after it had started. Tønjum, who was now Hydro's medical specialist, instructed Norcem Comex Subsea to remove Shields as medical director. He was replaced by Molvær.[62] The dive was suspended while this process was under way, and the divers – who were by then



The Pipeline Repair System in the large hall at Nutec. Testing this automated welding solution was an important part of the OTS series. Photo: Einar Andersen

at 280 metres – were forbidden to do anything until the new medical director was in place.[63] The operation then continued as planned.

A slow compression profile was used for the three dives to 360 metres. The divers worked every day in water with a temperature of 3-5°C. An important technical goal of the project was to test a new fully automated welding set, with a remote control system developed by Sintef in Trondheim. Both this and manual welding were tested. The welding set worked satisfactorily. A number of medical examinations were conducted. Physician Kari Todnem was responsible for the neurological studies. The divers were trained to measure the nerve conduction speed in their arm, and carried out a visual evoked-response test. Performed at various depths, these tests showed that nerve conduction speed in the arm declined with increasing depth. The visual test also showed that the same happened with nerve conduction speed in the brain. At full depth, the divers presented neurological symptoms such as poor balance and trembling hands. They had problems sleeping while simultaneously feeling exhausted. Some were nauseous or had diarrhoea. Even though they ate well, their weight went down. Three of them were so ill that they could not work. Under such high pressure, the divers were extremely sensitive to temperature changes. They became very cold in the habitat at 29°C and sweated if it was more than 31°C.[64]

After the dive, the subjects were to undergo an extensive health check. Even more turbulence occurred among the medical professional over these examinations. Norcem Comex wanted to serve the divers alcohol to celebrate the conclusion of the first dive in May. The three diving physicians protested about this. At a coordination meeting on 8 May, the issue of consuming alcohol during the four-day test period was discussed. Tempers rose, and the physicians were threatened with physical violence. The person concerned had made similar threats before and had attacked and half-throttled a third person during recent months. The matter was accordingly raised in writing by physicians Molvær, Arthur Dick and John Hjelle. They wrote to Mellingen, Getz and Birkeland to ensure that their complaint was not allowed to drop.[65]

This was not the first time alcohol had been served after a deep dive. Ever since the first Deep Ex experiment in 1980, the tradition had been to take a glass of champagne when the divers reached the surface.[66] In the Troll dive, the decision was taken to give each diver a half-bottle of whiskey when they reached surface pressure as a reward for the tough physiological tests they had undergone. The bottles had been opened and drunk before the post-dive investigations were complete, and no physician had intervened.[67] It was well known in medical circles that the use of alcohol was unfortunate. Johan A Aarli, senior consultant in the neurological department at Bergen's Haukeland Hospital, wrote a letter in the summer of 1985 to director general Mork at the Directorate of Health:

> A certain amount of alcohol consumption is not unusual immediately after a deep dive. We would note as a preliminary observation that relatively small amounts of alcohol led to EEG changes far greater than we are used to observing from the influence of alcohol. That appears to confirm the assumption that the central nervous system is particularly vulnerable after a deep dive.[68]

There were several reprehensible aspects to the dive. The ethics committee, which was responsible for clearing the operation in terms of medical and research ethics, was uneasy about the lack of continuity in the project management and considered postponing the second dive. It demanded that "the responsible physician for dive 1 remains in the project management for dive 2". In reality, this did not happen. Dick, the project physician for dive 1, charged very high fees and was replaced by Shields as the diving medical officer for Norcem Comex.[69] After the dive began, the latter demanded that all health information – including personal notes – be transferred to him. Medical personnel were asked to sign a declaration of confidentiality which contained a clause concerning the ownership of original medical data and providing the opportunity for onward sale of the information. This also applied to the major expanded examinations before and after the dives, including lung tests by Einar Thorsen, ear-nose-throat (ENT) checks by Molvær, neurological testing by Ragnar Værnes, and neurological/neurophysiological examinations by Todnem.[70] Giving away health data was an unfamiliar concept for the Norwegian physicians, who maintained that Norwegian law governing medical professionals and data protection had to apply. Both Molvær and Todnem refused to sign and were threatened with dismissal.[71] Norcem Comex presented a written demand on 4 July 1986 that Molvær, who had then taken over as medical director, be removed from all activities related to the dive. The divers were then at 360 metres. Nutec, with Mellingen in the forefront, refused to comply with this demand. If it had been accepted, Hjelle would have been the sole person with diving medicine responsibility at Nutec, which the centre could not permit on safety grounds. As a compromise solution, Molvær signed with the reservation that the issue of the ownership of original medical data should be considered by the legal faculty of the University of Bergen, the Directorate of Health, and the Norwegian Medical Association.[72]

The ethics committee furthermore demanded that a formal contract be established between Nutec and Haukeland Hospital on the medical assessment of divers before and after the dive. Norcem Comex refused to accept the draft contract, and a signed version did not exist even after the medical examinations for dive 2 had been completed.

The divers returned to the surface on 20 July. That same evening, Norcem Comex invited them to a restaurant for a big dinner with copious amounts of alcohol. Molvær expressed regret at the incident in a medical report for OTS dive 2, since the consumption of alcohol was known to mess up the results.[73] The divers were in the middle of their medical examinations. EEG measurements as well as neurological, ENT and neuropsychological examinations were scheduled for the day after the party.[74] But the damage had already been done. However, the next dive – OTS 3 – was conducted as planned without irregular episodes.

How did the divers who took part in the OTS series assess the experience? Trond Hansson was positive. “He is an astronaut of the deeps,” wrote *Adresseavisen*. Hansson was aware of the health risk associated with deep diving, and was initially sceptical to being a guinea pig, but changed his mind after studying reports from earlier dives. After the dive, he felt fine and could also contemplate participating in more experimental dives.[75] He thought he had been looked after well and securely compared with the conditions familiar from his operational diving – including DSV *Tender Comet* on Statfjord. He experienced one episode of HPNS, which lasted about 10 minutes, but had not had the bends.[76]

The divers made good money, with a saturation supplement of NOK 185 000 for 24 days under pressure. That was on top of their regular monthly pay of NOK 16 000. All in all, this added up to a very good reward in a short time, but must be set against the fact that the body was subject to such great stress that an individual could perform a maximum of two such dives a year.[77] Pay was accordingly not the most significant consideration. It was the challenge, the excitement and the "honour" which attracted.

Børge Ousland, a well-known Norwegian Polar traveller and mountaineer, was another participant in the OTS dives. Although he was in very good physical shape, he found the experience extremely stressful. "I wouldn't do it again," he said a few years later:

> It's not worth the money. But I was inexperienced at the time. The excitement drove me. The deeper, the tougher. And then there was this market value, of course. As a freelancer, you lived off an image. Hydro paid Nutec in Bergen to conduct the pressurisation. The company wanted to prove that repair work was possible at such depths. If I remember correctly, Hydro's company medical officer went out and described the experiment as successful and without problems while the divers were still in decompression and nobody knew anything at all about the outcome. I had problems getting out of bed in the morning for six months after the dive. I was worn out. Exhausted. Not in my body, but in my brain. Three hundred and sixty metres is too deep. The breathing gas is as dense as porridge. The muscles powering the lungs must work hard to force the thick gas through the thin respiratory channels.[78]

Ousland suffered no lasting harm after the dive. But not all the participants were equally fortunate. Three other divers had their health so badly undermined that they lost both their diving licence and their ability to work.

Warnings against deep diving

As mentioned above, the NLIA and the NPD had different roles as official regulators with regard to the research dives and the diving business in general. The former was authorised to approve the research dives, but responsibility for approving and monitoring deep diving in practice – with pipelaying operations, for example – rested with the NPD. Both regulators had the same access to information from the experimental dives, but drew different conclusions about the safe depth for diving.

The NPD received a letter from the NLIA in April 1988 which noted that three of the divers who had taken part in the OTS dives in 1986 had developed medical conditions – despite the fact that the operations had been declared a success.[79] The NLIA assumed that the illnesses identified by the physicians were related to the diving and took the view that such dives should be halted until the medical risks had been clarified. It asked the NPD to assess whether it was medically acceptable to make deep dives offshore. Alternatively, even stricter requirements should be set for the employer's programme for medical supervision and long-term monitoring of the divers.

However, the NPD was unwilling to listen. It took a sceptical view of medical warnings that diving deeper than 180 metres involved a higher degree of risk, and preferred instead to listen to that section of medical opinion which was more solution-oriented towards deep diving. Providing the technology was improved, the depth limits could be extended. How deeply this view had become entrenched in the NPD was revealed by the Storting's consideration of the OTS development project in 1983-84. The NPD then assured the Ministry of Local Government and Labour that it was fully possible to develop equipment which would make diving operations in 350 metres acceptably safe. The NPD thereby wanted to ensure that technical solutions were developed which made diving at such depths secure while getting Oseberg developed with its oil landed in Norway. Since 1985, the NPD's official line had been that diving to 200 metres could be conducted on a routine basis, to 300 metres was permissible with medical follow-up, and to more than 300 metres had to be demonstrated to the regulator as acceptable.[80] In other words, how deep diving would be allowed to go was determined by the results of verification dives to those depths.

The NPD had to take account of overall resource management on the NCS. At the same time, it was responsible for diver safety. But it did not look as if the health and safety of the divers were the first priority. Information manager Jan Hagland stated that the letter from the NLIA would not change the NPD's standpoint. "On the basis of current technical and medical knowledge, we believe it is acceptable to dive to 400 metres," he said. At that time, it was not considered practical to replace manual labour with remotely operated subsea technology. It would be very expensive to develop such technology, the NPD maintained, and argued that diver intervention was essential for repairing acute pipeline damage.

A number of working dives deeper than 180 metres were conducted on the NCS from 1978 to 1990, involving an estimated 40-50 divers.

Stein Rygland during a medical examination before a Deep Ex dive begins. Photo: Anders Lindahl

The first was carried out to 207 metres by Dolphin Services on the "silver block" in 1978.[81] Guidelines were replaced in 197-207 metres on Gullfaks during September 1979 and April 1980. Divers from Subsea Dolphin dived to 185 metres on Veslefrikk in 1981, and two dives were made by Oceaneering to 180 metres at unknown locations in 1983.

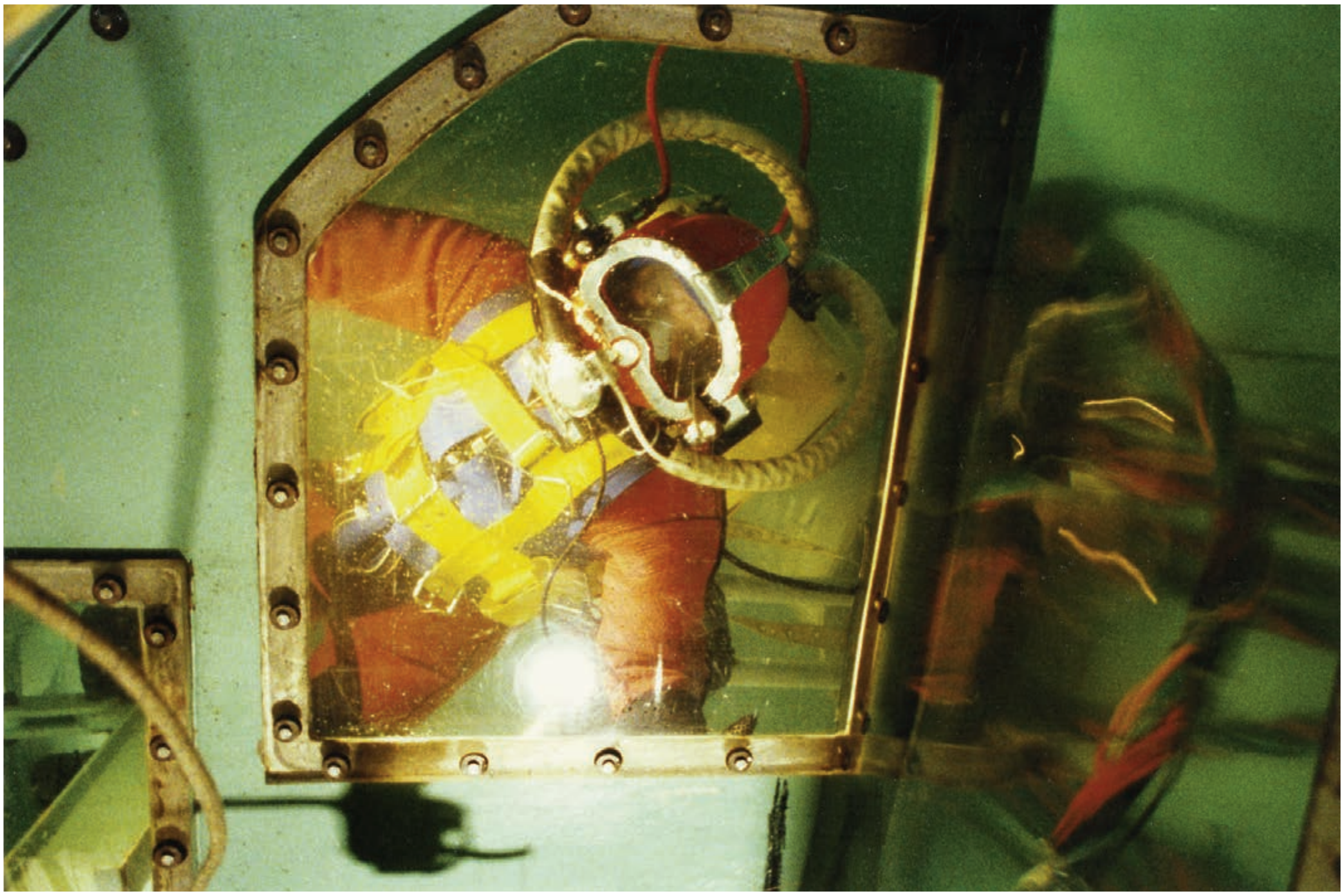
The Statpipe line was being laid in 1984, and diving took place from June to August. Many divers were involved. Pipeline connections were made by Seaway in depths ranging from 180 to 220 metres. No cases of the bends were registered. Two divers took part in the deepest operation, to 248 metres off Utsira.[82]

A guidepost for well 34/7 was burnt off in 248 metres on Tordis East during 1984, while a blowout preventer (BOP) was salvaged in 266 metres on Snorre in 1986. Oceaneering carried out template installation in 175-186 metres on Veslefrikk in June of the following year, and more work was done on this field in 180 metres during 1988 and 1989.[83] The final dives in this category took place from July to September 1989 in 218 metres on Gullfaks C. Some 20-25 divers took part in this major saturation diving job, which involved welding pipelines to risers via expansion loops. Four dives were conducted by Aker Comex, each with 10 days of bottom time plus decompression.[84]

The deepest working dives on the NCS have accordingly been to 248 metres. As far as is known, no working dive deeper than 180 metres has taken place in these waters since 1990. It appears that the medical warnings issued in the late 1980s were taken seriously in practice by the operators and diving companies. After the OTS series to 360 metres, no research dives were conducted to similar depths. The deepest were to 220 metres in 1989 and 250 metres in 2002.

Medical disagreement over the 400-metre limit

Several factors led to a faster-than-expected decline in demand for deep diving. The industry opted to invest in developing remotely operated subsea technology. This progressed rapidly and became so advanced that it could replace divers on a growing number of fields. That was precisely a point which the medical experts seized on. As the consultant in the occupational medicine department at Haukeland University Hospital, Todnem was one of the researchers in Norway who knew most about hyperbaric medicine during the 1990s. She warned against setting the limit as deep as 400 metres. On the basis of the available medical evidence, she wrote a letter dated 2 December 1991 to the NPD, Statoil and Hydro in which she asked the companies to revise their goal of establishing safe diving down to 400 metres. The 46 divers who had performed deep dives on the NCS had participated in a medi-



Tomas Bauer tests the UBA-450 breathing system during the 220-metre dive at Nutec in 1989.
Photo: Trond Hansson

cal investigation which had revealed a number of minor injuries to the brain and spine in them all. The scope of this damage correlated with the depth the divers had descended to and the number of dives they had made. Sufficient medical evidence had been accumulated to suggest that such diving was so risky that it would be better to develop new strategies for installation and maintenance of oil platforms on the NCS. The companies should concentrate instead on remotely controlled subsea technology. She justified this view as follows: "Our experience with deep diving is not good. Four of the 46 divers have lost their diving certificate as a direct consequence of a deep dive. They suffered permanent interference with brain function after the dive, which meant that they no longer met the requirements for holding a diving licence …"[85] Nor was anything known so far about the long-term effects of deep diving.

Her statements were based on the results of a research project concerning the long-term effects of saturation diving, which she had been conducting with colleagues at Haukeland Hospital and Nutec since 1986. She took the view that, although an experimental dive had been successful from a physiological perspective in that the subjects survived and seemed well after the dive, it was not necessarily successful from the individual diver's perspective. Those who suffered less visible damage – of a neurological nature, for example – could have their lives significantly worsened as a result of the experiment.[86]

Other hyperbaric medicine specialists, such as Brubakk, were more open to the possibility of finding a future solution for deep diving. From 1985, he had been affiliated to the department of biomedical research at Trondheim's Centre for Medical Technology. He observed:

> Todnem and I are in agreement right up to the conclusion. Saturation divers operate in rough environments under physical conditions which inflict punishment if you breach them. The question is whether we have opportunities to conduct these operations without hazard if we observe the rules of the game. The answer is probably yes, but we are in certain grey zones … We humans are not constructed to rummage about several hundred metres down. But seeking out elements we are not constructed for, but which we learn how to master within certain limits, is precisely a characteristic of human nature.[87]

Brubakk concluded that it was still possible to dive close to 400 metres, but that more research had to be done to improve procedures and control systems so that the diving became as safe as possible.[88]

Since dissent prevailed in medical circles about the long-term effects of deep diving, the NPD was free to choose the advice it wanted to hear and allow the 400-metre limit to remain. As we will see in the next chapter, the results of the research dives were not the only criterion involved when the NPD considered this limit.

Common interests

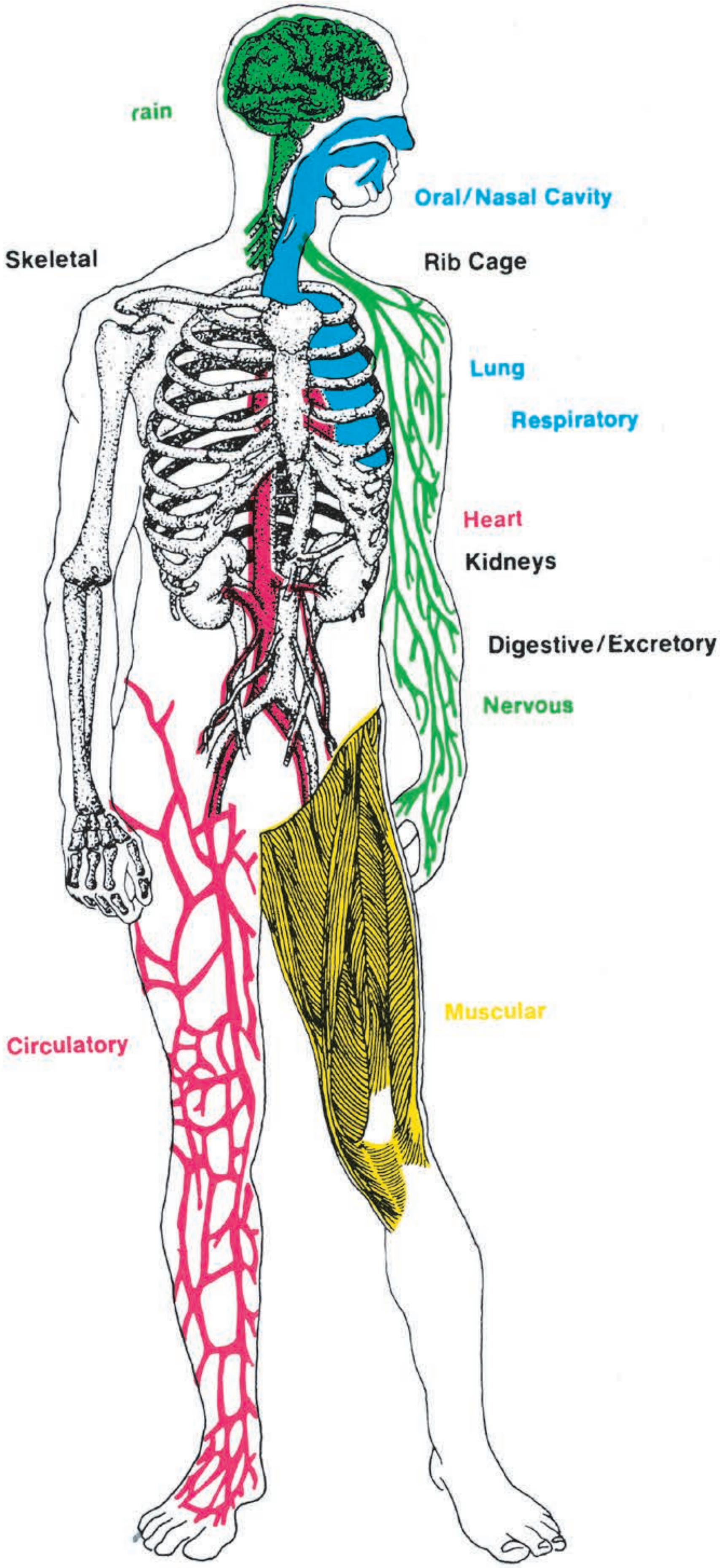
From 1980 to 1990, the decade when diving research was at its peak at the NUI/Nutec, technological optimism was the dominant mood. The major international projects aimed to demonstrate that it was possible to dive safely to great depths. The depth record in Norway was set as early as 1981 with the 504-metre Deep Ex II dive. A world record of 686 metres was set for a simulated dry dive at Duke University.

But this research was not conducted merely to set records and to acquire knowledge for its own sake. The experimental dives took place because the oil industry needed to show that it was safe to work at the depths required by pipelaying across the Trench. Landing petroleum in Norway was a significant component in Norwegian oil policy. The political guidance for this was established in the "10 oil commandments" as early as 1971. By the 1980s and 1990s, the time had come for practical implementation of the political visions. The operators were responsible for the actual laying and operation of the pipelines. And it was these oil companies which financed research on deep diving.

For various reasons, everyone involved wanted the experiments to succeed. The oil companies and diving contractors needed the dives approved in order to get permission for their development projects to start as planned. The NUI/Nutec needed recognition from its clients (the oil companies) to secure more research projects, and the divers wanted a good reputation in the job market. However, a common feature of subsequent reports from the latter was that the unpleasant effects of deep diving – the difficulty breathing, the exhaustion, and the post-dive weariness, not least mentally – had been significantly under-reported. Immediately after a dive, it was pleasure that the whole thing had been successfully completed which characterised the press reports among others.

The oil companies which had secured permission to develop and which had "proved" that they could respond to emergencies with diving joined forces in the 1990s to maintain the necessary preparedness. No serious accidents occurred with either oil or gas pipelines, and remotely operated subsea solutions developed in the meantime rendered diver assistance in depths as great as 400 metres unnecessary.

The pragmatic solution embraced by the NUI/Nutec and the NPD was fortunate both for the oil industry and for Norway's oil-based economy. It never became necessary to use the contingency diving which the oil companies had demonstrated that they could do, so the only people who risked anything were the relatively few divers who provided their own bodies for medical experiments to show that such dives were possible. Some of them were injured and lost all or part of their health because of these trials.


rain
Oral/Nasal Cavity
Skeletal
Rib Cage
Lung
Respiratory
Heart
Kidneys
Digestive/Excretory
Nervous
Muscular
Circulatory

Chapter 10

What is the limit?

The NPD took action in November 2002 and declared that diving should no longer be conducted in depths beyond 180 metres on the NCS. At that time, this seemed like an obvious conclusion – there was a limit to how deep humans could dive. The media described the treatment of the North Sea divers as a national working environment scandal. But it was not a new issue which Norway as an oil nation had to confront. The warnings had been many and clear. This was a question not only of whether the limit should be set at 180 metres, but also of the general conditions to which divers had been subjected in the North Sea. It is therefore pertinent to ask why the oil companies and diving contractors had accepted that employees for whom they were responsible should expose themselves to such a high level of risk. Why had the regulators and the politicians failed to set clearer limits earlier?

One obvious answer presents itself – namely that Norway quite simply could not afford to set such boundaries until it was in a position to manage without divers, that diver safety was sacrificed for economic interests.[1] Such an answer or explanation underlay not only the reports many critical journalists wrote about the diver issue, but also to a great extent the studies conducted on behalf of the Norwegian government. Although this answer is accurate, it nevertheless fails to provide a satisfactory explanation of why so many dominant players took a different view at the time. First, a number of measures were adopted which improved conditions for divers. Looking at the different interest groups which contributed at various crossroads to extending the permissible diving depth, each of them was undoubtedly convinced that they had arrived at a reasonable position. That applied not least to the NPD, which now finally took action but which had earlier vouched with great apparent conviction for most of the deep diving which took place on the NCS. It also applied to Nopef's officials, who were in no way satisfied

Brain, bones, breathing, lungs, heart, nervous system, muscles, blood circulation – most of the body's functions were particularly hard hit by diving.
Illustration: US Navy diving manual

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with the working conditions of their diver members but who were willing for a long time to accept a steady extension of deep diving.

As we have seen, the NPD paid close attention at all times to the research dives at Nutec. When its diver section assessed possible negative health effects of North Sea diving, however, the tight-knit networks of dominant diving medicine specialists abroad were much more influential. Knowledge and attitudes which prevailed in these groups, particularly in the USA, the UK and France, were crucial for both the major issues which dominated the NPD's work from the mid-1980s and into the 1990s – the acceptable depth limit for dives, and the problem of competing diving tables.

The diving tables

The latter problem had, of course, been known ever since Winsnes and Smith-Sivertsen first discussed the possibility of establishing standard tables in the late 1960s. Critical questions had been posed by the divers over the tables used since they joined Nopef in 1977. The newly created NPD diving section initially confined itself to requesting that the companies report the tables they actually used.[2] Regarding these as commercial secrets, the companies complied only reluctantly. When the NPD finally received the tables, however, staff in the diving section were not quite sure what they should do with them. Just like Winsnes, they struggled to identify criteria for an objective and scientific assessment of the tables.

It was one thing to conduct extreme research dives and investigate whether the divers were injured by them. Assessing the nuances in the tables used on an everyday basis in the North Sea was another matter entirely. The question was whether anyone was actually capable of doing it. Know-how among the Norwegian specialists in the early 1980s was weak compared with larger and more experienced professional teams in the USA and France. Rosengren, head of the NPD's diving section, was certainly aware of that. He had himself participated in diving research for Comex.[3] As long as no alternative existed, his section ended up approving all the tables submitted to it. A possible temporary solution would have been to adopt the US Navy's tables as a minimum standard. But these were by no means perfect. As mentioned above, they were not tailored for lengthy work under the extreme conditions prevailing in the North Sea – not least the cold water. It was generally appreciated, both by the regulator and in the Norwegian diving community, that great uncertainty prevailed about long-term use of these tables.[4] But many divers nevertheless regarded the US Navy tables as safer than the many company versions which used faster ascent times.

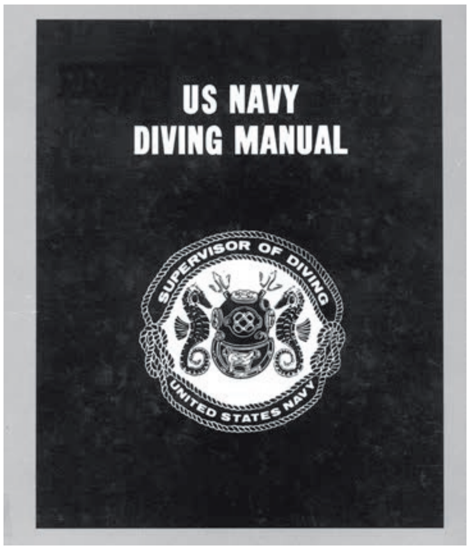
U. S. NAVY STANDARD AIR DECOMPRESSION TABLE

Depth (feet)	Bottom time (min)	Time to first stop (min:sec)	90	80	70	60	50	40	30	20	10	Total ascent (min:sec)	Repetitive group
			Decompression stops (feet)										
150	5										0	2:30	C
	10	2:20									1	3:30	E
	15	2:20									3	5:30	G
	20	2:10								2	7	11:30	H
	25	2:10								4	17	23:30	K
	30	2:10								8	24	34:30	L
	40	2:00							5	19	33	59:30	N
	50	2:00							12	23	51	88:30	O
	60	1:50						3	19	26	62	112:30	Z
	70	1:50						11	19	39	75	146:30	Z
	80	1:40					1	17	19	50	84	173:30	Z
160	5										0	2:40	D
	10	2:30									1	3:40	F
	15	2:20								1	4	7:40	H
	20	2:20								3	11	16:40	J
	25	2:20								7	20	29:40	K
	30	2:10							2	11	25	40:40	M
	40	2:10							7	23	39	71:40	N
	50	2:00						2	16	23	55	98:40	Z
	60	2:00						9	19	33	69	132:40	Z
	70	1:50					1	17	22	44	80	166:40	**

Depth (feet)	Bottom time (min)	Time to first stop (min: sec)	110	100	90	80	70	60	50	40	30	20	10	Total ascent (min: sec)	Repetitive group
			Decompression stops (feet)												
170	5												0	2:50	D
	10	2:40											2	4:50	F
	15	2:30										2	5	9:50	H
	20	2:30										4	15	21:50	J
	25	2:20									2	7	23	34:50	L
	30	2:20									4	13	26	45:50	M
	40	2:10								1	10	23	45	81:50	O
	50	2:10								5	18	23	61	109:50	Z
	60	2:00							2	15	22	37	74	152:50	Z
	70	2:00							8	17	19	51	86	183:50	**
	90	1:50						12	12	14	34	52	120	246:50	**
	120	1:30				2	10	12	18	32	42	82	156	356:50	**
	180	1:20			4	10	22	28	34	50	78	120	187	535:50	**
	240	1:20			18	24	30	42	50	70	116	142	187	681:50	**
	360	1:10		22	34	40	52	60	98	114	122	142	187	873:50	**
	480	1:00	14	40	42	56	91	97	100	114	122	142	187	1007:50	**
180	5												0	3:00	D
	10	2:50											3	6:00	F
	15	2:40										3	6	12:00	I
	20	2:30									1	5	17	26:00	K
	25	2:30									3	10	24	40:00	L
	30	2:30									6	17	27	53:00	N
	40	2:20								3	14	23	50	93:00	O
	50	2:10							2	9	19	30	65	128:00	Z
	60	2:10							5	16	19	44	81	168:00	Z

* See No Decompression Table for repetitive groups
**Repetitive dives may not follow exceptional exposure dives

7-12 Change 2 U.S. NAVY DIVING MANUAL



Extract from a US Navy diving table. Ranging from about 46-55 metres, the depths shown in the table correspond to the area where a diver could suffer nitrogen poisoning from breathing ordinary air.
Source: US Navy diving manual

The most obvious solution was still to draw up a standard table, as Winsnes and Smith-Sivertsen had contemplated. This could be based on a conservative interpretation of the existing solutions – in other words, taking the best from the different variants. It was generally appreciated that the longer divers took to ascend, the smaller were the chances of gas accumulating as bubbles in their bodies. The NPD had the power to introduce such tables, even if this would increase industry costs. Little mental arithmetic was required to work out that such conservative tables could be very expensive for the industry. It was one thing to take precautions, but what if the requirements specified an unnecessarily long ascent? Possible action against the companies demanded a certain degree of courage, a strong will and great professional self-confidence on the part of the NPD. Naturally enough, the latter also looked at what happened elsewhere. None of the countries regarded as comparable had specified common diving tables.

In December 1984, the NPD signalled for the first time that it planned to evaluate the company tables.[5] This was still not about a

Albert Johnsen worked in 3X during the early 1970s, and acted as diving supervisor for a period. After a theoretical education, he became the diving manager for Mobil's Statfjord organisation and then for Statoil.
Photo: Leif-Tore Skjerven

common standard, but the regulator had now indicated that it was considering the possibility. A comparison of the tables already received by the NPD showed that the difference between the fastest and most conservative ascent times was a whole week for diving to 1 000 feet (305 metres).[6] Given the saturation supplements paid to the divers and the fact that a diving spread could not be used for work during decompression, the company opting for the slowest table faced very substantial additional costs.

Foreign companies were not alone in seeing opportunities to save money by operating with tight ascent times. In March 1984, many divers in Stolt-Nielsen Seaway (SNS) reacted when it introduced diving tables with noticeably faster ascent times than the US Navy's version.[7] While the company's tables were conservative in deep water, they matched Comex in permitting more rapid decompression from medium depths. When diving to 54 metres, the table reduced the ascent time by 23-28 per cent. This had major consequences for the many SNS employees who dived on Ekofisk, since this was more or less their daily working depth.

One way to assess the effect of the relevant tables was to compare their impact on reported cases of the bends. After using the new tables for a year, SNS could demonstrate that it had not experienced a single incidence of this condition. 2W and Oceaneering, who both claimed to base their operations on the US Navy tables, had suffered five and six cases respectively.[8] With such results, it was difficult to claim that SNS's faster ascents gave poorer results than the US Navy tables.

However, a number of factors other than the actual decompression time in the tables could affect the incidence of the bends. When matters were urgent, the companies did not always abide by their specified standards. Both Norwegian and foreign divers could report that pressure on them during the actual work was greater in the foreign companies than in Norway's SNS. US diver Gerry Cronin, who joined Seaway in the 1980s, recalls how the modern equipment and the actual pace of diving made it more attractive to work for the Norwegian contractor:

> SNS's DSVs were the best. No other company had anything similar at the time. With two modern bells on board, which could both be operated inside the ship, efficient navigation systems and a lot more new and good equipment, it was a lot easier to dive safely. I remember one episode when a supervisor specifically ordered me to work more slowly while I was in the water. I'd never experienced that before.[9]

Another problem in comparing companies based on registered incidents of the bends was under-reporting. First, the criteria for defining this condition were often unclear. And a diver could have symptoms without reporting them.

How far were the oil companies responsible?

The introduction of internal control by the NPD opened a way to prevent competition over diving tables – without the regulator setting a standard. This regulatory philosophy required the oil companies to ensure the best possible level of safety both for their own employees and for contractor personnel. Where the government had not drawn up regulations, the operator itself was required to develop procedures and standards which gave good results. The combination of internal control and the general spotlight on safety after the *Alexander L Kielland* disaster helped to give the safety proponents among top management greater room to manoeuvre. Albert Johnsen, diving operation superintendent at Mobil, was one of these enthusiasts. He told *Stavanger Aftenblad* in October 1984 that the US oil major would demand that the diving contractors operating on Statfjord use the strictest decompression tables.[10] He referred precisely to the fact that internal control also required Mobil as operator to accept responsibility for safety during diving.

Johnsen's initiative was a model example of the action which internal control was intended to inspire. When a big operator made demands, the diving contractors had to accept them. But more than a statement from a local diving superintendent in one oil company was needed to overturn the basic competitive realities. First, all the operators had to set the same strict requirements. Moreover, what a safety enthusiast stated one day could be undermined the next if procurement departments in the companies still accepted the lowest bid. And the pressure to identify the cheapest possible solutions was given a sharp boost when oil prices virtually collapsed in 1986 and lay below USD 10 per barrel for a time.

At a conference on diver working conditions organised by Nopef in 1987, Johnsen admitted that the problem of diving contractors who competed by underbidding each other was far from overcome.[11] Like other members of the Statfjord organisation, he had by then begun to work for Statoil. One problem he had encountered in his eagerness to get Mobil and Statoil to take the safety challenges of diving seriously was that the oil companies traditionally did not regard diving as part of their business. It was a service they sourced externally. Of course, the oil companies had long experience of buying services from contractors in a number of areas – such as drilling. But the latter was historically linked with the oil industry in every respect. Oil companies and drilling contractors had learnt how to work with each other, and the companies accordingly always had in-house experts who could decide at any time to monitor the work being done. But they seldom had similar knowledge of diving. When the industry expanded offshore, oil company representatives could stand shoulder-to-shoulder with the relevant diving contractors and demand results. Few had any appreciation of the challenges faced by the divers under water. In-house expertise on diving needed to be built up before the oil companies could seriously take on the responsibility formally assigned to them under the internal control regime. Johnsen himself resigned from his diving-related job in Statoil.[12]

How deep?

In the mid-1980s, the NPD's diving section shelved all efforts to regulate the diving tables used by the contractors. It gave priority instead to a pressing need to clarify how far down a diver could go. This issue had not become less significant after diving associated with the Statpipe project was completed in 1984. The first stage of the Gullfaks development was at its most hectic between 1984 and 1986. This field lay in 130-220 metres. And the Storting gave the go-ahead for developing Troll in 300 metres of water during December 1986. Installation of the actual Troll A gas platform and associated pipelines to Kollsnes and back across the Trench to Zeebrugge was completed in 1996. But the parliamentary decision assumed that the required diving capacity was available. In the meantime, a number of large and medium-sized oil and gas discoveries would also require diving in deep water. Veslefrikk, in 185 metres, was approved for development in 1987 and came on stream two years later. Saga received one of the biggest technological challenges in May 1988, when it was given the job of developing Snorre – a difficult reservoir in 300-350 metres of water. Shell got the green light during December 1988 to develop Draugen in 251 metres in the Halten Bank area of the Norwegian Sea. Major projects – Sleipner, Oseberg and so forth – with the potential to boost diving in rather shallower waters were also approved in this period. All the principal installations on Ekofisk were jacked up in 1987 because the seabed in the area had subsided about seven metres since production began. This was enough to have significant consequences for decompression time when diving on the field. However, the picture which emerged was unambiguous – a future was envisaged in which diving on the NCS gradually moved into deeper waters.

The dilemma was clear enough for the Norwegian diving business as a whole. A halt could be called by saying that diving was possible to

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such-and-such a depth, but no further. If this limit were set shallower than what seemed the likely working depth on the many new installations, the scale of diving was likely to be drastically curtailed. The oil companies and the subsea entrepreneurs had to turn the long-established vision of a diverless future into reality.[13] There was every reason to believe that, were such a technology to become functional, it would also undermine diving in shallower waters. The alternative was to gamble on the assumption that the limit at which it was physiologically possible for people to work had not yet been reached, and that the challenge lay in a continued improvement of equipment and safety procedures.

When the Storting approved the development of Oseberg and the landing of oil from that field in 1983, a crucial condition was that the NPD would vouch for the ability to conduct diving operations down to 300 metres.[14] This decision also showed how science, politics and responsibility could easily intermingle on major projects. The OTS pipeline to Øygarden would go as deep as 350 metres, giving a 50-metre shortfall before a development could be regarded as fully acceptable. The Ministry of Local Government and Labour nevertheless gave the Storting the assurances it required to reach a development decision by stating that developing the necessary equipment was entirely feasible. In other words, the ministry assumed that no medical constraints existed for diving to 350 metres. The OTS dives at Nutec in 1986 confirmed the final 50 metres for the NPD (see chapter 9). All the same, with a very expensive development already under way, it would have taken a lot for a different conclusion to have been reached.

The controversies associated with the many research dives at Nutec helped to make it politically difficult to use the outcome of development-related tests by the oil companies as the only criterion when determining a limit for deep diving. The latter was not simply a matter of suitable equipment and how much a person could cope with under the conditions which prevailed in a controlled experimental dive. It was also a question of how much risk was acceptable and what sort of general working conditions should apply for a diver. The local government ministry accordingly wanted to secure a limit for deep diving which was more firmly entrenched. A task force was established in May 1986 with the mandate to assess "at which depths it was acceptable to conduct diving operations on the NCS".[15] This body included representatives from the NPD, the Directorate of Health and the NLIA. The AODC represented the contractors, the Norwegian Industry Association for Oil Companies (Nifo) the oil companies and Nopef the divers.

It was the Troll development which created a particular need to extend the boundaries for deep diving on this occasion. In practice, however, the task force had no real influence on this project. In December

A diver shooting with a Cox gun. One of the key problems in discussing how deep divers should be allowed to descend was that conditions during practical dives could be very different from those experienced in controlled experiments.
Photo: Børre Børretzen

1986, even before it had completed its work, the Storting considered an extensive plan for the first phase of the Troll development.[16] The gas pipelines from the field would lie in depths down to almost 400 metres. That exerted a strong influence on the recommendations available to the task force. Ready in the autumn of 1987, its report was unanimous. The following main conclusion could only be interpreted as a green light for conducting very deep dives on the NCS:

> Dives have been made in the sea to a depth of 300 metres, and a number of chamber dives have also been made to depths greater than 400 metres. On the basis of the experience thereby gained and discussions with active divers, the task force finds that it can recommend 400 metres as the depth limit which can be accepted, on the basis of current knowledge, as defensible for diving operations on the NCS.[17]

A number of requirements which had to be met before such dives could take place were listed, to be sure, but none was of such a character that it presented any immediate obstacle to the big diving contractors then operating on the NCS. They were general requirements of the type which called for "acceptable, tested procedures" and an extensive programme of health monitoring, for simulating the relevant dives beforehand in shallow water, for TV monitoring of the divers, and for an acceptable and appropriate outfitting of the diving spreads. The task force found that research and development were still required in certain areas, particularly in the depth range down towards 400 metres. However, its recommendation of a 400-metre limit was not formulated as a requirement.[18] That opened the way for a further shifting of the boundaries if required. In other words, the action team had not only vouched for the

Storting's speed-up of development decisions on Oseberg and Troll but also opened for the Norwegian diving sector to follow the oil industry into even deeper waters.

Knowledge, scepticism and consensus

The action team which assessed diving in deep water was naturally aware of the experimental dives carried out under Nutec's auspices (see chapter 9). Børge Minsaas from the Directorate of Health, who represented the medical expertise on the team, was also well aware that these experiments were controversial. In 1983, he had been a member along with both Smith-Sivertsen and Tønjum of an internal diving medicine committee in the directorate.[19] Possible health-related constraints on a constant increase in the depth limit for diving were not a key issue in the team's work. References to possible long-term injury from deep diving do not appear in the minutes and memos it left behind. On the other hand, the team placed great emphasis on references to foreign research results which could be interpreted to indicate that it was possible to work in very deep water without too much risk.

Instead of the Nutec research, the team clearly gave greater weight to the impressions it had formed during a visit to Germany's GKSS-Unterwasser-Simulationsanlage (Gusi) outside Hamburg.[20] Recommendations from the German scientists noted in the team's minutes were optimistic. They saw no serious restrictions on diving operationally to 450 metres. Reference is made to claims that HPNS could be treated without problems through reducing pressure by 10 bar, that constraints on deep diving were not medical but purely technical, and that these could be overcome through increased investment. The trip to Germany must have helped to make it easier to discount the growing scepticism in parts of the Norwegian medical community.

Union in deep water

Nopef was represented in the deep diving action team by Melvin Kvamme and Trygve Gulliksen. Given the many objections this divers' union had to safety regulation of diving in Norway, a more critical attitude might perhaps have been expected on increasing the depth of diving on the NCS. The Nopef representatives on the team were clearly concerned to promote demands that deep diving had to utilise the best possible equipment and that the divers had to be given sufficient rest. But neither Kvamme nor Gulliksen argued noticeably at any point for a strict lower limit on diving depth.

Action teams and committees can have their own dynamic. In this case, nevertheless, it seems clear that Kvamme and Gulliksen were expressing the views of the Nopef leadership. At that time, Nopef did not want a strict limit on the depth to which dives could be made. As a contribution to the work of the team, Nopef drew up a memo which began by stating that working dives to 400 metres had been proved both physically and mentally possible. This memo is, moreover, the only place in the written material left by the team which refers to the experimental dives at Nutec – but then with a clearly positive interpretation.

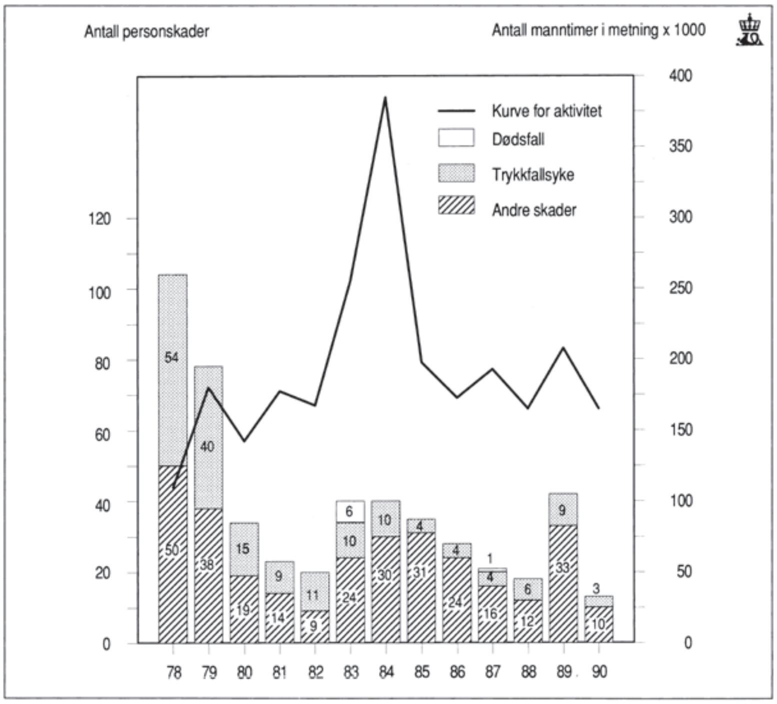
The Nopef representatives were naturally considerably further removed from the discussions among the physicians than Minsaas from the health directorate, for example. But even they could not fail to notice the dispute. When Tønjum quit Nopef, it was generally known in diving circles that this related to his critical professional assessments of diving on Statpipe.[21] When the conclusion was nevertheless so unanimously in favour of moving the boundary, Nopef also chose to believe the medical specialists who concluded that everything was under control.

Neither the unionised divers nor others in Nopef's leadership had any opportunities to check the claims of these experts. But few other professional groups are likely know as much about their own physiology as divers. Had Nopef been sceptical to extending the limits for deep diving, the union would have had every opportunity to get the most critical physicians to front for it. Individual divers were doubtful about an extension on the basis of their own experience and that of their work colleagues with deep diving.[22] All the same, Nopef's representatives can hardly been blamed for acting contrary to the dominant attitude among the divers. At that time, no diver was arguing loudly for a strict limit on diving depth.

The question of deep diving limits presented Nopef with a conflict of interest. On the one hand, the union wanted to promote the solutions which best safeguarded the health of its own members. On the other, it was clear that these self-same members would be hardest hit if the depth limit was too strict. This duality clearly affected Nopef's arguments. Although its memo was entitled "Maximum diving depth and limiting factors", a significant part of it dealt with the necessity of taking decisive action to protect the future of the Norwegian diving industry. Nopef also, of course, subscribed to the final conclusion reached by the action team that not only should the permitted limit for deep diving be extended but also preference should be given to Norwegian personnel in order to build up and maintain domestic diving expertise.[23]

Despite many underlying contentious issues, the statistics show a noticeable improvement in operational safety during the second half of the 1980s. The death of British diver William Carr after losing his

Fig. 4.16.2.a
Totalt antall personskader i forbindelse med dykking på den norske kontinentalsokkelen i perioden 1978–90



The total number of personal injuries suffered in connection with diving on the NCS in 1978-90. As the figure shows, a clear improvement in the number of registered cases of the bends was experienced in the early 1980s. The figure says nothing about possible long-term damage as a result of diving.
Source: NPD annual report 1990.

helmet in 104 metres of water provided a tragic reminder that things could still go wrong.[24] Even if the *Byford Dolphin* incident is included, however, the number of diving accidents was substantially lower in the 1980s than in the previous decade. Moreover, the statistics show a clear decline in the number of reported cases of the bends.[25] Large diving contractors had substantial follow-up from land and could therefore get to grips more easily with safety challenges on their own account. Moreover, clear signs existed that the operators were increasingly taking the internal control regulations more seriously. The oil companies, at least, became more concerned with ensuring that their drilling contractors could point to a decline in accidents. That, after all, was precisely the purpose of performance management. A possible unfortunate side-effect of such pressure on contractors from the operators was that the system encouraged under-reporting. The diving companies naturally feared losing their contracts. Some divers recall cases from this period when they felt pressured to refrain from reporting symptoms of the bends. It became known in 1987 that Norcem-Comex Subsea was treating its divers with Valium during normal decompression.[26] Nopef reacted to what it claimed was an attempt to camouflage cases of the bends. Conscious attempts at such concealment are unlikely to have been so numerous that they undermined a genuine improvement. While the companies could document gains with the more measureable aspects

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of diver working conditions, however, fears grew that North Sea diving could cause long-term damage.

The doctors and the divers

The 1977 Working Environment Act included a section which specified that pollution in the form of noise, gas and the like was prohibited unless it was clear that this would have no ill effects for the workers.[27] In other words, the burden of proof lay with the employer. But this Act had not been extended to diving. The purely technical challenges of diving could be improved through trial and error, although disastrous consequences might ensue if everything was not in order to begin with. Where the long-term effects of diving were concerned, however, the divers had no option but to trust the physicians who said everything was in order.

But diving can have negative health effects on various parts of the body (nerves, lungs, bones and so forth). So this issue is to some extent a question of different forms of medical expertise. A neurologist, who is an expert on the interaction between brain and nervous system, will take a different approach to a physiologist. The latter deals with the body's functions, a discipline closely allied to biology. The most important source of the problems associated with diving – the various gas mixes pressed out of the body under pressure – nevertheless remains the same. Hyperbaric medicine is the collective term for the medical study of diving effects. Like other specialisms, this subject has developed various structures to determine what is to be regarded as an international consensus.

Compared with the other main medical specialities, however, the practice of hyperbaric medicine was limited in global terms to a small group. Research on the impact of deep diving was also particularly difficult, simply because there were few regions of the world where this activity had been conducted systematically over a long period. Moreover, hyperbaric expertise differed from much other medical knowledge in that a relatively large number of the physicians concerned were paid directly by the same companies and institutions which exposed divers to harm. That applied to naval, commercial and research diving. But physicians and medical researchers working in association with these institutions had the same type of education as most other doctors. In addition, they were supposed in principle to adhere to the same standards of medical ethics. Many hyperbaric medicine specialists also swapped between jobs in the public health sector and assignments financed directly by operational diving institutions. The financial ties between diving physicians and the bodies conducting diving were nevertheless strong. If the doctors put their collective foot down and declared that deep diving was hazardous, they would also undermine large swathes of offshore diving and thereby the basis for the discipline in which they were experts. In other words, they faced more or less the same dilemma as the unions.

A number of the Norwegian physicians who joined the hyperbaric medicine community from other and more independent medical specialisms reacted negatively to its close ties with the oil industry. Another typical feature has also been noted – many of the relevant physicians were divers themselves.[28] That was not necessarily negative. Experiencing personally what diving involved could help the doctors concerned to pose the right questions, and give them a better understanding of the individual diver's problems. By diving themselves, however, many physicians became gripped with the same fascination which affected all sides in the diver community. An outsider could experience this community as a specific kind of culture, where pushing back the boundaries of the possible was as highly valued as it is in "extreme" sports today.

Regardless of the underlying material ties and attitudes which prevailed in the hyperbaric medicine community, discussions were cloaked in very scientific terminology. As with all languages and jargons, however, plenty of scope existed for disputes over interpretation in which dominant views could establish positions of power, and in which alternative thinking was either suppressed or frozen out.

International gurus in hyperbaric medicine

American Peter B Bennett and Briton David Elliott were regarded by many in the diving community during the early 1980s as the foremost specialists in hyperbaric medicine. They were the authors of *The Physiology and Medicine of Diving*, which became an international standard work in the field when it first appeared in 1983.[29] Bennett and Elliott described many forms of health damage which could occur when diving in deep water. Bennett won recognition for the most detailed description of HPNS. In some cases, the diver's working memory was shown to have been reduced. The two authors nevertheless insisted for a long time that the relevant symptoms soon disappeared, and that HPNS caused no lasting injury to the divers. They maintained that, as long as a diver avoided the bends, no threat of long-term effects existed.

Their strong position was reinforced through the key role they played in a number of the institutions developed for both diving in general and hyperbaric medicine in particular. Both had worked for the oil industry alongside their academic positions. Elliott held various posts in Shell from 1976. The pair also popped up repeatedly on leading boards, in publications and at conferences staged by such organisations as the International Marine Contractors Association (IMCA), the European Diving Technology Committee (EDTC) and the Diving Medical Advisory Committee (DMAC).[30] Similar international institutions can be found in most industries, where various researchers, civil servants and company personnel forge networks to disseminate information and, in some cases, harmonise regulations, standards and procedures. The EDTC was a relatively open organisation in which government agencies, physicians and companies participated on an equal footing. Nopef also attended a number of its meetings. The IMCA was an industry-run institution, an international variant of the type of employer association affiliated to the Confederation of Norwegian Enterprise (NHO). Since it was often the same people who represented their country and their institutions in all these bodies, however, the division of roles could become a little fluid. Where Norway was concerned, the NPD's diving section was particularly active in these networks. Olav Hauso, a long-serving member of the section and its head from 1993, was chair of the EDTC for a period.[31] Among Norwegian medical specialists, Alf Brubakk was a long-standing participant in both the EDTC and the DMAC. A physiologist, he led a number of studies related to compression problems commissioned by the oil industry.

Participation in international institutions provided the NPD and other Norwegians in diving-related positions with useful information and contacts. However, a number of physicians who entered the diving field from outside could find its networks to be proponents of a fairly unassailable unanimity which provided little opportunity to ask critical questions. This reality would eventually generate considerable friction between physicians and the NPD and within the Norwegian medical community.

Norwegian diving research

The warnings about deep diving sounded in the early 1980s by Smith-Sivertsen and Eidsvik, from their backgrounds as diving medical officers at Haakonsvern, were based not on independent research but on their own experience with North Sea divers and general reading of the medical literature in the area. Both men worked actively for more independent research on the subject.[32] Smith-Sivertsen, who had turned his attention in the late 1970s to occupational medicine, became uncomfortable over time with the role he had personally played in connection with the DWP commission.[33] Eidsvik, who had vouched to a great extent for the Skånevik dive in 1978, had also developed a more critical attitude. In January 1983, the Norwegian Research Council for

Science and the Humanities (NAVF) called a meeting where an action programme was presented for strengthening research on hyperbaric medical research in Norway.[34] The initiative for this event was taken by the director general of health's advisory committee on hyperbaric medicine, which counted Smith-Sivertsen, Eidsvik and Tønjum among its members. The invitation to attend summed up the status of diving research:

> Generally speaking, research in hyperbaric medicine, a relatively new medical discipline, is relatively underdeveloped compared with the classic research fields. Such research and development activity in Norway is confined to a small group at Nutec in Bergen with contacts in the physiology institute at the University of Bergen. Although this has undoubtedly laid a foundation which can be built on further, progress has been considerably slower than expected and in relatively restricted areas of hyperbaric medicine.[35]

The invitation expressed a general scepticism over international research in the field. It also suggests that physiology represented an overly narrow approach to the challenges posed by diving. Its content sparked a reaction from the NPD. A letter to the health directorate signed by Ognedal as head of the safety department stated in part that "three independent bodies around the world have found no objective basis for long-term effects of HPNS on the central nervous system".[36] The NPD's letter does not specify which "independent bodies" are being referred to. A little later the same year, however, a conference held in Stavanger at the initiative of the NPD by the European Undersea Biomedical Society attracted the most prominent international researchers in the field.[37] With Bennett as the leading voice, one international scientist after another claimed that they had not observed lasting neurological damage as a result of deep diving.[38] The only speaker to support Smith-Sivertsen's warnings, couched in general terms, was Johan A Aarli from the neurological department at Haukeland Hospital.[39] Since all the international specialists in hyperbaric medicine were connected with the US, British and French navies and the Comex research centre, good grounds existed for questioning the neutrality of their research. Aarli and several of the physicians working for an independent Norwegian research programme also noted that a dominant proportion of the hyperbaric medicine specialists were physiologists rather than neurologists, even though neurology was the subject of much of the discussion.[40]

As usual when new research assignments are to be awarded, fierce competition broke out between various institutes both before the actual programme had been formulated and during the allocation process

Peter Bennett from Duke University (left), Benno Schenk from the Zürich University Hospital and Shell's David Elliott in serious discussion during a research dive in Norway. Bennett and Elliott were regarded as "Grand Old Men" in international hyperbaric medicine circles.
Photo: Anders Lindahl

itself. The main problem for the promoters of the plan was that the NAVF did not have substantial funds of its own to provide. When the programme was finally ready in the autumn of 1984, Statoil ranked as the largest contributor to its funding.[41] Plans called for the research to continue to be pursued through Nutec. However, a substantial share of the work was to be carried out at Haukeland, with the neurological department given a more central role than before. At the same time, much contract research was planned with the issues defined and the funding administered by the oil companies themselves.

Despite complex compromises between different interests, Norwegian deepwater hyperbaric medical research received a genuine boost from the second half of the 1980s and into the 1990s. No other part of the world allocated similar amounts for this purpose. The fact that the oil companies provided much of the cash imposed financial ties similar to those which already existed in the international hyperbaric medical research community. Since much of the research was tied to Nutec, which after all possessed the only realistic "lab equipment", new researchers were drawn into a setting with strongly established views. But the sheer scale of the research and the fact that part of it was channelled through the NTNF meant that a large proportion of the work was carried out by more independent universities and hospitals. That also came quickly to affect its direction.

As head of neurology at Haukeland, Aarli was responsible for a heavyweight department where diving was only one of a great many issues. New research funds meant that criticism of the experimental dives then under way eventually became increasingly vocal. Todnem, a neurologist, was one of the scientists who had their first encounter with diving through the Nutec experiments. She did not confine herself to such research dives, and was soon beginning to look at the impact of general work diving in the North Sea. Together with a number of other researchers linked to Haukeland's neurological department, she submitted a preliminary report in the spring of 1989 which presented strong indications that deep diving could have serious long-term consequences.[42] The investigation had been financed by Statoil's Gullfaks C organisation. The initial report was submitted before the work had been completed because plans called for relatively extensive diving in about 217 metres of water that summer.

Although the warnings were clear enough, there was never any question of cancelling Gullfaks C diving that summer. The content of the report caused a stir when it became known. It was divided into two sections. First, specific medical studies were conducted in connection with individual dives. However, that part of the report which attracted most attention was a broad health survey covering 156 divers in all – in other words, a large proportion of those working on the NCS at the time. Their health was compared with a control group comprising non-diving offshore workers and policemen. While 133 divers in the sample had done both saturation and air diving, 23 had only been involved with the latter.

The average age of the divers surveyed was 32. That in itself said something about such personnel on the NCS in the late 1980s. It was still not that many years since diving had really taken off in these waters during the mid-1970s. Although a diver with 10 years of experience was to be regarded as a veteran, this remained a group of relatively young men. None of those involved in the study had been invalided as a result of diving. But many other disturbing signs were found. No less than 33 per cent of the divers had suffered from the bends with symptoms involving the nervous system, and 51 per cent had experienced the bends with pain and/or nervous-system symptoms. Compared with the control group, the divers were generally in poorer health – even though they were keen to keep in good shape. The clearest negative effects related to their ability to concentrate, memory, muscular coordination, skin sensation and so forth. Many of the negative findings were related to episodes of the bends. However, the survey also indicated that a number of the negative effects were attributable to deep diving *per se*. In addition, it was demonstrated that these effects increased with age and fairly independently of whether the person concerned had experienced the bends.[43]

Labour Party representative Olav Akselsen referred to the investigation in the Storting's Question Time on 29 October 1989.[44] He gave special emphasis to the information that half the divers surveyed had suffered from the bends. However, Johan J Jacobsen, the non-socialist minister of local government and labour, could reassure the Storting that cases of the bends had been reduced from 54 in 1978 to five-six per annum. In his question, Akselsen noted that the unions claimed the results indicated that all saturation diving should be regarded as experimental and had to be monitored accordingly. The NPD was not going to let this allegation go unchallenged. In a letter to the ministry, it stated that an industry which had operated on a large scale both internationally and on the NCS could not be considered experimental.[45]

Speaking up for the divers

With Todnem, the divers had for the first time acquired a heavyweight specialist in hyperbaric medicine who not only expressed doubts about the way diving was conducted but who also involved herself actively in their cause. Edited versions of the Gullfaks investigation were subsequently printed in different variants in a number of respected international medical journals.[46] In April 1991, Todnem defended a PhD thesis based on the same material.[47] This event attracted great attention, including a report across several pages in *Dagbladet*.[48]

In Norwegian academic practice, a PhD defence is an exercise which seldom has direct consequences for the labour market. Todnem's must be the only thesis in Norwegian history which came close to causing a strike. The following day, the executive committee of the union branch in SNS resolved that no diver would descend further than 180 metres until satisfactory insurance arrangements were put in place.[49] The company responded with a letter which threatened to sue union officials for any loss it might incur as a result of the resolution. Divers who took part in such an action were threatened with dismissal.[50] Employees were asked to submit an individual written declaration on how far they would observe the branch resolution. However, this strong reaction by the SNS management did not go down well with the public. Nor would the approach adopted by the union have had any genuine effect, since the diving regulations already prohibited any diver being forced to descend deeper than 180 metres. That was confirmed by the NPD in response to questions from several newspapers.[51] By compelling its employees to forego the right to refuse to dive beyond this depth, SNS was actually breaching a safety regulation. But the NPD, which was responsible for enforcing the rules, would not take any action against the company.

The unwillingness of the NPD to put SNS in its place could have been influenced by a general distrust of the investigations which formed the basis for the union's threats of action. That such distrust existed was clearly demonstrated a few days later when Hauso, from the NPD's diving section, stated in Stavanger daily *Rogalands Avis* that diving posed no threat to health.[52] "If you had a son who was a diver, would you have recommended that he dive deeper than 180 metres?" the journalist asked. Hauso replied that he would, providing the conditions were right and the "son" healthy enough. He also noted that continuous deep diving to 300-400 metres was being conducted in Brazil without negative effects.

The NPD's scepticism about the studies conducted by Todnem and the other Haukeland doctors was demonstrated even more clearly when a somewhat expanded and edited version came to be printed in the autumn of 1991.[53] On this occasion, the NPD itself was among those commissioning the work. When the report had been printed and issued, the NPD went to the surprising step of enclosing an unsigned insert containing a number of methodological objections to the investigation.[54] Without citing a single reference, the insert concluded that further studies were needed before any clear relationship could be established between changes in the nervous system and exposure to diving and the bends.

It is difficult to interpret the NPD's treatment of this report as anything other than a disavowal of the work done. That annoyed the medical staff at Haukeland. The central content of the report had been accepted at that time in the form of a PhD and approved by several international scientific journals. In a reply to the NPD, Todnem concluded together with professors Harald Nyland and Aarli that: "We disassociate ourselves from assertions that the long-term medical effects of diving on the nervous system are not known in 1992. A responsibility rests on the oil industry and the government to prevent damaging effects from saturation diving". The Haukeland doctors could not have put their position more plainly.

Kari Todnem was educated as a neurologist at Bergen's Haukeland Hospital. Her PhD was based on investigations she had made of divers on the NCS. She was strongly committed to improving their conditions. Until 1993, she headed a newly created occupational medicine department at Haukeland. Photo: *Stavanger Aftenblad*

Research for the industry versus political activism?

How could the NPD's diving section, which was not itself any kind of scientific medical institution, overrule the best qualified Norwegian medical expertise in this area? Like most of the directorate's other employees, the section head was an engineer. The NPD's most important methodological objections were that many divers had a considerable diving career before they were issued with a bell diving certificate. The study was also criticised because the interviews had not been conducted blind. In other words, those who carried out the interviews were aware that the subjects were divers and not members of the control group. The researchers were aware that their investigation posed methodological problems. It had simply not been possible to conduct blind interviews because the relevant divers were at work.[55] The objection that many of them had dived a lot, even before they were certified for bell diving, was considered self-evident. Not a single diver in the survey had begun his diving career as a bell diver. The general attitude at Haukeland was that the relevant studies were not only good but also represented fairly groundbreaking research.[56] On the basis of her research, Todnem was appointed to head a newly established occupational medicine department at the Bergen hospital.

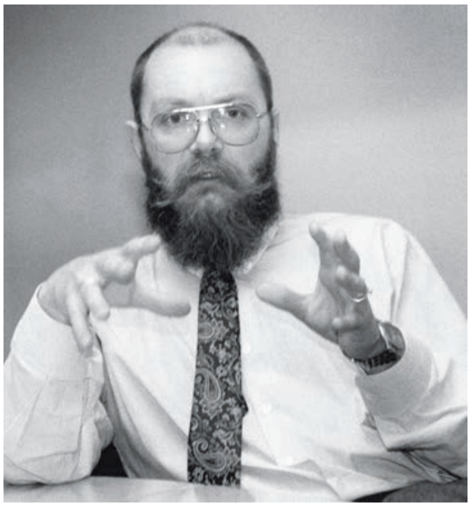
A lot was a stake here, as both the NPD and the medical researchers were aware. Todnem and the other physicians at Haukeland became involved in the diving case as medical specialists rather than as political activists. Through their involvement in many of the research dives, they were nevertheless fully aware of how economically significant it was in strategic terms for the government to be able to vouch for diving work in deep water. Although the Working Environment Act had not been applied to diving, it would be politically difficult to maintain offshore diving on its current scale and in its current manner if the study's conclusions were correct.

The NPD's diving section – which had insisted for many years that deep diving was harmless provided specific safety rules were observed – would also feel it had suffered a loss of prestige. Hauso, with support from the directorate's leadership, could be so adamant in public even after Todnem's investigation had been published because he was convinced that she was wrong.[57] He chose instead to believe the dominant view which prevailed among medical specialists in the international networks to which he himself belonged. Through his involvement with the EDTC and at various international conferences, Hauso was personally acquainted with both Elliott and Bennett. The first of these had a particularly strong position in Norway because he was a member from 1984 to 1990 of the executive committee of the NAVF, which channelled funds to scientists involved in research related to the deep diving experiments at the NUI/Nutec. He held this role while also acting as a diving adviser for Shell, which obviously had a special interest in deep diving as operator for the Troll Gas development. Bennett and Elliott expressed their dislike of Todnem's research on several occasions. While the latter's articles were accepted by several international professional journals, one was rejected by *Undersea Biomedical Research* – where Bennett sat on the assessment committee.[58] His objections were very similar to the methodological concerns expressed in the NPD's "insert" to Todnem's 1991 report. The same article was later approved for publication by another reputable British scientific journal.[59]

Todnem may have encountered considerable resistance in that part of the medical community which was closest to the oil and diving companies, but she attracted great attention in the media. The diver safety issue had not aroused such public scrutiny since the late 1970s. These media reports played their part in encouraging divers to visit her and tell their stories. Many of them felt that they had finally found a scientist who understood their position. Todnem described the hazards of diving in a way that was easy to understand. She pointed out that, even if experimental and deep dives were successful from a physiological perspective in that the divers survived and appeared to be in perfect health, they were not necessarily a success from the individual's point of view. A person who suffered less visible injuries – of a neurological nature, for example – could be seriously affected for life. She illustrated the effect of the bends by suggesting that the condition could age the sufferer by an extra 10 years.

From the platform provided by her new post as head of the occupational medicine department, Todnem proposed measures which could improve the position for divers. Her most important medical advice also accorded with the views of other hyperbaric physicians – cases of the bends had to be reduced in number and treated swiftly.[60] Other recommendations related more to organisational conditions. She maintained that it was important for divers to have permanent jobs, but that the average working life for a saturation diver should be limited to 10-15 years. Divers should be covered by good insurance policies in case they lost their diving certification. Furthermore, she recommended that divers work for transitional arrangements allowing them to change to other careers. She noted that, while reporting cases of the bends to the NPD was important, it must not lead to the discrediting of DSVs or individuals since this could risk under-reporting. And she maintained that diver training should be improved and extended to ensure that those completing it were well versed in hyperbaric medicine, physiology and techniques.

The discussion with those physicians who vouched for deep diving was still couched in medical terminology. In appropriate contexts, both sides allowed it to become clear what they actually meant. Todnem took the view that a large part of the dominant diving research activity was in the industry's pocket. Similarly, many of the hyperbaric physicians who were close to the companies regarded Todnem as a kind of political activist. She had no background in politics, despite being educated at a time when such activism was not unusual in student circles. Her commitment was nevertheless more political than that of earlier hyperbaric physicians in the sense that she also dealt with non-medical conditions which could affect diver health and safety. In an article in a Nopef magazine, she asked whether diving would become a new work scandal.[61] That was clearly a political statement. But it was also a recognition based on her own experience as a researcher and a physician.



Olav Hauso was an active member of the NPD's diving section, and became its head in 1993. He represented the directorate in several international diver-related organisations. Photo: *Stavanger Aftenblad*

From protest to new diver commission

Despite the new research results and Todnem's warnings, the Nopef leadership did not change its favourable view of the principle of permitting dives deeper than 180 metres. The union's newspaper reproduced a statement from Todnem which could be taken to mean that she did not support an absolute lower limit.[62] But she nevertheless made it clear that nobody could guarantee that things would go well with those taking part in deep dives. She pointed to experience which indicated that one in six divers would get the bends when diving below 180 metres, and that the risk increased with depth. Of Todnem's many proposals, the Nopef leadership chose to concentrate on opportunities for divers to retire to a secure job after a certain time in the profession. Nopef

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president Lars A Myhre and the then deputy president, Sande, sent a letter directly in July 1991 to prime minister Gro Harlem Brundtland in which they requested such an arrangement.[63]

Nopef's failure to use Todnem's investigations to press for an absolute lower depth limit for diving could be related to the conflict of interest facing divers in the early 1990s. Although it was becoming ever clearer that diving could have serious health effects, the divers were not in a strong negotiating position to demand improvements. After all, calling for an absolute ban on deep diving could speed up the development they feared most of all – that the companies would replace the bulk of their work with diverless solutions. However, the discussions on Todnem's studies contributed to the establishment for the first time of a wide-ranging, integrated public inquiry on diving.

At the end of March 1992, Marit Kromberg was appointed by the Ministry of Local Government and Labour to chair a commission of inquiry which would asses the health and safety aspects of work diving and submit proposals for improving conditions.[64] The commission was to look not only at oil-related diving but also at other such work in Norway. Kromberg was a department head at the Directorate of Health. The majority of the other commission members were senior officials from institutions which had long accepted the operating parameters which had prevailed for diving until then.[65] In addition to providing the commission's secretary, the NPD was represented by Hauso, who had of course been active in the polemic against Todnem. Sande, who represented Nopef, was the most critical voice on the commission. Although required to report as early as the following December, the commission's final conclusions were not submitted until December 1993 – a year behind schedule, in other words.[66]

Good reasons existed for asking the commission to look at all professional diving, including inshore work. Although great public attention focused on North Sea diving, the accident frequency in diving activities pursued by a number of small companies in rivers and lakes and along the coast was higher than on the NCS. Whilst the last offshore-related diving fatality had occurred in 1987, five inshore divers died between that year and 1992 – in other words, about one a year. Conditions were even worse in amateur diving, which was pursued more or less without any form of regulation. Some 34 such divers died over the same period, an average of almost six a year.[67]

The Kromberg commission's comparison with inshore diving confirmed that a substantial improvement in operational aspects had occurred offshore. Equipment was better and more robust. Diving contractors, oil companies and divers themselves had developed procedures and routines which helped to avoid many of the hazardous conditions implicated in the fatal accidents of the 1970s. Moreover, the NPD had finally settled in 1991 on a common decompression table which could serve as a standard on the NCS.

Decompression standard and new regulations

Work on the final formulation of a standardised decompression table was led by Tønjum.[68] By comparing the tables used by Oceaneering, Subsea Dolphin, Rockwater, Comex and SNS, his team could see that the differences were smaller than when the NPD had first attempted a coordination in the early 1980s. Experience had prompted the companies to incorporate safety margins in certain areas. The final proposal was based on the most conservative sections of all the tables. This standard remains in force at the time of writing in 2009.

The NPD also took the view that regulation of diving operations had been tightened with a revision to the rules which came into force in 1991.[69] In accordance with the internal control principle, the new regulations went even further in the direction of functional requirements than the 1981 version. As an introductory general goal, section 12 of the regulations states:

> As far as is possible in practice, equipment and procedures used in manned underwater operations must be such that no single failure during use leads to unnecessary risk of health damage or life-threatening conditions for the personnel involved … Analyses must accordingly be conducted to clarify the consequences of an individual failure and a series of failures in and when using facilities which are significant for the safety of underwater operations.

The underlying idea here and in a number of other sections was that the oil companies and diving contractors subject to the regulations were to conduct risk analyses at all levels of their operations. The significant aspect was not how the companies achieved greater safety, but their ability to demonstrate that such an improvement had actually occurred. On certain points, however, the new regulations set stricter and more specific requirements than the earlier rules. These included specifications for the size and level of comfort in compression spreads and bells. But many divers were negative to an extension of the permitted duration of bell runs from seven to eight hours.[70] The time divers were allowed to spend in saturation was also raised. Under the new regulations, a stay at working depth could not exceed 14 days down to 180 metres and 10 days beyond that. Given the time required for compression and decompression, this represented in reality an extension compared with the 1981 rules.

These changes were justified by the NPD as an adjustment to international practice. It had been possible to operate with similar durations earlier, but only the basis of exceptions and exemptions. The directorate took the view that safer tables and greater operational security would offset the fact that some divers had to spend longer working underwater. Einar Wold Svendsen – who was a senior executive at SNS in 1992 – commented on the new regulations after they had been in force for six months. In his view, they functioned well and provided a general improvement in safety. At the same time, he supported the divers' objections concerning bell runs and saturation time:

> Has the duration of bell runs and saturation time increased? Of course they have. To believe anything else would be impossibly naive. Which company in its right senses would price a job on the basis of poor efficiency and/or more 'expensive' divers in saturation than are required by the regulations – which it moreover expects all its competitors to apply in their calculations? … In such cases, a maximum duration equals a minimum duration, which also coincides with the optimum duration (except for the divers).[71]

Lengthening bell runs and saturation times did not help to improve relations between the NPD's diving section and the unionised divers, even though both regulations and statistics showed that a marked improvement had occurred in the technical aspects of safety. Nopef's original demand had been to cut bell runs to five hours. With the increased awareness of diver problems resulting from Todnem's research and the media reports, many divers hoped that the Kromberg commission would produce a new consensus on the status of diving and, on that basis, arrive at a common solution which served everyone concerned. Given the way conditions in the diving sector developed while it was at work, however, the commission could hardly have been anything other than an arena for conflict. Its report discussed the importance of long contracts and permanent employment for improving the stability and security of diving as a career. While the findings were being finalised, however, Stolt Comex Seaway – which was represented on the commission, of course – resolved to transfer to a foreign flag and make the bulk of its permanent Norwegian employees redundant. In October 1993, just before the commission's report was to be published, Sande submitted a long list of points on behalf of Nopef which disagreed fairly substantially with the proposed text.[72] Most of the objections focused on the way the sharp growth in personnel on short-term contracts represented a step backwards for most type of HSE work. Nopef's many dissenting comments produced no extensive changes to the report.

However, they clearly had an effect on the foreword, which was introduced with the following laconic summary of the position:

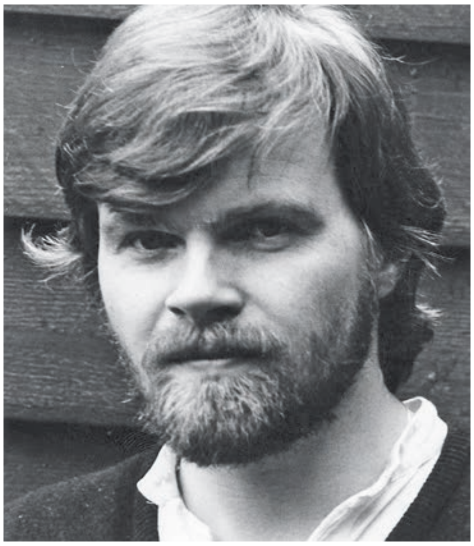
> The Norwegian-based diving industry in the petroleum sector is changing, and is now dominated by foreign companies. No Norwegian diving companies exist today in the petroleum sector. Three of the four remaining Norwegian-registered DSVs were transferred to foreign registration in the spring of 1993, with the consequent dismissal of the Norwegian maritime personnel. This position might be regarded as paradoxical.[73]

Godøysund

When the Kromberg commission approached the end of its work, nothing had happened to reduce the antagonisms which prevailed between the hyperbaric medicine specialists. No matter how much coverage Todnem received in the media, little changed as long as the NPD preferred to listen to the physicians who vouched for deep diving. In order to achieve a final clarification of the potential for damaging long-term effects, it was accordingly proposed to hold yet another consensus conference which brought together all the international expertise in this field. Held at Godøysund outside Bergen in June 1993, the meeting aimed to arrive at a statement or manifesto which summed up what everyone was agreed on. That proved difficult, since neither Elliott nor Bennett were willing to admit that they had failed to detect such after-effects in their studies. After much argument, the conference arrived at the following collective statement:

> Changes have been identified in the bones, central nervous system and lungs of divers who have not been involved in diving accidents or exposed to other known working environment burdens. These changes are largely small and do not affect the quality of the diver's life. However, they are of such a character that they could affect the diver's future health. Scientific knowledge is limited and further research is required to determine more precisely the scale of the long-term effects of diving.

This "manifesto" was considerably more moderate than the conclusions drawn by Todnem and her colleagues. The most important opponent of the Haukeland team in Norway was Brubakk, who had supported Elliott and Bennett in the tussle over the conference's final statement. He was working at the time on a major research project financed by Statoil in Trondheim. Following the conference, he spoke positively about the



Leif Sande was an industrial worker with a background from such workplaces as the Mongstad refinery north of Bergen. As a leading Nopef official, he was often involved in diving-related issues – not least as a member of the Kromberg commission. He became president of Nopef in 2000, and has headed the Industry Energy union since 2006. Photo: Nopef/Industry Energy

possibility of diving as deep as 400 metres but said that more research was needed to improve procedures and control systems in order to ensure that the operations were as safe as possible.[74]

The Kromberg commission has failed to take a position on the two conflicting medical views. In its discussion of possible long-term damage from diving, the commission made no reference to research reports from Todnem or others. However, the commission was much more open to the existence of negative long-term effects than the NPD, which had long bluntly rejected such a possibility.[75] In its consideration of the medical research, the commission concluded that having several scientific teams in partial competition with each other was beneficial. At the same time, it supported the decision of the Ministry of Social Affairs to give Haukeland a national responsibility for hyperbaric medical treatment. The hospital was also made responsible for advising other health services on issues related to hyperbaric medicine. It is difficult to interpret this as anything other than a recognition of the work done by physicians such as Aarli and Todnem.

If 1993 marked a climax in the heated debate on diving, it was followed by an anticlimax. Todnem quit Haukeland to become a senior consultant in neurology, first in Stavanger and then in Trondheim. But the medical disagreements persisted. The engineers in the NPD's diving section continued to pin their faith on Bennett, Elliott and that part of the international medical community which believed it was possible to conduct extensive deep diving without suffering permanent injury. Their underlying justification was unchanged from the anonymous insert included with Todnem's report in 1991. While this wing accepted that a disturbingly large number of divers had health problems, it maintained that the cause of these conditions had yet to be established with scientific certainty.[76]

Given the philosophy which underpinned the internal control system, it might seem a little paradoxical that such attitudes were allowed to dominate one of the NPD's sections. From the mid-1980s, the directorate assumed that the oil companies would conduct risk analyses and select technological solutions with a very low threat of accidents or injuries. In the terminology employed, the cut-off criterion was 10^{-4}.[77] This meant that the risk one chose to live with had to be very, very low. In the diving sector, the NPD faced two relatively heavyweight groups of medical specialists, with one claiming to identify serious injuries and the other arguing that these were not proven. Translated into risk analysis terminology, this would nevertheless mean that the probability of something being wrong was very high. So high, in fact, that every engineer would have been sent back to the drawing board if this had been a question of a specific platform design or aspect of drilling technology. In a sense, that is precisely what did happen – not because the NPD put its foot down but because the oil companies eventually experienced so many problems associated with diving that they decided to do without it.

In some parts of the Norwegian diver community, it has occasionally been claimed – to put it fairly bluntly – that Todnum was responsible for the complete collapse of diving on the NCS in the years after 1993. As we will see in the next two chapters, this development had far wider causes than safety alone. First, subsea technology had gradually been devised which looked capable of providing an alternative to most forms of diving. Second, the Norwegian diving industry was threatened by a globalisation wave which produced a completely new type of company within a few years. However, the decisions taken by the oil companies to cease using divers were not unaffected by the bitter conflicts within the medical community and the tensions between researchers, regulators and diver unions.

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Chapter 11

Subsea technology replaces the divers

In the late 1980s, when deep research dives were being repeatedly criticised in the media, subsea technology had made such strides that it was on the verge of replacing divers and making them to some extent redundant. Diverless systems offshore were becoming a reality. Forward-looking technology choices were made in this period. The systems developed came to dominate in later development projects and can be classified as a technological leap forward on the NCS. Subsea technology advanced along two paths. One involved the development of remotely operated vehicles (ROVs), which could be used for observation and deepwater working. This allowed them to support and partially replace divers. The second focused on the actual seabed production facilities, with the oil companies gradually adopting solutions which could be installed and maintained entirely without diver support.

A number of factors promoted the development of flexible subsea solutions during this period. The oil price slump in 1986, which left prices stable at a low level of around USD 10 per barrel, meant that the profitability of new projects had to be assessed more stringently than a few years earlier when a barrel of oil cost USD 30 or more. This new price regime created a growing demand for more intelligent and less expensive solutions in terms of both investment in and operation of offshore installations. Another factor was that the concrete technology exemplified by the giant Condeeps was reaching its physical and financial limits. Alternatives were needed. The commitment and creativity of Norway's research and development teams blossomed, greatly assisted by politically driven support from the oil industry through technology or "goodwill" agreements with the Norwegian government. Ideas

A Sea Hawk at work.
Photo: Tor Jan Wiik

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which had been tested on a small scale were further developed through research projects and turned into standard solutions. A number of projects related to flexible diverless satellites were executed during the 1980s. Work involving diver inspection, maintenance and repair of underwater oil installations was both expensive and risky.

ROVs offered a good alternative. Moreover, diving technology was banging its head against a physical depth limit. It did not appear that research projects at Nutec or elsewhere could eliminate this barrier to acceptable diving by humans. Where the limit lay was a matter of dispute, not least among medical specialists. That was also an important reason why the oil companies made a commitment to developing diverless systems for offshore use.

Eyes under water – the first ROVs

Remotely operated subsea installations found today on Snøhvit, Åsgard and many other NCS fields are specially designed to be installed, maintained and repaired by ROVs. The latter are equipped with manipulator arms and specialised tools, and can perform a number of operations. In addition to inspection, maintenance and repair of modules, they can be used to survey pipeline routes, dig trenches and level out seabed terrain. Specialist ROVs can perform underwater flame cutting and welding. All these advanced jobs are controlled by operators on the surface.

The oil industry understood at an early stage that using machines for subsea work offered major benefits. Hiring a DSV with a full crew was expensive, and diving always involved a certain level of risk. Subsea technology began with remotely operated underwater cameras to inspect drilling operations. *Ocean Viking* used two additional guidewires to run such a camera up and down. Eventually, cameras were placed on a moveable base so that they could film in all directions,[1] but could not be classified as submersible vessels. From the late 1970s, far more mobile cameras known as "eyeballs" were adopted. These were sufficiently manoeuvrable that they qualified as a remotely controlled vehicle (RCV, an earlier term for ROV).

Phillips was the first oil company to adopt the eyeball on the NCS. During drilling on Ekofisk, an RCV 225 unit was used to assist in installing the base plate used to route the drill bit. This RCV could also observe gas escaping from the borehole. It was manoeuvred from a control room on the surface vessel via a cable. In addition to visual inspection, eyeballs were used to monitor divers in order to enhance their safety. They were equipped with powerful searchlights which lit up the worksite for the divers. These units made it easier to acquire an overview of a job and to plan the work in advance. On the other hand, the

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An RCV 225 eyeball was used on Ekofisk for visual inspection of drilling operations and monitoring divers to enhance their safety. Photo: Tor Jan Wiik

divers not infrequently had to rescue the eyeball. Its long cable had a tendency to become entangled, or it could quite simply get stuck.[2]

Elf was also a relatively early adopter of ROVs. Such units were used for inspection during the final phase of construction work on Frigg in 1976-77, but experience was not entirely positive. The electronic, electrical and mechanical components on ROVs were unstable during this initial phase. Moreover, personnel had little training in their use. The technical problems were so great that they came close to frustrating Elf's whole commitment to ROVs. Slowly but surely, however, operators received better training and vehicle functionality became more reliable. Equipping ROVs with high-resolution low-light TV and colour photography cameras made them more useful for inspection jobs. It was also an advantage that such units were operated directly from the rig, eliminating the need to use expensive DSVs.

Pipeline inspection on Frigg was initially carried out by manned submersibles, but ROVs were adopted from 1981 with equally good results. An ultrasonic shortwave navigation system combined with a receiver on the ROV allowed the latter to follow the pipeline and take photographs and videos along the way.[3]

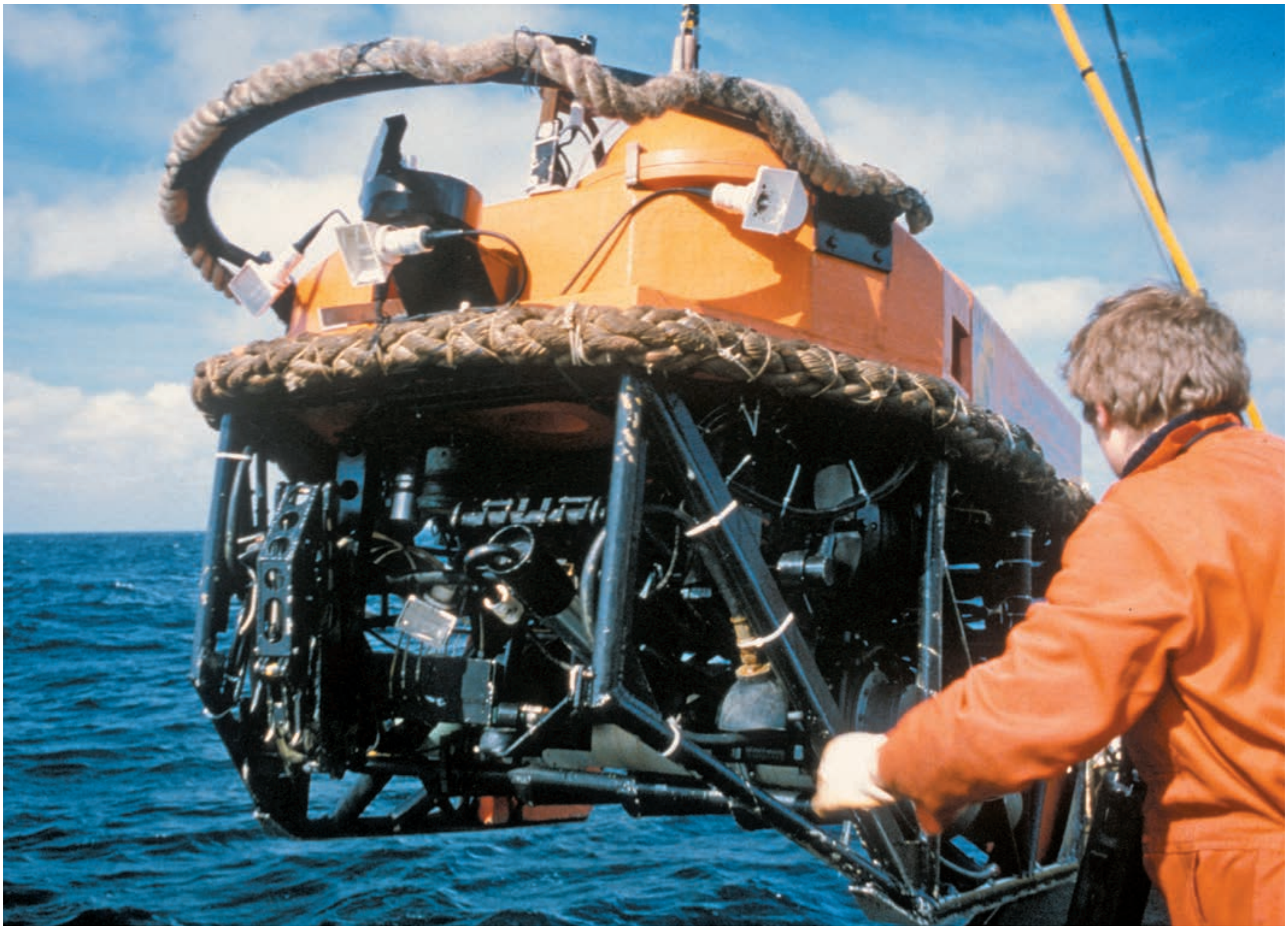
Equipped with manipulators and tools

One Norwegian innovation was the Snurre, which some claimed to be the world's most advanced ROV of its day. Two gripper arms allowed it to perform simple jobs. A camera at the front end monitored the work. Development began at the former Myrens Verksted engineering works in Oslo and was continued by the Continental Shelf Institute (IKU) in cooperation with DNV. The first test in seawater was conducted during the summer of 1973.[4] It was controlled with a helicopter-type joystick, and the operator could follow its movement on a video screen while another monitor presented sonar signals used to navigate with. Snurre's first important job was cleaning and inspecting three concrete platforms on Frigg in March 1980, using water jetting. A wheeled frame was then attached to the front of the ROV to maintain a constant distance between hose and concrete wall. Snurre's thrusters counteracted the power of the water jet and kept the ROV in position.[5]

The Snurre ROV carried out cleaning and inspection of three concrete platforms on Frigg during March 1980.
Photo: Norwegian Petroleum Museum

Research in this area was pursued in several countries. By the late 1970s, ROVs were being manufactured in Canada, France, Japan, Norway, the UK, the USA and the Soviet Union.[6] In addition to Snurre, the Consub II from the British Aircraft Corporation and the Scorpio from America's Amtek were used on Frigg.[7] Ranked as the leading ROV of its day, the Scorpio was used on all the NCS fields from around 1980 to the mid-1990s. An open frame made changing components easy. The first version, featuring a manipulator arm for simple jobs, could descend to 600 metres. Its operators made their own basic tools which the vehicle could use. The ROV's motor developed a not-very-powerful 25 horsepower, but it progressed quickly to 50 and then 100 hp. A second manipulator was also added. Depth is no longer a constraint today, and a Scorpio can now be manoeuvred down to 2 000 metres.[8]

Ninety per cent of the inspection programme on Ekofisk in 1989 was carried out with ROV assistance. By then, these units had acquired such equipment as sonar and up to five underwater cameras able to take panoramic and close-up photographs. In addition came various types of work modules, including ones for weld cleaning and anode installation. A basket could also be installed for carrying divers to their work site.

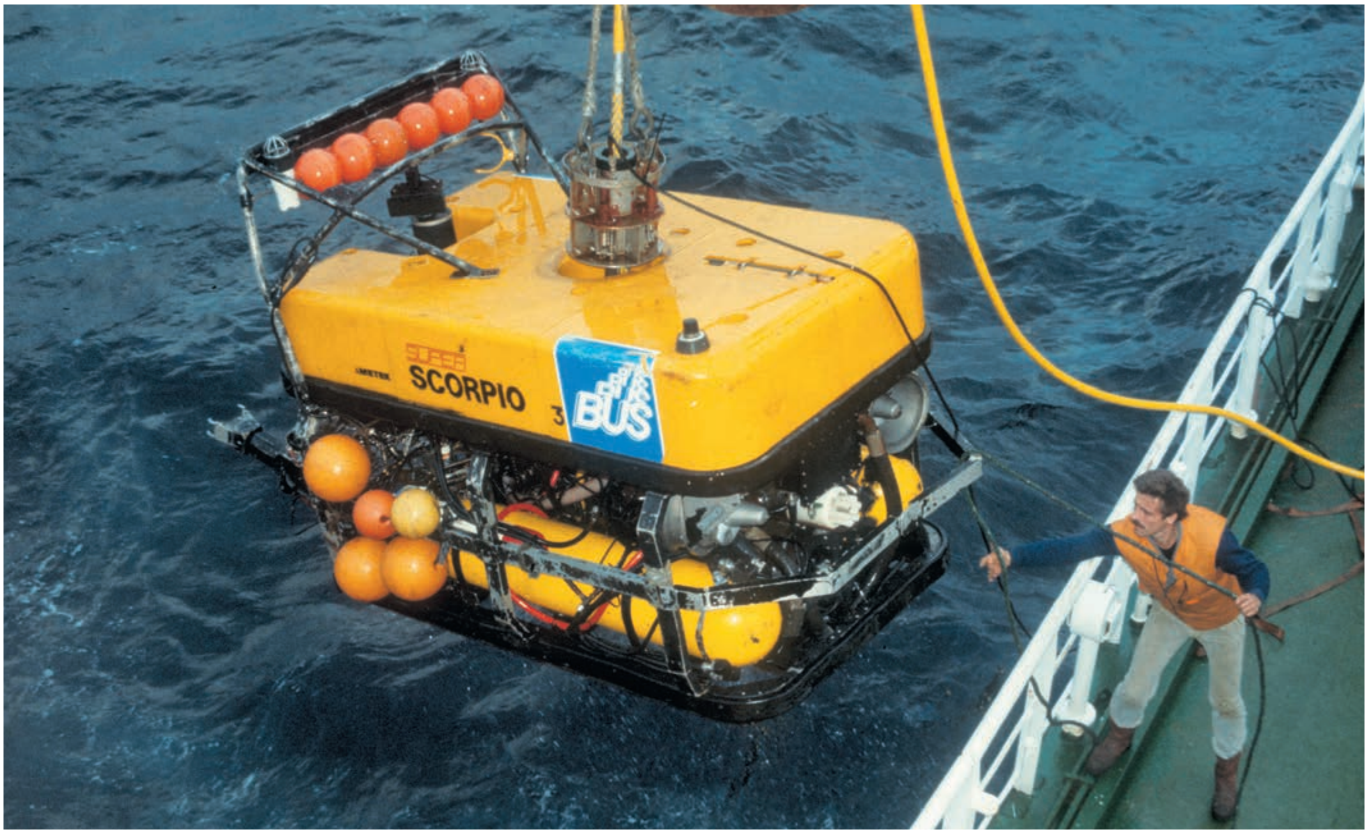


Developed in Norway, the Snurre ROV could do simple jobs with the aid of its two gripper arms.
Photo: Norwegian Petroleum Museum

At the end of the 1980s, ROV technology had completed its first trial-and-error stages and these vehicles were largely able to replace divers in a number of areas. The first diverless inspection on Statfjord took place in 1996.

ROVs can handle far more operations today. They use water jetting to clean subsea structures of the marine fouling which accumulates in large quantities on platforms and causes extra wear and tear. The fouling can also conceal cracks which need repairing and the anodes used for corrosion protection on steel structures. ROVs utilise special equipment to measure galvanic voltages between the anode and the steel in order to make sure that the former corrodes rather than the latter.

Comparing results from earlier years allows engineers to determine whether the steel has started to corrode and the local anodes need to be replaced. If anodes have fallen off, the ROV can attach new ones. Specialised vehicles also perform non-destructive testing (NDT) of steel structures – in other words, inspect them without taking samples of



The Scorpio was the leading ROV, used on all Norwegian offshore fields from around 1980 to the mid-1990s.
Photo: Børre Børretzen

the actual steel. A special manipulator arm with software and tools has been developed for this job.[9]

ROVs can also be used for mapping ahead of underwater work. A special camera is then sent down to film in darkness and over long distances before another ROV descends with lights and a normal colour photography camera. Remotely operated tools (ROTs) do the actual job, which could comprise a module replacement, for example.[10] The ROT acts then almost like a lorry to draw out the module. It can also pull a pipeline into a subsea module and make a connection between them. ROTs designed to work on templates must be small enough to secure easy access.

A survey ROV is used in large pipelaying projects to map bottom conditions. It carries cameras which film the seabed while running up and down the pipeline route several times, so that the actual laying operation can be carefully planned. ROVs are also needed in the next phase of the project. Where long free spans occur, the ROV can set up trestles at suitable intervals to support the pipeline. It can also prepare trenches using a kind of digger or powerful water jetting equipment to excavate soil before the pipeline is laid.

An inspection ROV is serviced before being placed in its "garage" and submerged in the sea, ready for new assignments.
Photo: Tor Jan Wiik

ROVs have become invaluable for removing offshore installations. They were used on Frigg, for example, to cut off jacket legs so that large crane barges could lift the resulting sections onto barges for towing to land.[11] These vehicles are being fitted with ever more advanced equipment designed for particular jobs. Imagination is almost the only constraint on what an ROV can do.

ROV operator – a new profession

Highly qualified people are required to operate an inspection ROV. Such jobs, where the operator sits and monitors the camera for 12 hours a day, call for close attention. Personnel doing this work are recertified every other year.

During the first phase of ROV development, no special training existed for their operators. Divers often took these jobs, but the commonest approach was to employ people with technical qualifications.[12] ROV operators were usually not stationed permanently offshore, but flown out only when something went wrong and the ROV had to be launched and controlled. The drawback with this approach was that the equipment had then stood unused and uninspected for a long time. When it was needed, something unexpected often happened. Nor were the ROVs as reliable as they have become today. ROV operators are now part of the permanent rig crew, and have acquired a higher status. When such personnel are permanently stationed on board, they can

Inspecting a Scorpio on deck.
Photo: Tor Jan Wiik

The ROV operator on Sleipner keeps an eye on the monitors.
Photo: Tor Jan Wiik

maintain the ROV, plan work in advance and customise the required tools. This means that ROVs have become much more reliable in operation. The ability to repair them on the vessel rather than having to take them to land is crucial, since an ROV out of operation would be very expensive for its owner.[13]

The first course for ROV operators was held at Nutec in 1982.[14] Since 2000, these people have had their own professional training programme leading to a vocational certificate.[15] Apprentices now learn on simulators, providing very realistic exercises in all conceivable circumstances.

Diverless satellites and fields

Weak oil prices prompted a stronger emphasis from the late 1980s on reducing offshore development costs. Both the oil companies and the government agreed that this was necessary. Production systems had to be simplified and made more efficient. Greater attention than before was paid to investment and total life-cycle costs. What would the maintenance bill be, and could equipment be recycled or removed later? The latter question also had an environmental aspect.

Developing satellite and stand-alone fields without diver assistance offered a solution to some of these challenges. Subsea technology also made it possible to produce in ever deeper water and to introduce floating production units as a flexible new approach. Tension-leg platforms, catenary-moored semi-submersibles and production ships could be tied to subsea wells. In addition, existing production platforms could be supplied from remotely operated subsea satellites.

The first diverless production system on the NCS was developed for Gullfaks and brought on stream in 1986. Proven in 1978, this field lies 20 kilometres south-west of Statfjord in 130-220 metres of water. Equipped with three concrete platforms, it ranked as the first large NCS development with a Norwegian operator in the shape of Statoil.

Its subsea project built on basic research with underwater installations already conducted through the Skuld programme, which began in 1980. Backed by Elf, Hydro, the NUI and Sintef, this focused on remote operation of installations over a distance of 20 kilometres. Elf, the biggest contributor to Skuld, built a simulation station to test the reliability of the control system, which involved electrohydraulic operation of Xmas trees and a manifold. This solution proved reliable in operation and could be installed without diver assistance.[16] Statoil adopted the remote control system for use on Gullfaks, where six seabed templates were installed without divers even though the water depth was no more than 140 metres and accordingly well within the 180-metre limit. Tore Halvorsen, then assistant technical manager in the oil division at Kongsberg Offshore (KOS), observes:

> This was an extremely interesting period. We'd always previously used divers if we ran into difficulties. We were probably the first company in the world to find a solution for diverless installation. And the answers we came up with were developed from scratch.[17]

Elf drew on its experience from the Skuld programme to develop East Frigg, a Frigg satellite brought on stream in 1988. Three templates were installed using ROTs in roughly 100 metres of water without diver assistance. East Frigg was the first entirely platform-free field in the North Sea. It was equipped with two production stations and a manifold station, which collected the gas before it was piped the 18 kilometres to Frigg for processing. All production and control functions were remotely operated from the main field. The pilot projects developed for Gullfaks and East Frigg under the auspices of Statoil and Elf respectively demonstrated that a market existed for diverless solutions on the NCS.

Tore Halvorsen, then assistant technical manager in the oil division at Kongsberg Offshore (KOS), observes: "We were probably the first company in the world to find a solution for diverless installation".
Photo: Scanpix

A third pilot project worth mentioning is Hydro's diverless Troll Oseberg gas injection (Togi) development.

Towards standardised subsea solutions

A number of fields were developed in the 1990s with subsea production systems. Satellites to Statfjord, Sleipner and Gullfaks were tied back to Condeeps. Norne and Åsgard were provided with production floaters connected to associated subsea wells. Yme and Heidrun, featuring a jack-up and a concrete-hulled TLP respectively, were also tied to production systems on the seabed.

The Statfjord North and East satellites were tied back to Statfjord, with its three concrete platforms, during the 1990s through subsea facilities which ranked as the world's largest at the time. These comprised six templates in 250-290 metres of water, with a total of 18 Xmas trees linked to Statfjord C.

Sleipner East, located west of Egersund and close to the UK-Norwegian boundary, was developed with two templates for subsea-completed wells tied back to the Sleipner A Condeep.

An important refinement of the templates was made on the small Yme field in the Egersund basin, which came on stream in 1996 with Statoil again as operator. Controlled from a jack-up in 90 metres of water, the actual template was made a little smaller than before so that it could be installed from a drilling rig. Its innovative feature was that plates were folded out like an umbrella over the template to provide protection once it was safely on the seabed.[18]

Another field where it was necessary to think diverless was Norne. Located in 380 metres of water, this came on stream in 1997. It was developed with a production and storage ship tied to five templates with 14 Xmas trees and control modules on the seabed. Compared with earlier structures, the Norne templates had been sharply reduced in size. Flexible risers carried the wellstream up to the ship, which was equipped with processing facilities on deck and oil storage tanks. The system was extremely flexible compared with the big concrete platforms, and the ship could be transferred to produce other fields if desirable. It had diverless emergency response systems.

Incorporating several fields in one and the same contract with Kongsberg Offshore led to greater coordination. A "tool pool" was established between fields with the same technical design, for instance, allowing them to share installation equipment and spare parts. That led to substantial savings. Other licensees began to choose the same solution for their subsea installations.

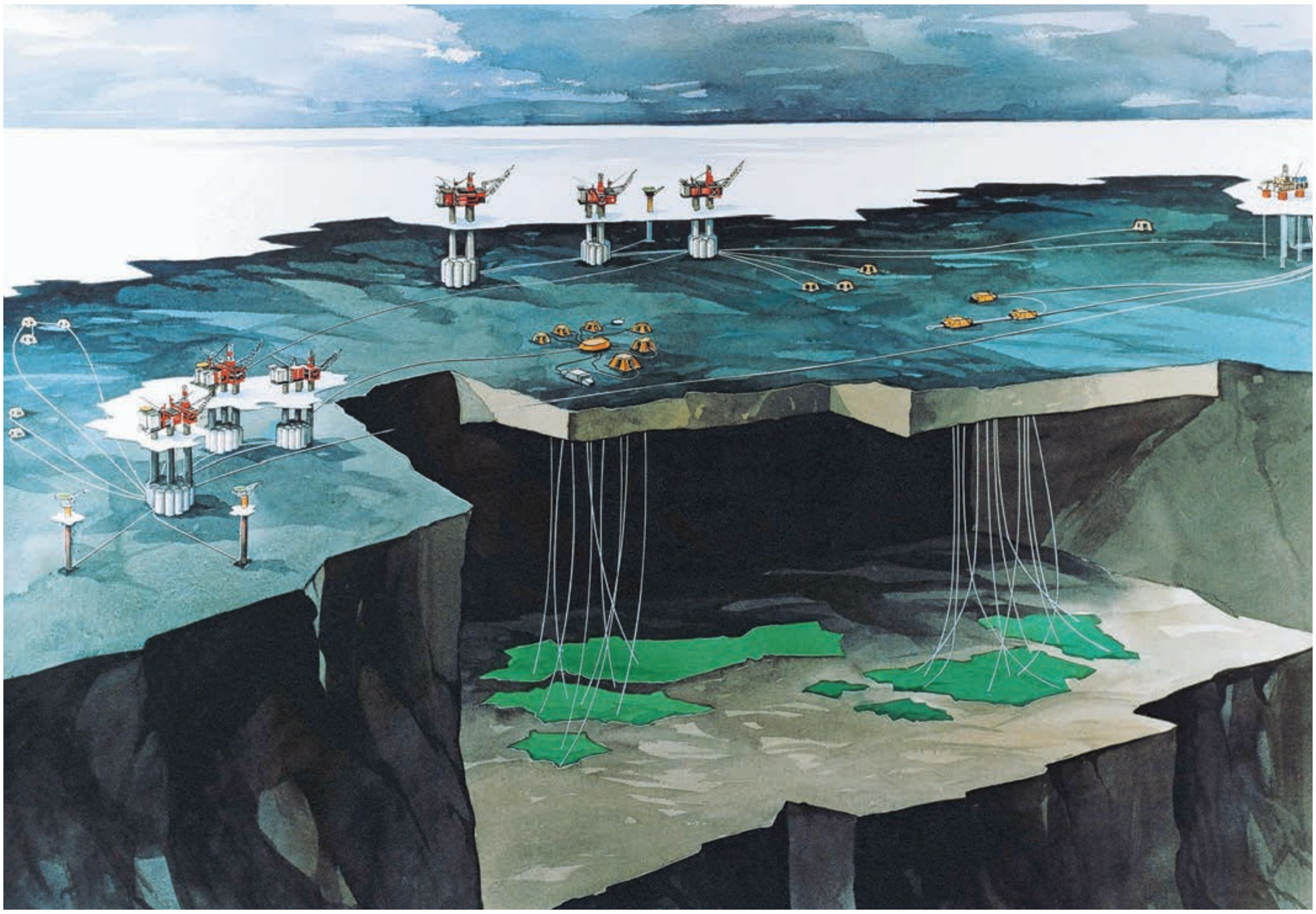
Two giant subsea installations ready for dispatch to Ormen Lange. Each measures 44 x 33 metres.
Photo: Hydro/Scanpix

An astonishing technological leap forward occurred on the NCS in the 1990s, characterised by close cooperation between supplier and customer and between licensees. The most important step towards a standardised solution was the hinge-over subsea template (Host) concept, which began life as a collaboration between Statoil and Kongsberg Offshore in 1993-94. This was intended to be a fully equipped fold-out subsea template – in other words, a further development of the idea used on Yme and Heidrun.

The structure could pass through the moonpool on a mobile drilling rig when folded up, and then be opened out when installed on the seabed. This extremely flexible design was like a Lego system, which could be tailored to each company's special and different field solutions. Its building blocks were the same regardless of the project concerned, and could be assembled to suit any possible subsea development.[19]

The aim was for the equipment to be far cheaper to manufacturer and install than conventional templates, and the results lived up to expectations. A single Host module weighed around 25 tonnes, and a full template less than 100. Conventional structures tipped the scales at 400-600 tonnes, and had to be installed from a big and expensive crane barge. The modularised Host system could be transported by supply ships and handled by the ordinary crane on a rig.[20] This offered substantial savings compared with day rates for a crane barge. Moreover, the templates with their subsea Xmas trees were quick to bring on stream once installed.

A very solid reduction in development costs per well was achieved in 1986-98. Each well on Gullfaks A cost NOK 170 million in 1986. That was down to NOK 85 million for the Statfjord satellites in 1992, and NOK 45 million for Norne by 1994. The cost per well utilising Host modules came to NOK 30 million in 1996.[21]

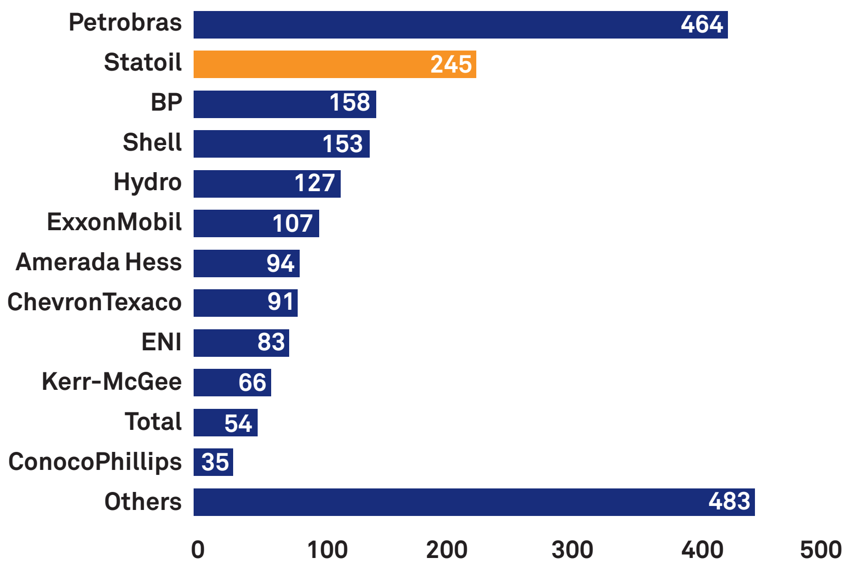


Statfjord satellites tied back to the main field. Photo: Statoil

From being a technology for the specially interested, subsea solutions have developed into a key component of offshore developments. Few places on Earth have so many subsea wells as the NCS. Statoil is the second largest operator of such solutions, with 245 installations, surpassed only by Petrobras with 464.

Applications for subsea installations have become increasingly varied over time. Processes which previously took place on the platform – such as water injection to maintain reservoir pressure when the field reaches a mature phase – are now carried out on the seabed. Underwater separation is also possible today, reducing costs and improving recovery substantially.[22]

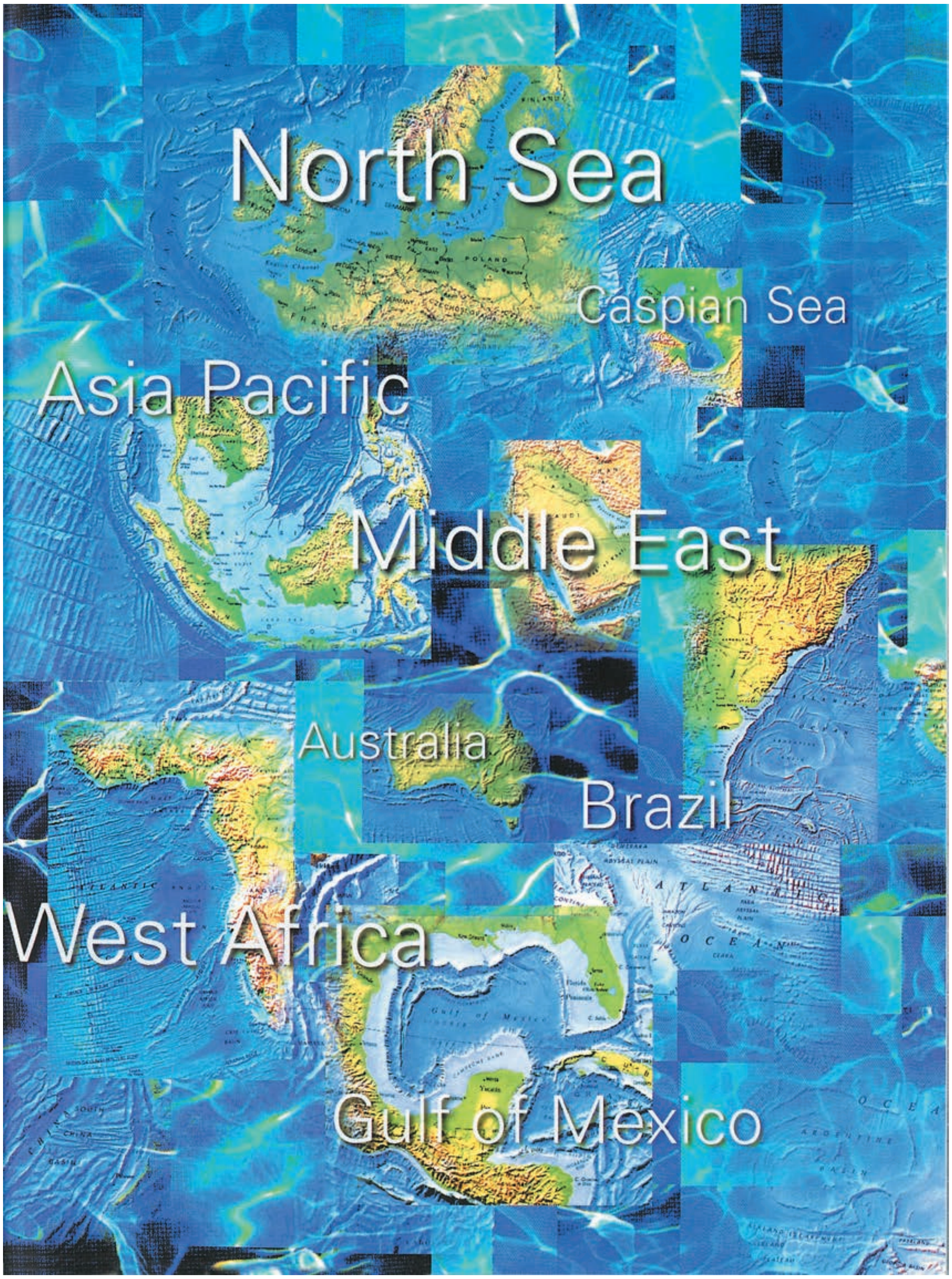
It is important in this context to appreciate the massive technological progress made with diverless systems in order to understand the reduction in diving activity on the NCS during the 1990s.



The number of subsea wells operated by various oil companies in 2005.
Source: Statoil

Underwater activity has not declined over the past 20 years. On the contrary, it has flourished as never before, but with the aid of ROVs and the development of standardised subsea facilities which can be installed and maintained without diver assistance.

As we shall see in the next chapter, this technological shift eventually had a big impact on diver employment.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Asia Pacific
Middle East
Australia
Brazil
West Africa
Gulf of Mexico

Chapter 12

National protectionism, globalisation and a new deal

Many people around the world view the way Norway has overcome the challenges posed by oil operations in the North Sea with great admiration. In area after area, Norwegian specialists showed that they could master the technological challenges. Domestic enterprises acquired a dominant role both among the oil companies and on the supplies side. Regardless of which causes led to which outcomes, Norway ended up with a work culture, company structure and public support and regulatory regime in a fruitful relationship with each other. Although government supervision of diver safety faltered, a political desire always existed for Norway to be a key player in the diving industry as well. The starting point was good. An interest in diving and subsea technology existed in the Norwegian shipping sector, and a national diving community had emerged in the navy and certain amateur diver groups. While diving on Statpipe was in full swing, it was difficult not to think Norwegian industry was succeeding in this business. With the contracts from Phillips on Ekofisk and Statoil on Statpipe, SNS was by far the largest diving contractor on the NCS. From the mid-1980s, it nevertheless became clearer and clearer that Norway's diving community was heading for a crisis.

As the biggest company, SNS became vulnerable to general cyclical fluctuations in the oil industry. The oil price slump of 1986 created

As the only large Norwegian diving company, Stolt-Nielsen Seaway (SNS) appreciated that it needed a global orientation to survive. Source: Stolt Comex annual report 1993.

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great uncertainty. This was also when the industry seriously began to feel the impact of the very special regulatory conditions, where many measures intended as improvements simultaneously undermined the competitiveness of the Norwegian diving business. At the same time, many people in the oil companies believed that Norway would manage without diving in the future. That applied not least to Statoil and Hydro. Why strive to establish a suitable offshore-related diving education, appropriate research institutions, viable Norwegian contractors and so forth if there was no future for any of it? Why struggle to maintain a domestic diving industry in the face of clearer and clearer signs that this was hazardous for the divers?

Norwegianisation of the diving industry

The vision of a diver-free oil industry was launched in the late 1970s. During the first half of the 1980s, this ceased to be a loose idea. Many engineers in the oil sector believed that a development of this kind could be right around the corner. Such expectations were frustrating for the diving industry and particularly for the divers themselves. The 1986 Nopef memo on deep diving put the position as follows: "Since development began in the North Sea, diving has occupied an intermediate position where people believed further progress was wasted in an industry which would soon be overtaken by diverless techniques."[1] Nopef took the view that this was an unrealistic Utopia, and warned against ending up in a position where diving was nevertheless required and people were pressured to undertake unacceptable operations because equipment, competent personnel and routines were lacking. Instead, the union wanted to shift to a stronger commitment to Norwegian diving – including in deep water:

> Norway has an opportunity to build leading-edge technology which will place Norwegian industry in a special position for diving. Most deep diving will take place off Norway in the future. We have technical and medical expertise to build on. In this area, we need to escape from the servile approach of using foreign consultants and appreciate that we are probably the country which knows most about deep diving today, and that we have the opportunity to become a leader in this field in the future. This would make it possible for Norwegian industry to sell its knowledge to foreign industry, rather than vice versa.[2]

The Norwegian diving industry had long followed the same development path as the other offshoots of the offshore supplies sector. Companies such as Aker, Kværner, Norwegian Contractors, Smedvig, Odfjell and PGS all received various forms of start-up assistance, both directly from the government and indirectly via Statoil. All these enterprises also benefited from government initiatives to tailor various types of relevant research and education. By the mid-1980s, SNS was the only remaining large Norwegian company in its sector of the oil industry, just as PGS had become the sole domestic survivor in seismic surveying.

With shipowning capital behind it and based on solid Norwegian maritime traditions, SNS established a small fleet of modern DSVs which were fully comparable with the vessels utilised by the foreign diving contractors. Many foreign divers on the NCS believed that the company had the best available diving equipment in the early 1980s. But even SNS had not got where it was without initial help from the government. First, it benefited from the general political demand that the industry should be Norwegianised, which was enforced through the Ministry of Petroleum and Energy. Foreign operators who wanted to be on good terms with the authorities could achieve that precisely by being positive to Norwegian suppliers. So, even though SNS had equipment which was well suited for the maintenance contract on Ekofisk, its nationality helped it to retain that job. The company was aware that it would hardly have won the big and important contract for the Statpipe development without pressure from the ministry and a positive attitude by operator Statoil.[3] This form of protectionism accorded fully with practice in the rest of Norway's supplies industry. It was usually defended by pointing out that the foreign diving companies benefited from similar support in their respective home countries. Norwegian industrial interests often found themselves losing out to the informal networks of engineers and procurement personnel in the oil companies and their foreign suppliers. The oil companies had a tendency to stick with firms they already knew at home, regardless of quality and price. A widespread perception prevailed both in the Norwegian diving community and in other parts of Norway's offshore industry that the British oil sector pursued even more favourable protectionist policies. The fact that activity in the UK sector had begun a little earlier made it all the harder for Norwegian companies to win work there.

It was first towards the end of the 1970s that the Norwegian government made serious demands for an increased domestic share of deliveries. This approach was continued with undiminished vigour by the centre-right governments under Kåre Willoch from 1981. Many foreign oil companies hoped that access would be easier under a non-socialist administration. That applied particularly to Mobil, which was fighting to retain the Statfjord operatorship against Statoil's determination to secure this role. Although Willoch was sceptical about the state oil company's dominant role, he was in a minority within his own coalition government. His most important weapon for weakening Statoil was to give Hydro a more central role. Moreover, pressure for the largest possible Norwegian deliveries became particularly strong after large parts of the Norwegian engineering industry were hit by a serious crisis from 1982.

The foreign diving companies naturally noted the government's Norwegianisation drive. They also saw that a growing number of future diving contracts would be placed by Statoil and Hydro, and perhaps also Saga. One way to succeed in such conditions was to secure as much of a Norwegian identity as possible. The simplest way for a foreign company to do this was to establish a Norwegian branch with a local office and preferably a Norwegian name. No diving company admittedly went as far as the US catering firm which established itself as "Norske Norwegian" (or Norwegian Norwegian).[4] After all, most of the domestic diving companies had English-sounding names. Nevertheless, an underlying reason for the many name changes which followed was the desire to appear as Norwegian as possible.

Companies such as Oceaneering, Sub Sea International, Taylor Diving and Comex all had representation offices and a certain amount of storage capacity in Stavanger as early as the 1970s. Comex's Norwegian arm operated under the name Comex Norway. In the early 1980s, all these companies resolved to strengthen their Norwegian appeal by acquiring the many small domestic companies in the diving business. This was the most important reason why SNS remained as the only Norwegian company. Taylor Diving, which generally operated in Norway through its UK subsidiary 2W, strengthened its Norwegian affiliation through a collaboration with shipping company Wilh Wilhelmsen. It accordingly acted for a time under the names Wilhelmsen Underwater Engineering and Wilbar. Oceaneering cooperated with Odd Berg, Norwegian Contractors and Sweden's Safe Offshore (Consafe), and worked for a time under the name Inocean. Sub Sea International joined forces with Fred Olsen and Subsea Dolphin, which embraced the remains of 3X (see chapter 7). Comex initiated a collaboration with Norcem and operated for a time as Norcem Comex in Norway. This jungle of names because so complicated that even divers working permanently under one and the same management on land had big problems remembering the right name of the company employing them.

Value creators or foreign branches?

The acquisition of a section of the Norwegian diving community by the foreign companies gave grounds for hoping that a larger share of the value creation would occur in Norway. Examples existed of Norwegian offshore suppliers where foreign ownership was not an issue, precisely because the bulk of the work and technology development took place in Norway. Few in the Norwegian oil community, for example, cared that Kongsberg Offshore was first owned for a long time by Siemens and later by a US company.[5] Nevertheless, the actual Norwegian contribution in the form of personnel, relevant engineering expertise, and research and technology development remained relatively modest in the foreign diving contractors.

Taylor Diving, Oceaneering and Sub Sea International – the three premier diving companies of US origin – all had their main base for North Sea operations in Aberdeen during the mid-1980s, where they operated either through or in collaboration with UK partners. Even when the Norwegian-registered branches secured work on the NCS, a significant part of the resources required – such as project management, engineering expertise, divers and equipment – was transferred from the UK. With the exception of Comex, which drew many of its resources from its Marseilles headquarters, the UK and Aberdeen became the main centre for value creation from North Sea diving. Even Comex transferred a significant part of its activities to the UK. The Norwegian branches of the foreign diving companies largely remained representation offices. Several of them gradually reduced the Norwegian content they had acquired by taking over the small domestic companies. Comex, 2W, Subsea Dolphin and Oceaneering had substantial assignments on the NCS in 1986 with 20, 20, 10 and four employees respectively in Norway.[6] By comparison, SNS operated with 180 divers in Norway.

Protectionist start-up assistance was of little benefit for SNS when this was not followed up with a regime which ensured that all the companies were subject to the same type of regulation. As long as its competitors could operate on the basis of terms set by other flag states, a level playing field would never be possible. The company could acquire as much modern equipment as it liked, but the return on this investment remained dependent on how much diving work could be done on the seabed. This meant that factors such as diving tables, shift/tour routines, rules on permissible time in saturation, bell and water, and so forth were crucial competitive factors. That would always be the case in the diving sector. The chain of jobs done in one and the same company became increasingly lengthy and complex. Nevertheless, the willingness of divers to sacrifice themselves was ultimately crucial for the return on the investment made.

Norway had many industrial facilities where the capital investment was so large that their owners could not afford to leave them unused at night. The oil installations on which the divers worked were an example. Adopting the saturation method meant that diving similarly acquired a more industrial character, with opportunities for a kind of shift work.

But diving differed from most other types of capital-intensive industrial work in that it ultimately always remained important how long and how intensively the individual diver was willing to work. Bottlenecks on an oil platform could always be removed by putting in extra personnel. The advanced diving spreads were less flexible. Working time always had to be related to a much larger number of hours and days spent in decompression. Once a diving spread was filled with divers, few opportunities existed for expanding capacity. In circumstances where a bottleneck arose in the work, capacity could naturally be expanded by hiring another DSV. That was also done, although it represented an expensive option. In a great many cases, however, the same could be achieved far more cheaply by persuading the individual diver or diving team to accept an extension to the time spent in saturation. It would naturally have been possible to develop a system which compelled the oil company and the diving contractor, and thereby also society, to pay the price of a larger safety margin in diving. However, that could only function if all the companies faced the same terms. This was not possible as long as some companies could operate under a completely different regulatory regime, with entirely different safety margins, than the one governing the Norwegian contractors.

Norway had placed itself in a position where key measures to improve the working environment and safety of divers simultaneously undermined the chances of success for the only Norwegian diving company. Moreover, the rather strange position had been established in which the domestic diving industry became a loser in relation to other Norwegian supplier companies. While the engineering industry eventually became competitive without too many support measures, the differential between companies operating under the Norwegian regulatory regime and those subject to other flag-state rules became simply wider and wider. Oil companies could thereby make considerable savings by maintaining a high Norwegian share of deliveries in those industries where the gap between domestic and foreign tenders was narrow, and concentrating the foreign share where the differences were substantial – as in the diving industry. In periods when the pressure to reduce costs was particularly heavy, it was tempting for the Norwegian oil companies to do the same.

SNS found the position so acute in 1986 that it wrote to Arne Øien, the recently appointed petroleum and energy minister, to request his help.[7] The company had learnt that the inspection contract on Ekofisk was to be almost halved in the following year. At the same time, it had failed to win large and strategically important contracts on Oseberg and Gullfaks. Operators Hydro and Statoil had in both cases given the jobs to the lowest bidder. Øien was an economist who had been a director general in the Ministry of Finance. He was accordingly almost certainly aware that Norwegian companies who begged on their knees for help had a tendency to exaggerate their problems. Given the low oil price, SNS was not the only Norwegian offshore supplier in difficulties. Moreover, the position was at least as difficult for many of the foreign companies. According to SNS' own figures, its turnover equalled the combined earnings from all the major contracts held by the four big foreign diving contractors on the NCS.[8] But the company's argument was genuine enough. It failed to secure the Oseberg and Gullfaks contracts because the cost of being so strongly tied to the Norwegian regulatory regime made its bids more expensive. That did not augur well for the future.

In fact, SNS and most of the other foreign contractors got over the 1986 hump fairly quickly. The demanding jacking-up job on Ekofisk meant that the decline in work was smaller than expected. In the years that followed, the pace of development on the NCS was stepped up sharply. All the political goals of the 1970s for maintaining a moderate production rate were abandoned. With Saga's operatorship for the Snorre field, Norway had obtained no less than three domestic companies all pressing for a steady supply of development projects. A new generation of economists argued that the most sensible course of action was to pump up the oil as quickly as possible and put the money in financial assets, rather than spreading output over a longer period. Increased activity in the oil sector was the government's most important instrument for breathing life into a Norwegian economy which was otherwise hit by a banking sector collapse and rising unemployment. This sharp expansion helped to ensure that enough diving assignments were still available to SNS and the foreign contractors. The fact that growth nevertheless failed to materialise reflected the fact that diving services formed a steadily declining proportion of overall activity on the NCS.

Petroleum and energy minister Arne Øien signalled that Norwegian oil industry suppliers could no longer expect the same type of protectionism which had prevailed earlier. Photo: Norwegian Petroleum Museum, Frigg collection

From stable operation to collapse

SNS survived without direct support from Øien in 1986, but the foreign contactors picked up the signals. When Norwegian oil companies such as Statoil and Hydro willingly awarded diving contracts to contractors who ran most of their diving operations from Aberdeen, operating on the basis of the Norwegian regulatory regime ceased to be a crucial criterion for securing contracts on the NCS. SNS could hope that Øien, as the representative for a social-democratic government headed by Gro Harlem Brundtland, would adopt a more supportive attitude than the Willoch administrations. However, Øien was a different type of social democrat from those shaped by an earlier generation of industry poli-

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cy giants such as Jens Christian Hauge and Finn Lied. He played, for instance, a key role when the government proposed the creation of a separate Norwegian International Ship Register (NIS) in 1987. This allowed Norwegian shipping companies to move their vessels to a register which allowed them in practice to avoid many of Norway's regulations. That represented a move in the opposite direction to the diver demand that foreign-flag companies should operate under one and the same regulatory regime.

The announcement many had feared came in 1989, when Phillips cancelled SNS' long-term contract on Ekofisk. This was justified on the ground that the installations had been in place for so long that constant monitoring for possible crack formation and so forth was no longer so necessary. The diving still to be conducted would be carried out on short-term contracts. SNS was accordingly forced to make people redundant for the first time. Some 70-80 Norwegian divers on DSV *Seaway Harrier* had to find other jobs.[9] That represented about a third of the Norwegian divers in permanent employment. A number of the pioneers who had long formed the core community among Norwegian divers suddenly found themselves out of work. *Seaway Harrier* did succeed in securing the occasional assignment on Ekofisk over the next few years. The Norwegian divers could thereby see that Rockwater's *Semi II* DSV had a significantly bigger slice of the work. However, Phillips had abandoned all plans to maintain diving on the basis on long-term contracts. SNS was less well placed than many of its competitors to secure the short-term jobs.

Statoil – from supporter to international oil giant

The other cornerstone which had helped to maintain a permanent staff of Norwegian divers was the maintenance contract SNS took over from 2W on Statfjord. Diving there was conducted after 1987 by *Seaway Pelican*, which lay year-round out on the field with the exception of short assignments on some of the neighbouring fields and even shorter periods at land.[10] Divers flew to and from the ship by helicopter, like other offshore workers. The unionised divers had hoped that Statoil, as far and away the biggest operator on the NCS, would help to secure orderly conditions for their profession. Diving from *Seaway Pelican* was the nearest they got to that. So many Norwegian divers were greatly relieved when SNS secured a three-year extension of the contract.

However, this award had a sequel which showed that the job hung by a thread. Foreign contractors Oceaneering and Subsea Dolphin, which had bid unsuccessfully, appealed to the Ministry of Petroleum and En-

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Rockwater's *Semi 2* on Ekofisk. As can be seen, this unit was well equipped. When the long-term contract from Phillips to SNS was terminated, this semi-submersible DSV was increasingly seen on Ekofisk.
Photo: Scanpix

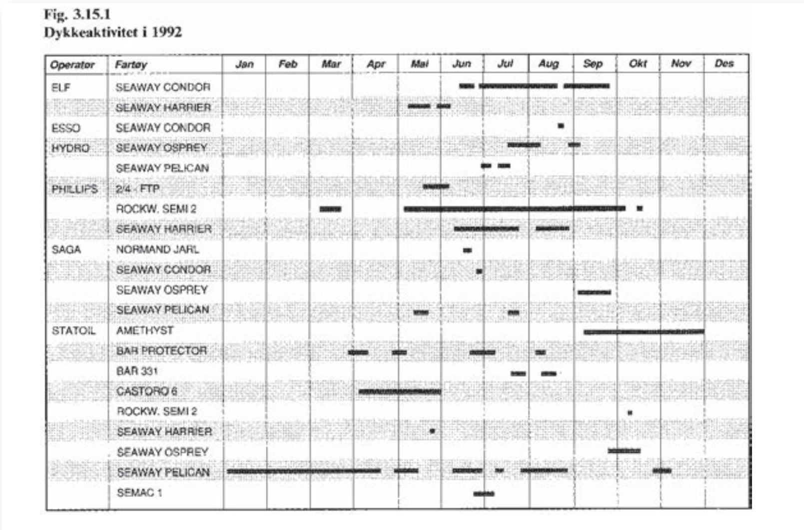
ergy. Eivind Reiten, the then minister, rejected their complaint on the basis of assurances from Statoil that all the proper procedures had been followed. But the state oil company then initiated an internal investigation, which identified a number of serious errors. As early as the award in January, an international oil journal had questioned the possession of shares in the DSV which secured the contract by a number of Statoil employees.[11] This was first picked up by the Norwegian media when it became known in August 1990 that the internal investigation had led to substantial changes in Statoil's senior management. However, the affair was then trumpeted as a scandal.

It transpired that no less than 27 Statoil employees, mostly in senior positions, had invested their own money in the K/S A/S Nevi SNS Diver VII limited partnership, which owned *Seaway Pelican*. Ownership of this DSV by a limited partnership, separate from SNS, was a typical form of organisation in the shipping community which had become involved in Norway's diving industry. However, the separation did not make it any less questionable that a number of Statoil employees had stakes in the ship. If *Seaway Pelican* had failed to secure the relevant contract, it might have had to be laid up and lose money for the Statoil personnel in the limited partnership. The internal investigation revealed that the invitation to tender was specifically tailored for *Seaway Pelican* in that the contract focused not on what could be provided in the way of diving services but solely on technical specifications for the vessel. Moreover, Statoil had agreed to give SNS special diving experience in deep water, which was later incorporated in the contract terms. Having underbid everyone else over an experimental dive in deep water for the Royal Navy, Statoil hired SNS to do the actual diving. The latter set its own price. Since Statoil's spent more on the job than it earned, the whole business could be regarded as a subsidy for SNS. Even on the basis of the invitation to tender for the big Statoil contract, SNS's bid for the Statfjord job had been calculated very creatively in relation to the invitation to tender to ensure that it came out best. The investigation concluded that Oceaneering's *Stena Wellservicer* would have been a cheaper and technically superior solution.[12]

The controversy, which was blown up as an internal scandal in Statoil, contained many underlying political elements – not only among those who had helped to secure the contract for SNS but also in the team responsible for the critical internal investigation. Many people on *Seaway Pelican* reacted to the way the report was presented in *Aftenposten*, and not least to a claim that the DSV was less seaworthy than competing vessels.[13] It is easy to imagine that this contract award could have had a far more serious outcome for Statoil chief executive Harald Norvik if his position in the company had been weak – and particularly if the press had got hold of the story before the top management managed to deal with it.[14] A number of journalists interpreted the personnel changes as part of a clear-out of the regime which had been headed by Norvik's predecessor, Arve Johnsen.[15]

That an internal group in Statoil contributed to helping Norwegian companies was clearly in accordance with the role played by the company in the 1970s and 1980s under Johnsen's leadership. It was well known in oil circles that SNS had problems, and that the company largely stood or fell with the Statfjord assignment.[16] Immediately before the contract was awarded, SNS was kept alive with a loan guarantee from Bergen Bank. At one point, the latter demanded an assurance that the company would secure the relevant contract before agreeing to a refinancing. The fact that SNS did not own *Seaway Pelican* itself but leased the vessel from a limited partnership was an expression of its financial difficulties. This vessel was basically mortgaged – the company could utilise it, but not receive its charter fees.

The contract award can be interpreted as a parallel to the rather more unconscious form of protectionism which Norwegian companies claimed they faced in the UK. Norwegian engineers in Statoil and at many of the suppliers often had the same kind of education. They chose each other quite simply because it was easy to deal with somebody who spoke the same technical language and was familiar with the same standards, and in whom one could have confidence. But such a communal feeling was hard to defend when many of the key participants exploited the networks which existed to award each other financial benefits. Norvik told *Aftenposten* that he could not exclude the possibility that a number of his own subordinates had profited from the award of the contract to SNS.[17]



This figure clearly illustrates how various DSVs operated in 1993. Some stayed most of the time in one location, while others sailed back and forth between several parts of the NCS.
Source: NPD annual report 1993

Immediately before the scandal was exposed, Norvik had signed an agreement with BP on an extensive strategic alliance. With ambitions to become an international oil company, it was important for Statoil to signal that the protectionist encouragement of Norwegian enterprises belonged to the past. At the same time, a number of its employees felt that the disappearance of the only Norwegian diving company would have negative consequences. The unionised divers in Nopef were naturally the most frustrated group of all.[18] They risked having to leave a company where most of the employees were unionised and where most of the diving was based on Norwegian regulations and agreements for one subject to less stringent rules, where labour was brought in from abroad and where unions were weak. Nopef demanded to see the relevant report in order to build up a genuine defence.

But Statoil was not keen to release its internal investigation report. The companies which had failed to secure the contract made it clear that either the job was transferred to them or they would take legal action against Statoil to secure compensation.[19] Had the conclusions in the report been in line with the allegations in *Aftenposten*, they would have had some basis for a step of that kind. SNS also threatened sanctions against Statoil because information had leaked out which described the company in disparaging terms.[20] The outcome was that Statoil appointed a new project team. Only its actual findings were made public on this occasion.[21] They might have been tailor-made for the position the state-owned company found itself in. The report stated that an error had been committed in failing to submit the contract to the corporate management before it was implemented. That let Norvik off the hook. Unlike the secret report, the new review found that SNS provided the best solution for Statoil. The latter accordingly avoided possible legal

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Harald Norvik was Statoil's chief executive from the departure of Arve Johnsen in 1988 to 1999. He was concerned to develop the company into a more international, market-oriented group. One consequence was less direct help to Norwegian suppliers. Under Norvik, Statoil resolved to concentrate on technology which did not require diver assistance. Photo: Statoil

action. With such conclusions, the unionised divers in SNS undoubtedly also felt that the first investigation report would quietly disappear. The press accepted this, without asking further questions. A completely new issue had attracted public attention. Saddam Hussain's Iraq had invaded Kuwait, and it looked as if Norway might be drawn into a Middle Eastern war.

The bottom drops out

Although SNS retained the Statfjord contract, these events had demonstrated with full clarity that the willingness to solve the diving challenges by tailoring contracts which helped to ensure a stable, predictable profession had been weakened. Instead, Statoil's solution to the safety problems associated with diving was a declaration that its operations would become diverless in the near future. This was no longer a matter of vague visions, but a specific goal. At a meeting of the Norwegian Oil Industry Association (OLF) in 1991, a senior Statoil executive stated that diving would no longer be conducted on the NCS by 2000.[22] Like Phillips, Statoil felt that sufficient control had now been established over subsea installations to make the previous level of continuous inspections unnecessary. So it came as no surprise when Statoil terminated the long-term SNS contract in 1993. That foreign companies did not take over the job was little consolation for the Norwegian diving community. Statoil was not alone in its ambitions to operate without divers. Hydro announced that it would be running its installations in this way from as early as 1994.[23]

According to the Association of Offshore Diving Contractors (AODC), almost 1 400 saturation divers were working in the North Sea when activity peaked in 1984-85.[24] This total sank gradually to 770 by 1992, of whom 160-180 worked on the NCS. Norwegians accounted for 80-90 of the saturation divers. From the 1980s, the number of dives on the NCS was registered by the NPD with a reasonable level of accuracy. After peaking in 1984 while Statpipe was being laid, the scope of saturation diving remained fairly stable at roughly 200 000 work-hours in saturation per annum up to 1992.[25] Surface diving rose somewhat in connection with the jacking-up of Ekofisk installations. Apart from a spike in 1992, with the laying of the Zeepipe line, this part of the business declined year by year. The upswing in connection with Zeepipe helped to make the contrast with the following years all the greater. While 2 252 surface dives were made and 177 211 work-hours spent in saturation during 1992, these figures had dropped to 47 and 28 662 respectively by 1996.[26] Surface diving was reduced to a 50th of its peak level. Similarly, saturation diving declined to a 10th of the good years in the 1980s. The bottom had fallen out of the diving market on the NCS. This meant that a profession had largely been wiped out. Stolt Comex Seaway (SCS), which remained as the largest diving contractor on the NCS, had to implement redundancies. Its workforce was reduced from 130 divers to a permanent core of 30-40 saturation personnel.[27]

From diving company to global diving contractor

However, what was in every respect a crisis for the North Sea divers and Norwegian diving expertise was not such a problem for SNS and its dominant owner, Jacob Stolt-Nielsen Jr. Although the number of divers declined, the total amount of work for the diving contractors remained unchanged. Its vessels and its expertise, with ever better and more flexible ROVs, meant that the largest Norwegian diving company was well placed to secure contracts on the new fields which were due to be diverless. Before these technological opportunities could be exploited to the full, however, the company's business philosophy underwent a fundamental shift. The contrast between August 1986 – when SNS begged for protectionist support from the Norwegian government – and the early 1990s was so great that it can only be explained as a paradigm shift.

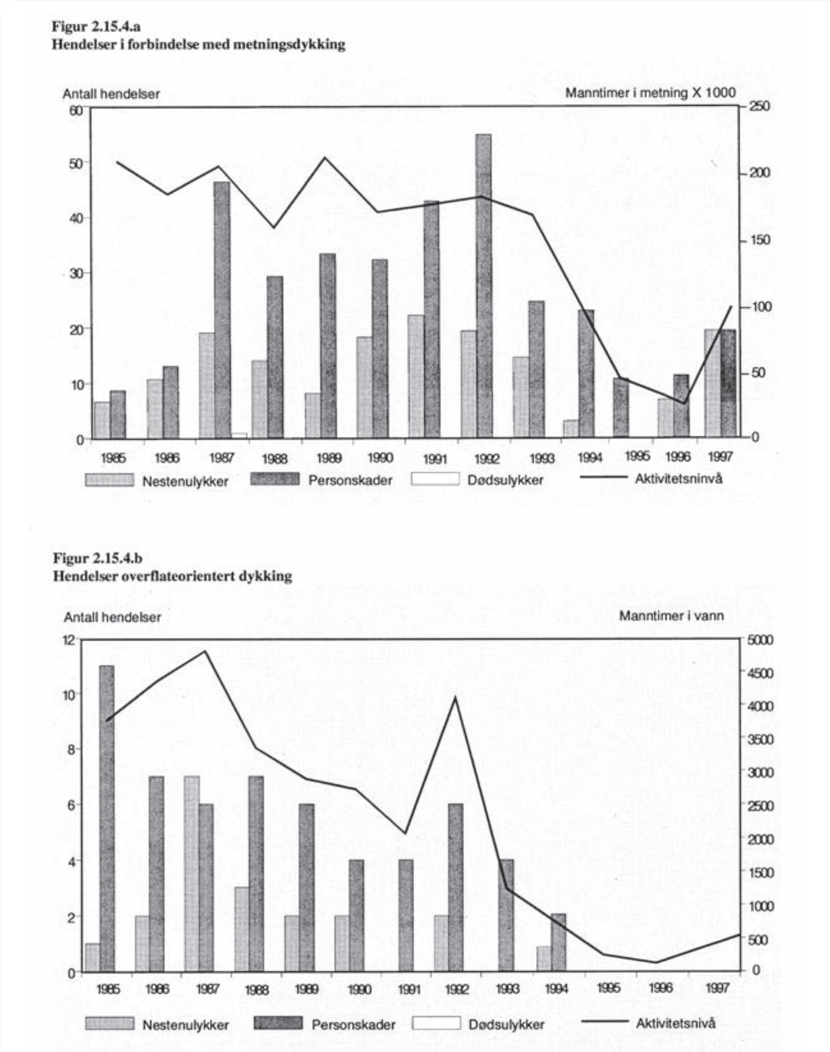
The oil business and all its associated industries has always had an international character. From the mid-1980s, the world economy experienced a sudden and sharp growth in direct foreign investment, which would have major consequences for all oil-related operations. A wave of mergers and acquisitions washed over the globe. In most cases, these transactions were part of a process which created larger and more international combines. But a number involved hostile takeovers which were pushed through in opposition to the local management and workforce, and the relevant company ended up being divided into smaller units. One book after another from around 1990 gave this new phenomenon the title of globalisation.[28]

SNS found internationalisation both a necessity and an opportunity. Stolt-Nielsen himself and the company management naturally noted both the visions of the Norwegian oil companies for a diverless future and a growing scepticism towards supporting domestic enterprises through various protectionist measures. To secure the company's future, winning contracts on the UK continental shelf (UKCS) accordingly became more urgent. Oil companies operating on the UKCS had not expressed corresponding visions of a diverless future. Moreover, British offshore activity was largely being pursued in shallower waters than on the NCS. SNS acquired a diving base in Aberdeen during 1989, and had already registered a UK subsidiary. It thereby acquired the same position in the UK that several foreign diving contractors had long held in Norway, and could – like them – easily employ British divers who could be transferred to the NCS on UK terms of employment when required.

While the Norwegian safety regime had been a disadvantage in competing for contracts on the NCS, it would prove to be beneficial in other parts of the world. The extensive use SNS made of ROVs and much other advanced, automated subsea equipment represented in many respects an adaptation to the strict safety requirements on the NCS. This technological expertise gave SNS an edge when oil operations moved into deeper waters in other regions. At the same time, the 1990 contract from Statoil, which long hung by a thin thread, became crucial for the company's future. SNS suddenly began making money. That was important at a time when everyone was seeking to buy up everyone else. In 1992, it was announced that SNS was merging with Comex to create SCS. This was no branch which changed its name to enter a specific market more easily, but a genuine Norwegian acquisition of ownership. The strategist behind the merger was Stolt-Nielsen. So the takeover appeared on the surface to be a small victory for the Norwegian diving business. Which diver in Norway would have thought in the late 1960s that mighty Comex itself would be acquired by a Norwegian?

In reality, however, the new company was yet another sign of the weakening of Norway's diving community. Comex – which began, of course, as a product of a French national commitment to what was regarded as a technologically advanced industry of the future – had gradually become more British. Without support from the French state, the company struggled to survive. When Stolt-Nielsen took it over, the winner was the British part of the company. Most of what was left of SNS's activities in Norway were transferred from Haugesund to the Comex facility in Stavanger. Those SNS divers who had kept their jobs when the Statfjord contract was lost at about the same time found the position particularly difficult since they were now spread around on Comex DSVs. Most of the diving personnel on these were Britons who were paid on the basis of day rates rather than the comprehensible pay system which the unionised SNS divers were used to. The Comex divers, who were naturally also hit by the general decline in diving activity, regarded the Norwegian newcomers as a threat. Such conditions do not create a good working environment.

It soon became clear that Stolt-Nielsen's strategy with the acquisition did not involve either strengthening Norway's diving community or developing Norwegian subsea technology expertise. The headquarters of the new company were placed in Aberdeen, where both SNS and Comex already had offices. Locating the merged company's research and development in the Scottish oil capital was equally important. In that context, SCS acquired the National Hyperbaric Centre, a British



This figure clearly illustrates the collapse in diving work after 1993.
Source: NPD annual report 1997

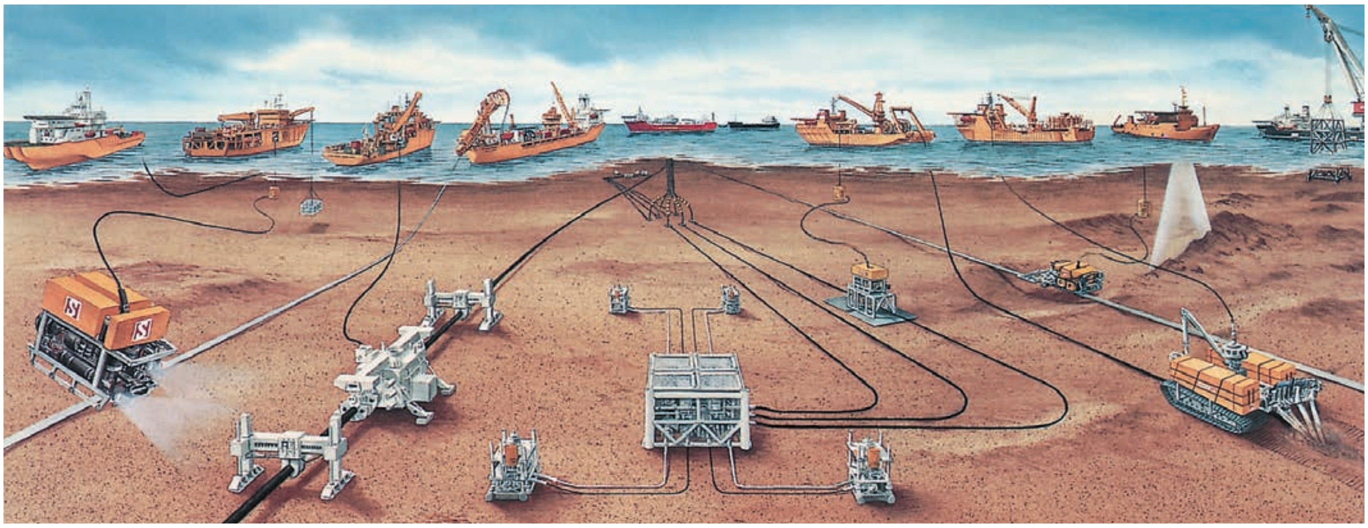
parallel to the NUI. SCS, soon renamed Stolt Comex, retained a substantial division in Norway. But there was never any doubt that this was part of a much larger organisation. Within a few years, the company had just eight permanently employed Norwegian divers. The Stolt Comex goal was to be a global diving and subsea contractor, and it succeeded in this ambition. At its creation, the company had operational offices in Marseille, Singapore, Brazil, the Netherlands and Norway. This international foothold was further strengthened in the years which followed through substantial acquisitions in both the USA and France. By 2000, the time had come for another name change, and the company operated for three years as Stolt Offshore. That proved a difficult period. The expansion had not always been equally purposeful. In 2003, the company was reorganised under a new management and a further name change, this time to Acergy.

Subsea projects off west Africa accounted for around 40 per cent of Acergy's operations internationally in 2007. The company had a large fleet of pipelaying vessels and ships specially designed for the installation and maintenance of subsea facilities. Among these were also a few DSVs, including a converted *Seaway Falcon* under the new name *Acergy Falcon*. Activities at the Norwegian subsidiary in Stavanger were not insignificant, but this unit was clearly part of a large global player. After Stolt-Nielsen sold out, the Norwegian majority on the owner side ended. Britons dominated both board and top management. The 14-strong management team included only one Norwegian, with the rest British or French.

A global industry

The merger of SNS and Comex was followed by corresponding developments in the rest of the diving industry. Despite the sharp reduction in diving on the NCS, such activity was by no means over internationally. On the contrary, in fact. The offshore-related part of the oil industry expanded strongly off Brazil and west Africa as well as in parts of Asia. None of these areas had diving restrictions comparable with those eventually developed in Norway. In a number of them, offshore installations stood in water depths where ROVs and automated technology were the only alternatives. However, operations in many regions were pursued in a mix of deep and shallow waters where diving was regarded as the best and cheapest option. The main trend was for pure diving companies to be replaced by a few dominant global contractors who spanned the range from diving to advanced subsea vehicles. Companies also emerged which specialised in delivering advanced subsea structures and pipeline systems but which did not have their own diving sections. A large part of the technological development in most of the companies took place in Aberdeen or parts of the US Gulf of Mexico – the traditional centre for the diving industry. However, technology advances in Norway were by no means insignificant. While the remains of the former SNS went international, companies also existed which built up a presence on the NCS to exploit Norwegian subsea and maritime expertise. Another period began when names changed more quickly than even experienced divers could keep up with. On this occasion, however, it was not national affiliation but a global presence which characterised both mergers and acquisitions as well as the actual naming.

One of the few companies which retained its old name was America's Oceaneering. Founded as a pure diving company in 1964, it had its last Norwegian diving assignment in 1989 on Veslefrikk. In line with the general trend in Norwegian diving, its subsidiary in Norway then



Equipment available to Stolt Comex Seaway (SCS), including DSVs and ROVs, immediately after the merger with Comex. The company maintained that it was thereby equipped to take on assignments wherever offshore oil operations were being pursued around the world.
Source: SCS annual report

resolved to drop all diving activity and concentrate on developing and operating ROVs. That did not apply to Oceaneering's international organisation, which maintained substantial diving expertise. But the multinational parent company also concentrated increasingly on automated subsea technology. While its ROVs were built in Louisiana, a significant part of the engineering capacity for developing these machines was located in Norway. The advantages of the Norwegian subsidiary were not only the generally high level of Norway's engineering expertise and the role of the NCS as a kind of laboratory for testing subsea technology, but also the generally stringent safety standards applied there. In addition to meeting requirements for robust and functional equipment, it was necessary to operate without divers as a possible backup. By managing all ROVs used in its activities throughout the North Sea from Norway, Oceaneering ran counter to the general trend in the diving sector. By the winter of 2009, it had some 5 500 employees globally. Of these, just over 500 belonged to the company's Stavanger office.[29]

Many Norwegian divers in the 1970s and 1980s would also have been surprised had they known that the remains of the diving division in Halliburton belonged to a Norwegian in 2009. During the early years after 2000, Norwegian investor Kristian Siem secured a controlling interest in Subsea 7. This subsea and diving contractor was the result of a complex process of acquisitions and mergers which had roots on one side in the venerable Norwegian steamship company Den Søndenfjelds-Norske Dampskipselskap AS (DSND). In the early 1990s, the latter had acquired a number of floating offshore units with dynamic positioning. It then took over the diving section of Halliburton in 2002 – including the remains of 2W's organisation in Aberdeen. With his large shareholding, Siem was chair of the company. However, his affiliation with Norway was limited. The company's shares were admit-

tedly traded on the Oslo Stock Exchange but, like Stolt-Nielsen, Siem had moved from Norway in the 1990s. He paid tax on his personal fortune in New Jersey. The management of the company comprised senior executives with backgrounds from Halliburton, 2W, Coflexip, Stena Offshore, Brown & Root and others. A Norwegian first appeared in the management hierarchy at the local subsidiary in Stavanger.

Subsea 7 competed in the same market as Acergy and Oceaneering. It had a similar number of construction and pipelaying vessels, as well as six large DSVs. That reflected the sharp expansion in international diving from the middle of the first decade of the 21st century. One of these DSVs was a modernised version of the old *Seaway Pelican*, now called *Pelican*. Like the other companies, most of Subsea 7's diving operations were pursued outside Norway. Some 5 000 employees globally put it on a par with Oceaneering. Its Stavanger office counted some 350 employees, mostly engineers.

A fourth large global subsea contractor is the French company Technip. This had its origins in Coflexip, a company which previously specialised in flexible flowlines for offshore installations. Following a number of mergers and acquisitions, the company is no longer confined to large subea assignments. It also produces piping systems for oil installations and refineries on land. Like SNS, Coflexip considered acquiring Comex in the early 1990s but ended up merging with Stena Offshore in 1994. It acquired Aker Maritime's subsea business along with other assets in 2000. However, the Norwegian subsidiary with around 300 employees in 2009 was small in relation to the 21 000 Technip personnel worldwide. When the company was still called Coflexip, it usually hired in divers from contractors as required. Its international expansion meant diving became so extensive that it became incorporated in Coflexip's core expertise. A certain amount of diving expertise also became important in the Norwegian subsidiary.

Continued diving

The big global subsea contractors made increasing use of in-house Norwegian diving teams after 2000 because the operators abandoned their goal of fully diverless working. Plans drawn up in the early 1990s to manage without divers had proved overambitious. Even when diving was at a low ebb, the companies were required to have an emergency diving response in case anything should go wrong with the pipelines crossing the Norwegian Trench.[30] This was achieved through collaboration between the operators. Statoil, Saga and Hydro awarded a joint contract for subsea services in 1993 to Rockwater,[31] while Phillips, Elf, BP and Amoco established a collaboration over subsea work – including diving – at the southern end of Norway's North Sea sector.

The new expansion in diving had many causes. As long as the water was relatively shallow, divers remained useful for pipelaying and its associated welding. They were also needed to replace old risers on producing fields. Much of the equipment which had been placed on the seabed during the expansive phase of the NCS had aged and needed replacing. Although a good deal of the new equipment was more automated, it often had to be connected to older technology – a job where divers were essential. That applied to facilities intended both to boost recovery from the old big fields, and to produce new small discoveries. Many of the latter, in fact, were commercial precisely because they could be tied back to existing platforms and pipelines. That often called for the use of divers. They proved far more flexible and thereby often more economic than specially tailored diverless solutions.

As long as diving proved useful and profitable in shallow water, it could in many cases also be a useful tool at greater depths. That revived the question of how deep divers should be permitted to go. The NPD regarded diving to 180 metres as no problem. If it was to go deeper, the directorate wanted more intensive health monitoring of divers and various other additional measures.[32] Britain set the corresponding division between deep and ultradeep diving at 250 metres. Efforts were made in the late 1990s to establish a similar boundary on the NCS. The question first came up in connection with the development of industrial standards through Norsok. A key goal for this collaboration was to harmonise regulations so that companies could move from one national continental shelf to another with a minimum of friction. A limit of 250 metres would harmonise with other European countries. The NPD agreed to relax its requirement.[33]

Kristian Siem secured control after 2000 of the diving business which had been pursued by Halliburton-controlled 2W. Subsea 7 had its head office in the UK and a small subsidiary in Norway.
Photo: Scanpix

This new relaxation of the rules was useful for Statoil and Hydro.[34] It was easier to maintain an emergency diving response at 250 metres than at 180, and would cover all the fields developed on the NCS. Pipelines and other equipment only lay deeper over a few kilometres in the Trench. In the event of an accident, one option was to lay a new pipeline in the deepest part of the Trench and tie it into the existing, shallower sections on either side. Another option was to secure remotely installable mechanical connections. That made it possible to do away with all diving-based emergency response between 250 and 360 metres.[35] Although no operational dives were made at such depths during the relevant period, maintaining such preparedness was expensive for the companies.

With the increased political attention being paid to diving on the NCS, however, extending the limit for deep diving solely on the basis of what other countries considered acceptable was difficult. Many years had passed since dives had been made to extreme depths in Norway. In 2002, it was 15 years since the OTS dives to 360 metres and 12 years since the Gullfaks C experiment and the demonstration dive to 300 metres in Bergen's By Fjord. To be on the safe side, a new test dive was planned at Norwegian Underwater Intervention AS (NUI), which had been split off from Nutec in 1998 to focus on work under water. The decision to amend regulations and standards had to rest on a Norwegian scientific base.

Failed test prompts new diving standards

A dry simulated dive to 250 metres was carried out from 26 February to 18 March 2002 in the test chambers at NUI. One purpose of this exercise was to measure the occurrence of "silent" bubbles during pressure changes and decompression to the surface. The dive was also intended to maintain and demonstrate NUI's emergency response system for evacuating saturation divers to a lifeboat-mounted pressure chamber during a crisis. The procedures followed were the same that would be used for a possible operational dive to this depth, and were in line with the requirements set by the NPD. Eight test subjects took part. One was a medical student, while the others were professional saturation divers from Statoil, Hydro and Stolt Halliburton Joint Venture, which was then Esso's supplier of emergency deep-diving response. All seven were part of the pipeline repair system (PRS) team maintained by the operators, and were among those who would be drawn on if repairs became necessary to pipelines or other installations in deep water.[36]

As with several of the earlier experiments at NUI/Nutec, however, this test proved a failure. Six of the eight participants were recorded afterwards as suffering injuries. Some time after the dive, three were out of diving for good as a result of this damage.[37] The reasons why a fourth diver left the industry were more uncertain. During the legal action taken by groups of divers against the Norwegian government (see chapter 13), various interpretations were presented of the extent of the injuries suffered by these divers. But the test dive was sufficiently unsuccessful for it to have immediate consequences.

When the results of the experiment became known through the media, the oil companies with Statoil in the lead adopted a self-imposed operational limit of 180 metres.[38] Internal control and the effort to develop regulations based on functional requirements, without too many detailed rules, meant that an unambiguous ban was never formulated. According to the internal control principle, operations should be acceptable at all times. As close to a ban as possible under the applicable regulations was achieved when the NPD also stated that it regarded diving beyond 180 metres as unacceptable. The directorate clarified its position further by making it clear that permission would not be given for diving deeper than 180 metres were the companies to seek such authorisation under the existing regulations.

So what about the old demand that the companies maintain a diving-based emergency response in the event of an accident with pipelines down to 360 metres in the Trench? Karin Andersen from the Socialist Left put this question to Conservative local government and labour minister Victor Norman. He responded that, were something to happen which could not be repaired without divers, the oil companies would have to shut down the relevant installations while awaiting suitable technological solutions. Nobody followed up this reply with a request for further amplification or studies. Norman's brief response represented a drastic break with what had been the most important underlying political condition for petroleum-related diving. The oil companies naturally had a substantial self-interest in being able to get down in very deep water were something to happen at these depths. From a purely financial perspective, they could nevertheless gamble on everything going well in any event, and thereby drop the need to maintain a diving-based emergency response for very deep water. Research activities at the NUI/Nutec in the 1980s would not have been so extensive without the political demand for a suitable diving-based response.

On most occasions, tighter safety regulations increase costs for the businesses concerned. In this case, paradoxically enough, the outcome was a reduction in spending. The signals given in the Storting told the companies that they no longer had to maintain an expensive diving-based emergency response for deep waters. For those divers who participated in the NUI test, and who were part of such an emergency response contract, this position represented a double paradox. Not

From the research dive at NUI in March 2002. Several of the participating divers faced problems after this experiment. This became known at the same time as the diver issue was under consideration by the Storting. The unsuccessful outcome accordingly played a part in the tightening of the regulations on the maximum permitted diving depth.
Photo: Einar Andersen

only were most of them injured, but the contract under which they worked was soon revoked. The new 180-metre boundary was both a tighter regulation and a deregulation. In practice, it was now up to the oil companies to conduct risk assessments of whether they should let old pipelines lie and accept the possible cost of a complete shutdown if anything went wrong, or immediately start to ensure that equipment in the relevant depths was tailored as far as possible for automated diverless technology.

That such a fundamental change in the conditions for diving on the NCS could be implemented without debate partly reflected the reality that many years had passed without a single incident involving deepwater pipelines. The emergency response which had been put in place was never used. It could be asked whether the probability that something would go wrong might not increase as the relevant installations and pipelines aged. With the increased focus on diver health, however, the balance sheet suddenly looked different.

A future for NCS diving

The criticism which followed the unsuccessful experimental dive in 2002 posed problems for the groups still seeking to develop Norwegian diving expertise. Although the emergency response contracts were cancelled, diving on the NCS continued to increase fairly sharply. Its scale was still small in 2002, with 12 000 work-hours in saturation. That figure was up to 54 000 in 2004, declined again in 2005 but rose to just over 100 000 in both 2006 and 2007.[39] Although surface diving was minimal, it reached about half the level of the late 1980s. In other words, a genuine revival of diving as a viable profession occurred in the Norwegian petroleum sector.

It had long been envisaged that activity on the NCS would take place in ever deeper water. And many important new fields did indeed lie in depths beyond the limits now set for diving. Ormen Lange lay in 800-1 100 metres, Snøhvit in 310-340. Since both these fields were developed with processing transferred to land, however, substantial diving work was only involved on that part of their installations which were close to shore. During completion of the Snøhvit landfall at Melkøya outside Hammerfest, for example, divers were used to install valve stations on the pipelines. Despite the many new fields in deep water, a recognition emerged that a significant proportion of the remaining reserves on the NCS were located in small discoveries associated with existing fields west of the Trench. Divers were used for a hot tap operation (drilling a hole in a pipeline without emptying it first) in 150 metres on the new Tampen Link pipeline near Statfjord.[40] The important aspect for the future was its clear acknowledgement that diving had come to stay on the NCS.

Although it had been accepted that divers should not descend beyond 180 metres, diving of the kind which took place on Tampen Link was still demanding. Most of the earlier fatal accidents and long-term injuries which had now been identified among the pioneer divers could be related to dives at even shallower depths. Major health, safety and environmental challenges accordingly continued to be posed by the diving revival. Had lessons been learnt from earlier errors? The accident statistics suggested that they had. Despite the increased scale of diving, no fatal accidents had occurred since 1987. Nor were new incidents of the bends recorded after 2000. But that does not mean the work had become risk-free. Three serious near-misses were recorded in 2007 – including a fire in an engine room and a power supply failure on a DSV. Both incidents could have been very serious for divers in the water had they not been brought under control. In the third case, a diver was pulled down from 22 to 35 metres by an ROV. The biggest uncertainty remained the possible long-term effects of diving. Minimising cases of the bends had largely eliminated what was regarded as the most important reason for the long-term injuries suffered by many pioneer divers. Nevertheless, a degree of uncertainty continued to prevail about the effect over time of possible types of decompression sickness which were less serious and more difficult to record.

When diving was at a low ebb in the late 1990s, it was conducted on short-term contracts. That practice continued after 2000. This meant that, even if the jobs were given to Norwegian-registered diving companies, virtually all the divers – regardless of nationality – were hired and paid by foreign firms registered in the UK and Singapore. Employment lasted only from the time the diver went on board until he left, so they had no job security.

Statoil, as the largest operator by far on the NCS, took new steps with the organisational framework for diving. It accepted that, in order to do something about diver safety, overall working conditions had to be better organised. The use of short-term contracts was rejected. An action team appointed in 2006 developed a specification for subsea contractors hired to work for Statoil. This built on the results of a study conducted by an action team led by Statoil, with representatives from Hydro, Esso, Subsea 7, Acergy, the research institutions and the diver education section at Bergen University College. Nopef and the NPD had observer status. The team's report laid the basis for all the measures subsequently adopted by Statoil, Hydro and Esso to improve diving safety.[41] These include requirements that divers be given a permanent job and a career plan, combined with a commitment to develop new diving equipment and build new DSVs.

Two five-year contracts awarded by Statoil in 2007 to diving and subsea contractor Technip Norge AS represented a substantial expansion in the company's diving capacity. The divers taken on had to have a career plan which included a programme for monitoring their diving exposure and long-term health follow-up. For the first time, the contract of employment for an individual diver accorded with the provisions of Norway's Working Environment Act by setting no time limit.

Purely technological advances also made diving both safer and more comfortable. Like so many other industries, diving had made considerable strides through exploiting the opportunities offered by modern computer technology. That included controlling the right gas mixes. Diving spreads on the latest DSVs were more ergonomic. Under its long-term contract from Statoil, Technip worked on a completely new type of diving system which aimed to eliminate many of the hazards which had earlier caused a number of serious incidents. Instead of receiving breathing gas through a long umbilical, with mixing at the surface, a diver would carry a back-mounted system to recirculate breathing gas. A new type of electrically heated dry suit also eliminated the need to pump hot water from the surface. In practice, that eliminated the umbilical which had been a hazard in itself, was heavy to drag around, reduced diver flexibility and took up a lot of space in the bell. All that remained was a thin cable for data transfer, which allowed surface personnel to communicate with and monitor the diver. Once again, it seemed, relatively stringent safety requirements on the NCS helped to drive diving technology forward.

By 2009, the large global subsea contractors had a substantial number of DSVs with an associated group of divers as part of their core expertise. The number of divers was small compared with the large

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groups of engineers and construction works which dominated these companies. A high proportion of engineers reflected the fact that this is a very technology-intensive industry. Where diving is feasible, however, the competent diver still remains important for the offshore oil industry – even when using the most advanced subsea equipment. The many challenges posed by offshore diving still have to be fully overcome, but the new generation of divers works under operating parameters and with equipment which the pioneers could only dream about. Many people were accordingly disappointed that virtually all public attention had focused for a whole decade on the many errors made earlier.

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Chapter 13

The diver issue

The years after 1993 proved an anticlimax for the Norwegian divers. Only a few of them retained their diving jobs. Some secured either management posts or other types of work in the diving companies. Most were forced to find something completely different to do. The labour market was not at its best. Norway had been through a period of property and bank crises, and of relatively high unemployment. However, the business cycle was on the way up again. Although few of the divers had an education beyond their necessary diving training, their versatile background as problem-solvers for all types of underwater work was a good basis for alternative careers. Most also secured other kinds of work. Many managed well. But it soon transpired that a worryingly high proportion failed to cope with the transition. Their time as North Sea divers had left its mark.

The Haukeland doctors

In many respects, the groups of experts who had dealt with the divers in Norway also found the post-1993 period to be an anticlimax. That applied not least to the medical specialists. With all research diving halted and a diving industry which had swiftly declined to a fraction of its previous size, the need to monitor active divers had been reduced to a minimum. After being a recurring topic in public debate until 1993, virtual silence descended on diving and the divers. The reduction in work naturally also meant fewer acute diver injuries to deal with. The role as the institution responsible for following up hyperbaric medicine challenges accordingly had little practical significance for the occupational medicine department at Haukeland Hospital to begin with.

A diver looks back. Arne Jentoft recalls old times.
Photo: *Stavanger Aftenblad*

Physicians at this newly established unit had more than enough other problems to deal with.

From the second half of the 1990s, however, the physicians observed that a growing number of former North Sea divers were being referred to them from other health institutions around the country. They also noted another worrying trend. Svein Eidsvik, who was still a diving medical officer at Haakonsvern and had a finger on the pulse of the earlier diving community, told *Dagbladet* in December 1997 that he knew of six former North Sea divers who had committed suicide.[1] He received support for his comments from Harald Nyland at Haukeland, who linked the many suicides to the position which former North Sea divers suffering from occupational injuries found themselves in after the diving market collapsed:

> We know they've been successful people with good incomes and high status. Their jobs suddenly disappeared. Nobody was prepared to accept an overall responsibility for them any more. The government hasn't quite understood the problems facing these fellows. They have to fight for years to get disability allowances, for instance. That leaves them worn out and disillusioned. Many marriages fail …

The Haukeland physicians took the view that the complaints reported by the divers were similar to those established by Todnem in her general health investigations. Many of the sufferers had got worse, making the consequences for their quality of life all the more serious. The position was not improved by the fact that many of those who sought to get help felt they were banging their heads against a brick wall of government bureaucracy. Haukeland's occupational medicine department was commissioned in January 1998 to study which types of diver injury should entitle the sufferer to compensation. The Kromberg commission had requested such a clarification as early as 1993. On its own initiative, the department also decided to study the issue in greater depth. Senior consultant Einar Thorsen in the hyperbaric medicine section secured the appointment of an internal committee which aimed to sum up everything known about possible long-term consequences of diving.[2] This body comprised 11 physicians from a number of Haukeland departments as well as Eidsvik and Jan Risberg from Haakonsvern. They were all people who had viewed activities in the diving industry with scepticism for many years.

Presented three months later, the committee's report dealt with the effects of diving on the individual's pulmonary (lung) function, nervous system, hearing and balance, risk of developing aseptic bone necrosis, and possible damage to mental functions. Literature referenced in all these medical fields identified major or minor effects from diving.

Key members of the team in Haukeland Hospital's occupational medicine department which investigated the pioneer divers. From left: Endre Sundal (neurologist), Professor Einar Thorsen, Kari Troland (psychologist), Marit Grønning (neurologist) and Ågot Igens (statistician).
Photo: *Dykkernytt* no 1/2005

New publications had also appeared in several of these areas since the 1993 Godøysund conference. Drawing on their investigations of the many divers referred to Haukeland, the physicians asked for the first time whether divers could suffer from post-traumatic stress disorder (PTSD). This condition had been identified as an occupational injury in such vulnerable professions as the police, fire-fighting, rescue services and so forth. The physicians maintained that good grounds existed for a closer investigation of whether many divers also suffered from it. Although they took the view that diving of the kind carried out by many North Sea divers could cause long-term injury, the report concluded that further research was required in each of the fields studied. They did not have to wait long before such work was initiated.

When diving seriously entered the agenda for public debate after 1999, a pressing need again arose to clarify the general effects of deep diving and the health consequences for the individual diver. Haukeland was commissioned on 4 July 2000 by the Ministry of Health and Social Affairs to conduct a more extensive health survey of both former and remaining active divers. This study was even more detailed than those carried out by Todnem in the late 1980s. Divers were called in for observation over a continuous three-day period. Just over 100 of them participated between 2000 and 2002 in a survey which covered all possible relevant health issues – from neuropsychology to lungs and hearing. A preliminary report was submitted to the ministry in July 2003, followed by the final version in December 2004.[3] Various sub-studies subsequently appeared in international journals.[4]

Since the basis for the Haukeland study had been divers referred for health checks on the basis of the complaints they suffered from, the sample was not random. More than 100 divers had been studied before the final report was submitted, which represented a substantial proportion of Norway's North Sea divers. That such a large percentage had been referred for health checks was a disturbing sign in itself. In order to ensure the most representative sample, a number of those who had been referred were excluded from the statistical calculations. The report built on 81 former North Sea divers aged 35-66. This group was considerably older than when Todnem conducted her investigations, with an average age of 51.6 years and an active diving career averaging 18.6 years. Since the study was so detailed and covered such a large proportion of former North Sea divers, it represented valuable research material. As with Todnem's studies, it was pointless to conceal from the health personnel conducting the tests and interviews that those involved were divers.

Many people had earlier believed that divers treated for the bends were completely cured. But the Haukeland investigation concluded that a clear link existed between the most serious form of this condition (neurological or Type II decompression sickness) and long-term effects on the nervous system.[5] Many divers had balance problems, disruption of their sense of touch, and neck and back pain. The divers studied showed "an intact ability to solve complex problems when speed was not a requirement". The speed, power and steadiness of motor skills were also normal. On the hand, the subjects showed rather poorer results for tasks which called for attentiveness, concentration, memory, mental speed and flexibility. Results also supported a number of other earlier hypotheses about possible negative health effects after extensive deep diving. The study made it clear that the causes of the divers' problems could be complex. No less than 96 per cent of divers investigated had been exposed to life-threatening incidents, which demonstrated in itself that they had collectively survived very difficult working conditions. In order to come up with more answers, the Haukeland team continued its investigations with the aim of mapping the health effects on the largest possible sample of divers who had worked on the NCS.

An international consensus conference was again staged for the world's hyperbaric medicine community on 15 September 2005, this time in Bergen. Most of the medical specialists who had made their mark on the debate since the late 1970s were present, including Bennett and Elliott.[6] While the various positions had not changed a great deal, the most important difference from the Godøysund meeting in 1993 was that far more results were available to support the view that deep diving could have long-term effects. As at earlier conferences, the final declaration was disputed. However, the following statement acknowledged that the Haukeland team was right on significant points:

The consensus conference on hyperbaric medicine in session in Bergen during September 2005. Peter Bennett is third from left in the front row.
Photo: Vidar Fondevik

> It has been scientifically documented that changes in pulmonary function, the central nervous system, the skeleton and the hearing/balance system can be identified in some professional divers. The size of these changes is very variable and has the potential to affect the quality of life of the divers. Knowledge of the exact mechanisms is still limited and calls for more research. This requires the adoption of preventive measures, including health monitoring, for future diving.[7]

Following the conference, the Ministry of Labour and Social Inclusion urged the Petroleum Safety Authority Norway (PSA) – the former safety division of the NPD spun off as a separate regulator in 2004 – and the NLIA to take the signals from the medical specialists seriously.[8] The ministry referred explicitly to research at Haukeland and called on the industry itself to apply the precautionary principle when planning and executing diving work.

North Sea Divers Alliance

The increased attention paid by the medical profession to the divers during the 1990s was not entirely self-generated. The diver community which had existed in association with the largest diving contractors and at social meeting places in Stavanger and Haugesund more or less collapsed with the sharp contraction of the industry in the early 1990s. Divers found themselves spread around the whole of Norway. Many returned to the local communities where they had grown up. Certain of the divers who were suffering from long-term effects got legal help from Nopef to secure their basis social welfare rights.[9] However, a great many struggled on their own with what they perceived as diving-related health problems. During the 1990s, divers Rolf Guttorm Engebretsen and Tom Engh took on the laborious task of contacting the divers suffering problems around Norway.

Engebretsen had grown up with a father who was a diver, and dived for the first time in the North Sea as a very young man in the early 1970s. He was affiliated with Norwegian contractor 3X for a long time, and became a foreman there in the late 1970s. His most important diver-related experience had been on the Condeeps. Engh worked as a diver for the Oslo Fire Brigade in the late 1960s. During the 1970s, he was a colleague of Engebretsen at 3X. He became disabled after a dive for ScanDive from DSV *Arctic Seal* in 1978, and was one of the divers involved in Todnem's general health investigation.[10]

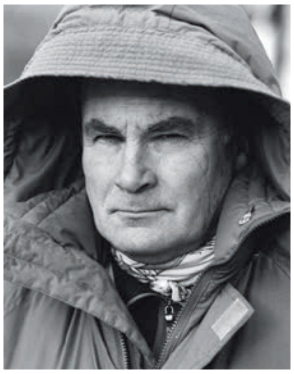
Neither man belonged to the group of unionised divers who had promoted the diver cause to the companies and the government from the late 1970s to the 1990s. Engh was invalided out at roughly the same time as the SNS divers first unionised, while Engebretsen was a diving supervisor and foreman. They accordingly got to grips with the diving case without a background in the type of organisational culture which the Nopef divers were trained in by the LO system. That would later contribute to a good deal of internal friction between the divers. The tireless efforts of Engebretsen and Engh to call attention to the diver issue helped them during the 1990s to build a substantial informal network of divers who had suffered problems as a result of their North Sea careers. This network also embraced divers who had been Nopef members.

As with the unionised divers, appeals to the general public through the media became the most important weapon available to the pair. Engebretsen was an important source when Eidsvik reported in 1997 that six former North Sea divers had committed suicide. The breakthrough for their work was a big article across five pages in the magazine supplement of business daily *Dagens Næringsliv* on 15 May 1999. This report began with an account by Engh of an incident during the

construction of the concrete GBS for Britain's Cormorant platform in 1977. It then interviewed doctors who had voiced criticisms about North Sea diving in the late 1980s and 1990s. The introduction to the article revealed that Engh had written a letter to the King. A couple of days later, at the official inauguration of the Norwegian Petroleum Museum, Engh delivered this letter to the monarch in person. The hand-over was a kind of stunt which took the organisers and the King's security guards by surprise.[11] Engh quickly stepped back after saluting the monarch. The event had no follow-up apart from its success in attracting further attention to the diver issue.

A series of long articles on the fate of the divers in *Dagbladet* that September aroused the ire of many Norwegians.[12] Yet again, the stories told by the divers were followed up by critical comments from Eidsvik at Haakonsvern and physicians from Haukeland. The divers had once again become a public "issue".[13] In addition to the extensive coverage by full-time press and TV reporters, many freelance journalists became so angered by what had happened to the divers that they became direct supporters. Some contributed actively to gathering documentation. Others drew on their background as writers.[14] However, the basis for

Rolf Guttorm Engebretsen devoted most of his time from the mid-1990s to bringing the fate of the North Sea divers successfully to public attention in Norway.
Photo: *Stavanger Aftenblad*



Tom Engh suffered an occupational injury as a result of diving in 1978. Together with Rolf Guttorm Engebretsen, he played a key role in establishing the North Sea Divers Alliance (NSDA).

public attention was completely different from earlier rounds of media coverage. Until the late 1990s, the discussion had focused on whether the diving industry should be regulated in a way which prevented the divers from injuring themselves through their work. At the turn of the century, however, the challenges posed by diving had primarily become a question of healing old wounds – of responsibility and compensation.

At one point, it looked as if the issue would be quickly resolved. Social affairs minister Magnhild Meltveit Kleppa announced on the 6 December 1999 that the non-socialist coalition government headed by Kjell Magne Bondevik was willing to establish a compensation scheme.[15] She promised rapid action and pledged that the divers would not meet a bureaucratic wall this time. The accounts given by Engebretsen, Engh and a number of other divers had made an impression. The divers felt that they now had considerable public sympathy for their cause. Engebretsen and Engh came across as forceful spokesman with great appeal both at public meetings and in the media. At a big conference organised by the Federation of Oil Workers Trade Unions (OFS) in late January 2000, they presented the divers' case to an audience which included Statoil's newly appointed chief executive Olav Fjell and Siv Jensen, first deputy chair of the right-wing Progress Party.[16] Like the others in the auditorium, they were clearly moved by what they heard. A contact was established which would ultimately lead to financial compensation and political support. The increased media attention had greatly extended the network around Engebretsen and Engh. In the time to come, they described themselves as representatives for the North Sea Divers Alliance (NSDA).

But the next development was a disappointment for the divers. Early in April 2000, then social affairs minister Guri Ingebrigtsen announced that all North Sea divers would receive a compensation of NOK 200 000.[17] At the same time, anyone who so wished could have their level of disability reassessed by specialists in hyperbaric medicine. This was far too little to satisfy the divers. They were agreed that any compensation for their injuries and losses would have to be substantially larger than the government offer. It was now clear that the issue was so politically sensitive and had such a scope that it demanded a more extensive assessment. The newly installed minority Labour government led by Jens Stoltenberg resolved on 13 June 2000 to establish a commission of inquiry on the diver issue. Petter A Lossius, a judge at the Borgarting Court of Appeal, was appointed to chair this independent investigation on 2 March 2001.

The Lossius commission

The inquiry was given a very broad mandate. It was to assess all aspects of the diving industry in the North Sea during the "pioneer period", defined as the years between 1965 and 1990.[18] The commission was to investigate whether any basis existed for claiming that injuries had been caused by diving. This meant in practice that it was asked to provide a qualified assessment of the dispute on the consequences of diving which had prevailed in Norway's hyperbaric medicine community since the early 1980s. However, the mandate adopted by the Storting specified that the commission should make use of the investigation of diver health then being conducted at Haukeland.

Given that a link was established between diver injuries and the type of diving which had gone on, the commission was to assess whether anyone could be held accountable for this and whether a legal liability rested on the government or other players. It would be up to the Storting to consider the commission's recommendations. As the mandate was formulated, the commission was required to come up with a kind of historical judgement over North Sea diving. But it was given a deadline of December 2001 despite the scope of the mandate, to ensure that the divers would not risk another long wait.

The establishment of the commission, the extensive health studies at Haukeland and the creation of the NSDA had once again dramatically changed the position of the divers. They had secured a number of arenas where they could act collectively. The Storting's mandate specified that the NSDA should be given observer status on the Lossius commission. This prompted certain moves to put it on a more formal footing, and the organisation was officially founded on 26 August 2001.

Nevertheless, the NSDA continued to act as an informal network. No reliable sources exist about the number of divers it represented at any given time. The biggest growth in members and contacts was achieved in connection with the media reports during the autumn of 1999. These recruits included former elected Nopef officials such as Henning O Haug and Arne Jentoft. A substantial group of former North Sea divers still existed who felt they had managed well, and who were either still working for diving contractors or had secured other types of jobs. This group could find the many stories about diver health problems difficult. A lot of them were proud of the work they had done in the North Sea, and did not want to be regarded afterwards as invalids. On the other hand, should the Storting end up proposing a general compensation scheme for everyone who had performed a certain number of dives in the pioneering days, this group was also interested in the NSDA's efforts.

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During the first phase of the Lossius commission's work, collaboration in the network of divers associated with the NSDA functioned well. They made an active contribution not least by digging out the names of former North Sea divers. Various NSDA representatives participated in many of the interviews conducted to acquire information for the commission, and had the opportunity to put questions. As the work advanced, however, a mutual distrust developed between several commission members and the divers. Some of the former were felt by the NSDA's representatives to be too close to interests which might bear a liability for the errors made. For its part, the commission found it difficult to relate to the untraditional, informal way in which the NSDA was organised.

The OFS and Nopef unions withdrew in June 2002 from a contact forum created in connection with the commission, reflecting growing distrust among the divers in its work. On 30 September, the NSDA also formally quit as an observer. One motive for establishing the commission had been to reach a kind of consensus on the errors committed. The prospects for achieving that goal were not the best, since all the diver organisations had broken more or less symbolically with the inquiry even before it reported. This was a perspective discussed by professor Henning Jakhelln, a well-known Norwegian specialist on labour law, in *Dagbladet* immediately before the report was presented.[19] He noted that conflicts of interest existed because one commission member worked for DNV, which had been a party with an independent responsibility on the regulatory side. Another member was employed in a company part-owned by DNV. Jakhelln also noted that both members with a medical background came from only one of the two groups which had clashed over the health consequences of diving. The Haukeland side was not represented.

Report, White Paper and recommendation

The Lossius commission completed its final report on 31 December 2002, a year after the Storting's original deadline. Immediately after the New Year, it was presented to Victor Norman as minister of labour and government administration. The report bore witness to the extensive work done by the commission.[20] Despite the distrust expressed by the divers during the final phase, a number of the commission's principal conclusions represented an unambiguous admission that North Sea diving had imposed extraordinary burdens on those who carried it out. In a comment summarising its findings, the commission noted that roughly three out of four divers had experienced accidents or illnesses. More than half had suffered the bends. The report also pointed out that every fifth diver had lost consciousness during a dive, and no less than 83 per cent had experienced life-threatening conditions while diving. Dealing with the roles of both the NLIA and the NPD as regulators, it unambiguously concluded that regulation of diving up to 1978 had been weak.[21] Furthermore, the commission placed great emphasis on the long-running dispute over which government agency should be responsible for regulating the diving sector. It took the view that this argument had delayed safety work and thereby probably contributed to incidents.[22] In its principal conclusion, the commission went a long way towards suggesting that the Norwegian state had an objective legal liability towards the divers:

> The commission believes that, viewed overall, a strong argument exists that the state has a legal duty and should therefore bear the economic liability for the injuries suffered by a number of divers as a result of diving in the North Sea and for injuries which could give rise to delayed effects.[23]

When the Ministry of Labour and Government Administration submitted a White Paper in June 2003 based on the Lossius commission's report, it built on the most critical comments in that document – both on diver health and on safety work by the government and the companies.[24] The introduction to the White Paper was an unambiguous admission that the government accepted a moral responsibility for the mistakes made, and that the divers would be compensated for this:

> The government's intention is that the pioneer divers who did a groundbreaking job in the North Sea from 1965 to 1990, also known as the pioneering period, will receive reparation and the financial compensation to which the Storting and the government believe they are entitled. The government accordingly believes that a compensation scheme should be established for the pioneer divers, and that this group should receive collective recognition.[25]

But the White Paper departed from the commission's recommendations on one key point. With reference to assessments by the legal department of the Ministry of Justice, the government denied that the state had an objective legal liability for the position in which the divers found themselves.[26] This point was to be important in the further follow-up of the diver issue. Where the framework of a compensation scheme was concerned, the government presented only general formulations. It was stated that compensation would not be related to possible previous payments. Furthermore, the White Paper emphasised that consideration had to be given when determining the size of any payout to equal treat-

Henning O Haug (top) and John A Haugestad (above) are the president and deputy president of the Offshore Divers Union (ODU). Both were members of the North Sea Divers Alliance until 2004, when they left to found the ODU. Like many of the other divers in this organisation, Haug was active in Nopef. Haugestad was a diving supervisor for many years. Photos: John Steve Haugestad

ment with other groups which had been compensated by the state. The actual form of a scheme was postponed until the budget debate that autumn.

More than three years had now passed since the Storting resolved to appoint a commission to assess the diver issue. The constant postponements began to resemble the unjust process which had characterised the framing of safety regulations in the 1970s. During the Storting's Question Time, Ågot Valle from the Socialist Left noted that a number of divers were deeply in debt and needed urgent measures to keep their creditors at bay. The ministry was prepared for such criticism. Norman announced when presenting the White Paper that NOK 10 million had been allocated as a fund to which divers in financial distress could apply for payouts of up to NOK 200 000. He also reported that NOK 1.5 million had been appropriated to establish a foundation which would operate a helpline for divers. This was to be administered by the Norwegian Church Abroad.

In the White Paper, the government made it clear that it wanted the biggest possible Storting majority behind what it called "the final settlement for the divers".[27] This formulation expressed a genuine desire to eliminate the political headache which the diver issue had become. As a minority coalition, the centre-right Bondevik government remained in office through the goodwill of the Progress Party to its right. Together with the Socialist Left and the Centre Party (largely representing farm interests), the Progress Party had often spoken in support of the divers. The latter also had sympathisers in several of the other parties. By passing substantive consideration of the issue to the Storting's standing committee on local government, the coalition avoided the burden of securing agreement on such a complex matter.

Nor did the local government committee find this an easy subject. An open hearing was held in the Storting on 10 November 2003, where Engebretsen and Haug were among those who spoke on behalf of the divers. During the hearing, Engebretsen said that an acceptable settlement had to comprise a one-off payment, a pension scheme and treatment for the divers' injuries. By that time, it was clear that the committee would not agree on a scheme before Christmas. Progress Party representative Per Sandberg, who was the committee rapporteur on this issue, and committee chair Kleppa from the Centre Party agreed that it was more important to reach the right result than to act hastily.[28]

The final negotiations in the local government committee took place in early March 2004. It was long the goal to achieve a unanimous recommendation. The governing parties and Labour wanted a solution where the divers as a group were treated in relation to their degree of disability. At the same time, they were all to receive a similar sum as compensation and restitution. The minority, comprising the Progress

Party, the Socialist Left and the Centre Party, wanted an individual approach where compensation was calculated on the basis of how long a disability had lasted. According to the majority, each diver would receive a one-off payment of NOK 200 000. Pressure from the minority led to some increase for various types of disability. The Storting finally resolved on 9 March that compensation for full disability would be increased from NOK 1.7 million to NOK 2.3 million.[29] Adding in the NOK 200 000 lump sum, the highest compensation any diver could receive was thereby NOK 2.5 million.

Since relatively few divers would qualify for the maximum payout, the difference between the majority and minority was not frighteningly large. According to the majority, the final bill for the settlement would be NOK 400-500 million. The minority calculated that its proposal would cost some NOK 700 million. The majority recommendation represented the largest collective government compensation settlement in Norwegian history. If the goal had been to reach a final solution to the diver issue, an additional cost of roughly NOK 200 million might not have been overmuch for Norway – particularly when the revenues generated for the country by oil are taken into account. Government income from the petroleum sector totalled NOK 200 billion in 2004, and the government oil fund amounted in the same year to NOK 1 000 billion. The majority was unquestionably concerned with establishing a precedent. Since the government insisted that the compensation should be paid over the regular budget, rather than from the oil fund as the minority was demanding, this represented a genuinely large outgoing which had to be accommodated with other budget items. The diver issue may not have been finally resolved even with the minority's proposal. In any event, the political effect of the majority recommendation was predictable. Sandberg told *Stavanger Aftenblad* that the scheme would arouse irritation among those the Storting wanted to help and honour. "I don't think we're writing the last chapter with this," he said. His observation was immediately confirmed by Engebretsen as the NSDA spokesman: "NOK 2.5 million is a laughably small amount. We don't accept it as an apology for the treatment we've suffered".

Arguing over apology and compensation

Most Norwegians did not regard NOK 2.5 million as a small amount. That was undoubtedly also the basic view of the Storting majority, which wanted a ceiling for payments to the divers. The amount involved was of such a size that the divers risked losing a certain degree of public sympathy if they demanded more. With the payout scheme now proposed, none of the divers could claim to be in any acute distress.

But Engebretsen nevertheless had most of them on his side when he concluded unambiguously that the amount was insufficient. Only those who were completely disabled would receive the maximum payout. The divers maintained that the total would not look so large if it was divided by the number of years the relevant recipients had had to suffer from their injuries. Those divers who had been most closely involved in the process leading to the final Storting decision undoubtedly also found the way the scheme was agreed a further source of dissatisfaction. The divers had hoped that they would in practice have been included in the negotiations, that the Storting would end up with a plan which they could support. Instead, they felt once again excluded.[30]

The process for paying compensation was nevertheless implemented, regardless of the divers' protests. These payouts and the assessment of each diver were left to a specially appointed board. Although many divers remained dissatisfied, the efforts by the NSDA to get the diver issue into the limelight had yielded genuine financial results. Many divers had received payments in several stages. Some had received insurance payouts from their own companies. For the majority, the first payment had come since 1 July 20002, when the then Ministry of Health and Social Affairs established a scheme for North Sea divers who had suffered lasting ill health which reduced their earning ability. They could receive a grant of up to NOK 200 000. The following November, Statoil established its own compensation scheme for all divers on the NCS – including those who had not worked on its own projects. The top payout was NOK 750 000. Financial support was also provided for surviving family members. As with the ministry's scheme, Statoil linked payouts to the level of disability. A diver's assets above a certain level were taken into account, too. The company allocated roughly NOK 77 million in all to this scheme.

The final payments under the Storting's compensation scheme began in 2005. Those who wished could take the money in small amounts over a lengthy period. However, virtually everyone opted for a lump sum. Some NOK 500 million had been paid at 1 January 2009.[31] This was allocated to about 200 divers who had been able to establish that they were fully or partly disabled as a result of their work in the North Sea.

The court case and diver divisions

Instead of being finally settled by the Storting's compensation scheme, the diver issue persisted as an unresolved conflict. The next logical step for the divers was legal action. Their lawyers focused on the finding from the Lossius commission – rejected by the justice ministry's legal department – that the state might have an objective liability for the divers' fate. It was assumed that, could this be established, the compensation sums might also be increased. For many divers, the conflict with the government had acquired a character which meant that a judgement against the government for its behaviour in the diver issue could be seen as a form of restitution in itself. From that perspective, the dispute retained both a political and a psychological aspect.

But the consideration of the issue by the Storting also ended the solidarity between the various diver groupings. As early as 2001, it had been proposed that the NSDA should develop a more formal democratic structure.[32] That was rejected. Until the final vote by the Storting, most of the divers accepted the NSDA's mode of organisation. During the relevant years, a number of divers with a background as elected officials in Nopef – including Haug – also served as spokesmen alongside Engebretsen and Engh.

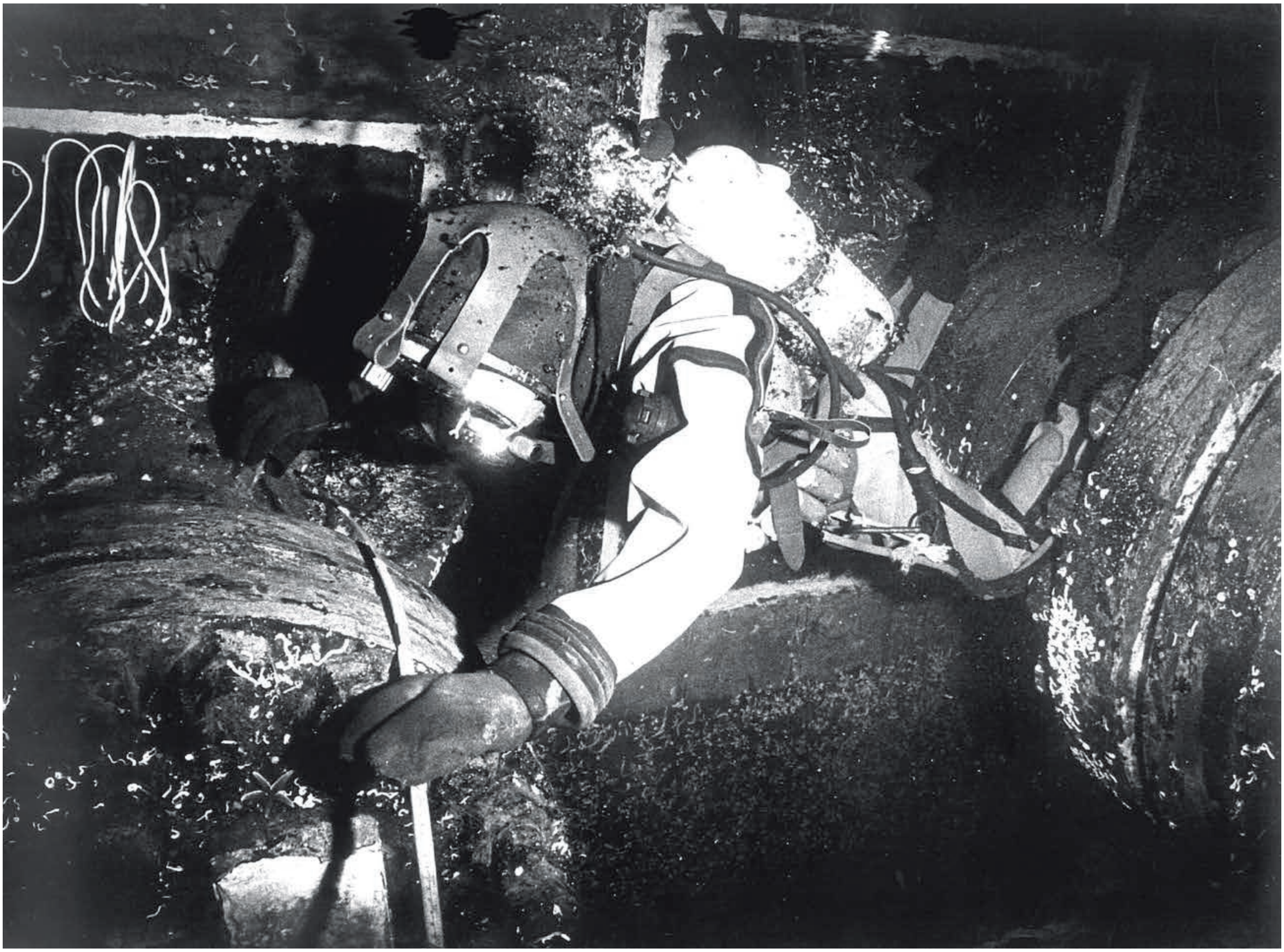
During 2004, several underlying conflicts found expression in a full-scale split. A number of divers left the NSDA on 18 October 2004 to establish the Offshore Divers Union (ODU). Like most other organisational breakups, the clash between the divers contained elements of personal antagonism, with mutual accusations of lies, inappropriate behaviour and so forth. The distinctive background of the divers may have helped to reinforce this aspect of the conflict. It also seems possible that the disagreements were exacerbated because many of the numerous journalists who had espoused the divers' cause joined in the disputes on one or other of the sides. Nevertheless, the split was an expression of genuine underlying antagonisms among the divers. People associated with Nopef were the main supporters of the ODU, which also received a certain amount of start-up help from the LO. It was not unnatural that those who reacted most strongly to the NSDA's structure were divers with organisational experience.

At its most heated and personal, the conflict found partial expression in claims that divers in the rival group had exaggerated how many saturation dives they had made and the like. These allegations also had a basis in reality. With their background in SNS, the divers organised in Nopef had suffered their biggest burden in the form of hours spent in saturation. As we have noted earlier, however, saturation diving might have been burdensome but was conducted in more orderly forms than the less organised bounce diving which prevailed in the 1970s, where Engebretsen and Engh had their background. For their part, the latter pair and their supporters frequently maintained that Nopef as an organisation had never secured a breakthrough for the divers' interests. They highlighted the links between the Nopef leadership and the Labour Party, which had been in government with a political responsibility for diving in many of the relevant years.

In the time which followed, the diver organisations devoted substantial time and energy to rebutting each other's accusations. These clashes did not help to strengthen the divers' cause in public opinion. The clearest expression of the hostile relationship between the two sides was provided by a documentary on the TV2 channel, which largely reflected the distrust of the dominant NSDA leadership among some of the ODU divers.[33] A key element in the programme was the presentation of the Cormorant episode in 1977 by Engebretsen and Engh. Whether this incident occurred in the way it was described in retrospect did not affect any of the main trends in Norway's diving history. It was primarily important because of the central role it played in the account presented by Engebretsen and Engh to the media when the diver issue really captured public attention during the late 1990s. The many divers who flocked to the NSDA at that time chose to believe the episode because they had experienced many similar incidents themselves. It was first when antagonism between the diver groups increased that the story was seriously questioned. The problem for Engebretsen and Engh was that part of the account rested solely on their own evidence and that of a third diver.

Despite the disagreements between the two diving groups, both agreed that the government settlement was inadequate. They opted to take legal action against the state separately and with their own lawyers. The original plan was to hear the NSDA's case first. Since that organisation refused to accept the appointed judge because it alleged a conflict of interest, the ODU was the first to appear in the Oslo District Court during the winter of 2007. Conducting its case together with the LO union Industry Energy, it secured a judgement in August 2007 that the government was liable to pay compensation on an objective basis.[34] The government appealed. The NSDA's case started on 28 January 2008 and ran until 9 May, with the court finding for the government in September.[35] At roughly the same time, the state won its appeal against the ODU in the Borgarting Court of Appeal. An attempt by the NSDA to appeal directly to the Supreme Court was rejected. So the ODU case remained to be heard by the Supreme Court in the spring of 2009.

The legal process over the diver issue acquired its own dynamic and a scope which goes far beyond the parameters of this history. Unless a compromise is reached which all sides can accept, the case will be making its way through the legal system for a long time to come. Compared with the period when the issue lay with the Lossius commission, which was supposed in principle to act as an independent third party but which presented an assessment or "judgement" on a more general political basis, the legal process became in many respects a reprise of earlier conflicts. The commission, Norman's White Paper and the local government committee's recommendation were unambiguous in finding that the divers had suffered an injustice, and the government accepted a moral liability for that. From that perspective, one might have expected that the actual court cases could be confined to more legal hairsplitting over the state's objective liability. For many divers, the hearings nevertheless became an arena for presenting their story to the public in its full breadth. The civil servants who conducted the cases on behalf of the government responded to that and sought to strengthen their position before a final judgement by denying that personnel at the NPD and other relevant agencies had committed any errors. As a result, the legal process failed to produce reconciliation and consensus over possible errors. On the contrary, it reinforced old antagonisms.



Conclusion

Jobs exist which are more dangerous than others, but which nevertheless get done because they are regarded as particularly important. Diving on the NCS provides an example. The divers who toiled to bring early production from Ekofisk on stream, who found themselves day after day during the 1980s in cramped saturation spreads and diving bells so that the first pipelines could be laid across the Norwegian Trench, who helped to recover the dead from the wreck of *Alexander L Kielland*, or who were involved in the intensive construction phase for the strategically important Snøhvit field in the far north have all done work of invaluable significance for Norway. It could be argued that being involved in something so important has an intrinsic value – and many divers have felt this to be so.

Right from the start, however, everyone fully appreciated that the type of work being performed on the oil installations out in the North Sea was hazardous. That applied to the oil companies, the diving contractors, all relevant government agencies which dealt with diving at different levels, and the divers themselves. During the early years, this was confirmed by the many fatal work accidents and a large number of cases of the bends. At the same time, nobody knew for certain what the long-term consequences for a person's health might be if they spent a whole career exposing their bodies and minds to the extreme burdens involved in working under high pressure.

As we have shown in this volume, uncertainty persists about the impact of subjecting the human body to the type of loads experienced by divers in deep water. It remains unclear how deep it is possible to dive without incurring burdens which could cause lasting injury. But, as we have also seen, it was possible to make diving a far safer job. Diving tables have improved. Better, more robust and safer diving technology, tailored to diver needs, has been developed over the years. Government regulation of diving has become both stricter and more precise. At the same time, Statoil's recognition after 2000 that secure employment terms for the individual diver also have consequences for safe diving demonstrates how important financial and organisational parameters can be. But it remains a pertinent question whether this could have happened earlier.

As we have shown, there were many good reasons why things developed as they did. It is hard to imagine that an industry involving so much risk could have avoided a period of trial and error before all the challenges faced had been seriously overcome. Nevertheless, there was nothing fated about the history of North Sea diving. Many crossroads existed where action by the government, the oil companies, the diving contractors and the divers themselves could have taken a different route. Much would probably have looked different if safety regulations had been introduced by the government at a far earlier stage. However, such regulations would not have changed much by themselves. The British, who put safety rules in place before Norway, had even more accidents. This was a question not only of whether the regulations imposed the right requirements but also whether an organisation existed to enforce them.

Excluding diving from Norway's Working Environment Act for so many years was undoubtedly far more important for further development than delayed regulations. The seasonal nature of the international diving industry when it came to Norway, along with short contracts, relatively small companies and poor conditions for unionisation, did not provide the best conditions for getting to grips with safety challenges.

The Working Environment Act built on the basic assumption that the workplace or the technology had to be tailored to the person rather than vice versa. The burden of proof for possible negative health effects from the work carried out rested with the responsible companies, not the individual employee. Several sections of the Act helped to facilitate active participation by unions. The Act's provisions contrasted so sharply with practice in the diving sector that it would have influenced the type of company which won contracts. So it was not without good reason that the unionised divers campaigned so hard to get this legislation extended to them. Had they succeeded with that in the late 1970s, and if the Act's provisions had really been taken seriously, there would either have been no diving at all or this work would have had to be done in a completely different way.

Safety work for divers on the NCS took many strides forward when the NPD established its diving section in 1978. From lagging behind the UK, the Norwegian divers were then better placed. But the NPD's opportunities to intervene were limited as long as the Working Environment Act did not apply and diving regulation was partly subject to the shipping regime – which included acceptance of the flag-state principle. Defended by the Ministry of Trade, the latter meant in part that foreign DSVs could operate with different working-time rules from vessels registered in Norway. The flag-state principle created the impossible position that important safety improvements could simultaneously weaken the competitive position of Norwegian companies. This was a known problem. Different governments were reluctant to deal with it because shipping interests were given greater weight than the negative consequences for diving.

With the development of the internal control system, initially in the form of regulations and from 1985 through primary legislation, the NPD contributed to a crucial clarification of responsibility for the safety challenges posed by diving. From then on, this lay unequivocally with the oil company operating the exploration blocks, fields or pipeline projects where the divers worked. The oil companies and the diving contractors had a responsibility for the way diving was conducted as clients and employers even before the introduction of internal control. It was the oil companies which were awarded licences and which thereby secured access to big revenues if they found oil and gas. Under the Norwegian licensing system, it was up to the oil companies to determine the organisation of work in the petroleum sector. Nothing ever prevented the oil companies from carrying out the necessary diving themselves, developing their own diver teams and acquiring other relevant diving technology competence. There were good financial reasons why they opted instead to hire such expertise from dedicated diving contractors. They also set crucial guidelines for the way diving was to be conducted through their contractual terms. With internal control, the oil companies could not hide behind the fact that diving risk had been contracted out or the lack of regulatory development and supervision by the government. Accidents must not occur. Work was to be done in a safe way. It was up to the oil companies to ensure that this happened.

The oil companies continued to use diving contractors even after the introduction of internal control. As a direct consequence of the clarification of responsibility, however, they strengthened their own diving expertise. A number of the companies, not least Norway's Statoil and Hydro, paid greater attention to diver safety and health both when awarding contracts and in following up the work. At the same time, the clarification of responsibility through internal control helped to speed up work on old plans to develop diverless technology. Applying the same type of risk calculations used for other safety work in the petroleum sector indicated that phasing out all types of diving was the most obvious solution to the challenges. When the oil companies acknowledged a few years into the present century that a certain amount of diving could not be avoided, they were much more aware than before that they set the operating parameters for this activity.

The Lossius commission and the Storting's decision placed an unambiguous political and moral responsibility on the Norwegian state for the fate of the pioneer divers. At an overall level, the conclusion of this historical review of the North Sea divers and diving off Norway must be the same as that reached by many other assessments of the diver issue – diving was speeded up for long periods in spite of its high risk because the work done by the pioneer divers on the NCS was too important to be halted. That perspective makes it meaningful to claim that diver safety was sacrificed for economic interests. For a Norway increasingly dependent on oil revenues, these interests were very large indeed.

Regardless of whether the moral, political and legal responsibility for the errors committed in the diving sector is assigned to the companies, the government or both, the history of North Sea diving cannot be understood without also taking account of the beliefs, attitudes and culture which have dominated among the divers themselves and in the specialist groups surrounding them. The work culture which prevailed among the pioneer divers suited in many ways the underlying financial and political interests. These were young men who were willing to sacrifice something in order to overcome the challenges they were presented with. For many of them, mastering difficult jobs was a matter of honour. In addition, the combination of insecure employment, a generally tough pressure of work, and bonus systems helped in a number of cases to promote a form of behaviour where the individual diver was willing to take chances. Even when the divers joined unions, it was difficult to overcome such attitudes among them. Nopef pursued active campaigns to improve their safety conditions, but even it was ensnared by the conflicted position of the divers over the issue of how deep it was acceptable to dive. Given the outlook for the future of diving on the NCS from the mid-1980s, divers correctly feared that stringent requirements could help to reduce jobs.

Similarly, diving technology specialists could reveal attitudes which put a high value on extending boundaries. The establishment of the NUI/Nutec provided Norway with a competent hyperbaric technology facility which was also highly significant for diver safety. But the terms on which this centre was founded, the financing of its assignments and the strong political desire to cross the Norwegian Trench and produce oil in deep water, meant its expertise could hardly be clearly neutral. Diving medical officer Smith-Sivertsen's warnings that it should not allow itself to be governed by "financial interests or be steamrollered by technological enthusiasm" identified an important aspect of Norway's diving technology and hyperbaric medicine communities.

The key issue for both foreign and Norwegian hyperbaric medicine specialists was long to clarify how far it was possible to push the human body, rather than to identify possible long-term injuries. The NPD, on behalf of the Norwegian government, could point out repeatedly that heavyweight international hyperbaric medicine specialists vouched for the boundaries applied at any given time in the Norwegian regulations. That was correct. But the research referred to by the NPD was simultaneously closely tied financially to the oil industry. The divers needed a genuinely independent body which could protect them from the financial interests of the oil companies and the government. In many respects, they also needed somebody who could protect them from themselves. This first emerged when an independent hospital team got to grips with the diver issue. A growing number of physicians began to ask questions about North Sea diving. The breakthrough for a different way of thinking came when a team at Haukeland Hospital secured sufficient funds to conduct research based on hypotheses which partly threatened to undermine important preconditions for the whole industry if they proved correct.

Notes

Chapter 1

1 E-mail from Johannes Straumøy, 18 October 2006.

2 E-mail from Johannes Straumøy, 1 January 2007.

3 Børretzen 1986, p 153.

4 Bjørn Kahrs, speech at the diving seminar, 2004.

5 Erling Krange 1994, p 26.

6 Børretzen 1986, p 153.

7 Swann 2007, pp 88-91, and Leif Tore Skjerven, "Oljerelatert dykking før 1966 og pionerdykking i Nordsjøen" [Oil-related diving before 1966 and pioneer diving in the North Sea], 10 June 2008.

8 Leif Tore Skjerven, "Oljerelatert dykking før 1966 og pionerdykking i Nordsjøen" [Oil-related diving before 1966 and pioneer diving in the North Sea], 10 June 2008.

9 Vidar Fondevik, leading article in *Dykkenytt* no 2, 2004.

10 Warner & Park 1990, p 24.

11 *Dykkenytt* no 1, 2005, p 10.

12 Before Comex, Sanford Brothers was responsible for diving on board. It probably supplied gas from the surface.

13 The remainder were drilled by *Drillship*, *Endeavour*, *Glomar Grand Isle*, *Orion*, *Gulftide* and *Sedneth I*.

14 Warner & Park 1990, p 23.

15 E-mail from Johannes Straumøy, 1 January 2007.

16 Limbrick 2001.

17 Tungland 2004, pp 10-14.

18 Leif Tore Skjerven interviewed by Norway's Igor Centre for Working Culture, 4 June 2003, in connection with Tungland 2004.

19 Tungland 2004, p 16.

20 *Stavanger Aftenblad*, 25 June 1969, "Stavanger-dykkere utenfor Afrika" by Leif Tore Skjerven.

21 *Stavanger Aftenblad*, 29 October 1968, "Fjernsynsopptak under vann".

22 *Stavanger Aftenblad*, 3 August 1971, "Dykkerselskapet 3X satser på Nordsjøen".

Chapter 2

1 www.kulturminne-ekofisk.no.

2 Swann 2007, pp 363-369.

3 Birkeland 2001.

4 Interview with John A Haugestad, 2 May 2003.

5 Interview with Per Røgenes, 10 March 2005.

6 Birkeland 2001.

7 Interview with John A Haugestad, 2 May 2003.

8 *Stavanger Aftenblad*, 4 August 1971.

9 With the Ekofisk tank in place, filling a tanker took about a day.

10 From *Tankbåt olje – Port Ekofisk*, information film about 1971.

11 Interview with John A Haugestad, 2 May 2003.

12 From *Tankbåt olje – Port Ekofisk*, information film about 1971.

13 Interview with Paul Roy Pallesen, 4 February 2004.

14 Interview with Teddy Broadhurst, 29 November 2002.

15 Interview with John A Haugestad, 2 May 2003.

16 Schønhardt 2002, p 110–111.

17 Swann 2007, p 171.

18 Report from the LO's diving committee, June 2004, pp 10–11.

19 Swann 2007, p 171.

20 2W was sold to Halliburton and then merged with Taylor Diving. The company was known as 2WT in 1982–85. Reported by Sjur Lothe, 16 June 2005.

21 *Dagbladet*, 5 December 1973, "Norsk dykking settes utenfor oljeletingen".

22 *Stavanger Aftenblad*, 6 June 1972, "Behov for utdanning av dykkere i Norge".

23 *Stavanger Aftenblad*, 6 July 1973, "Dypdykkingsfirma dannet".

24 *Rogalands Avis*, 23 October 1972, "Ikke arbeidsoppgaver, men folk til å utføre dem er hovedproblemet".

25 *Stavanger Aftenblad*, 21 July 1973, "3X får nye kontrakter".

26 Swann 2007, pp 236–259.

27 Børretzen 1992, pp 181–184.

28 Ibid, p 181–184.

29 Flemming 1977, pp 242.

30 *Bergens Arbeiderblad*, 1 April 1975, "Verdens farligste yrke!".

31 Interview with Paul Roy Pallesen, 4 February 2004.

32 Interview with Karl Jørgensen, 23 June

2004. "The emergency chamber was a parody, of course. You had to undo loads of bolts in order to get it up on deck. If the ship had collided, [we wouldn't have stood a chance]. But we didn't – or wouldn't – think about that. Or if it really started to burn, I wouldn't have been sitting here."

33 Ekofisk industrial heritage website, article on the Storting's decision to land oil and gas at Teesside and Emden.

34 Interviews with Albert Johnsen, 15 April 2005, and Karl Jørgensen, 23 June 2004.

35 Bevan 2005, pp 13-15.

36 Interview with Karl Jørgensen, 23 June 2004.

37 Interview with Karl Jørgensen, 23 June 2004.

38 Schønhardt 2002, p 108.

39 Albert Johnsen, evidence in the Oslo District Court, 3 April 2008.

40 "Report concerning explosion and fire on board M/V *Arctic Surveyor* the 30th of March 1975", dated 12 May 1975, Ragnar Winsnes.

41 Recounted by Eyolf Assersen on p 82 of Tungland 2004.

42 Interview with Karl Jørgensen, 23 June 2004.

43 "Report concerning explosion and fire on board M/V *Arctic Surveyor* the 30th of March 1975", dated 12 May 1975, Ragnar Winsnes.

44 Interview with Bjarne Sandvik, 15 October 2001.

45 *Phillipsrevyen* 4/1985.

46 Kåre Brakstad, Ove Stave and Anthony Aakre in an interview with the Igor Centre for Working Culture, 25 April 2003.

47 www.kulturminne-ekofisk.no

48 Swann 2007, pp 368–369.

49 Interview with Albert Johnsen, 15 April 2005.

50 Captain Arthur Taylor was the first head of the marine department, and was succeeded in 1982 by Per Røgenes. Interview with Per Røgenes, 10 March 2005.

51 Det Norske Veritas was also involved in developing inspection and welding equipment, including the first ultrasonic device for use under water. Interview with Per Røgenes, 10 March 2005.

52 Ernst W Amundsen interviewed by the Igor Centre for Working Culture, 3 April 2003.

53 Kåre Brakstad, Ove Stave and Anthony Aakre in an interview with the Igor Centre for Working Culture, 25 April 2003.

54 Kvendseth 1988, p 133.

55 Kåre Brakstad, Ove Stave and Anthony Aakre in an interview with the Igor Centre for Working Culture, 25 April 2003.

56 A project was implemented in 1980 to modernise and standardise tables used for surface-based diving. It was conducted by the NUI under the leadership of Arne-Johan Arntzen and diving medical officer Svein Eidsvik. The trials led to a modified US Navy surface decompression table intended to provide greater safety. NUI Report No 30 80, pp 8-10.

57 Interview with Per Røgenes, 10 March 2005.

58 *Phillipsrevyen* 4/1985.

59 Bevan 2005, pp 122-123.

60 Kathryn Steenson, "Pipelines to Scotland", article at www.kulturminne-frigg.no.

Chapter 3

1 Interview with Gerry Cronin, 9 October 2008. Trained as a diver in the US Navy, he reported that when he was diving for Subsea in the mid-1970s, five of his colleagues had been involved in combat in Vietnam.

2 Swann 2007, p 163.

3 Limbrick 2001, p 3.

4 Ibid.

5 Unlike a great many other mammals, and like the apes, humans cannot swim instinctively. Humans and apes have a body form which means that they naturally adopt a vertical position in water. Elaine Morgan has argued in several popular science books, such as *The Aquatic Ape* (1982), that humans descend from an "aquatic ape". This theory is not taken seriously in scientific circles.

6 Ryggvik & Smith-Solbakken 1997, p 33.

7 Assessments of the geographical origins of divers are based on membership lists from the Offshore Divers Union (ODU). Our conversations and interviews with other divers confirm this impression.

8 Tungland 2004, p 88.

9 Ibid, p 92.

10 Interview with Jan Erik Halsteinsen, 23 September 2005.

11 Interview with Ove Stiansen, October 2007.

12 Interview with Leif-Tore Skjerven, 4 June 2003. Igor Centre for Working Culture.

13 Interview with Gerry Cronin, 9 October 2008. US naval divers committed to four years of service from the start of their training as naval commandos. Since many had already served for several years on ships or elsewhere in the navy before starting diver training, they could have considerably more than four years of military experience.

14 Interview with Ove Stiansen, October 2007.

15 NOU 2003, 5.

16 Tungland 2004, p 16.

17 Ibid.

18 *Norwegian Petroleum Museum's Yearbook* 2006, pp 41-56.

19 *Norwegian Petroleum Museum's Yearbook* 2006, p 56.

20 Interview with Albert Johnsen, 24 April 2007.

21 Statistics for the total number of divers on the NCS are reproduced in NOU 2003, 5, p 105. The figures are taken partly from Bevan & Gosling and Kahrs, but are based on estimates. The archive of the Lossius commission (chapter 13) contains a list of people defined as Norwegian pioneer divers, which has about 350 names. Since a number of these were not diving for periods, it is unlikely that Norway's divers exceeded 300 at peak. However, lists from the late 1970s contains names which do not appear in the commission's list. The figures are accordingly very uncertain.

22 Resumes of diving education for crew of *Gulftide/Glomar Grand Isle*. These two were received by the Norwegian Labour Inspection Authority on 30 July 1971.

23 NOU 1975, p 50.

24 Jørn Bjerga 2003.

25 Swann 2007.

26 Jørn Bjerga 2003.

27 Tungland 2004, p 14.

28 Interview with John A Haugestad, October 2007.

29 www.kulturminne-ekofisk.no, articles under “working life” on diving, substantially based on John Haugestad’s notes.
30 Interview with Per Jakobsen, November 2007.
31 Related in a number of interviews conducted by the Igor Centre for Working Culture.
32 *Bergens Arbeiderblad*, 1 April 1975, “Verdens farligste yrke!”.
33 Ibid.
34 Stein Hansen and Tor Skoglund, “Lønnsutviklingen 1962–2002”, *Økonomiske Analyser* 5/2003. Average annual pay in 1962 was NOK 17 000. It had reached NOK 320 000 by 2002.
35 Interview with Anders Lindahl, 6 March 2006.
36 Swann 2007, p 214.
37 Contract between Skandinavisk Undervann Service A/S and Johannes Emil Straumøy, dated 1 May 1968.
38 Interview with Leif Tore Skjerven, 4 June 2003, Igor Centre for Working Culture.
39 Interview with Gerry Cronin, 9 September 2008.
40 Interview with Per Jacobsen, November 2007. His information is based on tax assessment records and diving logs.
41 The overview of Norwegian and foreign divers shows that the former were in a minority even in the most active period during the 1970s. Since Norwegians eventually became over-represented in Stolt-Nielsen Seaway, where they were permanent employees and dived for much of the year, the average number of dives per Norwegian diver could well have been higher than for their foreign counterparts. This is unlikely to have offset the greater numbers of foreigners. Since many of the latter were a long way from home, moreover, they were probably interested in diving as much as possible once they were at work.
42 Asenjo 1979.
43 Interview with Einar Andersen, 10 April 2003, Igor Centre for Working Culture.
44 Interview with Leif Morten Rasch, 24 April 2003, Igor Centre for Working Culture.
45 Interview with Per Arne Jacobsen, November 2007.
46 *Bergens Arbeiderblad*, 1 April 1975, ”Verdens farligste yrke!”.
47 *A-magasinet*, 1975. Undated, from Jens Smith-Sivertsen’s archive of cuttings.
48 Ibid.
49 Ibid.
50 Interview with Ove Stiansen, October 2007.
51 Letter from Arne Jentoft at Nopef to the Directorate of Health, 27 November 1981. “Støyproblemer i lugarer og oppholdsrom på dykkerfartøyene” [Noise problems in cabins and public rooms on the DSVs].
52 *Bergens Arbeiderblad*, 1 April 1975.
53 Ryggvik & Smith-Solbakken, 1997.
54 Ibid, p 232.
55 Branch 16, Nopef. Minutes, meeting of 5 July 1977. The branch’s minutes go back before the employees affiliated with Nopef. Their title must accordingly have been added later.
56 Interview with Arne Jentoft, 22 August 2006.
57 Interview with Per Jacobsen, November 2007.
58 Interview with Arne Jentoft, 22 August 2006.
59 Interview with John A Haugestad, 1 November 2007.
60 Statutes for the 3X union branch, undated. Haugestad believes the branch was formed in the autumn of 1974. Its existence is confirmed by a correspondence with the “diver offshore committee” on 1 April 1975. The letter is addressed to Duesveien 13, Stavanger.
61 Branch 16, Nopef, minutes.
62 Branch 16, Nopef, meeting 2 March 1977.
63 Nopef, annual report, 1981, p 22.
64 Nopef, annual report, 1983, p 24.
65 Reproduced in *Nopef nytt* no 198. Extract from newspaper article by diver Trygve Gulliksen.
66 Ryggvik & Smith-Solbakken, 1997, p 236.
67 Rasmussen 1989, p 2.
68 Swann 2007, p 449.

Chapter 4

1 The description of the accident is based on interviews with Henry Munkejord (offshore worker on *Ocean Viking*) in September 2005 and Bjørn Lilleland (Norwegian diver, involved in the accident) on 22 November 2005, and in *Stavanger Aftenblad*, 10 March 1971. The police report after the incident has not been found. Lilleland, who tried to access the report in connection with a compensation claim, believes that one was never written.
2 *Aftenposten* did not report the first accident. The second was reported in five lines of small print in the evening edition of 7 May 1971.
3 *Stavanger Aftenblad*, 10 March 1971.
4 *Stavanger Aftenblad*, 7 May 1971.
5 Interview with R G Engebretsen. Often referenced in the media, including a leader in *Aftenposten*, 4 March 2004. A documentary shown on TV2 in May 2007 questionned whether the incident had actually happened. It was noted, for instance, that Engebretsen must have been 19 at the actual opening, below the age limit. However, a number of divers have confirmed that little effort was made at the time to check ages. Divers with professional expertise confirm that divers very probably worked on or in association with the rig at the relevant time. Regardless of whether the incident happened as reported here, it has flourished as one of many stories from the pioneering days of the diving business, and thereby helped to shape the self-image of the divers.
6 Ryggvik & Smith-Solbakken, 1997, p 15.
7 Recommendation from the diving committee, part 1. *Historikk og generell orientering* [History and general orientation]. 1957.
8 Otto Inge Molvær, “Glimt frå baromedisinens historie i Noreg” [Glimpses from the history of baromedicine in Norway]. Norwegian Baromedical Association 7/12-07.
9 Proceedings of the Storting, 1959, p 1958.
10 Royal decree, 30 January 1959. The decree built on the Worker Protection Act of 7 December 1956.
11 Limbrick 2001.
12 Ibid, p 39.
13 Ryggvik & Smith-Solbakken, 1997, p 76. The following bodies inspected *Ocean Traveler*: the Directorate of Civil Aviation, the Electrical Safety Authori-

ty, the State Inspectorate of Explosives and Flammables, the Board of Telecommunications, the Norwegian Labour Inspection Authority, Det Norske Veritas and the Norwegian Maritime Directorate.

[14] Letter from the Ministry of Industry to Esso, 6 July 1966.

[15] *Aftenposten*, 12 December 2005.

[16] Principal engineer Ragnar Winsnes, 4 July 1966. Report from a visit to Ocean Systems Inc in Stavanger on 1 July 1966. Winsnes begins the report with an outline of how the journey began with a Braathens flight from Oslo to Stavanger at 08.00, and also notes that he left Stavanger at 19.30 – again on a Braathens flight.

[17] Ibid.

[18] Ibid, p 3.

[19] Letter from R J Loeffler, Exxon Exploration Norway, to Nils Gulnes, Norwegian Petroleum Council, 3 October 1966.

[20] Letter from E Otnæss at the Norwegian Labour Inspection Authority to commander and submarine diving medical officer Jens Smith-Sivertsen.

[21] Letter from Jens Smith-Sivertsen to the Norwegian Labour Inspection Authority, 19 December 1966.

[22] Letter from Jens Smith-Sivertsen to the Norwegian Labour Inspection Authority, 5 April 1967.

[23] Letter from the Norwegian Labour Inspection Authority, 23 November 1967.

[24] Interview with Dr Hans Benestad, 15 October 2005. Benestad went offshore repeatedly in the North Sea to provide medical follow-up of divers with the bends for Ocean Systems and Comex until the spring of 1971. He received special training in diving (hyperbaric) medicine from Comex in France. According to a 1971 letter to the Norwegian Labour Inspection Authority, Benestad checked the divers regularly every six months. Letter from Benestad to Winsnes at the Norwegian Labour Inspection Authority, 20 March 1971.

[25] "Kontinentalsokkelen. Dykkerulykken 3 October d.å. på *Ocean Viking*" [Continental shelf. Diver accident on 3 October on *Ocean Viking*]. Jens Smith-Sivertsen. Statement to the Ministry of Industry, 2 January 1968.

[26] Ibid. Smith-Sivertsen refers to metres rather than feet. We assume that this is a typing error, although it is repeated. If not, the information would conflict with diving practice at the relevant date. *Ocean Viking* drilled for Phillips in block 16/11, where the depth was 67 metres or 202 feet.

[27] Swann 2007, p 286, describes a completely different chain of events for the Sanford Brothers accident involving *Ocean Viking*. It reports that two divers died in a bell, but that the Norwegian authorities were unable to determine the cause of the accident after a detailed investigation. The author refers to an oral source. If this description is correct, it relates to an unrecorded accident – not the one we discuss here. If so, it must have occurred some time between 1966 and 1967, when the company had a contract on *Ocean Viking*. The most probable explanation is that the author is wrong, and that the report is an example of the problems which can arise from relying overmuch on oral sources for an event which occurred a long time before.

[28] "Kontinentalsokkelen. Dykkerulykken 3 October d.å. på *Ocean Viking*". Jens Smith-Sivertsen, 2 January 1968.

[29] "Kontinentalsokkelen. Vedrørende dykking fra boreplattformer etc" [Continental shelf. Concerning diving from drilling rigs, etc], 11 January 1968. Signed by Knut Dæhlin at the Ministry of Industry. Sent to Esso Exploration, Amoco Norway Oil Company, Petronord and Phillips Petroleum Company.

[30] Proceedings of the Storting (1965–66), p 2260.

[31] Ryggvik & Smith-Solbakken, 1997, p 77.

[32] Ibid, p 74.

[33] North Sea Offshore Committee-Norway (NSOCN), minutes of meeting, 16 November 1967.

[34] Recommendation no 2 from the Norwegian Petroleum Council concerning proposed safety regulations, etc, for prospecting and drilling for submarine petroleum deposits.

[35] Ibid.

[36] Oslo District Court, case no 05-028758TVI-OTR/03. Authority was delegated to the Norwegian Labour Inspection Authority on 11 July 1969.

[37] The surviving records from the Norwegian Labour Inspection Authority's involvement with North Sea diving were transferred on 21 November 2005 to the Asta foundation, which is putting them in order before sending them to the National Archives of Norway. When transferred, the records were generally in a disorganised, incomprehensible condition. A great deal of correspondence has clearly disappeared for good. Nevertheless, the main reason for the lack of direct correspondence between the NLIA and the companies between 1968 and 1971 is probably that there was little or no contact during the period. An indication of this is that the circular issued immediately after the accident of 9 March 1971 makes no reference to contact between the companies and the NLIA or the letter from the Ministry of Industry after the 1967 accident. It is reasonable to assume that, if the NLIA had conducted inspections in this
period, it would be possible to find not only an inspection report but also certain orders or comments which would have been relevant when summarising contacts between companies and regulator.

[38] Letter from Knut Dæhlin and Thorgrim Haga at the Ministry of Industry to Jens Smith-Sivertsen, 5 June 1968.

[39] Interview with Jens Smith-Sivertsen, 17 October 2006.

[40] Letter from Ragnar Winsnes at the Norwegian Labour Inspection Authority to V Hempleman, Royal Naval Physiological Laboratory, 28 November 1968.

[41] Letter from P D Griffiths at the Decompression Sickness Central Registry to Ragnar Winsnes at the Norwegian Labour Inspection Authority, 10 July 1969.

[42] Letter from Bjarne Dahlberg and Ragnar Winsnes at the Norwegian Labour Inspection Authority to Dr Muren, Royal Maritime Administration, Stockholm, 15 January 1968. Diving tables.

[43] The Norwegian Labour Inspection Authority to all diving operators connected with exploration and drilling for submarine petroleum resources on the Norwegian continental shelf. Signed by Bjarne Dahlberg and Ragnar Winsnes, 26 March 1971.

44 The letter in itself can be used to support the view that no orders were issued by the Norwegian Labour Inspection Authority from January 1968 to 1971.

45 Marseilles Conference, 15 April 1971. Dr Fructus to Ragnar Winsnes.

46 The Norwegian Labour Inspection Authority to all diving operators connected with exploration and drilling for submarine petroleum resources on the Norwegian continental shelf, 26 March 1971.

47 Interview with Bjørn Lilleland, 22 November 2005.

48 "Undersøkelse av dypvannsdykkere som arbeider i Nordsjøen" [Investigations of deepwater divers working in the North Sea]. Letter from Hans Benestad to the Norwegian Labour Inspection Authority, 20 March 1971.

49 Jens Smith-Sivertsen, letter to the Norwegian Labour Inspection Authority, 11 August 1971.

50 Ibid.

51 Medical Commission for Divers, memo of 22 September 1970. "Autorisasjon av dykkerleger" [Authorisation of diving phyicians].

52 Letter from the Directorate of Health to the Norwegian Labour Inspection Authority, 29 June 1971. "Godkjenning av dykkerlege" [Approval of diving physician].

53 Letter from the Norwegian Labour Inspection Authority to the Ministry of Industry, 14 May 1971. "Arbeidstid for dykkere" [Working time for divers].

54 The Ministry of Industry to all operators on the NCS, 12 July 1971. "Arbeidstidsbestemmelser for dykkere på den norske kontinentalsokkelen" [Working-time provisions for divers on the NCS].

55 www.number-10.gov.uk/output/Page1376.asp.

56 Letter from Ragnar Winsnes to John Prescott, 23 August 1971.

57 Ranken 1971.

58 Mineral Working (Offshore Installations) Act 1971. Proposals for regulations on diving operations.

59 Minutes from meeting of 13 May 1972 at the Atlantic Hotel, Stavanger, concerning diving issues. Meeting at the Atlantic Hotel, Stavanger, 17 July 1972, concerning British proposal for offshore diving regulations.

60 Meeting on 8 June at the Ministry of Industry, Oslo. On diving regulations.

61 The remaining records of the Norwegian Labour Inspection Authority contain no correspondence between the Norwegian Labour Inspection Authority and the Ministry of Labour after 1972.

62 Meeting at the Atlantic Hotel, Stavanger, 17 July 1972, concerning British proposal for offshore diving regulations.

63 Winsnes' minutes have a rather confusing form. The first section comes across as joint comments by him and industry representatives. This is followed by a section where he comments on the proposal, apparently on his own account. It is unclear in a number of passages what reproduces Winsnes' own views and what merely presents the views of others.

64 Meeting at the Atlantic Hotel, Stavanger, 17 July 1972, p 1.

65 Ibid, p 4.

66 Swann 2007, p 448.

67 Carson 1982. Woolfson, Foster & Beck 1997.

68 NOU 2003, 5, p 117.

69 Limbrick 2001, pp 42 and 184.

70 A quarterly review for the Norwegian Labour Inspection Authority from the autumn of 1974 indicates that the regulator was awaiting draft regulations from the UK (Norwegian Labour Inspection Authority, Kvartalsoversikt, second quarter of 1974). In an interview with *Bergens Tidende* that autumn, Winsnes commented that the regulations would soon be ready (*Bergens Tidende*, 28 September 1974).

71 Pedersen 2001, p 20.

72 *Stavanger Aftenblad* reported the accident in a small item on 17 January 1974.

73 The first inspection mentioned in the form of a report in the Norwegian Labour Inspection Authority's archive was carried out on the *Waage Drill I* rig on 19 November 1973. "Rapport fra inspeksjon om bord i *Waage Drill 1* den 19. november 1973". The rig carried Comex diving equipment.

74 "Inspeksjon. Drilling rig *Transocean III*. 2.12.73" [Inspection. Drilling rig *Transocean III*. 2 December 1973]. Report from the Norwegian Labour Inspection Authority to the Norwegian Maritime Directorate, 17 December 1973.

75 "Rapport fra inspeksjon om bord i *Blue Water 3* utenfor Shetland, 12. juni 1974" [Report from inspection on *Blue Water 3* off Shetland, 12 June 1974]. From the Norwegian Labour Inspection Authority to the Norwegian Maritime Directorate, 25 July 1974.

76 "Rapport fra inspeksjon om bord i *West Venture* utenfor Shetland, 13. juni 1974" [Report from inspection on *West Venture* off Shetland, 13 June 1974]. No report can be found from Winsnes' inspection of the rig in Le Havre. This indicates that reports from a number of inspections could be missing.

77 Limbrick 2001, p 96. Bjørn Wilhelm Kahrs 2004, p 42.

78 Interview with Bjørn Lilleland, 22 November 2005. Lilleland worked with Per Skipnes on *Ocean Viking*.

79 "Rapport vedrørende dykkerulykke den 16. januar 1974" [Report on diving accident of 16 January 1974], Ragnar Winsnes.

80 Statement from the Norwegian Labour Inspection Authority, 25 June 1974.

81 *Stavanger Aftenblad*, 17 March 1974. *Stavanger Aftenblad* was one of the few newspapers to carry a brief report the day after the accident. Neither it nor other papers followed it up.

82 Limbrick 2001, p 115. The accident was mentioned in a brief item in *Rogalands Avis*, 30 August.

83 Limbrick 2001, p 121. The accident was mentioned in a brief item in *Rogalands Avis*, 7 February 1975.

84 Limbrick 2001, p 125.

85 "Report concerning explosion and fire on board *Arctic Survivor*". Ragnar Winsnes.

86 Limbrick 2001, p 127.

87 *Bergens Tidende*, 28 September 1974.

88 NOU 1975, 38. "Sosiale og helsemessige konsekvenser av petroleumsvirksomheten" [Social and health consequences of the petroleum activity].

89 NOU 1975, 50. "Oppsynet med fiskeri- og petroleumsvirksomheten" [Regulation of fishing and petroleum activities], p 43.

90 In addition to the diving contractors, the draft was circulated on this occasion to relevant government agencies, such as the Norwegian Petroleum Directorate, the Norwegian Maritime

Directorate, the Directorate of Health, the Ministry of Industry, the LO and the Norwegian Employers' Confederation.

91 Bjørnson, 1993.

92 Act on Worker Protection and the Working Environment, etc, 4 February 1977.

93 Woolfson, Foster & Beck 1997.

94 Ryggvik & Smith-Solbakken, 1997.

95 Royal decree of 24 July 1977. Ryggvik & Smith-Solbakken, p 159.

Chapter 5

1 Reported by John A Haugestad, p 67, Tungland 2004.

2 E-mail from Rolf Guttorm Engebretsen, October 2006.

3 www.kulturminne-ekofisk.no, article on the Ekofisk tank's history by Kristin Øye Gjerde.

4 Interview with Karl Jørgensen, 23 June 2004.

5 E-mail from John A Haugestad, 17 August 2006.

6 *Stavanger Aftenblad*, 21 June 1973, "Tanken er underveis".

7 Norwegian Petroleum Museum. *A Petrorama*, Stavanger, 2000.

8 E-mail from Rolf Guttorm Engebretsen, October 2006.

9 Interview with Geir Ivar Jørgensen, 31 May 2007.

10 Ibid.

11 *Stavanger Aftenblad*, 13 October 1973, "Three X til Akergruppen".

12 E-mail from Rolf Guttorm Engebretsen, October 2006.

13 *Stavanger Aftenblad*, 21 June 1973, "Dykkerutstyr med TV".

14 Interview with Tor Jan Wiik, 20 September 2007.

15 Leif Tore Skjerven in an interview with the Igor Centre for Working Culture, 4 June 2003.

16 Jørgensen is used as an example for this estimate. He began his diving career in the UK sector during 1973 and made the last of about 2 000 dives in 1984. Of his dives, 1 200-1 400 took place inshore – in other words, 60-70 per cent were on Condeeps. Interview with Geir Ivar Jørgensen, 31 May 2007.

17 ThreeX Hybrid Decompression Tables, 31 December 1975, copy number 13, Norwegian Petroleum Museum archive.

18 E-mails from Geir Ivar Jørgensen, 1 July 2008, and Arne Jentoft, 21 January 2009.

19 *Stavanger Aftenblad*, 7 February 1975, "Engelskmann mistet livet".

20 Self-certification, Øyvind Lindland (formerly Kristiansen), dated 14 November 2001.

21 S Søndenaa, Norwegian Labour Inspection Authority, 16 January 1976.

22 Myklebust 1994, pp 106–114.

23 *Stavanger Aftenblad*, 13 December 1976, "Plattform evakuert".

24 *Sunnhordland*, 18 March 1977, "Stordabu – gjekk frå utenriksfart til supply i Nordsjøen".

25 *Sunnhordland*, 22 April 1977, "3 grader krenging gav PANIKK på plattforma".

26 Svein Terje P Førland, former plate worker on Statfjord A.

27 *Sunnhordland*, 12 October 1977, "Røyrarbeid for millionar må gjerast om på Cormorant".

28 *Sunnhordland*, 4 November 1977, "Senking av Cormorant A".

29 *Sunnhordland*, 11 November 1977, "Senkinga av Cormorant A førebels utsett".

30 Various versions of this story are told in the *Dråpen* magazine (2002) and in a film made by Basic TV Production AS (2005). It is given a big place in Knut Ørjasæter 2006 and in Christian Catomeri and Olivier Truc 2008. A documentary aired on TV2 in May 2007 cast doubt on whether the accident had really happened. A court case began on March 2009 between the NSDA and TV2 over this programme.

31 Interview with Geir Ivar Jørgensen, 28 September 2007.

32 Evidence by Johan Otto Johansen to the Oslo District Court, 9 April 2008.

33 Jørgensen reports that the many life-threatening incidents have been difficult to tackle afterwards. But it was not until many years later that the stress reactions kicked in and he became disabled. Interview with Geir Ivar Jørgensen, 28 September 2007.

Chapter 6

1 Lerøen 1996, p 77.

2 Ryggvik 1992, p 85.

3 Royal decree of 9 April 1965, section 33.

4 Hanisch & Nerheim 1992, p 156.

5 Nerheim 1996, p 17.

6 NOU 1972, 15.

7 Ibid, 15, p 46.

8 Ibid, 15, p 43. When the commission submitted its report, it was reasonably certain that a pipeline to the UK would get a go-ahead in line with Phillips' plans. That might have encouraged the commission to take the chance on such an optimistic assessment of prospects for overcoming the technological bottleneck presented by pipelaying across the Trench. The commission was unquestionably under political pressure to reach an optimistic verdict from interests seeking a pipeline to Norwegian soil. At the same time, the report's positive finding might also be useful in other negotiations with the Ekofisk licensees. The Norwegian negotiators could utilise a possible revival of the pipeline issue in anticipation of new technology to bring pressure to bear in order to ensure greater Norwegian ownership of and control over the pipelines laid from Ekofisk directly into the UK sector.

9 NOU 1974, 40.

10 Proceedings of the Storting, 1974, no 517.

11 DWP commission, report for the first half of 1974, p 1.

12 NOU 1974,40. Two appendices also dealt with problems of pipeline repair in deep water, which also touched in part on diver-related issues.

13 NOU 1974, 40.

14 Letter from Nils Vogt at the Norwegian Petroleum Directorate to Professor Bühlmann, 3 January 1974. Letter from Bühlmann to the NPD, 7 January 1974.

15 Norwegian Petroleum Directorate, memo to board members, 18 February 1974.

16 DWP commission, minutes of a meeting at the Ministry of Industry, 6 March 1974.

17 Interview with Jens Smith-Sivertsen, 12 December 2008. Smith-Sivertsen's growing disquiet at the lack of knowledge on all medical issues related to deep diving is confirmed by a letter he sent to the Norwegian Labour Inspection Authority in the summer of 1974. Among other issues, he stressed that

repeated dives increased the risk of the bends, and that the physical-mathematical models which provided the basis for decompression tables were inadequate (letter of 27 June 1974).

18 NOU 1974, 40, p 198.

19 Ibid, p 23.

20 Ibid, p 23.

21 Ibid, p 214.

22 Ibid, p 214.

23 Ibid, p 198.

24 Report no 90 to the Storting (1975–1976).

25 Ibid, p 18.

26 Proceedings of the Storting, 16 June 1976, no 422.

27 Proceedings of the Storting, 26 November 1974, no 171. Proceedings of the Storting, 16 June 1976, no 422.

28 Nerheim, 1996, p 39.

29 Swann 2007.

30 Ibid, p 327.

31 Norwegian Petroleum Directorate's annual report, 1986, p 111.

32 Norwegian Petroleum Directorate's annual report, 1979, p 54. See also subsequent annual reports under the heading "Diving".

33 Norwegian Petroleum Directorate's annual report, 1984, p 64.

34 Norwegian Petroleum Directorate's annual report, 1980, p 45 (Report no 78 to the Storting (1980–81)).

35 Hanisch & Nerheim 1992, chapter 6 on the construction of Statfjord. Lavik 1997.

36 Statistics Norway 1994, p 546.

37 Interview with Albert Johnsen, 24 April 2007.

38 *VG*, 1979 (undated from cuttings archive), "Dykkere som arbeider i Nordsjøen: Nordmenn presses ut."

39 Swann 2007, p 558.

40 The statement was made to *VG* by diving superintendent Per Staveland. In Ørjasæter 2006, p 97, the author speculates whether the problems faced by Norwegian diving companies in winning work in the late 1970s and early 1980s were due to a secret trade deal between the Norwegian and British governments, where Norway secured the construction of large concrete installations and the UK got diving. A number of factors argue against such a hypothesis (see chapter 12).

41 Quotation from *Statoil Magazine*, reproduced in Lerøen 1996.

42 Nerheim 1996, p 69.

43 Interview with Einar Wold Svendsen, 30 May 2006.

44 Interview with Magne Vågslie, 30 May 2006. Vågslie was the diving superintendent for SNS on *Seaway Condor* in the relevant period.

45 Swann 2007, p 437.

46 Interview with Arne Jentoft, 2 June 2006.

47 *Statpipe bygges* [Building Statpipe], Statoil information film about 1985.

48 Interview with Geir Egil Skrunes, 25 January 2006.

49 Interview with Sjur Lothe, questions by e-mail, 6 June 2006.

50 Lavik 1997, p 76.

Chapter 7

1 Kvendseth 1988, pp 144–145.

2 Telex from Phillips to the Norwegian Petroleum Directorate, 25 November 1980. Nopef's archive, National Archives in Stavanger.

3 *Stavanger Aftenblad*, 13 April 2000, Per Røgenes, "A. Kielland-tragedien".

4 *Petro* no 1–2005.

5 Letter from the unionised divers in Nopef, 18 August 1980, Nopef's archive, National Archives in Stavanger.

6 Telex from Phillips to the Norwegian Petroleum Directorate, 25 November 1980. Nopef's archive, National Archives in Stavanger.

7 Interview with Børre Børretzen, 1 February 2008.

8 Jørgensen recalls that his wife commented "you smell like a mothball" when he returned home after the operation. Chemicals were flushed out of his body for several days, and his urine was green and smelt like washing-up liquid. Interview with Geir Ivar Jørgensen, 31 May 2007.

9 Arne Sund, Steinar Ersland & Lars Weisæth, "*Alexander L Kielland*-katastrofen, 27. mars 1980. Redningspersonellets erfaringer. En foreløpig forskningsreport" [The *Alexander L Kielland* disaster, 27 March 1980. Experience of the rescue personnel. A preliminary research report]. Nopef's archive, National Archives in Stavanger.

10 Reported by Einar Andersen to the Norwegian Petroleum Museum, 30 June 2003.

11 Interview with Børre Børretzen, 1 February 2008.

12 Ryggvik & Smith-Solbakken 1997, pp 228–230.

13 *Arbeidervern*, no 5, 1983.

14 Ryggvik and Smith-Solbakken 1997, pp 230–231.

Chapter 8

1 It was not unusual at the time for Norwegian companies to front projects to the press in a way which suggested that national participation was greater than it actually was. In addition to Hydro and Statoil, partners in the dive were Elf, Total, Mobil, Shell, Conoco, Saga, Amoco, Amerada Petroleum and Texas Eastern.

2 *Rogalands Avis*, 8 February 1978.

3 Swann 2007.

4 Diver certification from John Kohl.

5 Certification of David Hoover by N J I McIver, 8 February 1978.

6 *Rogalands Avis*, 8 February 1978.

7 Letter from the Norwegian Labour Inspection Authority to Norsk Hydro, 13 February 1978. It confirmed a telegram sent about 16.00 on 10 February.

8 Memo from doctors K Grimstad and S Eidsvik to the Norwegian Labour Inspection Authority. The copy does not show the date, but it must have been sent in the days immediately after the accident.

9 *Bergens Tidende*, 11 February 1978. *Aftenposten*, 13 February 1978.

10 Jens Smith-Sivertsen, "Skånevikulykken – hva så", *Bergens Tidende*, 13 January 1978. Smith-Sivertsen had already suggested carbon dioxide poisoning immediately after the accident. This theory was regarded as the most probable explanation in Nils T Ottestad, *Ad dykkerulykke i Skånevikfjorden* [Concerning the diving accident in the Skånevik Fjord], Health Physics Service, University of Oslo, 13 February. It was also maintained as the most likely theory in a letter summing up the accident sent by the Norwegian Labour Inspection Authority to the Hordaland Police Authority, 14 December 1978.

[11] Diving certification from John Kohl.
[12] Letter from the Norwegian Labour Inspection Authority to the Hordaland Police Authority, 14 December 1978.
[13] *Bergens Tidende*, *Haugesunds Avis* and *VG*, 11 February 1978.
[14] According to *Aftenposten* on 9 February 1998, the following agencies had been involved ahead of the dive: the Directorate of Labour, the Ministries of Fisheries, Defence, Industry, Local Government and Labour, and the Environment, the Haugesund Port Authority, Kvinnherad local authority and police force, the Directorate of Coasts, the Naval Command, the Norwegian Labour Inspection Authority, National Institute of Radiation Hygiene, the Norwegian Petroleum Directorate, and Etne local authority and policeforce.
[15] Norwegian Labour Inspection Authority's archive, 27 December 1977. "Deepwater Hyperbaric Welding Program. Authority Approval of Diving Systems".
[16] *Bergens Arbeiderblad*, 9 February 1977.
[17] *Bergens Tidende*, 13 February 1978.
[18] Interview with Jens Smith-Sivertsen, 23 October 2006.
[19] Phone interview with Jens Smith-Sivertsen, 27 September 2006.
[20] Arne Skouen, "Ytring", *Dagbladet*, 16 February 1978.
[21] Ibid.
[22] Ibid.
[23] *VG*, 8 June 1978.
[24] From Jens Smith-Sivertsen's clippings archive. *Dagbladet*. Internal evidence shows the article was written in August 1978.
[25] Ibid.
[26] Ibid.
[27] Norwegian Broadcasting Corporation, 4 January 1978, "Arbeidsplass Nordsjøen".
[28] *Rogalands Avis*, 5 January 1978, "Ingen hoppet i taket".
[29] *Norges Handels og Sjøfartstidende*, 25 February 1978.
[30] *Stavanger Aftenblad*, 6 February 1979.
[31] *VG*, 2 February 1979, "Etterforskningen for dårlig?".
[32] Nilsen & Eggen 1979.
[33] Ibid, p 115.
[34] Provisional regulations for diving on the NCS, issued by the Norwegian Petroleum Directorate, 1 July 1978.
[35] *Vår Framtid*, 4-11 January 1978.
[36] Letter from the Norwegian Oil and Energy Employees Association (Noemfo) to the Ministry of Local Government and Labour, 28 May 1982.
[37] NOU 2003, 5.
[38] "Til de norske myndigheter, På vegne av NOPEF-organiserte dykkere" [To the Norwegian government, on behalf of the Nopef-organised divers], Arne Jentoft, diver. Archived 22 May 1978. Db-Saksarkiv II. 465.44/1.
[39] Letter to the Ministry of Petroleum and Energy from Nopef, 16 May 1978. "Dykkernes arbeidssituasjon" [Working conditions for divers].
[40] Interview with Jan Chr Warloe, 1 October 2008.
[41] Act on Worker Protection and the Working Environment, etc, 4 February 1977. Royal decree of 29 April 1977 concerning regulations for safety representatives and working environment committees.
[42] Ryggvik 2008.
[43] Smith-Solbakken 1997.
[44] Act on Worker Protection and the Working Environment, etc, 4 February 1977.
[45] Act on Worker Protection and the Working Environment, etc, 4 February 1977, section 8, sub-section 1.
[46] Ryggvik 2008.
[47] Ryggvik & Smith-Solbakken 1997, p 222.
[48] Regulations on inspection of diving systems, 21 February 1980. Regulations on inspection of diving systems, 10 April 1984. Interview with Per Rosengren, 22 August 2006.
[49] Provisional regulations for diving on the NCS, issued by the Norwegian Petroleum Directorate, 1 July 1978, with subsequent amendments, most recently 1 April 1980.
[50] Act on Worker Protection and the Working Environment, etc, 4 February 1977.
[51] Interview with Jens Smith-Sivertsen, 23 October 2006, and recommendation from an action team to assess working time for diving personnel, Stavanger, 3 May 1979. Letter from the Norwegian Oil and Energy Employees Association (Noemfo) to the Ministry of Local Government and Labour, 28 May 1982.
[52] Provisional regulations for diving on the NCS, issued by the Norwegian Petroleum Directorate, 1980, section 4, restrictions on diving operations.
[53] Royal decree of 26 June 1981.
[54] Letter from Nopef to the Norwegian Employers' Confederation, 27 October 1981. "Arbeidstid M.M. Seaway Diving A/S" [Working hours, etc, Seaway Diving A/S].
[55] Letter from the Ministry of Local Government and Labour to Nopef, 6 August 1981.
[56] Cited in letter from Norwegian Oil and Energy Employees Association (Noemfo) to the Ministry of Local Government and Labour, 28 May 1982.
[57] Letter from the Ministry of Local Government and Labour to Nopef, 6 August 1981.
[58] Letter from the Norwegian Oil and Energy Employees Association (Noemfo) to the Ministry of Local Government and Labour, 28 May 1982.
[59] Provisional regulations for diving on the NCS, issued by the Norwegian Petroleum Directorate, 1980, section 4, Restrictions on diving operations.
[60] Nopef annual report, 1981, p 22.
[61] Interview with Jan Chr Warloe, 1 October 2008.
[62] Nopef annual report, 1983, p 24.
[63] Distrust of the Norwegian Petroleum Directorate's diving section is confirmed by many interviews, in correspondence from the relevant period, and in a number of newspaper reports from that time.
[64] Ryggvik & Smith-Solbakken 1997, p 201.
[65] The distrust of the divers in Per Rosengren's management of the Norwegian Petroleum Directorate's diving section was confirmed in the legal actions pursued by the North Sea Divers Alliance (NSDA) and the Offshore Divers Union (ODU) in 2007 and 2008. The first of these lawsuits is covered virtually in its entirety (in Norwegian) at dykkersaken.no.
[66] Interview with Per Rosengren, 22 August 2006.
[67] Ibid.
[68] NOU 2003, 5, p 86.
[69] Norwegian Petroleum Directorate's annual report, 1980, section 2.2.7. Diving.

70 Beck, Woolfsson & Ryggvik 1998.

71 Ryggvik & Smith-Solbakken 1997, p 359.

72 Guidelines for internal control by licensees, 15 May 1981.

73 Nopef, branch 16. Minutes of meeting held between 00.30 and 01.15 on 16 March, the day of the accident. The divers in attendance included several who were involved in incidents associated with the accident. None of these were criticised in any way for their involvement with the incident.

74 Norwegian Petroleum Directorate, "Rapport i forbindelse med ulykke på Ekofisk-feltet om bord på *Seaway Falcon*, 16. mars 1983" [Report related to the Ekofisk field accident on *Seaway Falcon*, 16 March 1983].

75 Kahrs 2004, p 44.

76 NOU 1984, 11.

77 Ibid.

78 Ibid, p 18.

79 Ibid, p 31.

80 Letter from the public prosecutor's office for Rogaland to the chief of police for Stavanger, 16 December 1983. Annex to NOU 1984, 11, p 33.

81 Interviews with Per Rosengren, 22 August, and Magne Ognedal, 31 October 2006. Rosengren says it was the Ministry of Local Government and Labour which insisted that he should sit on the commission. The ministry based its recommendation in part on conversations with Rosengren's superior, Magne Ognedal.

82 Interview with Per Rosengren, 22 August 2006.

83 NOU 1977, 47, "Ukontrollert utblåsing på Bravo 22. april 1977" [Uncontrolled blowout on Bravo of 22 April 1977].

84 NOU 1986, 20, "Skredulykken i Vassdalen 5. mars 1986" [The avalanche accident at Vassdalen on 5 March 1986].

85 Letter from Nopef to the Norwegian Petroleum Directorate, 4 November 1981. This position is confirmed by Per Rosengren, who could report in retrospect that the Norwegian Petroleum Directorate found divers with two personal diving logbooks, one for use in the UK sector and the other for the NCS. Interview with Per Rosengren, 22 August 2006.

86 NOU 1984, 11, p 31.

87 Ibid, p 26.

88 Ibid, p 30.

89 Interview with Jim Rune Pedersen, 25 April 2006.

90 Letter from Nopef to the Ministry of Local Government and Labour, 24 February 1984. "Innføring av norske arbeidstidsbestemmelser med hjemmel i arbeidsmiljøloven for dykkere på utenlandske fartøyer, boreplattformer og flyttbare innretninger" [Introduction of Norwegian working time provisions pursuant to the Working Environment Act for divers on foreign vessels, drilling rigs and mobile units].

91 Ryggvik & Smith-Solbakken 1997, p 271.

92 Letter from the LO til Arne Rettedal, minister of local government and labour, 29 April 1985.

93 Letter from vice president Leif Sande at Nopef to Leif Haraldseth, minister of local government and labour, 9 October 1986.

94 Ibid, p 3.

95 Nopef's archive contains an undated letter sent from the Norwegian Petroleum Directorate to the Ministry of Local Government and Labour. The letter is endorsed with the following note from Kvamme: "Sending a copy of a missive I received from the NPD. It is working for our cause, it says."

96 Letter from the Norwegian Petroleum Directorate to the Ministry of Local Government and Labour, 4 February 1987.

97 Ibid.

98 NOU 1989, 15.

99 NOU 2003, 5.

100 Ibid.

Chapter 9

1 Pedersen 2001, pp 19-47.

2 Flemming 1977, p 238.

3 Letter from the Ministry of Foreign Affairs, dated 21 August 1974, concerning a French underwater experiment (Janus III) in a Norwegian fjord.

4 A committee was appointed on 9 April 1973 to assess technical diving aspects of work operations on pipelines in deep water. The committee comprised representatives from the Norwegian navy, Det Norske Veritas, Seaway Diving and 3X.

5 Draft letter from the Ministry of Foreign Affairs concerning a French underwater experiment (Janus III) in a Norwegian fjord.

6 Letter to E Rosness, director general of the Norwegian Labour Inspection Authority, from Gunnar C Torstensen, district manager for Rogaland, NLIA, dated 15 February 1978.

7 *Nationen*, 22 October 1977, "Rørledning mulig på 500 meters dyp".

8 Odd Pedersen, paper at the Norwegian Petroleum Society conference on 17-19 April 1985, "Tidligere – Nåværende – Fremtidige grenser for undervannsarbeidere" [Previous – Present – Future Limits for Underwater Workers]. The depth records in 2008 were 701 metres in a chamber and 535 metres in water.

9 "Deepwater hyperbaric welding programme". Information film.

10 Pedersen 2001, p 55.

11 Telephone conversation with Stein Tønjum, 25 April 2008.

12 NUI report 14–80.

13 NUI report 6–81. Programme for Deep Ex 81.

14 Dr Ragnar J Værnes, "Undervannssystemer og -aktiviteter" [Underwater systems and activities], NTNF's research programme on safety and emergency preparedness on the NCS, 1983-1989, final report.

15 NAVF, form for ethical assessment of research projects involving the use of human subjects. Signed by Russell E Peterson, 26 September 1980.

16 Participants in the 300-metre dive were Anders Hjelmert, Wigulf Schøll Larsen and Bård Holand (researcher) on heliox, and Gunnar Flaten, Anders Lindahl and Jan Onarheim (researcher) on trimix. Source: Interview with Anders Lindahl, 6 March 2006.

17 Interview with Anders Lindahl, 6 March 2006.

18 "The Norwegian navy has access to the US Navy diving manual and tables for saturation diving. However, it must be stressed as strongly as possible that these tables are not used for commercial diving and will accordingly be of no use to Norwegian diving contractors or the Norwegian Petroleum Directorate and/or the Norwegian Labour Inspection Authority, which will naturally approve

the tables used by the commercial diving contractors." Letter from Arne J Friis, Seaway Diving A/S, to the Norwegian Petroleum Directorate, dated 31 January 1974.

19 Jan Onarheim in a letter to the Storting's standing committee on local government, 19 November 2003.

20 Interview with Anders Lindahl, 6 March 2006.

21 Jan Onarheim in a letter to the Storting's standing committee on local government, 19 November 2003.

22 Participants in the 500-metre dive were Wigulf Schøll Larsen, Anders Lindahl and Bård Holand on trimix, and Gunnar Flaten, Richard Dawson and Ryggland on heliox. Stein Ryggland replaced Steve Porter, who held the world record for deep diving of 686 metres, set at Duke University. Porter did not participate in the dive because the doctors found some minor problems. Source: Interview with Anders Lindahl, 6 March 2006.

23 Pedersen 2001, pp 65–66.

24 Tønjum 1989, p 182.

25 *Petro* no 2 1985, "Dypdykking – fortsatt på eksperimentstadiet" pp 16–17. Interview with Stein Tønjum.

26 Interview with Anders Lindahl, 6 March 2006.

27 Bård Holand, Sintef, "Erfaringer fra et eksperimentdykk", *Dykkenytt* no 2, 1992.

28 Interview with Anders Lindahl, 6 March 2006.

29 Nutec Report no 5, 1982, *Deep Ex 81. General project*.

30 Nutec Report no 3, 1983.

31 Nutec Report no 12, 1983.

32 Letter from Jens Smith-Sivertsen to Torbjørn Mork, director general for health, dated 13 August 1982. Registry no 82/11465, Directorate of Health.

33 *Teknisk Ukeblad* no 3, 1982, "All diving deeper than 250 metres is still experimental," by Stein Tønjum.

34 Nutec Report no 3 1983.

35 Andersen 2006, p 188-189.

36 Interview with Stein Tønjum, 25 April 2008.

37 Pedersen 2001, p 88.

38 *Bergens Tidende*, 31 August 1985, "Fagfolkene drar".

39 *Petro* no 2, 1985 "Stein Tønjum går fra Nutec i protest", p 17.

40 *Petro* no 2, 1985 "Ta et oppgjør innen dypdykkingen i tide!", p 20.

41 Odd Pedersen, paper at the Norwegian Petroleum Society conference on 17-19 April 1985, "Tidligere – Nåværende – Fremtidige grenser for undervannsarbeidere" [Previous – Present – Future Limits for Underwater Workers].

42 Lerøen 1996 makes it clear that the USA regarded the sale of Troll gas to continental Europa as part of the Cold War. The Americans were not happy about the gas pipelines being laid from Siberia to Europe, which would make the Europeans dependent on energy supplies from the Communist state to east while providing the Soviet regime with revenues. President Ronald Reagan and his supporters in the USA wanted to limit the scope of Soviet gas sales, and Troll supplies represented a good alternative.

43 Pedersen 2001, p 89.

44 Telephone conversation with Stein Tønjum, 25 April 2008.

45 *Bergens Tidende*, 17 August 1985, "Kappløp om rekorddykk".

46 Telephone conversation with Tor Fjelddal, Norwegian Labour Inspection Authority, Bergen, 10 October 2006.

47 Interview with Per Rosengren, 13 January 2006.

48 *Aftenposten*, 6 September 1985, "Grønt lys for 450 meters dykk".

49 Professor Bo Arnesjø chaired the ethics committee. Its other members were hospital owner Toralf Eskedal, Dr Kristin Aspelund, representing the health authorities, Elsa Kristiansen representing the Norwegian Nurses Association, philosophy professor Gunnar Skirbekk, law professor Nils Nygaard and old people's home manager Inger J Knudsen as lay representative.

50 *Bergens Tidende*, 5 September 1985, "Ja til risikofylt dypdykk".

51 A number of NUI/Nutec reports were graded in this way, including NUI Report 6, 1981, Nutec Report 23, 1983, Nutec Report 98, 1985 and Nutec Report 99, 1985.

52 Nutec Report 99, 1985.

53 Nutec Report No 98, 1985.

54 *Dagens Næringsliv* magazine supplement, 15 May 1999, "For lut og salt vann".

55 Bjørn Gjerde, notes on the 450-metre/Troll dive at the NUI in Bergen, 1985, and Sigurdur Hafsteinsson, notes on the 450-metre dive at Nutec in September-October 1985, undated.

56 Memo from Ole Molvær, 2008.

57 "Medisinsk rapport fra 450 m dykk på Nutec 1985" [Medical report from the 450-metre dive at Nutec 1985], Alf O Brubakk, specialist diving medical officer, Stolt-Nielsen Seaway, dated 6 March 1986. Its conclusions were in line with an earlier article on central nervous system dysfunction associated with deep-sea diving, by Johan A Aarli, Ragnar Værnes, Alf O Brubakk, Harald Nyland, Haavard Skeidsvoll and Stein Tønjum, published in *Acta Eurol Scand*, 1985:71, pp 2–10.

58 Alf O Brubakk, professor of clinical physiology, Oslo District Court, 8 April 2008.

59 *Bergens Tidende*, 9 October 1985, "Alt bra med dykkerne".

60 Oral report from Kåre Segadal, NUI, May 2005.

61 Proposition no 109 to the Storting (1983–1984) on development of the Oseberg field, landing of the oil in Norway and the establishment of a crude oil terminal, etc, states that "the Norwegian Petroleum Directorate has told the Ministry of Local Government and Labour that it will be fully possible to develop equipment which makes diving to 350 metres acceptable in safety terms. The Ministry of Local Government and Labour accordingly believes that no basis exists for opposing the laying of a pipeline in about 350 metres of water, but emphasises that the licensees must devote the necessary resources required to develop such equipment".

62 T G Shields in a letter to O I Molvær, dated 13 November 1986.

63 Interview with Stein Tønjum, 26 June 2008.

64 Results from the investigation are published in Todnem et al 1990:17, pp 95-107.

65 Letter from Arthur Dick, Otto Molvær and John Hjelle to T Mellingen, T Getz and R Birkeland, Nutec, 9 May 1986, AKPD/EAJ.

66 Interview with Stein Tønjum, 26 June 2008.

[67] Alf O Brubakk, Oslo District Court, 8 April 2008.

[68] Letter from Johan A Aarli, senior consultant at Haukeland Hospital's neurological department, to Torbjørn Mork, director general of health, dated 27 June 1985.

[69] Letter to the regional committee for medical research ethics from O I Molvær, dated 30 July 1986.

[70] Kari Todnem, Oslo District Court, 7 April 2008.

[71] Memo from O I Molvær, dated 3 July 1986.

[72] Letter to the regional committee for medical research ethics from O I Molvær, dated 30 July 1986. A legal assessment was carried out by assistant professors Ørnulf Rasmussen and Rune Voll in "Utredning om rettslige spørsmål vedrørende behandling av medisinske data i forbindelse med OTS-dykk 3" [Study of legal issues related to the handling of medical data in connection with OTS dive 3], dated Bergen 9 October 1986. This study concludes that an anonymised release of these data would be illegal pursuant to Norwegian legislation and statutory regulations.

[73] "Monthly medical report for July OTS dive 2", Nutec, 25 August 1986, OIM/EAJ

[74] Memo by O I Molvær, dated 23 July 1986.

[75] *Adresseavisen*, 7 February 1987, "Modige menn – på 360 meters dyp".

[76] Interview with Trond H Hansson, 2 July 2008.

[77] *Bergens Tidende*, 25 June 1986, "185 000 for dykk til 350 meter".

[78] *A-magasinet* 10/93.

[79] Letter from the Norwegian Labour Inspection Authority to the Norwegian Petroleum Directorate, 20 April 1988. *Aftenposten*, 26 April 1988, "Arbeidstilsynet roper varsko mot dypdykking".

[80] Safety director Magne Ognedal, *I søkelyset* [In the Spotlight], P1 channel, Norwegian Broadcasting Corporation, 20.00-20.50, 29 May 1985.

[8] Torger Berge and Terje Tytlandsvik took part in this dive.

[82] Magne Vågslid, Oslo District Court, 15 April 2008.

[83] "Hyperbare dykk dypere enn 180 msv i Norge" [Hyperbaric dives deeper than 180 metres in Norway], unofficial list prepared by Kåre Segadal, Bergen, 26 October 2006.

[84] E-mail from Einar Wold Svendsen, 27 February 2009.

[85] Letter from Kari Todnem to the Norwegian Petroleum Directorate, Statoil and Norsk Hydro, 2 December 1991. Statoil's archive.

[86] "Det siste dykket" [The last dive], TV2 documentary, 29 March 1993.

[87] *A-magasinet* 10/93.

[88] Alf O Brubakk, Oslo District Court, 8 April 2008.

Chapter 10

[1] NOU 2003, 5, Report no 47 to the Storting (2002–2003).

[2] Ibid, p 81.

[3] Interview with Per Rosengren, 22 August 2006.

[4] At the request of the Norwegian Labour Inspection Authority, the Ministry of Foreign Affairs had contacted the US government in 1967 to secure access to research reports from the US Navy. (Letter from the NLIA to the foreign ministry, 1 August 1967.) One of the reports received by the NLIA discussed several sources of uncertainty related to the use of the relevant tables. (US Navy Experimental Diving Unit, report 6-645.) In the discussion of whether the Norwegian government should take the initiative to buy in tables from professor Bühlmann, Seaway Diving denied that the US Navy tables were suitable for commercial use in the North Sea. Letter from Seaway Diving to the Norwegian Petroleum Directorate, 31 January 1974.

[5] Letter from the Norwegian Petroleum Directorate to Comex, 17 December 1984.

[6] NOU 2003, p 81.

[7] Letter from safety representative Per Johansen to safety officer Alf Schønhardt at Stolt-Nielsen Seaway, 3 March 1984.

[8] NOU 2003, 5, p 81.

[9] Interview with Gerry Cronin, 27 March 2008.

[10] *Stavanger Aftenblad*, 17 October 1984, "Umulige krav gir sikrere dykk".

[11] Bolstad & Fjelldal.

[12] Interview with Albert Johnsen, 24 April 2007. Johnsen notes that problems in getting acceptance for his safety-related ideas contributed to his exit from the diving business.

[13] Norwegian Petroleum Directorate. Action team for assessing diving operations in deep water. The minutes are attached to the compendium, Norwegian Petroleum Directorate, 87 0058.

[14] Proposition 109 to the Storting (1983–1984) on development of the Oseberg field, landing of the oil in Norway and the establishment of a crude oil terminal, etc, p 33.

[15] Letter from the Ministry of Local Government and Labour to the Norwegian Petroleum Directorate, 5 May 1986.

[16] Proposition no 1 to the Storting, Annex no 13 (1986-1987). Budget proposition no 8, Annex no 2 (1986–1987).

[17] Working party on diving operations in deep water, recommendation, 1987. p 1.

[18] Ibid, p 2.

[19] Stein Tønjum, "All diving deeper than 250 metres still experimental". *Teknisk Ukeblad*, 19 August 1982. Minutes from a meeting of the director general of health's advisory committee on hyperbaric medicine, 1 February 1983.

[20] Memo, section for diving operations and mechanical equipment, Norwegian Petroleum Directorate, concerning visit to GKSS-Unterwasser-Simulationsanlage (Gusi), July 1987.

[21] *Petro* no 2, June 1985.

[22] Interview with Arne Jentoft, 1 April 2008.

[23] Action team 1987, p 2.

[24] Limbrick 2001, p 172. Norwegian Petroleum Directorate to Norsk Hydro. "Dykkerulykken på *Seaway Condor* 22. juli 1987" [The diving accident on *Seaway Condor* 22 July 1987].

[25] Norwegian Petroleum Directorate's annual report, 1989, p 92.

[26] Nopef memo. "Innsigelser mot dykketabeller hos Norcem-Comex Subsea A/S (NCS)" [Objections to diving tables at Norcem-Comex Subsea A/S (NCS)]. Sent to the Norwegian Petroleum Directorate, 13 April 1987. Documentation from the company on the use of these tables is attached. (Comex, Medical Book II) Medical Treatment. Kit no 3.

NorthSeaDivers_indhold.indd 382 11/03/14 11.35

27 Working Environment Act, 1977, section 8.

28 Interview with Kari Todnem, 5 June 2008.

29 Bennett & Elliott 1993.

30 Curriculum vitae for David H Elliott.

31 Evidence from witnesses, court hearing, 21 April 2008.

32 Minutes from meeting of director general of health' advisory committee on hyperbaric medicine, 1 February 1983. Attended by doctors Eidsvik, Sunde, Smith-Sivertsen, Tønjum, Lehman, Sunde and Minsaas. Much of the research relating to hyperbaric medicine was questionned at the meeting.

33 Interview with Jens Smith-Sivertsen, December 2008.

34 Notice of meeting on underwater medical research. Signed by Anders Omholdt, director general of the NAVF, 4 January 1983.

35 Ibid, p 2.

36 Letter from Magne Ognedal at the Norwegian Petroleum Directorate to the Directorate of Health's continental shelf office, 11 January 1983.

37 Norwegian Petroleum Directorate's annual report, 1983.

38 Shields, Minsaas, Elliott & McCallum 1983.

39 J Aarli, "Neurological consequences of deep diving. Some case studies". In Shields, Minsaas, Elliott & McCallum 1983. Norwegian researcher R J Værnes could also demonstrate certain problems in divers after a 360-metre heliox dive. However, he claimed to be able to show that the symptoms disappeared after a year. R J Værnes, "Reversible and possible irreversible CNS changes of deep diving. A discussion of some empirical studies". In Shields, Minsaas, Elliott & McCallum 1983.

40 Interview with Kari Todnem, 6 June 2008.

41 Programme for deepwater medical research. Letter from the NAVF to the Ministry of Local Government and Labour, 26 October 1984.

42 Todnem, Riise, Nyland & A Aarli 1989.

43 Ibid.

44 Proceedings of the Storting, 1989, 29 November – Question Time, p 972.

45 From the Norwegian Petroleum Directorate to the Ministry of Local Government, 19 February 1990.

46 K Todnem, H Skeidsvoll, R Svihus, P Rinck, T Riise, B K Kambestad et al, "Electroencephalography, evoked potentials and MRI brain scans in saturation divers. An epidemiological study". *Electroencephalography and Clinical Neurophysiology, 79*, 322–329. 1991.

47 Todnem 1991.

48 *Dagbladet*, 25 April 1991.

49 Ibid.

50 Ibid.

51 *Rogalands Avis*, 30 April 1991.

52 Ibid.

53 Nutec report no 35, 1991.

54 Norwegian Petroleum Directorate's comments on Nutec report no 35, 1991.

55 Letter to the Directorate of Health from Kari Todnem, senior consultant, occupational medicine department, Haukeland Hospital, 3 April 1992.

56 Marit Grønning, professor of neurology, and psychologist Kari Troland, Oslo, witnesses in the Oslo District Court, 8 April 2008.

57 Olav Hauso, witness in the Oslo District Court, 21 April 2008.

58 Interview with Kari Todnem, 6 June 2008.

59 Todnem, Nyland, Skeidsvoll, Svihus, Rinck, Kambestad et al 1991, pp 258–266.

60 *Dykkenytt* no 2, 1991 and *Nopef-aktuelt* no 4, 1991.

61 *Nopef-aktuelt* no 4, 1991.

62 Ibid. Asked whether it would ever be acceptable to send divers down to 400 metres, Todnem was not entirely negative: "I believe it can be done if diver selection becomes extremely thorough, if [the divers] can be monitored particularly well during the dive and if decompression procedures are improved."

63 Letter from Lars Andreas Myhre, Nopef, to prime minister Gro Harlem Brundtland, 12 July 1991.

64 Letter from the Ministry of Local Government to the chair and members of the commission, 27 March 1992. Signed by deputy director Gundla Kvam.

65 In addition to Kromberg, the commission's members were Olav Hauso, principal engineer at the Norwegian Petroleum Directorate, Rajinder Midha, medical specialist at the Norwegian Labour Inspection Authority, Christine Norhagan, head of division at the Ministry of Labour and Government Administration, Aase Rokvam, deputy director at the Ministry of Social Affairs, Leif Sande, vice president of Nopef, Pål Schiefloe, operations vice president at Stolt Comex Seaway A/S, Egil Takle, special adviser to the Norwegian Petroleum Directorate (secretary), and Jan Fredrik Andersen, medical specialist at the Directorate of Health (secretary from May 1993).

66 "Helse og sikkerhet i dykkevirksomheten" [Health and safety in the diving industry], report, November 1993 (the Kromberg report).

67 Ibid, table 4.3.

68 "Rapport om sammenligning av metningsdykketabeller og utarbeidelse av rammebetingelser for standardisering" [Report on the comparison of saturation diving tables and the preparation of operating parameters for standardisation], Norwegian Petroleum Directorate, January 1991.

69 Regulations for manned underwater operations in the petroleum activity, issued by the Norwegian Petroleum Directorate and the Directorate of Health, 11 June 1990.

70 *Nopef Aktuelt* no 8, October 1992.

71 *Nutec Dykkenytt* no 3, 1991.

72 From Leif Sande at Nopef to Marit Kromberg, diving commission, 8 October 1993.

73 Kromberg commission's report, foreword.

74 Alf O Brubakk, Oslo District Court, 8 April 2008.

75 Ibid, item 4.2.1.

76 This debate has much in common with the major conflict in the USA over the harmful effects of tobacco. David Michaels, who served in the Clinton administration during the 1990s, describes how industries subject to public criticism for causing possible health injuries develop the same type of relationship with scientists and research and deploy the same kinds of arguments as were used by the one side in the Norwegian debate. David Michaels, *Doubt is their product. How industry's assault*

on science threatens your health, Oxford 2008.

77 Marvin Rausan & Knut Øyen, "Risikoanalyse. Tilbakeblikk og utfordringer". In Lydersen 2004, p 93.

Chapter 11

1 Interview with Einar Wold Svendsen, 14 November 2005.

2 Interview with former ROV operator Ivar Engeberg, 31 May 2007.

3 The RCV 225 and another type of eyeball known as the ISEs Dart were also used on Frigg. *Underwater Technology 82*, Bergen, 1982, pp 202–203.

4 IKU, publ no 68, *Oppgaver og resultater 1974/1975* [Assignments and results 1974-75].

5 *Underwater Technology 82*, Bergen, 1982, pp 167–182.

6 Trillo 1978.

7 *Underwater Technology 82*, Bergen, 1982, pp 202–204.

8 Interview with former ROV operator Ivar Engeberg, 31 May 2007.

9 www.kulturminne-ekofisk.no

10 Dahling & Erlandsen 1999, pp 140–141.

11 Interview with Erik Sæstad, 31 January 2006.

12 Interview with Ivar Engeberg, 31 May 2007.

13 Interview with Erik Sæstad, 31 January 2006.

14 Interview with former ROV operator Ivar Engeberg, 31 May 2007. Engeberg started this course himself.

15 www.kulturminne-ekofisk.no.

16 www.kulturminne-frigg.no.

17 Dahling & Erlandsen 1999, pp 78-79.

18 Interview with Lars Inge Larsen and Johan Bruun Olsen, 26 March 2007.

19 One architect of the Host concept was Hans Jørgen Lindland at Statoil.

20 Dahling & Erlandsen 1999, p 166.

21 Statoil memo, "Viktige beslutninger for UVT-området i Statoil", 1998.

22 *Petro*, 3rd issue, 2005, p 45.

Chapter 12

1 Nopef memo, "Maksimal dykkedybde og begrensede faktorer" [Maximum diving depth and limiting factors], p 3. Submitted to a meeting at the Norwegian Petroleum Directorate, 1 October 1986.

2 Ibid.

3 Letter to petroleum and energy minister Arne Øien from Stolt-Nielsen Seaway A/S, 20 August 1986. In an annex, the company itself admits the significance of political pressure for the award of the Statpipe job, p 1.

4 Ryggvik 2002, p 313.

5 Ibid.

6 Letter from Stolt-Nielsen Seaway A/S, 20 August 1986. Annex.

7 Letter to petroleum and energy minister Arne Øien from Stolt-Nielsen Seaway A/S, 20 August 1986. Annex.

8 Stolt-Nielsen Seaway, oversikt over oppdragsmengde og ansatt dykkepersonell i Norge 1986/87 [overview of workload and diving personnel employed in Norway 1986-87]. According to this overview, SNS had contracts worth NOK 250 million on the NCS. Comex, Wilhelmsen Underwater Engineering, Subsea Dolphin and Oceaneering had assignments worth NOK 55, 60, 30 and 90 million respectively.

9 Interview with Leif Johansen, 3 April 2008.

10 Norwegian Petroleum Directorate's annual report, 1990.

11 *European Offshore Petroleum Newsletter*, 15 (2) (1990).

12 Kenichi Ohmae, *The Borderless World*, New York, 1990. Robert B Reich, *The Work of Nations. Preparing Ourselves for the 21st-Century Capitalism*, New York, 1991

13 *Bergens Tidende* and *Dagens Næringsliv*, 14 August.

14 *Aftenposten* journalist Henrik Width has not yet been willing to reveal his source for the relevant report. However, he maintains that the way Norvik reacted when it became known was a good indication that this was no deliberate leak. Interview 16 July 2008.

15 *Dagens Næringsliv*, 14 August 1990.

16 *European Offshore Petroleum Newsletter*, *15* (2) (1990). "Noble intentions' evolve into bid scandal". Although the newsletter had been the first to reveal that a number of Statoil employees had shares in *Seaway Pelican*, it concluded that the desire to save Stolt-Nielsen Seaway from bankruptcy was the main reason the contract was so well tailored.

17 *Aftenposten*, 10 August 1990, "Personlig profitt utelukkes ikke".

18 Information, Nopef's Statoil branch, undated.

19 *Dagens Næringsliv*, 17 August 1990.

20 *VG*, 9 September 1990.

21 Statoil, *Extra Status*, 21 November 1990.

22 Ibid.

23 Interview with Leif Johansen, 3 April 2008.

24 The AODC was later renamed the International Marine Contractors Association (IMCA). *Stavanger Aftenblad*, 4 November 1992, "For dyrt og risikofylt å satse på dykkere".

25 Norwegian Petroleum Directorate's annual report, 1984, p 64.

26 Norwegian Petroleum Directorate's annual reports, 1992 and 1996.

27 In 1991, 128 personnel on *Seaway Condor*, *Seaway Osprey*, *Seaway Harrier* and *Seaway Pelican* paid subscriptions to Nopef. Any who might not have been divers must have been diving support personnel. Report from Stolt-Nielsen Seaway A/S to Nopef, dated 16 May 1991.

28 Reich 1990, Omahe 1990.

29 Interview with Erik Sæstad, general manager ROVs, Norway UK, Oceaneering Norge A/S, 3 June 2008.

30 The Norwegian Petroleum Directorate's "emergency preparedness regulations" and the provisions in the regulations for manned underwater operations.

31 Memo from Geir I Mellgren, DTJ-UVA, to Henning Frostad, dated 8 February 1995, Statoil's archive, subsea section.

32 Requirements for dives beyond the 180-metre limit included equiping the DSV with two hyperbaric lifeboats, so that divers could be evacuated from two different depths. In an emergency where the divers were under varying pressures, the diffence between the depth limits could be so great that it was impossible to harmonise the pressures in a single lifeboat. Einar Wold Svendsen by e-mail to Kristin Øye Gjerde, 18 February 2009.

33 Norsok standard U–100 on unmanned subsea operations. Norsok retained the 180-metre limit for some of the

measures – such as the requirement for increased medical investigations and monitoring – but moved others to either shallower depths – active heating of breathing gases from 180 to 150 metres, for example – or greater. The maximum duration for saturation time, for example, was moved from 180 to 250 metres, and from 14 to 10 days at the latter depth. Einar Wold Svendsen, 18 February 2009. As long as Norsok operated within the framework of the internal control system on the NCS, all relaxations were conditional on their acceptance by the Norwegian Petroleum Directorate.

34 "Behovsanalyse, bemannede undervannsoperasjoner" [Demand analysis, manned underwater operations], Document number UVO 99.ra1/ews, Statoil's archive.

35 The decision base for the management in connection with the planned 250-metre dive at NUI, October 2002. Document number UVO U-00019, Statoil's archive, subsea section no 670.

36 The decision base for the management in connection with the planned 250-metre dive at NUI, October 2002. Document number UVO U-00019, Statoil's archive, subsea section no 670.

37 *Bergens Tidende*, 8 April 2003.

38 *Bergens Tidende*, 8 April 2003, "Dykkersatsing ble tilbakeslag".

39 Petroleum Safety Authority Norway, 18 April 2008, "Høy dykker aktivitet, få personskader" [High diving activity, few personal injuries].

40 Interview with Johan Bruun Olsen and Lars Inge Larsen, 26 March 2007.

41 Action team on diving after 2000 (AGDY 2000+).

Chapter 13

1 *Dagbladet*, 19 December 1997. "Dykkere begår selvmord. Mister livsmotet etter yrkesskade".

2 Einar Thorsen, Harald Nyland, Marit Grønning, Leif Aanerud, Stein G Nordal, Otto I Molvær, Kari Troland, Endre Sundal and Tor B Aasen. Report from the occupational medicine department, Haukeland Hospital, Bergen, on the health effects of diving.

3 "Helsestatus hos tidligere nordsjødykkere" [Health status of former North Sea divers]. Report to the Ministry of Labour and Social Affairs, occupational medicine department, Haukeland University Hospital, December 2004.

4 Sundal, Grønning, Troland & Einar Thorsen.

5 "Nevropsykologiske resultater fra undersøkelse av tidligere nordsjødykkere" [Neuropsychological results from investigations of former North Sea divers], paper to the diving seminar, Kari Troland, Haukeland University Hospital, 2004.

6 *Dykkenytt* no 2, 2005.

7 "Long-term health effects of diving. The Godøysund 1993 consensus conference revisited. An international workshop", Bergen, 15-17 November.

8 Report no 12 to the Storting (2005–2006), 7.1.2.

9 Interview with Henning O Haug, January 2009.

10 Interview with Rolf Guttorm Engebretsen, January 2009.

11 Interview with Tom Engh, January 2009.

12 *Dagbladet*, 20, 21, 22 and 23 September and 7 December. *Dagens Næringsliv*, 15 May.

13 The "diver issue" first appears as a term in Norway soon after 2000.

14 The following people with a media background have been particularly active supporters of the North Sea divers: Knut Ørejasæter, Jan Rustad, Torbjørn Bjerkseth, Terje Marøy and Styrk Jansen.

15 *Dagbladet*, 7 December 1999.

16 OFSA no 2, April 2000, p 3.

17 *Dagbladet*, 3 April 2000.

18 NOU 2003, 5, p 10.

19 *Dagbladet*, 10 December 2002. "Kan vi ha tillit til dykkergranskerne?"

20 The scope of the commission's work can be confirmed by the authors of this book, who have been given access to its records.

21 NOU 2003, 5, p 89.

22 Ibid, p 97.

23 Ibid, p 111.

24 Report no 47 to the Storting (2002–2003). Investigation of conditions for the pioneer divers in the North Sea.

25 Ibid.

26 Ibid, section 4.2.

27 Ibid, section 6.2.

28 NTB, 10 November 2003.

29 Recommendation no 137 to the Storting (2003–2004).

30 Interviews with Rolf Guttorm Engebretsen, Henning O Haug and John A Haugestad.

31 Aftenposten, 19 December 2008.

32 Interviews with John A Haugestad, January 2009, and R G Engebretsen, January 2009.

33 TV2, "Dykkere på dypt vann" [Divers in deep water], 7 May 2007.

34 Oslo District Court. Judgement, case no 05-028758TVI-OTIR/03.

35 Oslo District Court. Judgement and decree, 9 September 2008. Personal injuries from diving in the North Sea.

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