

Monitoring Oil Pollution from Oil and Gas Installations in the North Sea

Angela Carpenter

Abstract Oil and gas installations are a source of oil inputs to the North Sea. Those inputs can include oil discharge as a result of production processes or from accidental spills. Two bodies play a major role in monitoring oil inputs from those installations. The OSPAR Commission is responsible for monitoring oil and gas installations against various performance standards, collects samples from those installations to determine whether those standards have been met or exceeded, and also monitors accidental spills. The Bonn Agreement Secretariat also plays a role through its aerial surveillance and, more recently, satellite monitoring activities in the North Sea region. Once a spill has been identified and confirmed as being mineral oil rather than other types of oils or even algae or a natural event, the Bonn Agreement seeks to identify the source of that oil. Through a programme of surveillance activities, it also specifically monitors the areas around oil and gas fields. This chapter provides an overview of the activities of the OSPAR Commission and Bonn Secretariat as they relate to oil and gas installations and examines data on inputs of oil to the marine environment to identify trends in oil pollution from those installations.

Keywords Aerial surveillance, Bonn Agreement, Cuttings, North Sea, Oil platforms, Oil pollution, OSPAR Commission, OSPAR Convention, Produced waters, Satellite surveillance

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1 Introduction

Two bodies play a significant role in monitoring oil pollution from oil installations in the North Sea. The first is the OSPAR Commission, the body responsible for carrying out activities under the aegis of the Convention for the Protection of the Marine Environment of the North-East Atlantic, 1992 (OSPAR Convention) [1].

The OSPAR Commission is the competent regional organisation guiding international cooperation in the region, and a major role of the Commission is to develop harmonised policies and strategies, including drawing up programmes and measures under a number of thematic strategies [2]. Those thematic strategies are biological diversity and ecosystems, eutrophication, hazardous substances, offshore oil and gas industry (the focus of this chapter) and radioactive substances.

One of the roles of the OSPAR Commission is to monitor oil discharges from the offshore oil and gas industry in the North Sea and more widely in the OSPAR Maritime Area (see Fig. 1). Further information on the content of the OSPAR Convention and on the responsibilities of the OSPAR Commission is provided in chapter of this volume [3].

Region I of the OSPAR Maritime Area covers Arctic waters, an area including the Barents Sea where oil and gas production is expected to increase. Region II is the Greater North Sea, the area where the offshore oil and gas industry has been a major economic activity since the 1960s (see Fig. 2). The remaining OSPAR regions are Region III, the Celtic Seas; Region IV, Bay of Biscay and the Iberian Coast; and Region V, the Wider Atlantic.

The second body which monitors oil pollution in the North Sea region is the Bonn Agreement Secretariat, responsible for administering the requirements of the Agreement for cooperation in dealing with pollution of the North Sea by oil and



Fig. 1 OSPAR Maritime Area. *Source:* OSPAR Commission

other harmful substances, 1983 together with its amendments of 2001 (Bonn Agreement) [5].

Figure 3 identifies the zones of responsibility under the Bonn Agreement, where the eight countries bordering the North Sea have undertaken aerial surveillance, since the late 1980s, using specially equipped aircraft to detect oil and other harmful substances [6]. The UK has, since 2012, mainly used satellite imagery for first alerts, and these are followed up by further investigations including aerial surveillance [7].

While Ireland joined the Bonn Agreement in April 2010 as a Contracting Party, it does not undertake aerial surveillance activities. Geographically, therefore, the Bonn Agreement now covers an extended area to the west of Scotland and south-west England and the waters off Ireland extending into the north-east Atlantic. Only the North Sea area set out in Fig. 3 is considered in this chapter and generally only the area to the north of the zone operated jointly by the UK, France and Belgium.

Further information on the Bonn Agreement, its history and its actions to eliminate accidental and illegal pollution from ships in the North Sea is provided in chapter of this volume [8].

This chapter presents an overview of the activities of the OSPAR Commission and of the Bonn Agreement Secretariat related to monitoring oil inputs to the North Sea. It then presents a broad overview of the levels of inputs, both from oil and gas industry sources and from shipping, based on Bonn Agreement aerial surveillance



Fig. 2 Oil and gas production pipelines in the North Sea, 1991. Source: North Sea Quality Status Report 1993 [4, Figures 1–10, p 17]. *Note:* This figure shows oil and gas production platforms and pipelines in 1991, together with the position of oil wells and exploration drillings

data. A more detailed examination of trends in oil pollution specifically from oil and gas platforms as a result of routine operations and accidental spills is then presented, based on OSPAR Commission data. Finally, some conclusions are drawn as to trends in levels of oil pollution in the region over the nearly three decades for which data is available.

Fig. 3 Bonn Agreement zones of responsibility for aerial surveillance. *Source:* Carpenter (2007) [6, Fig. 1, p 151]



2 The Role of the OSPAR Commission in Monitoring Oil Inputs from Oil and Gas Industry

The OSPAR Commission’s strategic objective with regard to its Offshore Oil and Gas Industry Strategy (Offshore Strategy), part of the wider North-East Atlantic Strategy, is to “prevent and eliminate pollution and take necessary measures to protect the OSPAR maritime area against the adverse effects of offshore activities”, which includes exploration, appraisal or exploitation of liquid and gaseous hydrocarbons [2].

The Offshore Strategy requires the OSPAR Commission to implement the Strategy progressively and, where applicable, to follow on from and be consistent with commitments made under other OSPAR Strategies. In order to address programmes and measures related to the need to prevent, control and eliminate pollution under Annex III of the OSPAR Convention and to be adopted under Annex V of the Convention following identification of relevant human activities, the Offshore Strategy requires the Commission to collect information about threats to the marine environment from pollution or from adverse effects from offshore activities, to establish priorities for taking action and to establish and periodically review environmental goals to achieve the Offshore Strategy’s objectives.

Annex III of the Convention relates to pollution from offshore sources. Annex V of the Convention relates to protection and conservation of ecosystems and biological diversity [1].

As part of the process of achieving the objective of the Offshore Strategy, the Commission collects information on threats to the marine environment from pollution or adverse effects from offshore activities including exploration, appraisal or exploitation of liquid and gaseous hydrocarbons in the OSPAR Maritime Area [2]. A number of measures have been developed to monitor and control emissions, discharges and losses of substances from offshore installations. Information on discharges and waste handling from offshore oil and gas installations has been collected and reported since 1978, originally under the former Paris Convention of 1974 [9] and subsequently under the OSPAR Convention.

2.1 OSPAR Offshore Industry Committee Role and Responsibilities

The OSPAR Offshore Industry Committee (OIC) is responsible for facilitating the implementation of the North-East Atlantic Environment Strategy, and in particular the Offshore Strategy, by: developing and applying a risk-based approach for the management of produced water from offshore activities, keeping under review the need to actions to prevent potential adverse effects from offshore activities and also considering the implications of decommissioning redundant oil and gas installations [10].

Specific monitoring and assessment activities of the OIC, in line with the OSPAR Strategy for the Joint Assessment and Monitoring Programme (JAMP) [11] for the period 2014 to 2021, include annual data collection and periodic evaluation of the impact of discharges, emissions and losses of substances from offshore sources, which cause or are likely to cause pollution; improvement of tools to collect, process and interpret such data, together with appropriate initiation and review of technical studies including best available techniques (BAT) and best environmental practice (BEP); and preparing assessments, including assessments on specific issues, such as assessments of the impacts of decommissioned pipelines and cutting piles, and arranging for their publication [10].

2.2 Measures Relating to Discharges Contaminated with Oil

In 1986 PARCOM (the Paris Commission, the main executive body of the Paris Convention) put in place a recommendation (PARCOM 86/1) for a 40 mg/L emission standard for platforms, under which a standard of 40 mg/l for the average concentration of hydrocarbons in effluents discharged from platforms should be applied to all platforms constructed after 1 January 1988. It also indicated that emission standards should be set at or below this standard for all individual platforms, unless a Contracting Party could justify why it was unable to do so [12].

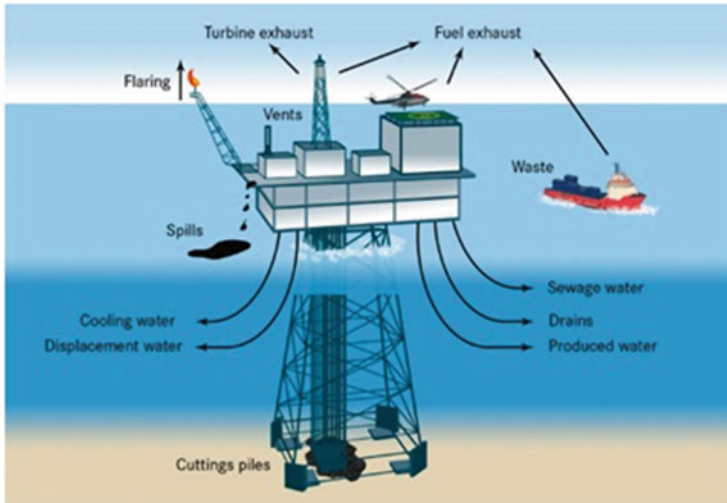


Fig. 4 Sources of oil inputs from oil and gas installations. *Source:* OSPAR Quality Status Report 2010 [14, Fig. 7.1, p 65]

PARCOM 86/1 was subsequently revoked, for produced water only, by OSPAR Recommendation 2001/1 for the Management of Produced Water from Offshore Installations [13]. Produced water (PW) is water that comes from the reservoir as a by-product of oil and gas extraction. PARCOM 86/1 remains applicable, however, to ballast water, drainage water and displacement water from offshore installations. DW is seawater used for ballasting the storage tanks of offshore installations which is discharged into the sea when oil is loaded into those tanks. Figure 4 illustrates the different sources of oil inputs that can be produced by oil and gas installations.

An additional requirement under Recommendation 2001/1, as amended by Recommendation 2006/4, was that, for each installation failing to meet the 30 mg/L standard, Contracting Party reports to the OIC should include an evaluation of BAT and BEP so that information was available on why installations cannot meet the performance standard [15].

Analysis of samples from oil and gas installations is conducted under an agreed reference method of analysis for the determination of dispersed oil content in PW [16]. The results of those analyses, which determine the number of installations failing Recommendation 2001/1 standards, are discussed at Sect. 5.3 in this chapter.

2.3 Measures Relating to the Use and Discharge of Drilling Fluids and Cuttings

Two measures are in place relating to the use and discharge of drilling fluids and cuttings. The first of these is OSPAR Decision 2000/3 on the use of organic-phase

drilling fluids (OPFs) and the discharge of OPF-contaminated cuttings [17]. OPFs are fluids which are an emulsion of water and other additives in which the continuous phase is a water-immiscible organic fluid of animal, vegetable or mineral origin. Cuttings are solid material removed from drilled rock together with any solids and liquids derived from any adherent drilling fluids.

While only small amounts of oil are discharged to the marine environment via OPFs in cuttings (see Sect. 5.2.1), some discharges were made from UK installations in 2010–2012. This is permissible, under Decision 2000/3, with prior authorisation of the national competent authority, and this may, for example, be for geological or safety reasons, or in exceptional circumstances. BAT and BEP must be applied in reaching the decision to authorise such discharges [17].

The second measure relating to discharges of drilling fluids are the guidelines for considering the best environmental option for the management of OPF-contaminated cutting residues [18]. While the use of BAT and BEP are described in Decision 2000/3, the guidelines set out how residue disposal should be managed, on a case-by-case basis by the national competent authority (NCA), to achieve the best environmental option in dealing with such residues.

Factors which could influence the decision by an NCA as to what is the best environmental option are outlined in the guidelines. These may include the location of oil and gas reservoirs and whether they are in remote or environmentally vulnerable areas. Technical factors such as the amount of drilled cuttings generated; availability of deck space, energy, etc., on the installation; and the meteorological conditions during operation should also be considered [18].

Environmental factors such as risk to human health; total energy needed to treat, transport, etc.; the OPF-contaminated cutting residues; and levels of emissions to air, water and sea sediment should be examined to compare different options for disposal of cuttings. Finally, a holistic evaluation of, for example, the economic feasibility of transporting to shore OPF cuttings for processing, reinjection of cuttings or offshore treatment of OPF cuttings for discharge to the sea is also required [18].

3 The Role of the Bonn Agreement in Monitoring Oil Pollution in the North Sea

As noted in Sect. 1, the Bonn Agreement has, since the late 1980s, used aerial surveillance to monitor the North Sea for oil pollution and pollution from other hazardous substances. More recently, it has also made use of satellite surveillance imagery, provided by the European Maritime Safety Agency (EMSA) under its CleanSeaNet programme [19].

The Bonn Agreement programme includes a number of different surveillance activities, and these are outlined at Sects. 4.1–4.3.

3.1 National Flights

In order to prevent illegal or accidental pollution of the North Sea, most Bonn Agreement countries, with the exception of the UK, undertake aerial surveillance to enforce maritime pollution rules and standards such as those set out under the MARPOL 73/78 Convention [20]. That Convention has designated the North Sea as a special area where mandatory methods are in place to prevent marine pollution by oil. Specially equipped aircraft are used to patrol the zones of responsibility set out in Fig. 3, although some flights also cross the boundaries of those zones.

Flights take place during both daylight and the hours of darkness and provide first reports on possible pollution incidents. A first report is where raw data on a slick has been obtained using specialised instruments such as synthetic aperture radar (SAR), side-looking airborne radar (SLAR) and infrared or ultraviolet (IR/UV) line scanners or cameras [21]. A slick may subsequently be verified as mineral oil or some other substance by experienced observers who are able to identify a slick from its appearance on the sea surface, for example.

In the event of there being doubt about the nature of a slick, sampling of polluted water may occur, and techniques such as combined gas chromatography and mass spectrometry techniques (GC/MS) can be used to analyse the substance and confirm whether it is oil or not. It can also be used to confirm the source of the oil discharge, e.g. from a specific ship, by comparing the sample of polluted water with samples taken from a ship suspected of being the source of the oil [21].

3.2 Coordinated Extended Pollution Control Operations

CEPCO activities are additional aerial surveillance activities where neighbouring countries, not necessarily Bonn Agreement countries, agree to cooperate to conduct intensive surveys in areas of high traffic density during a relatively short period (e.g. 24 h) or over a longer period (one week for a SuperCEPCO).

In 2000 six countries conducted CEPCO activities (Belgium, France, Germany, the Netherlands, Sweden and the UK). A total of 18 flights took place (7 by France) lasting a total of 45.5 h. Only nine slicks were observed (seven in daylight, two at night), one of which came from a rig in the German zone and one each from ships in German and Swedish zones [21, 22]. Generally, low numbers of flights, flight hours, observed and confirmed slicks and the source of slicks were apparent in all but one year between 2001 and 2013. 2007 had the highest number of CEPCO flights (73) and flight hours (208) with 35 slicks observed (1 at night). However, only five polluters were identified (all ships) from that year's activities. There were no CEPCO flights at all in 2003 or 2011.

An example of a SuperCEPCO was one organised between France and the UK, which took place from 12–18 October 2010 [23]. After nearly 107 flight hours, split 55.4 h during daylight and 51.2 h during darkness, only two slicks were observed

(one each in daylight and darkness). One slick was confirmed as a mineral oil spill of unknown origin, with an estimated volume of 2.13 m³. A similar exercise from 10 to 14 September 2012 between France and Spain (a non-Bonn Agreement country) saw six aircraft from five countries undertaking 42.7 flight hours (19.4 h during night-time). One slick was observed during daylight and confirmed as oil. The source of that slick, estimated at only 0.9 m³, was unknown [7].

3.3 Tour d'Horizon (TdH) Flights

Tour d'Horizon flights are conducted specifically to monitor offshore oil and gas installations located within the zone of responsibility of each Contracting Party. Patrol flights are arranged by the individual countries and cover predetermined routes.

Since 2003 additional data has been provided as a separate Annex (Annex II) in the annual aerial surveillance reports on the results of TdH flights [24]. That includes information on when flights took place and on flight routes, for example. It also includes summary results by country and presents: a breakdown by month, date and time, the position (latitude and longitude) and the quantity of oil (approximate amount) for observed spills; and, where it is known, the identity of the polluter is also included. This can be a rig, a ship or unknown (see Sect. 4.3). The additional data may also include some remarks about the nature of the sighting. Finally, a Detection Investigation Summary is also provided in the reports and includes a Government Inspector Assessment of the pollution incident and remarks about what action, if any, was taken; including legal action.

3.4 Satellite Surveillance Programmes

Remote sensing of oil and other harmful substances entering the North Sea had, until 2002, only been reported on from aerial surveillance activities. Since 2003, however, remote sensing from satellite surveillance activities has also been reported in the Bonn Agreement annual reports. As noted in Sect. 1, the UK has relied solely on satellite imagery provided through EMSA CleanSeaNet [19] as a source of first alerts of oil slicks in its zone of responsibility.

There are a number of early examples of the use of satellite programmes. In 2003, for example, the Admiral Danish Fleet HQ received approximately 100 satellite pictures while the Norwegian Coastal Administration (NCA) supported a national satellite programme called SATHAV. In the latter case, the Norwegian Space Agency had a long-term agreement to use Canadian RADARSAT images for the Norwegian Exclusive Economic Zone (EEZ). The NCA used satellite images between September and end of December 2013 for oil spill monitoring purposes and also for military ship detection [24]. Between 2003 and 2006, Germany was a

partner in an EU programme called OCEANIDES which, for example, developed tools for monitoring illicit marine oil discharges by advances in satellite image processing techniques [25].

In 2004, Sweden established a satellite programme and received over 150 satellite images covering both its North Sea and Baltic Sea areas [26] for a number of years thereafter. From 2004, the UK was involved in a tripartite satellite surveillance programme with Germany and the Netherlands using ENVISAT earth observation data provided by the European Space Agency (ESA)¹ and also RADARSAT images.

The EMSA CleanSeaNet [19] service was launched in April 2007. This service provided near real-time radar satellite imagery from RADARSAT and ENVISAT SAR satellites. CSN was available free of charge to all Coastal States in the EU and covered all European Sea Areas. 275 satellite scenes were provided for the North Sea region for marine pollution monitoring purposes [27]. North Sea CSN Service statistics have formed Annex IV of the Bonn Agreement surveillance reports since the report for 2009 when it delivered 326 images [28].

The Annex IV data includes the number of images delivered each month, together with information on CSN detections, and those detections checked and confirmed as being oil spills by member states. In 2013 there were 601 images delivered, 814 possible spills detected, 168 possible spills checked (21%), and 20 spills were confirmed as mineral oil [7].

4 Bonn Agreement Data on Oil Inputs from Shipping and Oil Platforms

This section examines the findings of the Bonn Agreement aerial surveillance programme between 1986 and 2013. The figures and tables in this section have been compiled using data from the Bonn Agreement aerial surveillance reports for those years and included all types of aerial surveillance activities, i.e. national flights, CEPCO flights and Tour d'Horizon (TdH) flights. It also examines the use of data obtained from satellite surveillance activities since 2003.

4.1 Observed Slicks in the North Sea from All Sources, 1986–2013

Figure 5 illustrates the level of aerial surveillance activity and number of observed spills for the period 1986–2013. That data has, since 1992, included identification

¹ See <https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/envisat> for further information on the ENVISAT programme.

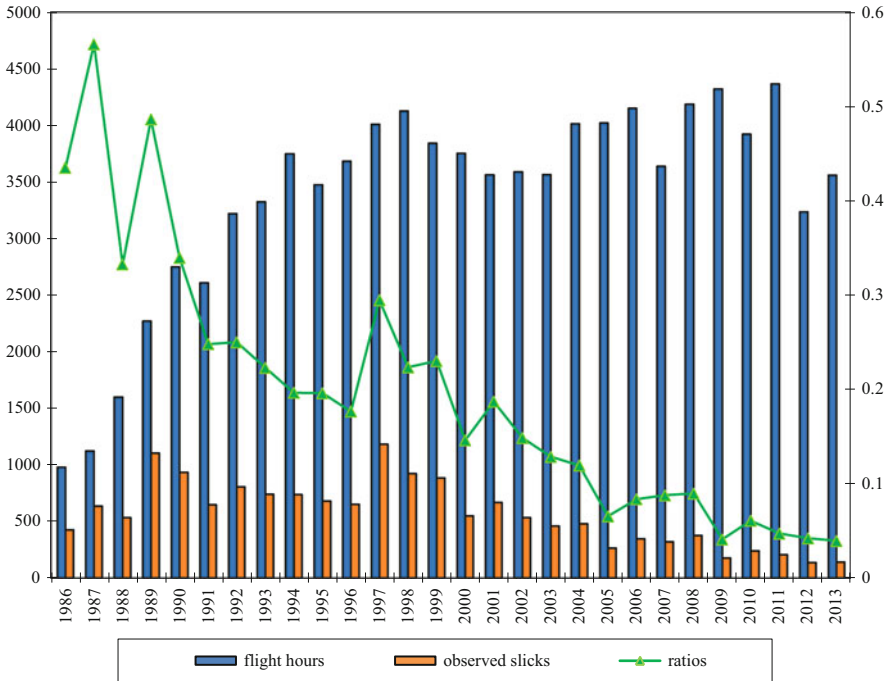


Fig. 5 Bonn Agreement aerial surveillance data for all North Sea countries, 1986–2013. *Notes:* Fig. 5 only includes observed slicks that are confirmed as mineral oil – since 2012 the Bonn Agreement has also reported slicks confirmed as being other substances. The number of flight hours and observed slicks is shown on the *left*, the ratio of slicks to flight hours on the *right*

of slicks during the hours of darkness, the result of improvements in technology on board surveillance aircraft, for example.

Figure 5 also illustrates the marked decline in the actual number of observed slicks over the 27 years for which data is available. From a high of 1,104 slicks in 1990 (and a further high of 1,181 in 1997), the number of slicks fell to 140 in 2013. During the same period, the number of flight hours rose from 977 in 1986 to a peak of 4,366 in 2011. As noted in the introduction, since 2012, the UK has mainly used satellite imagery, and this is reflected in the fall in total flight hours across the eight North Sea countries (3,235 h in 2012 and 3,558.6 in 2013).

In respect of the ratio of slicks to flight hours, i.e. how many slicks were observed for every hour of flying time, this has fallen from a high of 0.57 (just over one slick every half an hour) in 1991 to 0.04 (approximately one slick for every 25 h of flying time).

Until 2003 the number of spills reported both by country and as a total for all eight countries was the number of spills observed, without any confirmation of the type of spill. A spill may therefore have been an oily sheen on the water surface from an algal bloom, some type of weather phenomenon, or from another type of oil

such as cooking oil. Since 2003 the figures provided in Bonn Agreement annual reports are confirmed mineral oil slicks, and, from that year on, only confirmed mineral oil slicks appear in Fig. 5.

As an example of the difference made by confirming the nature of a slick, in 2003 there were 458 confirmed slicks across the North Sea compared to 592 slicks prior to confirmation. Also in 2003, there were 290 detections from flights out of the Netherlands, but only 191 of those were confirmed as mineral oil [24].

4.2 Results from Satellite Imagery Post-2004

As noted at Sect. 3.4, since 2004 satellite imagery has also been used to identify slicks (mineral oil and other substances), and, since 2009, EMSA CSN data has been reported at Annex IV of the Bonn Agreement annual reports. The data provided at Annex IV includes the number of images delivered each month, together with information on CSN detections, and those detections checked and confirmed as being oil spills by member states. In 2013 there were 601 images delivered, 814 possible spills detected, 168 possible spills checked (21%), and 20 spills were confirmed as mineral oil [7].

Table 1 compares the number of spills detected using satellite imagery between 2004 and 2013 against those detected using aerial surveillance. It shows the proportion of oil slicks confirmed as being mineral oil in those years from both types of data.

In Table 1 it is apparent that a higher proportion of slicks observed using aerial surveillance are confirmed as being mineral oil: less than 20% for satellite

Table 1 Confirmed spills from satellite imagery and aerial surveillance, 2004–2013

Year	Satellite imagery data			Aerial surveillance data		
	Spills detected	Confirmed mineral oil	% Confirmed	Spills detected	Confirmed mineral oil	% Confirmed
2004	378	46	12.17	540	429	79.44
2005	399	28	7.02	386	257	66.58
2006	407	86	21.13	478	347	72.59
2007	280	43	15.36	459	319	69.50
2008	700	90	12.86	559	375	67.08
2009	247	42	17.00	414	177	42.75
2010	411	29	7.06	414	238	57.49
2011	422	25	5.92	389	206	52.96
2012	509	31	6.09	227	136	59.91
2013	631	24	3.80	333	140	42.04

Source: Bonn Agreement annual reports for 2004–2013 (2008 to 2013 annual reports were, at the time of writing, available from the Bonn Agreement Secretariat at <http://www.bonnagreement.org/publications>; reports for earlier years are available by writing to the Bonn Agreement Secretariat)

detections in all but 2006 and more than 50% and as high as 80% for aerial detections in all years except 2009 and 2013.

With improvements in technology and the introduction of satellite imagery, it can be assumed that a higher number of slicks are being captured by all the surveillance activities. It can also be assumed that intentional oil spills are now less likely to occur than they were prior improved night-time surveillance and satellite observations. Where ship operators may previously have chosen to intentionally discharge oil into the North Sea during the hours of darkness, the risk of an oil slick being identified and tracked back to a ship has also been improved as a result of technological improvements and the introduction of satellite surveillance activities.

4.3 Sources of Oil Spills

The Bonn Agreement Secretariat has, since 1997, provided specific information on the source of oil spills, i.e. identifying whether they come from ships, from oil platforms or from unknown sources. Figure 6 illustrates that the number of slicks confirmed as coming from either rigs or ships during the period 1997 to 2013 is

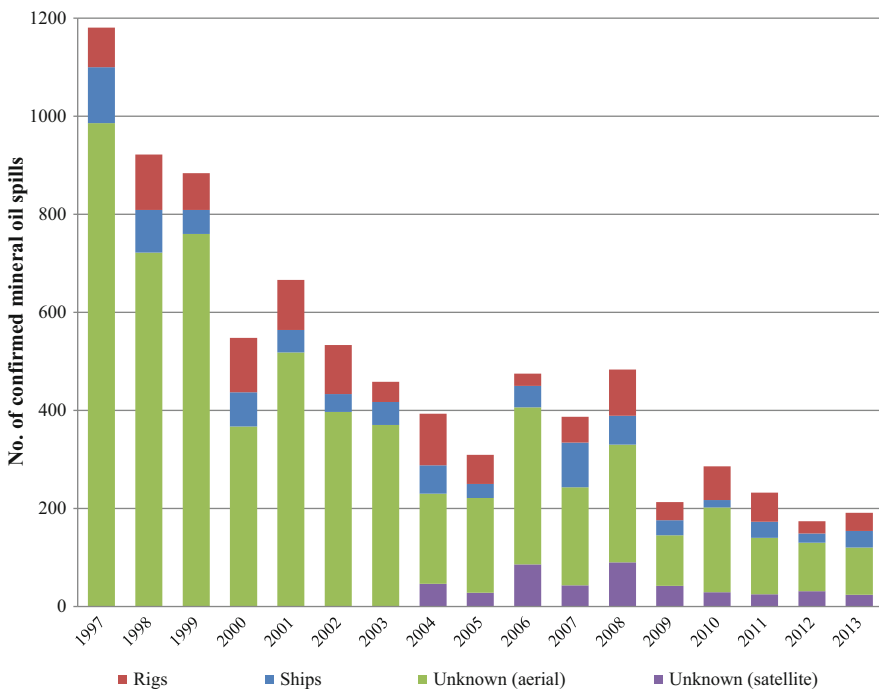


Fig. 6 Source of confirmed oil slicks from all sources, 1997–2013

quite low as a proportion of all confirmed mineral oil slicks. In 1987 there were 81 confirmed spills from rigs, 114 from ships and 986 of unknown source. By 2013, those numbers had fallen to 37 confirmed spills from rigs, 34 from ships, 96 from unknown sources using aerial surveillance data and a further 24 from unknown sources using satellite data.

The source of the majority of slicks remains unknown, even with the addition of satellite imagery from 2004 onwards. Figure 6 does, however, reinforce the fact that the total number of confirmed mineral oil slicks has continued to fall in the North Sea over many years.

Considering specifically those slicks that were confirmed as coming from oil and gas installations, Bonn Agreement TdH flights are one of the main sources of that information. Figure 7 presents data on the number of confirmed spills from rigs for seven countries between 1992 and 2013. France is excluded from Fig. 7 as it has no oil installations in its zone of responsibility. While France did undertake some TdH flights during some of the years, it reported only a single confirmed spill from an unknown source in 2005.

1992 saw the highest number of observed slicks from TdH flights with 121 slicks across the North Sea and 116 in UK waters. In subsequent years, the total number of observed slicks was 59 or less and, between 2003 and 2013, was less than 10 in 6 of those years. Apart from in 1992 there have been 9 or less spills in UK waters in the years where TdH flights took place, and no pollution was reported in many of those years. From 1993 onwards, the highest number of observed and confirmed slicks from rigs was generally located in Netherlands waters, the only exception being in 2001 when Belgium reported 22 slicks and the Netherlands 19 slicks.

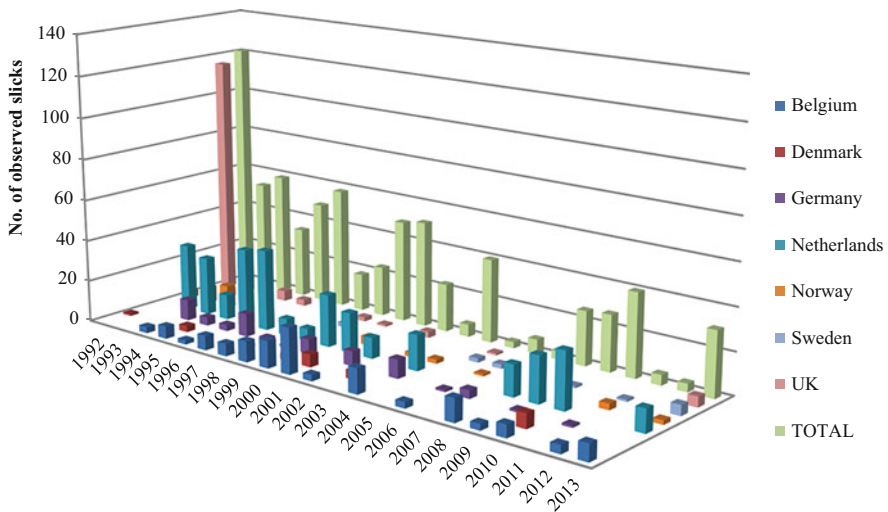


Fig. 7 Bonn Agreement Tour d’Horizon data on rigs as the source of observed slicks

Over time the reported data has provided more information on slicks from other sources observed during TdH flights. For example, since 1998 the reports have included ship-source slicks. Between 1998 and 2013, there were 8 years where additional slicks were observed and identified as coming from ships (e.g. 5 in 2000, 1 in 2003 and 4 in 2012) and 8 years where there were no observed slicks from ships. Since 2004, the TdH data has also included confirmed slicks from unknown sources. There were 9 such slicks in 2004 (8 in German waters, 1 in Belgian waters) and 15 in 2005 (e.g. spread across 6 countries with 5 in Netherlands waters and 4 in Danish waters).

5 OSPAR Monitoring Data on Oil Inputs from the Offshore Oil and Gas Industry

The majority of oil and gas installations in the OSPAR Maritime Area (see Fig. 1) are located in OSPAR Region II – the Greater North Sea, as illustrated in Fig. 2. For example, between 1990–1992 and 1996–1998 the number of platforms in the region increased from 300 to 475 and oil production doubled in the region for that same period. Geographically, major oil deposits were being exploited in the northern part of the North Sea in the Norwegian and UK sectors, while gas deposits were exploited mainly in the shallower southern regions in the UK, in the Danish and Dutch sectors and in shallower Norwegian waters [29].

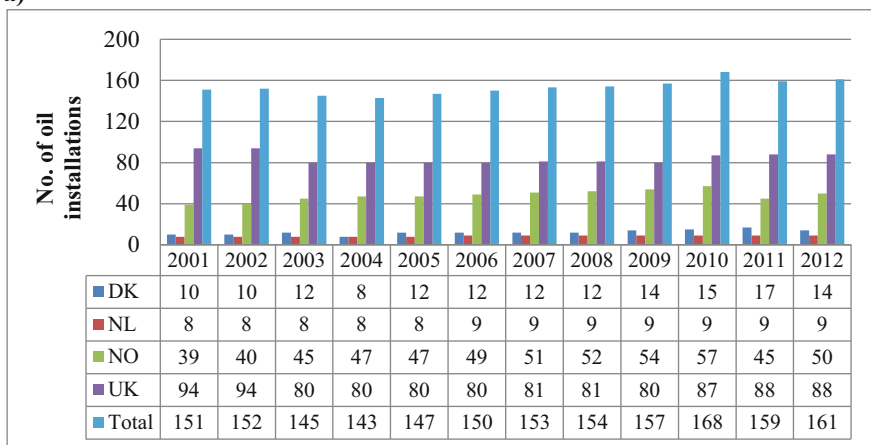
Figure 8a, b shows the number of oil and gas production installations in the North Sea between 2001 and 2012. Figure 8a, b includes only oil and gas platforms in production (including those where drilling is still ongoing). They exclude subsea installations, exploration and development drilling rigs with no simultaneous production and other facilities such as offshore underground storage and loading buoys. Denmark has no gas installations and therefore does not appear in Fig. 8b.

5.1 Oil Production in the North Sea

While oil production in the North Sea region doubled in the period 1990–1992 and 1996–1998, figures for total production of hydrocarbons (both oil and gas in total oil equivalents – toeqs) since 2001 show that there was a fall in production of almost 44% for the period 2001–2012. Figure 9 illustrates that total combined production figures for Denmark, the Netherlands, Norway and the UK fell from just over 513 million toeqs in 2001 to just over 290 million toeqs in 2012, and there are also fluctuations for each individual country.

Looking at each country in Fig. 9 individually, annual production in the Danish sector was less than 30 million toeqs during the period 2001–2012, falling to 16.29 million toeqs in 2012. Dutch production figures were less than 25 million toeqs in

a)



(b)

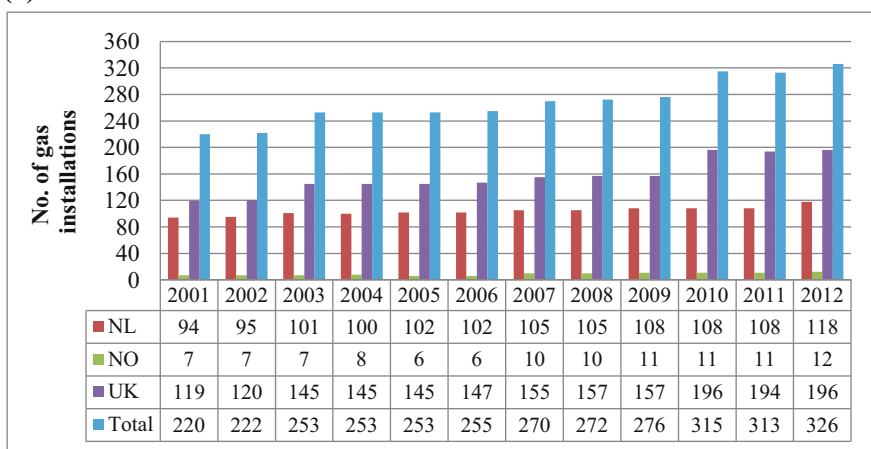


Fig. 8 Number of oil and gas production installations in the North Sea with emissions and discharges covered by OSPAR measures, 2001–2012. (a) Oil installations; (b) gas installations

all years and were 17.15 million in 2012. Both Norway and the UK have seen a large drop in production, Norway from a high of 264.6 million toeqs in 2004 to 170.5 in 2012 and the UK from a high of 211 million toeqs in 2001 to less than 86.5 million toeqs in 2012.

Overall, combining the production figures for the four North Sea states, there has been a fall from over half a billion toeq produced in 2001 to just over 290 million toeqs in 2012 (a fall of almost 42% in just over a decade).

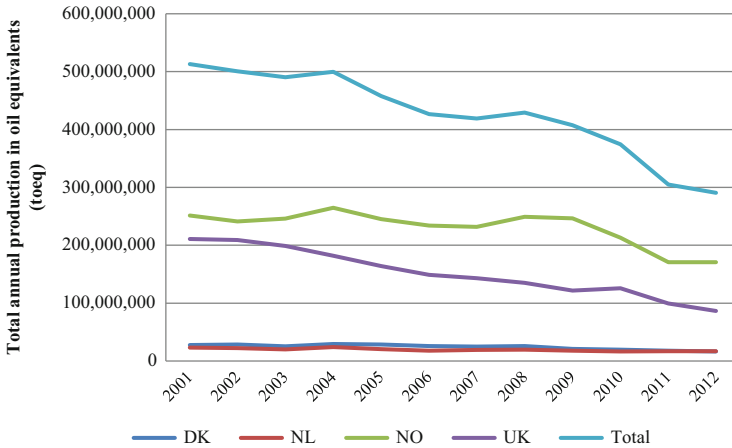


Fig. 9 Total annual production in total oil equivalents (toeqs) for the North Sea, 2001–2012

5.2 Discharges, Spills and Emissions from Offshore Oil and Gas Installations

A broad range of information is provided via OSPAR Commission reports on discharges, spills and emissions from offshore oil and gas installations to the North Sea.² That information includes: the name of the installation, quantities of water discharged during the year, annual average oil content and total amount of oil discharges (tonnes per year). Other information set out in the reports includes: discharges of oil-based fluids in cuttings either discharged to the sea or injected into disposal wells, volumes of produced water (PW) and displacement water (DW) discharged to the sea and the number of accidental spills together with the quantity of oil spilled.

5.2.1 Discharges via Cuttings

OSPAR data for the period 1984 to 1999 [30] identified the main source of oil discharges in the region as being via cuttings. In 1984 over 88% of total discharges in the Danish, Dutch, Norwegian and UK sectors came from cuttings. The UK had the highest proportion at 92.7%. Less than 8% of total discharges came from production water in those same sectors in 1984. By 1997, only the UK had

²OSPAR Commission reports on discharges, spills and emissions from offshore oil and gas installations are available at http://www.ospar.org/v_publications/browse.asp?menu=0008080000000_000000_000000 (select “search series” and “Offshore Oil and Gas Industry”). Reports are available for the years 1988–1989, 2000–2001 and then annually from 2002.

discharges of cuttings accounting for more than half of the total discharges in its sector (52%), while the figure for Denmark was 18%, and for the Netherlands and Norway was 0% [30].

No oil-based mud-contaminated cuttings (fluids containing low aromatic and paraffinic oils together with mineral oil-based fluids that are neither synthetic or of a class that is prohibited) have been discharged since 1996. Furthermore, almost no organic-phase drilling fluids (OPFs – see Sect. 2.3) and cuttings have been discharged since 2004 [31]. In that year 425 tonnes of oil and other OPFs were discharged via cuttings from Norwegian installations, down from a figure of 3,951 tonnes discharged by Norwegian and UK installations in 2000. From 2005 to 2008, there were zero discharges of cuttings to the sea after treatment.

More recently, in 2009, the UK released 0.3 tonnes of OPF to the sea in treated cuttings. That amount is tiny when compared to the amount of OPF cuttings injected. For example, Denmark injected 1,344 tonnes into disposal wells that year, Norway 26,937 tonnes and the UK 11,560 tonnes. By far the greatest amount of OPF cuttings were transported to shore for treatment and/or disposal. In 2009, Denmark transported 7,880 tonnes to shore, the Netherlands 15,381 tonnes, Norway 39,072 tonnes and the UK 35,101 tonnes. Therefore, in 2009, only 0.3 tonnes of OPF cuttings were discharged to the North Sea, 57,745 tonnes were injected into disposal wells, and 97,434 tonnes were transported to the shore [31].

Between 2010 and 2012, discharges to the sea from UK installations amounted to 1 tonne in 2010, 4 tonnes in 2011 and 5 tonnes in 2012 [32–34]. As noted at Sect. 2.3, authorisation would have been required from the competent UK national authority, under Decision 2000/3 [17], to allow those discharges to take place.

5.2.2 Discharges via Produced Water and Displacement Water

Since the early 2000s, the main sources of oil inputs to the sea have been inputs via PW and DW (see Figs. 10 and 11), together with accidental discharges (see Fig. 12a, b and Sect. 5.2.3). As noted in Sect. 2, PW is a by-product of oil and gas production operations and includes formation water, condensation water and reproduced injection water. DW is seawater used for ballasting the storage tanks of offshore installations so that, when oil is loaded into those tanks, the water is displaced and discharged to the sea.

Figure 10 illustrates the quantity of water discharged annually to the marine environment via PW and DW, together with volumes of PW injected back into the reservoir to increase pressure and stimulate increased yields and/or continued production from ageing oil fields. It also includes a combined figure for PW discharged and PW injected.

The volumes of PW and DW being discharged to the sea both declined during the period 2001–2012. The volume of PW fell from almost 400 million m³ of PW in 2001 (high of 423 million m³ in 2004) to 318.48 million m³ in 2012 (a fall of almost 25% between 2004 and 2012). The volume of DW also fell from 67.75 million m³ in 2001 to 34.4 million m³ in 2012 (a fall of nearly 50%). During the same period,

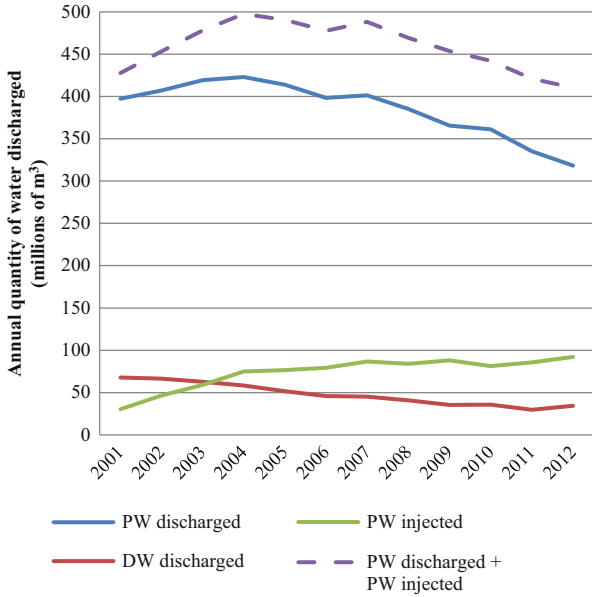


Fig. 10 Annual quantities of produced water and displacement water discharged to the North Sea and produced water injected, 2001–2012

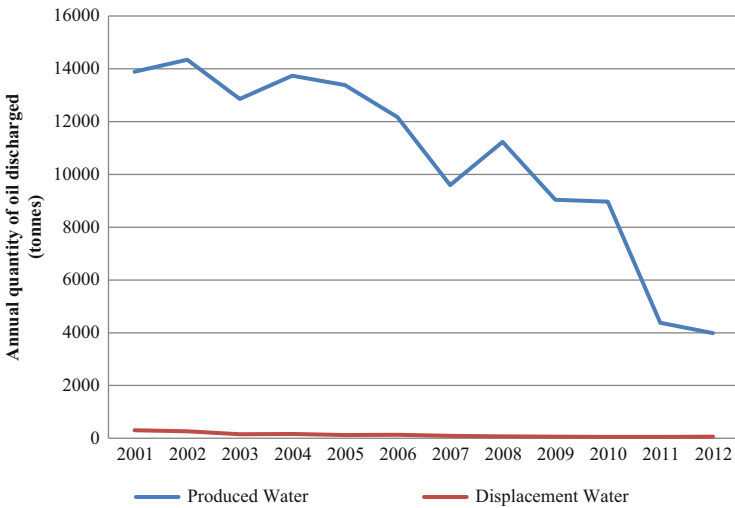
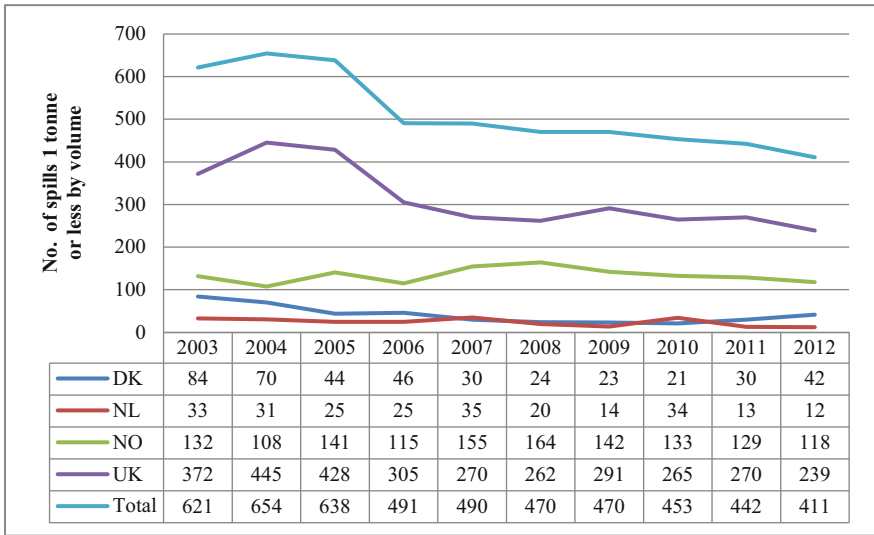


Fig. 11 Annual quantity of oil (in tonnes) discharged via produced water and displacement water, 2001–2012

(a)



(b)

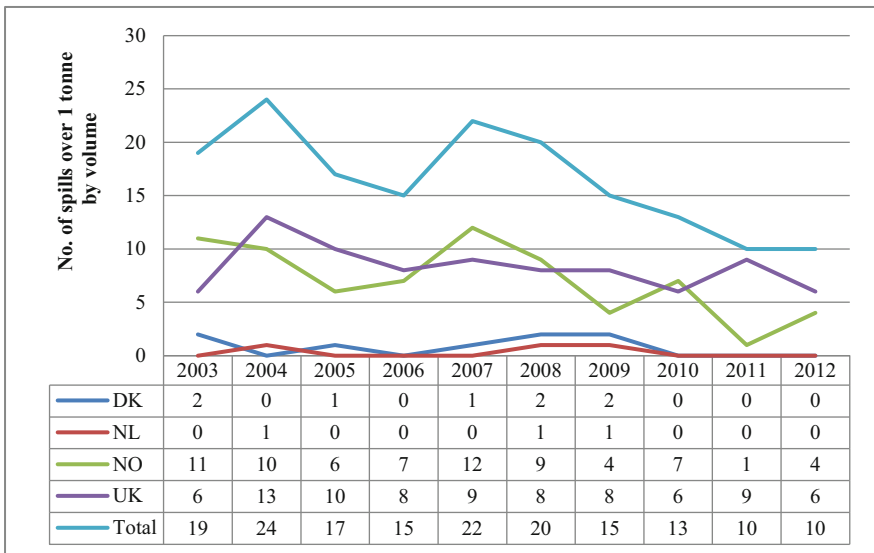


Fig. 12 Accidental spillages of oil in the North Sea from oil and gas installations, 2003–2012. (a) Number of oil spills 1 tonne or less by volume; (b) number of oil spills greater than 1 tonne by volume

the amount of PW which has been injected grew from 30.27 million m³ in 2001 to 92.13 million m³ in 2012 (an increase of over 300%).

The dashed line in Fig. 10 shows the combined totals for PW discharged to the sea and injected back into the reservoir. In 2001 the combined amount was 427.6 million m³, while in 2012 it was 410.61 million m³. The figure for combined discharged and injected PW in 2012 is 96% of that for 2001, indicating that there has been a move away from discharging PW into the sea to injecting PW back into the reservoir.

Between 2001 and 2012, the quantity of oil (in tonnes) being discharged from installations via PW and DW to the sea also fell (see Fig. 11). The quantity of oil discharged in PW fell from 13,892 tonnes in 2001 (14,345.5 in 2002) to 3,990 tonnes in 2012. The amount of oil discharged in PW in 2012 was therefore less than 30% of the figure for 2001. In the case of DW, the fall in the quantity of oil was from 262.6 tonnes in 2001 to 61.4 tonnes in 2012, with the volume in 2012 being slightly less than 20% of that for 2001.

5.2.3 Accidental Oil Spillages from Oil and Gas Installations

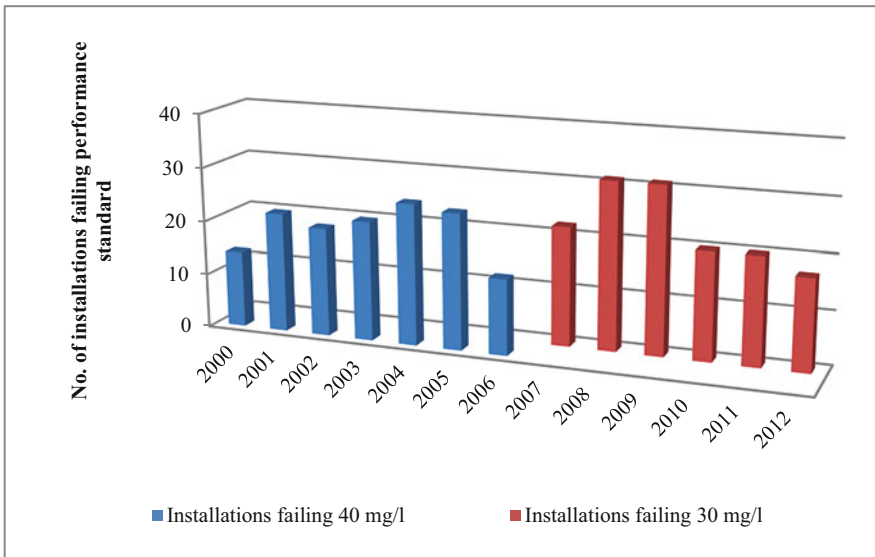
Figure 12a, b illustrates that the majority of accidental oil spills are one tonne or less by volume. In 2003 there were 621 spills of that size across the four North Sea countries and only 19 spills greater than 1 tonne by volume. In all years from 2003 to 2012, the vast majority of spills occur in the Norwegian and UK sectors, with around 60% of all spills in UK waters during that period (closer to 70% in 2004 and 2005). Accidental spillages are, by their very nature, unpredictable. Less than 5% of total oil discharges entering the North Sea came from accidental spills between 1999 and 2012, with the exception of 2007 when a single large oil spill from a Norwegian installation accounted for around 40% of total oil discharged in that year [31].

As noted at Sect. 4.3, the number of mineral oil spills identified by Bonn Agreement aerial surveillance activities has declined in the North Sea over many years. Those surveillance activities include monitoring the areas around oil and gas installations under Bonn Tour d'Horizon flights (see Sect. 3.3). That reduction over time is also apparent in the OSPAR data, with accidental oil spills having from oil and gas installations having fallen by around one third between 2004 and 2012.

5.3 *Installations Exceeding OSPAR Performance Standards*

OSPAR annual reports on discharges, spills and emissions from offshore installations exceeding the OSPAR 40 mg/L performance standard for dispersed oil between 2000 and 2006, subsequently 30 mg/L from 2007 [35] (see Fig. 13a). OSPAR also provides cumulative data on the total amount of oil discharged from those installations exceeding that performance standard (see Fig. 13b).

(a)



(b)

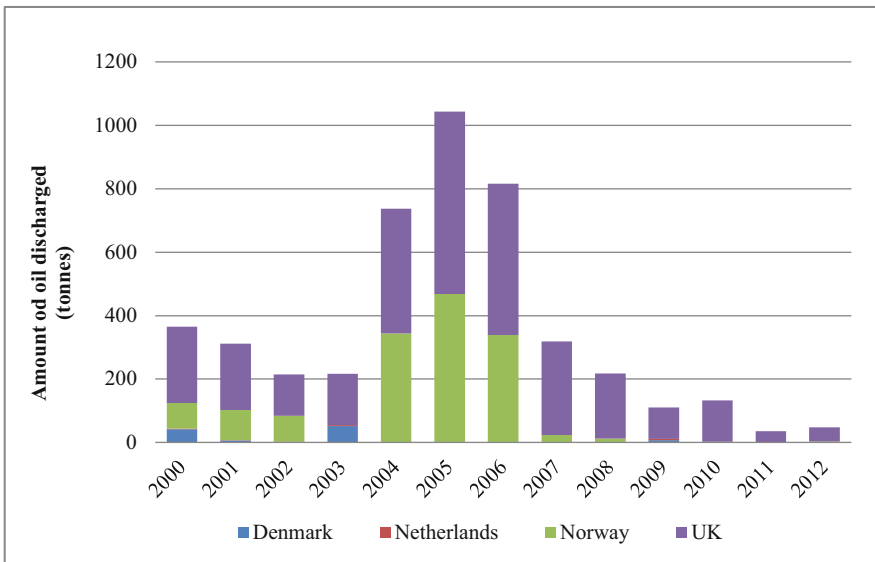


Fig. 13 Installations exceeding OSPAR Recommendation 2001/1 targets and amount of oil discharged (tonnes), 2000–2012. (a) Number of installations exceeding the 40 mg/L discharge target, 2001–2006; number of installations exceeding the 30 mg/L discharge target, 2007–2012. (b) Amount of oil discharged over 40 mg/L standard (tonnes), 2000–2006; amount of oil discharged over 30 mg/L standard (tonnes), 2007–2012

Samples of discharges of dispersed oil in PW are collected from both manned and unmanned installations. In the case of manned installations, a minimum of 16 samples are taken each month, from a point “immediately after the last item of treatment equipment in, or downstream of, a turbulent region, and . . . before any subsequent dilution” [2001/1 consolidated text]. Samples have, since 2007, been analysed using chromatography (GC) to measure oil concentration in samples [16]; prior to that, the analysis method used infrared detection (IR).

Data on the number of installations exceeding the OSPAR performance standard shows that, in 2001, there were 22 installations which failed to achieve the 40 mg/L standard (out of 151 oil installations and 220 gas installations), resulting in a discharge of approximately 312 tonnes of dispersed oil in PW to the sea in that year [36]. Eighteen of those failing installations were gas installations (15 UK, 3 Dutch), and four were oil installations (1 Danish, 1 UK and 2 Norwegian).

By 2012, under the stricter 30 mg/L standard, only 17 installations failed to achieve that standard, releasing 47.44 tonnes of dispersed oil in PW in that year [34]. Six out of the 17 were oil installations (1 Danish, 2 Dutch and 3 UK), while the remaining 11 were gas installations (1 Norwegian, 1 Dutch and 9 UK).

Overall, it is apparent that far fewer installations are failing the performance standard for discharges in PW, despite those standards having been made stricter. It also appears that gas installations are more likely to exceed the performance standard upon closer examination of OSPAR annual reports. What is clear is that far less oil is entering the marine environment of the North Sea from oil installations in discharges of PW.

6 Conclusions

This chapter has examined trends in the level of oil being discharged to the North Sea in general and in particular inputs from oil and gas installations. The majority of those installations are located in the waters of four countries – Denmark, the Netherlands, Norway and the UK. In the case of oil and gas production, the majority of such activities in the region have been located in the waters of Norway and the UK. Two bodies are responsible for monitoring the North Sea region, the OSPAR Commission (which also monitors the wider North-East Atlantic) and the Bonn Agreement Secretariat.

An overview of all inputs to the North Sea, using Bonn Agreement aerial surveillance data, shows that the number of observed and confirmed oil slicks in the region – from both ships and oil and gas installations – has fallen over a period of nearly three decades. Increased surveillance activities through aerial surveillance, and more latterly satellite imagery, shows that the number of oil slicks fell from around one slick for every hour of surveillance flights in 1991 to around one slick for every 25 h of flying time in 2013.

The introduction of surveillance activities during the hours of darkness, and the use of satellite imagery, has resulted in improvements in identifying the source of slicks and may act as a deterrent for ships that might previously have discharged oil to the sea at night or in more remote areas of the North Sea. Bonn Agreement surveillance activities have also been specifically targeted to monitor discharges from oil and gas installations (see Sect. 3.3) and support the work programme of the OSPAR Commission specifically related to the oil and gas industry.

The OSPAR Commission has in place a number of performance measures and targets against which oil and gas installations have to perform. For example, there are measures in place setting maximum permissible levels of oil in discharges from produced water [13] and from organic-phase drilling fluids (OPFs) and contaminated cuttings [17], together with agreed levels of sampling and methods of analysis [16].

Based on data reported annually by the OSPAR Commission, it is apparent that while the number of oil and gas installations in the North Sea has increased over the last decade, total annual production fell by almost 44% between 2001 and 2012. Many of the oil fields located in the North Sea are ageing, making it harder to extract oil and gas. One result of this has been increased reinjection of produced water back into the reservoir to increase pressure and improve yields from those fields. A further result has been that less produced water is discharged to the sea, while stricter standards on permissible levels of oil in that discharged water have resulted in less oil being discharged – down from 13,892 tonnes in 2001 to 3,990 tonnes in 2012, a fall of 70% [34].

Cuttings were the major source of oil entering the marine environment of the North Sea between 1984 and 1999 [30]. However, stricter standards, changes in drilling fluids, increased levels of injection of OPF cuttings into disposal wells and most significantly the vast majority of cuttings being transported to shore for treatment and/or disposal mean that virtually no oil enters the North Sea from that source. In 2012 only 5 tonnes were discharged to the North Sea [34] compared to 3,951 tonnes in 2000 [31], and special permission has to be sought from the competent national authority before any such discharges can be made.

Accidental spillages from oil and gas installations continue to occur. However, the number of total spills has fallen by around one third between 2003 and 2012 [34]. Less than 5% of accidental oil discharges to the North Sea come from oil and gas installations [31].

Overall, based on both Bonn Agreement Secretariat and OSPAR Commission data, it is clear that the levels of oil entering the North Sea from oil and gas installations has fallen in recent years. Continued monitoring, sampling against agreed standards and the use of best available techniques and best environmental practice and consideration of the environmental and economic impacts of the activities of installations should lead to further reductions in discharges from installations in the future.

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