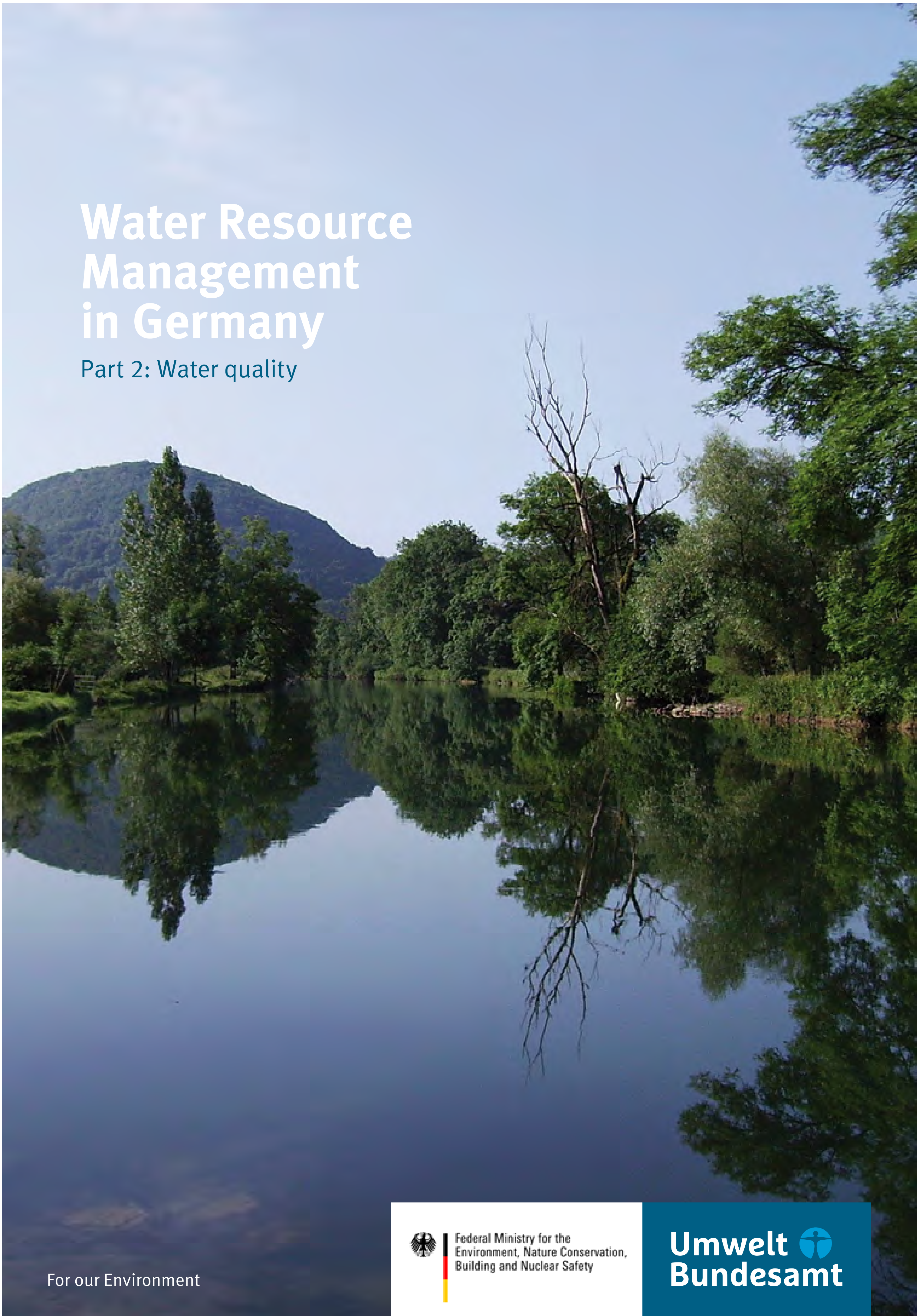
Water Resource Management in Germany

Part 2: Water quality



For our Environment

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

Umwelt Bundesamt

Water Resource Management in Germany

Part 2
– Water quality –

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Contents

0 List of abbreviations

Habitats Directive: EC Directive on the conservation of natural habitats and of wild fauna and flora

HELCOM: Baltic Marine Environment Protection Commission

LAWA: Bund/Länderarbeitsgemeinschaft Wasser (Working Group of the Federal States on Water Problems)

OSPAR: North-East Atlantic Marine Environment Protection Commission

1 Introduction

Our waters are used in a variety of ways, some of which entail man-made (anthropogenic) substance discharges. They influence the chemical quality of water bodies and may thereby harm the aquatic communities and impair usage such as drinking water abstraction. Usage-related influence also causes substantial changes to the water structure. Hydraulic engineering measures aimed at flood prevention and the development of rivers for navigation and power generation purposes have had a substantial impact on the nature and course of surface waters, which in turn has affected their ecological quality.

Surface waters and groundwater in Germany are analysed at regular intervals. Within the context of international and national monitoring programmes, the Federal States (Länder) and River Basin Commissions collate data on the biological and chemical status of surface waters, as well as on their hydromorphology. Nitrate and pesticides are particularly relevant in groundwater bodies. Assessments of substance discharges into groundwater and surface waters from point sources are based on the results of regular discharger monitoring. Together with model balance sheets, they provide information on the origins of pollutants, and facilitate the formulation of measures to reduce them. The assessment of pollution based on legally binding environmental quality standards (EQS) follows uniform principles.

The EC Water Framework Directive (WFD) which entered into force on 22 December 2000 is the first ecologically driven Directive dedicated to the protection of rivers and lakes, and calls for the extensive involvement of the general public. Inter alia, this was transposed into German law with the Ordinance on the Protection of Surface Waters (Oberflächengewässerverordnung – OGewV). The operational objective of the EC Water Framework Directive is to achieve good ecological and chemical status in surface waters, and good ecological potential in heavily modified or artificial water bodies. Environmental quality standards for chemical parameters and biological status classes have been introduced to facilitate monitoring of these objectives.

The Surface Waters Ordinance requires the type-specific measurement of surface waters and an integrative assessment of ecological status. Appropriate monitoring programmes have been designed and intensified accordingly. For the first time, this approach of ascertaining the biological colonisation of waterbodies and comparing this with the typical biotic reference communities occurring in the natural, undisturbed environment facilitates an integrative assessment of the ecological quality of marine and inland waters, and an insight into the probable causes of pollution. The development of suitable techniques is now largely complete in Germany, and many methods are already used in water resource management. The Surface Waters Ordinance demands sufficiently reliable and accurate results from chemical and biological analyses. For this reason, quality assurance of the data is now more important than ever before.

The EC Marine Strategy Framework Directive (MSFD), which entered into force in 2008, requires the comprehensive assessment and protection of all the key elements in marine ecosystems with regard to their mutual interactions and potential cumulative effects. The options for applying and adapting existing assessment techniques from the EC Water Framework Directive and the Habitats Directive are currently being investigated, but new assessment techniques are also needed.

This Report outlines the principal aspects of the status of surface waters and groundwater, with a focus on the current pollution situation. It also analyses the development of water quality among significant watercourses, large lakes, transitional (estuarine), coastal and marine waters of the North and Baltic Seas, which are assessed primarily using the criteria stipulated in the Water Framework Directive and the International Marine Protection Commissions OSPAR and HELCOM.

The assessments are based on data supplied by the Federal Government and Länder, including data from the Water Framework Directive management plans, summaries of documents published by LAWA and the national and international River Basin Commissions and communities, as well as on the results of scientific publications, research projects and the Federal Environment Agency's own work. By presenting facts and figures, this Report sets out to provide information about the status of Germany's waterbodies and highlight existing problems in the field of water conservation.

2 Basis for the assessment of groundwater and surface waters

2.1 The European assessment systems

The EC Water Framework Directive (WFD) and the EU Marine Strategy Framework Directive (MSFD) call on Member States not to deteriorate the status of water bodies ("deterioration ban"), and to improve it where a good status is not reached. The status of waters is integratively assessed using a range of assessment criteria such as the biological and chemical ones, water volume and hydromorphology (EC Water Framework Directive), as well as additionally noise and litter (EU Marine Strategy Framework Directive).

“Water bodies" were introduced by the EC Water Framework Directive as objects of assessment and management. Water bodies refer to certain sections or parts of waters underlying a uniform pressure and structure, and belonging to a specific "category" (groundwater, river, lake, transitional or coastal water) and "type". The ecological status of surface waters (rivers, lakes, transitional and coastal waters) is characterised as status “close to natural conditions”. The reference criteria for such status close to natural conditions and hence for the assessment are water type-specific reference conditions for the existence and frequency of flora and fauna, physico-chemical conditions (such as nutrients, oxygen, temperature and pH value) and hydro morphology. The ecological status is derived according to the degree of deviation from these reference conditions. Additionally, valid national environmental quality standards (EQS) apply to (specific) pollutants with regional relevance. By contrast, the chemical status of surface waters is assessed in terms of compliance with valid European-wide environmental quality standards for pollutants. Furthermore, the quantitative and chemical status of the groundwater is assessed.

In order to be able to assess the impacts of contaminants over a longer period, trend monitoring must be carried out with respect to biota, materials in suspension and sediment.

The EU Marine Strategy Framework Directive lists 11 descriptors of environmental quality for defining the ecological status of marine regions. Some of the descriptors refer to pressures (populations of all commercially exploited fish and shellfish, eutrophication (= oversupply of nutrients), existence of non-indigenous species, permanent alteration of hydrographical conditions, contaminants in the ecosystem and in seafood, marine litter, introduction of energy (e.g. noise), while others refer to the status of the ecosystem (biodiversity, food webs, sea floor integrity).

Below, aspects of water assessment which are equally applicable to groundwater and surface waters including coastal and marine are explained. These include basic principles for the specification of threshold values in groundwater and environmental quality standards in surface waters, together with requirements governing the confidence and precision of measurement results. The following aspects are covered in greater detail in the chapters cited:

- Quality standards and threshold values in groundwater and the assessment of quantitative status in **chapter 3.1**
- environmental quality standards in surface waters in **chapter 4**
- The assessment of biological, hydromorphological and physico-chemical quality elements in rivers and lakes in **chapters 5.1** and **6.1**, and
- The assessment of transitional and coastal waters and the oceans in **chapter 7.1**.

2.2 Quality standards/threshold values/ environmental quality standards for pollutants in water protection

A wide range of substances from households, industry, trade, transport and agriculture are discharged into waters. As analytical techniques become ever more advanced, an increasing number of substances are being found in ever smaller concentrations in water bodies. For such substances, the EC Water Framework Directive requires analysis of their relevance to both environmental protection and sometimes health protection, and where necessary, the specification of environmental quality standards.

The EC Water Framework Directive groups substances into those with EU-wide importance and those with local importance for groundwater and surface waters.

For surface waters (cf. chapter 4):

- EU-wide environmental quality standard for the chemical status are defined in Directive 2013/39/EU amending Directives 2000/60/EC and 2008/105/EC. Additionally, an action value for nitrate has been defined under the Nitrates Directive 91/676/EC.
- There are additional environmental quality standards for other specific synthetic and non-synthetic pollutants which are emitted into river basins in significant quantities to define the ecological status. In Germany, these environmental quality standards – like those for the chemical status – are defined in the Ordinance on the Protection of Surface Waters (Oberflächengewässerverordnung, OGewV)

For groundwater (cf. chapter 3.1):

- First of all, the chemical status of groundwater is defined by uniform European quality standards for nitrate (50 mg/l) and pesticides (0.1 µg/l per substance).
- Additionally, the Member States must specify threshold values for those parameters/substances which have led to an "at risk" classification following an inventory of pressures. However, a set of minimum European-wide parameters has been defined. In Germany, the threshold values are regulated by the Groundwater Ordinance.

2.3 Confidence and precision

The management plans must contain verbal or statistically verified statements on the precision and confidence of the monitoring results. For example, if the measurement results are close to the environmental quality standard, it is advisable to increase the measuring frequency in order to improve assessment reliability.

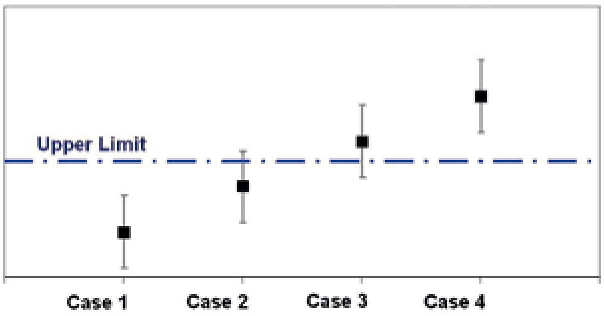
In order to ensure the quality and comparability of analytical results when implementing the EC Water Framework Directive, the Commission Directive of 31 July 2009 laying down technical specifications for chemical analysis and monitoring of water status (Directive 2009/90/EC) sets out minimum performance criteria for all methods of analysis applied. The Directive states that only techniques with a maximum measurement uncertainty (cf. **chapter 2.4**) of 50 %, and limits of quantification equal or below a value of 30 % of the relevant environmental quality standard should be used for the monitoring of waters.

2.4 Measurement uncertainties and control of limits

Every analytical result has a certain degree of measurement uncertainty (analytical result = measurement value ± measurement uncertainty) and is therefore merely an estimate of the true/correct value of a measurand in the sample analysed. In other words, the measurement uncertainty of a measured value is the range within which the true value of the measurand is expected to fall. Both the Guide to the Expression of Uncertainty in Measurement (GUM) of 2008 and the EURACHEM/CITAC Guide based thereon provide the basis for determining measurement uncertainty. International standard ISO 11352 "Estimation of measurement uncertainty based on validation and quality control data" was introduced in 2013 for the practical determination of measurement uncertainty in the laboratory.

A key task of environmental analysis is to examine whether limits are adhered to or exceeded. However, this becomes problematic if the measurement uncertainty does not permit a clear statement to be made. Only if the measurement result, including its measurement uncertainty, exceeds or falls below the limit it is possible to state clearly whether it has been exceeded or not (see cases 1 and 4 in **Figure 1**). By contrast, cases 2 and 3 do not permit a clear conclusion to be drawn, as the limit is within the range of the measurement value ± measurement uncertainty, and the possibility of an incorrect assessment cannot be ruled out.

Figure 1: Measurement uncertainties and consideration of limits



In practice, in cases 2 and 3 of **Figure 1**, it would not have been possible to make an unequivocal statement with high certainty, and therefore, a re-analysis, for example, would have been indicated. Where appropriate, the problem might be solved by using a different analytical technique with a lower measurement uncertainty. If compliance with/exceedance of a limit cannot be clearly confirmed despite such re-analyses, an individual decision should be reached on a case-by-case basis, whereby the probability of an incorrect assessment, the resultant potential risk and the economic aspects of other measures should be weighed up against each other.

One very pragmatic option for monitoring limits is to assume that values below the limit are compliant with the limit, while values above the limit exceed it, disregarding the measurement uncertainty of the analytical results. This approach, also known as a "shared risk", has a probability of at least 50 % compliance for measured values below the limit, and a risk of exceeding the limit of no more than 50 %. This approach is consistent with currently valid law when comparing annual averages with environmental quality standards.

2.5 Quality assurance

The accuracy and comparability of the data collected (cf. also **chapter 7.1.5**) is a key requirement for both the assessment and description of the status of waters and the assessment of anthropogenic influences and deducible measures. There are now a large number of national and international standard methods available for chemical, physical and biological analyses. The "German Standard Methods for the Examination of Water, Wastewater and Sludge" (DEV), comprising some 300 analytical methods, is a key reference work at national level.

The fundamental principles for the establishment of a quality assurance system are set out in standard DIN EN ISO/IEC 17025 "General requirements for the competence of testing and calibration laboratories", which has national and international validity. This requires various internal (within the laboratory) and external (between several laboratories, at national and international level) measures to be implemented in order to ensure and improve the quality of the analytical results.

Internal quality assurance measures include the following:

- Compilation of a quality management manual
- Documentation of the analytical methods used in the form of Standard Operating Procedures (description of the individual analytical steps from sampling to the result, including data storage and archiving of the analysed material)
- Documented validation/verification of applied analytical methods and determination of performance characteristics
- Providing evidence of the trueness and precision of the applied procedures on a regular basis by taking suitable quality assurance measures, e.g. using control charts or (certified) reference materials
- Compilation of specimen collections in biological analyses for the purpose of comparison and evidence
- Qualification and regular training of personnel in all analytical methods used
- Regular performance of internal audits (appraisals) and management reviews.

External quality assurance measures include:

- Participation in national and international laboratory comparisons, ring tests, training courses and workshops
- Laboratory audits (external audits) e.g. within the context of accreditation
- Random checks of field and laboratory results by an external, independent organisation not involved in the monitoring programme, particularly in the case of biological analyses.

One suitable way of ensuring or improving the quality of analytical data is the accreditation and notification of laboratories. The terms "accreditation" and "notification" are derived from Latin and mean "making credible" and "making known".

Notification entails the recognition/licensing and publication of laboratories which have been identified to be competent to carry out analytical tasks in areas regulated by law (e.g. for drinking water and wastewater analyses) by the relevant competent authority.

Accreditation of analytical laboratories is carried out in accordance with standard DIN EN ISO/IEC 17025. It involves the formal recognition of a laboratory's competence by an authorised body to carry out certain analyses. The aim is to ensure comparable test results, and linked to this, to improve the mutual acceptance of analytical results. Since 1 January 2010, Deutsche Akkreditierungsstelle GmbH (DAkkS) has been responsible for carrying out all accreditations in Germany in accordance with Regulation (EC) No. 65/2008. Deutscher Kalibrierdienst (DKD) and the former accreditation agencies DACH (Deutsche Akkreditierungsstelle Chemie GmbH), DAP (Deutsches Akkreditierungssystem Prüfwesen GmbH) and DATech in TGA GmbH (Deutsche Akkreditierungsstelle Technik) were merged to create DAkkS.

In order to ensure quality and comparability of analytical results when implementing the EC Water Framework Directive, at international level, Directive 2009/90/EC states that all laboratories involved in the monitoring of waters are required to establish a quality management system in accordance with DIN EN ISO/IEC 17025. Although accreditation is not compulsory, many laboratories regularly make use of this to obtain from an independent body the confirmation of their competency to perform certain analyses.

3 Groundwater

3.1 Basis for assessment

Groundwater resources in many areas are under threat because inputs of substances are still high and the buffer and filter effects of the soil layers above are finite. Groundwater contamination often manifests itself as long-term damage which is not immediately apparent. Remediation, if at all possible, will be very costly in terms of financial and technical resources, and extremely time-consuming. For this reason, preventive, nationwide groundwater protection is particularly vital. Systematic, regular monitoring of groundwater quality is a crucial element of groundwater protection. If measures have been introduced to protect or restore groundwater resources, the monitoring results can provide major insights into the efficacy and effectiveness of such measures. A number of substances have been analysed and evaluated with regard to their risk potential and probability of discharge over various periods. According to the stipulations of the EC Water Framework Directive, the groundwater status is assessed at the level of groundwater bodies, defined as "a distinct volume of groundwater within an aquifer or aquifers".

3.1.1 Quantitative status

The EC Water Framework Directive calls for a good quantitative status of all bodies of groundwater, as defined in Annex V no. 2.1 of the EC Water Framework Directive. The parameter for assessing the quantitative status of groundwater is the groundwater level. The quantitative status of groundwater is considered good if the available groundwater resource is not exceeded by the long-term annual average rate of abstraction. In very simplified terms, this means that the groundwater level may not be subject to any anthropogenic alterations that would result in

- Failure to achieve the environmental objectives for associated surface waters
- Any significant diminution in the quality of such waters
- Any significant damage to terrestrial ecosystems which depend directly on the groundwater body
- Alterations to flow direction causing saltwater or other harmful intrusions.

In practice, however, merely considering the groundwater level or its development is insufficient to be able to assess the quantitative status with an adequate degree of reliability. For this reason, it is necessary to evaluate the water regime in the individual body of groundwater or sections thereof.

3.1.2 Chemical status

Based on the EU Groundwater Directive (2006/118/EC), a daughter directive to the EC Water Framework Directive, quality requirements (so-called groundwater quality standard and threshold values) have been defined for a number of substances. If these values are adhered to in a body of groundwater, then the body of groundwater is considered to achieve a good status. If they are exceeded, nature and extent of the exceedance must be examined. On the basis of this examination, it may become necessary to record the body of groundwater as failing to achieve good status. In this case, Member States are obligated to carry out suitable programmes of measures in order to restore the good status, i.e. to reduce pressures to such an extent that the groundwater quality standards and threshold values are met. The EU Groundwater Directive sets out European-wide groundwater quality standards for the following substances and substance groups:

- Nitrate – 50 mg/l and
- Pesticides (= plant protection agents and biocides) – [groundwater quality standard for individual substance: 0.1 µg/l, summative groundwater quality standard: 0.5 µg/l].

These values were also implemented by the German Groundwater Ordinance of 9 November 2010. Additional threshold values have to be set at national level for other substances which could cause a body of groundwater to be recorded as failing to achieve good status. Threshold values for 8 further substances and substance groups are currently defined in Annex 2 to the Groundwater Ordinance (cf. **Table 1**).

3.1.3 Monitoring networks for reporting

Under the provisions of the EC Water Framework Directive, the Member States established networks for monitoring the chemical and quantitative status of groundwater by December 2006. The chemical status of groundwater is ascertained at operational measuring points and surveillance measuring points. Surveillance measuring points had been established primarily in unpolluted bodies of groundwater, whereas operational measuring points had been established in bodies of groundwater with poor status. In Germany, the Länder are responsible for the creation and operation of monitoring networks. In total, the Länder have 5,682 surveillance measuring points, 3,979 operational measuring points, and 8,960 points for monitoring quantitative status.

Around 20 years ago, the Länder and the Federal Environment Agency jointly created a nationwide monitoring network (hereinafter referred to as the EEA groundwater monitoring network) with around 800 measuring points, used for reporting to the European

Table 1: Groundwater quality standards and threshold values for the classification of chemical groundwater status

Name of substance	CAS no.	Threshold value	Derivation criterion
Nitrate		50 mg/l	Groundwater quality standard as per Directive 2006/118/EC
Active ingredients in pesticides and biocide products, including relevant metabolic, degradation and reaction products		0.1 µg/l each; 0.5 µg/l in total	Groundwater quality standard as per Directive 2006/118/EC
Arsenic	7440-38-2	10 µg/l	Drinking water – Limit for chemical parameters
Cadmium	7440-43-9	0.5 µg/l	Eco-toxicologically derived: PNEC + background value
Lead	7439-92-1	10 µg/l	Drinking water – Limit for chemical parameters
Mercury	7439-97-6	0.2 µg/l	Eco-toxicologically derived: PNEC + background value
Ammonium	7664-41-7	0.5 mg/l	Drinking water – Limit for indicator parameters
Chloride	168876-00-6	250 mg/l	Drinking water – Limit for indicator parameters
Sulphate	14808-79-8	240 mg/l	Drinking water – Limit for indicator parameters
Sum total of tri- and tetrachloroethene	79-01-6; 127-18-4	10 µg/l	Drinking water – Limit for chemical parameters

PNEC = Predicted No Effect Concentration
Source: Groundwater Ordinance, 2010

Environment Agency. These measuring points are evenly distributed all over Germany, and provide a representative overview of groundwater quality. The data from this network provides the basis for some of the assessments outlined below.

3.2 Status assessment

3.2.1 Quantitative status of groundwater bodies

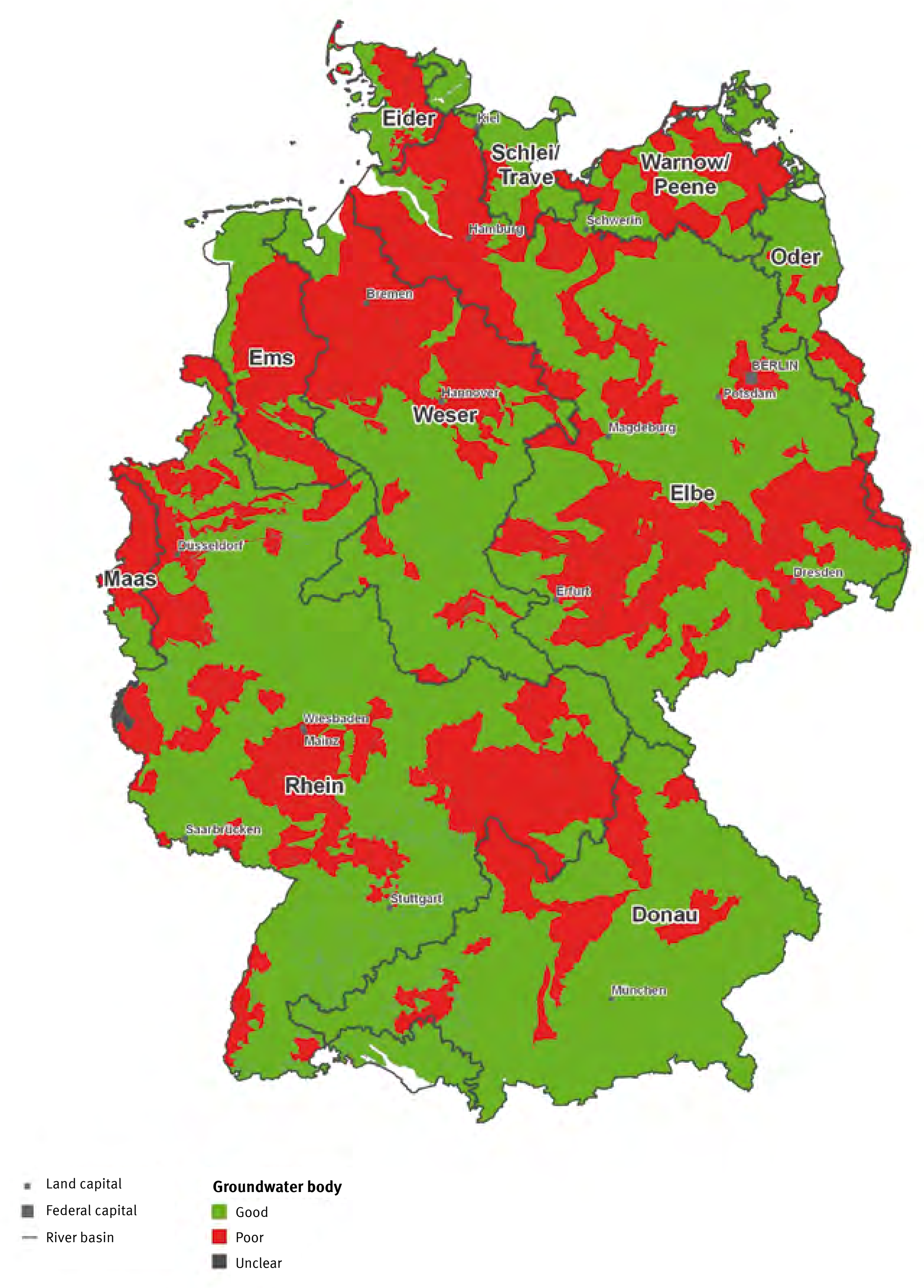
Figure 2 shows the quantitative status of groundwater bodies in Germany. Overall, there are only a few groundwater bodies in Germany with quantitative problems. Out of a total of around 1,000 groundwater bodies, only 38 (i.e. 4 %) failed to achieve "good quantitative status" in 2010.

Quantitative problems can arise, for example, in conjunction with mining activities, particularly open-cast lignite mining. In these regions, the groundwater level has often been lowered substantially over a number of decades. Even after mining has come to an end, it will take many decades for the groundwater to return to its natural level. In regions where salt deposits are mined on a large scale, there is an increased occurrence of man-made salt intrusions, which make that the status of the affected groundwater body is classified as "poor”. If the intrusion of saltwater is attributable to high levels of water abstraction, the groundwater body has a poor quantitative status. On the other hand, if the salt levels are caused e.g. by wastewater emissions from salt mining, the groundwater body will have a poor chemical status. The applicable assessment can only be determined on a case-by-case basis. Here too, it will probably take a long time for the groundwater body to attain a natural state and return to a "good status".

Figure 2: Quantitative status of groundwater bodies in Germany

Source: Federal Environment Agency; data supplied by LAWA, data source: Reporting tool WasserBLicK/BfG, as of 22 March 2010

Figure 3: Chemical status of groundwater bodies in Germany



3.2.2 Chemical status of groundwater

European-wide groundwater quality standards for nitrate (50 mg/l) and pesticides (0.1 µg/l), together with threshold values for relevant pollutants set by the Member States, are the benchmark for assessing the chemical status of groundwater. An assessment of the chemical status of groundwater in Germany indicates that 37 % of all groundwater bodies are in a bad chemical status. The main reasons are diffuse pollution with nitrate (27 % of groundwater bodies exceed the groundwater quality standard) and pesticides (4 % of groundwater bodies exceed the groundwater quality standard) from agriculture.

Nitrate in groundwater

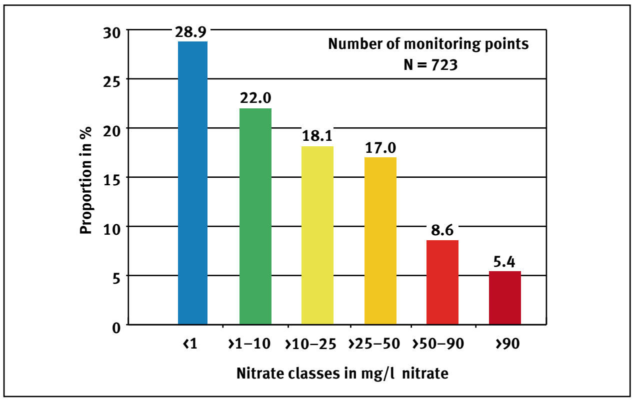
Nitrogen compounds – generally nitrate – are the most common reason for bad status of groundwater in Germany and most European countries. Based on data from the EEA monitoring network, the following picture shows the groundwater pollution in Germany (see **Figure 4**) in 2010:

Analysis results showing the nitrate levels in groundwater are available for 723 out of a total of around 800 measuring points in the EEA monitoring network for the year 2010. Around 51 % of all measuring points indicate nitrate concentrations of between 0 and 10 mg/l and are therefore not polluted at all, or only minimally. In around 35 % of measuring points, the nitrate content is between 10 and 50 mg/l. These points are significantly to heavily polluted with nitrate. The remaining 14 % of monitoring points are so heavily polluted with nitrate that the water cannot be used for drinking water abstraction without further treatment, because it exceeds the limit of 50 mg/l set by the Drinking Water Ordinance, in some cases significantly.

Clues to the principal reasons for nitrate inputs into groundwater are obtained by comparing the preferred land uses in the catchment area of a measuring point with the nitrate content in groundwater (cf. **Figure 5**). The lowest nitrate pollution level overall is found in the group of measuring points whose surrounding area is dominated by forest. Less than 5 % of points in this group have nitrate levels above 50 mg/l. If the surrounding area of the measuring points is dominated by grassland (meadows and fields), the number of points highly polluted with nitrate increases to 6.5 %. If there are farmland or settlement areas in the vicinity, then the proportion of measuring points with nitrate concentrations in excess of 50 mg/l increases to 23 % and 13 % respectively (**Figure 5**). Nitrogen inputs from agriculture are therefore the main reason for groundwater pollution with nitrate.

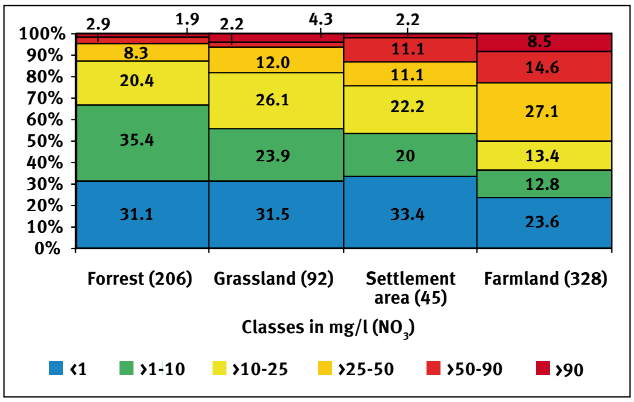
In order to protect the groundwater in regions with intensive agricultural use, in 1991 the EU adopted Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources (Nitrates Directive). The Nitrates Directive requires compliance with "best practices" in agriculture and the implementation of advanced reduction measures within the context of action programmes. Member States must both prove the effectiveness of the programmes of measures in the form of targeted groundwater measurements, and regularly submit reports to the Commission. The EU nitrate monitoring network provides the database for Germany's reports. Compared to the groundwater monitoring network, this network shall allow for fast, precise conclusions to be drawn regarding the effectiveness of the action programmes. For this reason, the measuring points are located in regions with significant nitrate contamination and the monitoring network is therefore not representative of groundwater pollution with nitrate

Figure 4: Overview of nitrate concentrations in groundwater in the Federal Republic of Germany, 2010



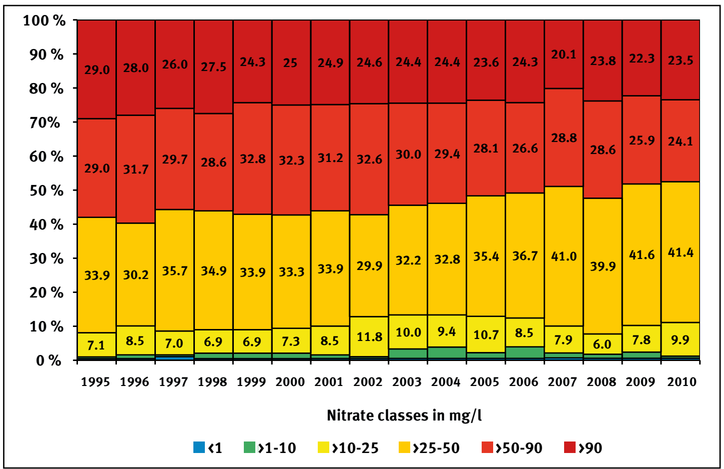
Source: Federal Environment Agency based on data supplied by LAWA

Figure 5: Distribution of nitrate concentrations in groundwater classified according to the dominant land use in the vicinity of groundwater measuring points (2010)



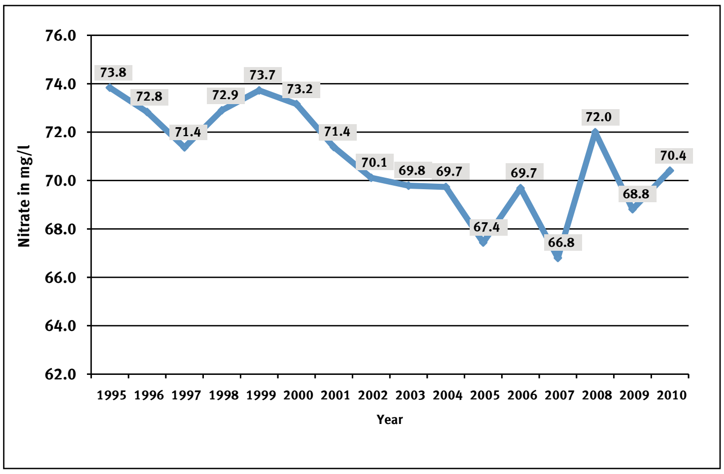
Source: Federal Environment Agency based on data supplied by LAWA

Figure 6: Development of nitrate concentrations at measuring points in the EU nitrate monitoring network from 1995 to 2010



Source: Federal Environment Agency based on data supplied by LAWA

Figure 7: Development of average nitrate concentrations at measuring points in the EU nitrate monitoring network from 1995 to 2010



Source: Federal Environment Agency based on data supplied by LAWA

throughout Germany as a whole. In Germany, the Länder, the Federal Government and water utility companies have been carrying out programmes to reduce nitrate pollution for more than 20 years.

Reporting under the Nitrates Directive shows how nitrate levels at the heavily polluted points of the EU nitrate monitoring network have changed over time (**Figure 6**).

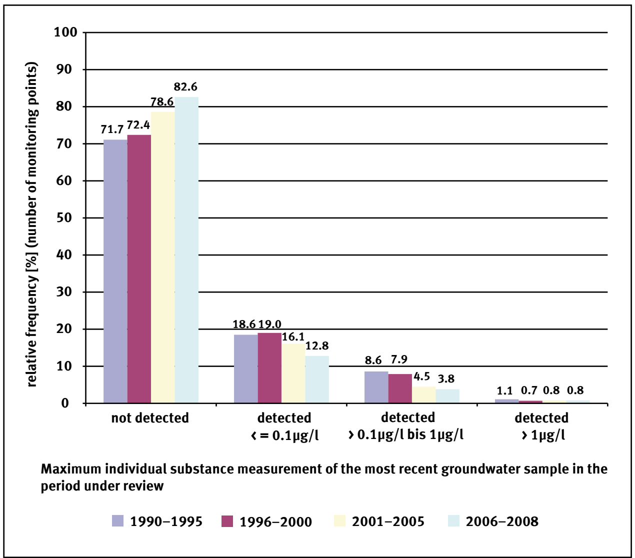
Overall, it can be noted that measures implemented under the various action programmes have led to a reduction in nitrogen inputs into the soil, leachate and hence into groundwater. Effects on groundwater nitrate concentrations may significantly be delayed, however, because the percolation time from the soil surface, through the water-unsaturated covering layers, into the groundwater can often take years or even decades. Apart from falling nitrate concentrations, however, the results of the study also indicate slight to significant increases in nitrate levels at 40 % of all measuring points in the EU nitrate monitoring network for the period 2004/2006 to 2008/2010. In the period 2000/2002 to 2004/2006 the rate was 31 %.

Figure 7 shows the development of average nitrate concentrations (arithmetic mean of all measurement data) in the EU groundwater monitoring network between 1995 and 2010. In the period 1995 to 2005, average nitrate concentrations decreased overall. Between 2005 and 2010, the averages strongly fluctuated from year to year, with a rather rising trend.

Pesticides

From time to time, the German Working Group on Water Issues of the Federal States and the Federal Government (LAWA), in collaboration with the Federal Environment Agency, compiles a summarising report on the contamination of groundwater with pesticides. The 3rd LAWA Pesticide Report was published in 2010, and provides an overview of groundwater pollution during the period 1990 to 2008. Throughout all four monitoring periods (1990-1995, 1996-2000, 2001-2005 and 2006-2008), there was a significant reduction in the number of measuring points at which the pesticide limit of 0.1 µg/l was exceeded (**Figure 8**). However, the decrease in groundwater pollution was found to be primarily attributable to decreasing discoveries of atrazine, desethylatrazine and several other active agents and metabolites whose use has been banned for years or even decades.

Figure 8: Frequency distribution of pesticide findings at filtered superficial groundwater measuring points in Germany over the periods 1990-1995, 1996-2000, 2001-2005 and 2006-2008



Source: LAWA

Between 2006 and 2008, 4.7 % of the 13,024 examined measuring points still exceeded the limit of 0.1 µg/l in groundwater close to the surface.

In addition to the description of the current pollution situation, it is also particularly interesting to examine the development of pesticide pollution over time. Similar to the 2nd LAWA Pesticide Report (2004), the 3rd Report also investigated the frequency of findings of selected individual substances commonly found in groundwater, such as atrazine, desethylatrazine, diuron and bentazone.

The report found that the number of measuring points with medium to very high levels of atrazine was declining. A similar development was also observed for desethlyatrazine.

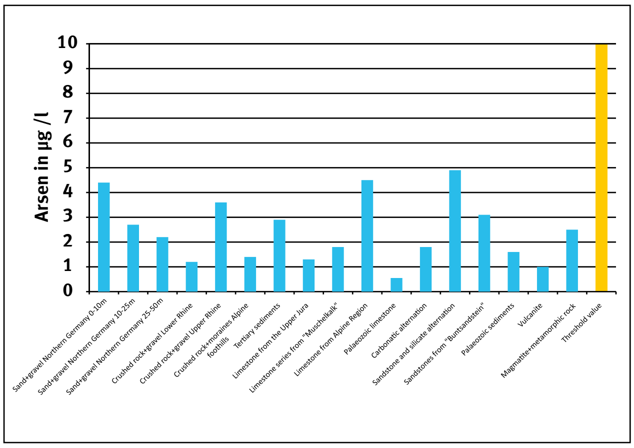
The situation for diuron is rather different. The total number of measuring points with diuron concentrations above or close to the limit of quantification is comparatively low compared with the findings for atrazine and desethylatrazine. Between 1990-1995 and 1996-2000, the number of measuring points at which diuron concentrations exceeded the groundwater quality standard of 0.1 µg/l increased from 57 to 67. In the subsequent periods 2001-2005 and 2006-2008, the number of points with diuron concentrations > 0.1 µg/l decreased to 42 and 37 respectively. A similar trend was not apparent in the case of groundwater pollution with bentazone, which is thought to have increased slightly between 2001 and 2008.

Arsenic

Arsenic is a natural (geogenic) element to be found in the subsoil. The natural background concentrations in groundwater – in relation to the 90 percentile – range between 0.55 µg/l in the limestone of the alpine region and 4.9 µg/l in the sandstone and silicate alternations. Taking all key hydro-geological units as a whole, this produces a “cross-unit background value” of approximately 2.6 µg/l As. At local level, natural arsenic concentrations may exceed 10 µg/l, which is the concentration limit for drinking water (cf. **Figure 9**).

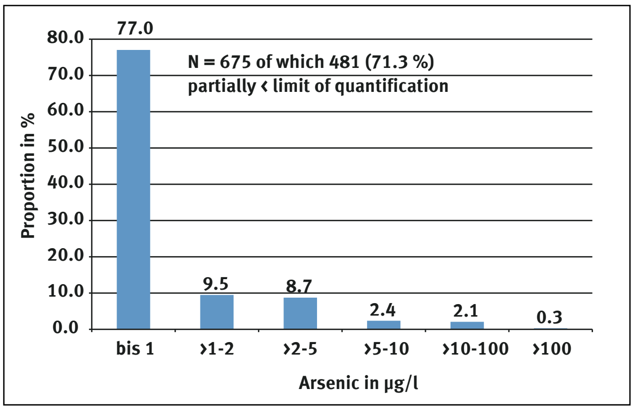
Since arsenic is not measured annually at all measuring points – it is known to be fairly immobile in groundwater, and its concentrations therefore generally only change very slowly – analysis results for the period 1999 to 2003 have been evaluated in summarised form. At 481 out of a total of 675 measuring points, at least one measured value of the relevant time series was below the limit of quantification. In total, an
analysis of distribution levels reveals that the average arsenic concentration over the period 1999 to 2003 was less than 1 µg/l at 77 % of the measuring points, and hence often below the limit of quantification.
At 21 % of points, the average arsenic concentration was between 1 and 10 µg/l and therefore still below the drinking water limit of 10 µg/l. At 2.4 % of points (i.e. at 16 individual measuring points), the average arsenic concentrations exceeded 10 µg/l. Whether this was due to natural (geogenic) causes or anthropogenic contamination would vary from measuring point to measuring point.

Figure 9: Distribution of natural background concentrations (90 percentile) of arsenic among the principal hydro-geological units in Germany (LAWA 2003)
For comparison: Threshold value (Groundwater Ordinanc)



Source: Federal Environment Agency based on data supplied by LAWA

Figure 10: Distribution of arsenic concentrations at measuring points in the EEA groundwater monitoring network (1999 to 2003)



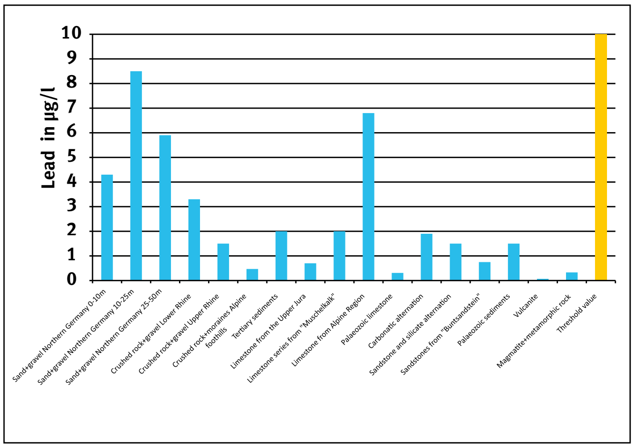
Source: Federal Environment Agency based on data supplied by LAWA

Lead

Like arsenic, lead is also a natural element to be found in the environment, e.g. in form of lead sulphide (galenite). However, its solubility in water is limited. The natural background concentrations of lead in groundwater – in relation to the 90 percentile – are between 0.07 µg/l in vulcanite and 8.5 µg/l in sand and gravel of Northern Germany. Taking all key hydro-geological units together, this produces a “cross-unit background value” of approximately 3.9 µg/l Pb. However, significantly higher natural lead concentrations may occur locally in individual cases.

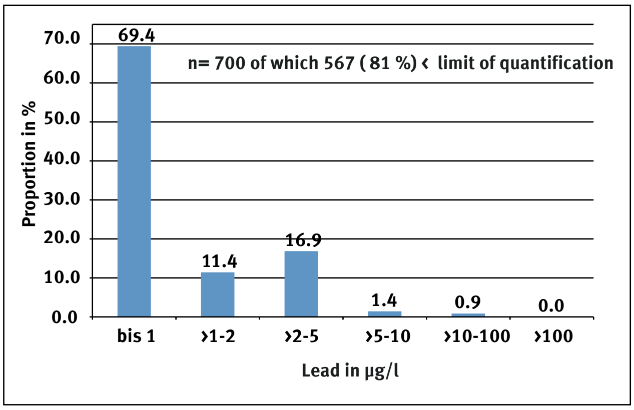
Measured lead values are more often below the limit of quantification than measured arsenic values, which means that the following mean figures are also influenced by the specified limits of quantification (cf. **Figure 12**, particularly the bar in the class > 2-5 µg/l). Overall, analysis results are available from 700 of approximately 800 measuring points in the EEA groundwater monitoring network for the period 1999 to 2003. For 567 points (81 %), when calculating mean lead levels, at least one value in the entire measurement series was below the limit of quantification. Only 0.9 % of all examined measuring points (6 points) had lead concentrations above the threshold value of 10 µg/l (cf. **Figure 12**). Here too, an analysis of each individual measuring point will show whether this exceedance is due to man-made groundwater contamination or naturally elevated lead concentrations in the groundwater.

Figure 11: Distribution of natural background concentrations (90 percentile) of lead among the principal hydro-geological units in Germany
For comparison: Threshold value (Groundwater Ordinance)



Source: Federal Environment Agency based on data supplied by LAWA)

Figure 12: Distribution of lead concentrations among measuring points of the EEA groundwater monitoring network (1999 to 2003)



Source: Federal Environment Agency based on data supplied by LAWA

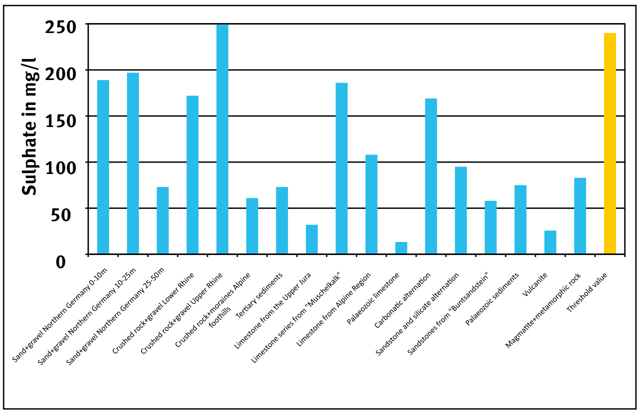
Sulphate

Like arsenic and lead, sulphate is a natural element to be found in groundwater. It is a reaction product of natural sulphur compounds (sulphides) or originates e.g. from gypsum, which is present in many geological formations. Seawater and deepwater may also contain substantial quantities of sulphate, which may enter adjacent groundwater reserves. Anthropogenic sources include sulphur emissions from coal-fired power plants, other incineration plants, fertilisers, building scrap and buildings themselves. As a conductive substance, sulphate has the potential to influence groundwater as a result of construction waste dumping.

The distribution of natural sulphate concentrations of key hydro-geological units is summarised in **Figure 13**. Natural levels vary between 13 mg/l in the limestone of the alpine region and 249 mg/l in grit and gravel of the Upper Rhine. The threshold value for sulphate is 240 mg/l and thus close to the natural background level of several groundwater units.

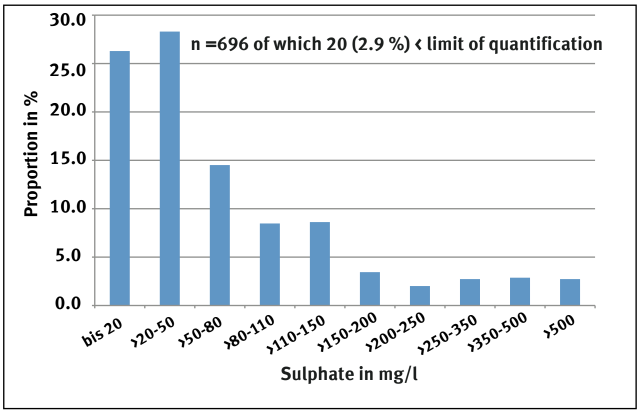
In 2008, 78 % of all measuring points indicated sulphate concentrations of between 0 and 110 mg/l, i.e. less than half of the threshold value. At a further 14 % of points, the average sulphate level was between 110 and 250 mg/l, and only 8.3 % of points exceeded the threshold value of 240 mg/l. Causes included salty water in the vicinity of salt deposits or groundwater from very deep groundwater aquifers, which often showed very high salt concentrations, and specifically sulphate concentrations. Here again, individual studies are needed in order to clarify whether the elevated sulphate levels had natural causes or are attributable to anthropogenic emissions.

Figure 13: Distribution of natural background concentrations (90 percentile) of sulphate among the principal hydro-geological units in Germany
For comparison: Threshold value (Groundwater Ordinance)



Source: Federal Environment Agency based on data supplied by LAWA

Figure 14: Distribution of sulphate concentrations among measuring points of the EEA groundwater monitoring network (2008)



Source: Federal Environment Agency based on data supplied by LAWA

3.2.3 Biology of groundwater

Unlike the quality assessment of surface waters, there is no traditional biological system from which an assessment of the ecological status of groundwater could be developed. Although groundwater is increasingly seen as a resource to be sustainably managed and an ecosystem with considerable natural capabilities and functionality that merits our protection, until now it has been viewed primarily from the perspective of water resources management. Statutory provisions and policy strategies are based primarily on substance- and usage-related protection concepts. There is a lack of biological assessment criteria and analysis techniques suitable for implementation purposes to be able to gauge the influence of anthropogenic changes and their impacts on groundwater ecosystems.

Figure 15: Groundwater fauna - minute, colourless and eyeless

Source: Karsten Grabow, University of Karlsruhe and Andreas Fuchs, Landau University

In order to close this gap, the Federal Environment Agency has initiated a multi-year research project focusing on the following key aspects:

1. Selection of suitable measurands and indicators
2. Inventory of selected locations
3. Identification of an appropriate ecological classification
4. Derivation of natural reference conditions and background concentrations
5. Proposal for an assessment system integrating the identified measurands to facilitate status assessment.

Identification of an appropriate ecological classification

Until now, factors such as the aquifer type (porous aquifer, karst aquifer and fissure aquifer), geology and permeability or productivity with regard to groundwater extraction were decisive in the classification of groundwater systems, and ecological criteria were ignored.

A key focus of the project was therefore to identify a spatially expedient classification of groundwater systems as the basis for an ecological assessment system analogous to the typology of surface waters. Thus, the project analysed the extent to which existing regional classification systems might be used for an ecosystem-based approach. Since the distribution of biotic communities does not follow any of the surface or subsurface classification systems tested, the researchers proposed a new classification scheme for groundwater ecosystems in Germany known as stygoregions. Faunistic properties are the decisive factor in stygoregions (see **Table 2**).

Derivation of reference conditions

Individual background levels were established for the sites analysed. Based thereon, initial reference conditions for an ecologically intact groundwater aquifer were deduced. An ecologically intact groundwater aquifer is well-shielded against surface inputs and the groundwater it transports is generally of drinking water quality. It is approximately characterised by reference conditions (see **Table 3**).

Table 3: Reference conditions for an intact groundwater aquifer

	Model groundwater aquifer
Fauna	
Proportion of crustaceans	≥ 70 %
Proportion of oligochaeta	≤ 20 %
Proportion of stygobionts (crustaceans)	> 50 %
GFI *)	≤ 3
Microbiology	
CFUs [m/l]	≤ 500
BA [cells m/l]	Alluvium: ≤ 0.9*103 to 1.2*105
	Karst: 3*103 to 4*105
	Fissures: 4*103 to 1.5*105
BCP [ng C/(l h)]	≤ 0.5
ATP total [pM]	≤ 30
ATP intracellular [pM]	0.3–50
BOD_5 [mg/l]	≤ 1.5
E.coli [100ml]	0

*) The Groundwater Fauna Index (GFI) is a yardstick for measuring the ecologically relevant surface influence. The index values are calculated on the basis of oxygen content, detritus volume and standard temperature deviation. Low index values indicate no or minimal surface influence, and vice versa.

Source: Federal Environment Agency, 2013

Colony-forming units (CFU), bacterial abundance (BA) depending on the type of groundwater aquifer, ATP production and biological oxygen demand (BOD) have emerged as the decisive variables for the purposes of microbiology.

The surface influence can be assessed using selected faunistic measurement variables, allowing the groundwater quality of non-surface-influenced and surface-influenced samples to be compared on the basis of faunistic indicators. The following parameters are recommended as reference criteria: the Groundwater Fauna Index (GFI), more than 50 % genuine groundwater organisms (stygobionta) in the community, and < 20 %

Table 2: Features of Germany's stygoregions

Northern German lowlands	Central German Uplands	South-Western Uplands	Northern Alps
There is almost a complete absence of groundwater fauna, due to its very fine sediment and low oxygen levels	Diversity characterised by diverse fauna (27 species)	High diversity (32 species)	Medium diversity (15 species)
	Characterised by ubiquitous groundwater species and post-glacial recolonisers	High proportion of genuine groundwater fauna, larger species - isopods, niphargus	Reduced spectrum of groundwater species
	High proportion of groundwater-alien species (surface influence)	Low proportion of groundwater-alien speciesn	Absence of groundwater-alien species

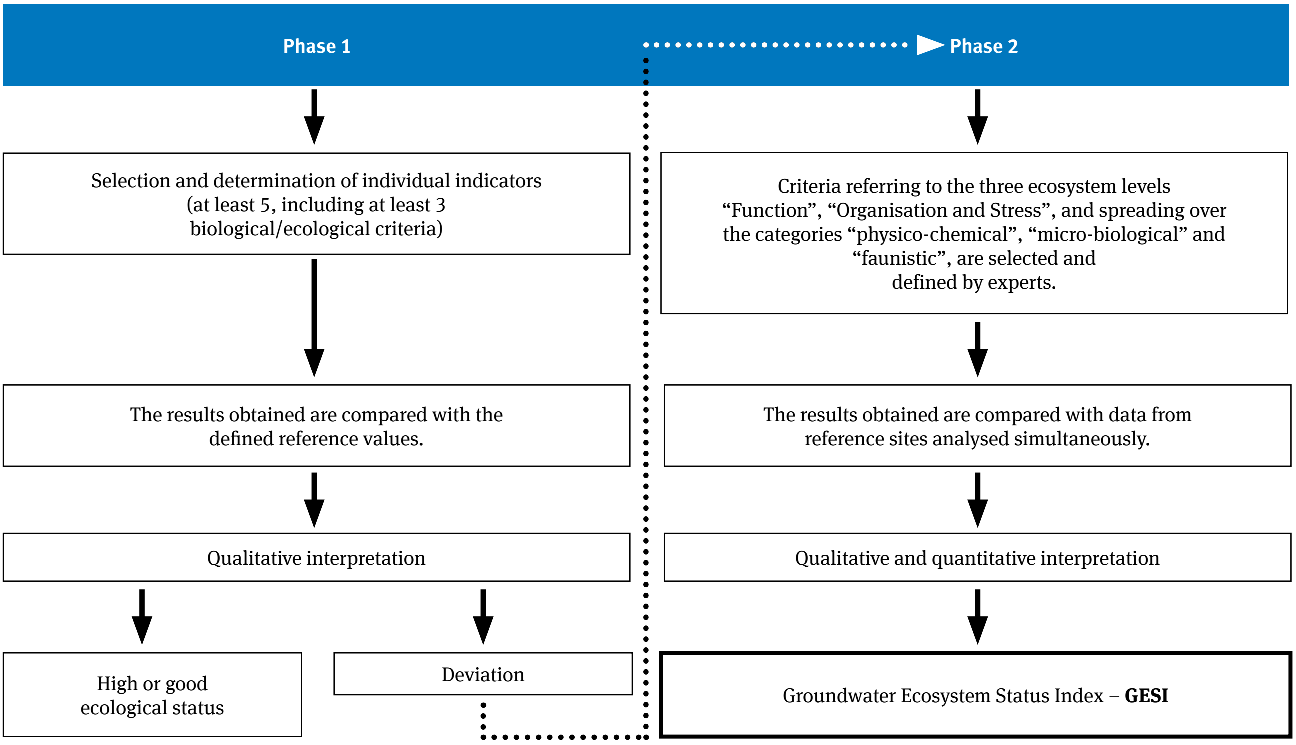
Source: Federal Environment Agency, 2013 groundwater-alien species (oligochaeta). Among stygobionta, the proportion of crustaceans should be > 70 %, since studies indicate that the proportion of crustaceans is a particularly reliable measurement variable.

By combining all these sub-results, it was possible to develop a potential assessment technique for a two-phase flowchart, whereby the complexity and meaningfulness increases significantly from phase 1 to phase 2 (**Figure 16**).

Due to the comparatively simple analysis work involved in phase 1, based on selected indicators and the background levels ascertained by the project, it is possible to determine whether the respective analysis site is in a "good status" or a "high status". In case of deviations, experts are consulted and detailed analyses carried out. Assessment according to phase 2 allows the calculation of an index and thus an allocation to a quality category, as known from the ecological status assessment of surface waters (**Table 4**).

This project has prompted significant progress towards a biologically-based assessment of groundwater status. However, further research work and experience of ecological groundwater monitoring is needed before it will be ready to use.

Figure 16: Proposed two-phase assessment flowchart



Source: Federal Environment Agency, 2013

Table 4: Proposed ecological quality categories for groundwater systems

Quality category	Ecological status	Comment
1	High	No anthropogenic interference ascertained, complies with the situation in reference monitoring sites
≥ 0.8–<1	Good	Deviation from the reference status is marginal and/or only temporary
≥ 0.6–0.8	Moderately impaired	The deviation from the reference status can be estimated to be minimal
≥ 0.4–0.6	Impaired	Significant deviation from a reference situation
≥ 0.2–0.4	Heavily impaired	Major anthropogenic interference ascertained, deviation from the reference situation in most of the selected parameters
0–0.2	Bad	Major anthropogenic interference ascertained, deviation from the reference situation in all or nearly all of the selected parameters

Source: Federal Environment Agency, 2013

4 Assessment of surface waters

4.1 Bodies of surface water

Surface waters vary considerably in terms of the differing morphological, hydrological and geochemical framework conditions in their biotic communities, and in their sensitivity to anthropogenic influences. In order to include their varying sensitivity to pollutants and other pressures in the assessment, the waterbodies are divided into large-scale ecoregions and small-scale waterbody types, as well as into bodies of surface water. This subdivision is an ecological prerequisite for classification, as required by Article 5 and Annex II of the EC Water Framework Directive, as one of the first steps in implementing the EC Water Framework Directive. The waterbody types are defined in Annex 1 to the Surface Waters Ordinance.

The body of surface water is the object of assessment and management. Bodies of surface water are delineated from one another if:

- The waterbody category (watercourses, lakes, transitional and coastal waters) changes (for example, if a river flows into a lake)
- The waterbody type (cf. **chapters 5.1.1, 6.1.1** and **7.1.1**) changes
- The status changes (e.g. if a wastewater discharge causes the status to be downgraded from good to moderate).

A body of surface water is generally allocated to a natural waterbody type. For each waterbody type, zoological and botanical reference lists are prepared of the species occurring in the natural state and their frequency. During assessment, the species found in the waterbodies under current pressure conditions and their frequencies are compared against this yardstick.

Bodies of surface water are also classified into "natural", "heavily modified" and "artificial" bodies of surface water. Bodies of surface water may be classified as "heavily modified" if their structures have been physically transformed by human activity to such an extent that their original reference status can no longer be expediently applied as an assessment yardstick. For example, dams or bayous where gravel was excavated are classified as "**h**eavily **m**odified **w**ater**b**odies" (HMWB). The damming of the water by the weir effects a change in the waterbody category from river to lake. **A**rtificial **w**ater**b**odies (AWB) are man-made waterbodies in locations where no water previously existed. In Germany, these are primarily open-cast mine lakes that have been created in former lignite mines, as well as dredged lakes, canals and drainage ditches. In heavily modified and artificial waterbodies, anthropogenic use means that a "good ecological potential" is the required environmental objective, rather than a "good ecological status".

4.2 Ecological and chemical status

The EC Water Framework Directive aims to achieve a good status of all bodies of surface water by 2015. A natural body of surface water has a good status if the ecological status is at least "good" and the chemical status is assessed as "good". Heavily modified waterbodies and artificial waterbodies have a good status if their ecological potential is at least "good" and their chemical status is assessed as "good".

4.2.1 Ecological status and ecological potential

The EC Water Framework Directive adopts an integrative approach when assessing the ecological status of surface waters, i.e. primarily according to the presence of biotic communities typical of the natural area. Hydromorphological and physico-chemical features have a supporting effect. Initially, the EC Water Framework Directive calls for the assessment of specified quality elements of ecological status (see **Table 5**).

To this end, a number of assessment methods have been developed in the Member States, and their development is still ongoing 13 years after the EC Water Framework Directive's entry into force (see **chapters 5.1.2, 6.1.2, 7.1.1**). The results of the national assessment methods are compared with one another in inter-calibration processes, and where necessary the techniques are readjusted to the class boundaries high/good and good/moderate, in order to ensure that the same evaluation yardsticks are applied throughout every European country (see **chapters 5.1.2, 6.1.2** and **7.1.1**). This process is not yet complete for all assessment methods. Of the required assessment methods for rivers and lakes, the methods for assessing invertebrates in lakes and fish fauna in the Northern German lowland lakes are currently undergoing practical testing. For transitional waters, the assessment methods for large algae/angiosperms and macroinvertebrates are currently at the practical testing stage. To date, no method has been developed for the assessment of phytoplankton in transitional waters, since the high degree of natural variability makes it impossible to establish reliable reference conditions. All other assessment methods are already being applied.

Of the assessment methods used for heavily modified waterbodies and artificial bodies of surface water, the methods for macrozoobenthos and fish fauna in watercourses are currently undergoing practical testing, whilst the method for macrophytes is under preparation. For heavily modified and artificial lakes, assessment methods are available for phytoplankton, phytobenthos and macrophytes. An assessment method for macrozoobenthos is currently under preparation.

Table 5: Quality elements of ecological status as defined by the EC Water Framework Directive

Quality element	Watercourses	Lakes	Transitional waters	Coastal waters
Biological quality elements				
Phytoplankton	X	X	X	X
Large algae/ angiosperms			X	X
Macrophytes/ phytobenthos	X	X		
Macro-invertebrates	X	X	X	X
Fish	X	X	X	
Hydromorphological quality elements				
Continuity	X [1]			
Hydrology	X	X		
Morphology	X	X	X	X
Tidal regime			X	X
Chemico-physical quality elements				
General chemico-physical elements	X	X	X	X
River basin-specific pollutants	X	X	X	X

Key:

	Assessment not required
X	Assessment method available
X	Assessment method currently being trialled
X	Assessment method not yet available

1) There are various assessment methods for fish ladders. Assessment of downstream fish passes and sediment continuity is still outstanding. There is a coordinated LAWA approach for reporting to the EU Commission.

Source: Federal Environment Agency in accordance with the EC Water Framework Directive and Annex 3 of the Surface Waters Ordinance

Ecological status comprises the following five classes: “high”, “good”, “moderate”, “poor”, and “bad” (see **Table 6**). The biological quality element with the poorest assessment determines the ecological status. The quality element “specific pollutants” may lead to a downgrading of the ecological status. Exceeding even one environmental quality standard for specific pollutants (**chapter 4.2.2**) means that the ecological status/ ecological potential can only be "moderate", even if the biological quality elements are all "good" or above.

Table 6: Representation of ecological status and ecological potential

Colour	Status	Potential *)
	high	
	good	good and above
	moderate	moderate
	poor	poor
	bad	bad

*) Potential is indicated on a large scale with grey hatching

Source: EC Water Framework Directive and Surface Waters Ordinance

Ecological classification is based on and derived from the reference conditions. The ecological status refers to a deviation from the reference. Such deviations are defined in the EC Water Framework Directive and the Surface Waters Ordinance as follows:

- A **“high status”** indicates “no or only slight anthropogenic changes compared to the values” of the reference state. For this reason, both the biological quality elements and the physico-chemical and hydromorphological quality elements should represent virtually undisturbed conditions, and the environmental quality standard for specific pollutants should be met.
- For a **good ecological status**, all biological quality elements should exhibit no more than slight changes due to anthropogenic pressures compared to the not affected surface waterbody type. The environmental quality standards for all specific pollutants must be met. Furthermore, the values for general physico-chemical parameters should lie within a range which ensures proper functioning of the ecosystem.
- For a **moderate ecological status**, all biological quality elements must at least be in a “moderate state”.
- If one or more of these biological quality elements is in a worse state, the waterbody must be classified as **poor** or **bad**.

Hence, classification as "poor" or "bad" occurs solely on the basis of the biological analysis results. Failure to comply with the values for the general physico-chemical quality elements is indicative of possible ecological deficits which may, but need not necessarily, lead to a downgrading from good to moderate. If the biological quality elements are sufficiently sensitive and cover all relevant pressures, and provided there is no delay in the biological response, failure to achieve the general physico-chemical quality elements will simultaneously indicate a status of “moderate” or below for one or more biological quality elements. By contrast, failure to meet the environmental quality standards for specific pollutants will always lead to a classification of "moderate" at best, even if all biological quality elements indicate a good status.

For "heavily modified" and "artificial" watercourses, the EC Water Framework Directive prescribes the objective of "good ecological potential", whose reference status ("maximum ecological potential") is based around the hydromorphological changes implemented in order to guarantee usage. This reference status is considered to exist once all measures intended to improve the morphology of the waterbody have been carried out without impairing its usage. In order to attain the environmental objective of a "good ecological potential", the most ecologically efficient measures must be used in order to ensure that the biotic communities under these conditions only deviate minimally from those of the "maximum ecological potential".

4.2.2 River basin-specific pollutants

Specific pollutants are assessed within the context of a classification of ecological status. For specific pollutants that are discharged in significant quantities, the Member States must derive environmental quality standards to protect the aquatic community on the basis of longer-term ecotoxicological effect data (Annex V, 1.2.6 of the EC Water Framework Directive). Substance volumes leading to concentrations of more than half the environmental quality standard at representative monitoring sites are defined as significant. In Germany, environmental quality standards with legally binding validity have been specified for a total of 162 pollutants (cf. **Table 7**). Compliance with environmental quality standard is verified using annual averages as prescribed by the EC Water Framework Directive.

Environmental quality standard for the ecological status of surface waters are defined on the basis of an EU chemical assessment as prescribed in Annex V, 1.2.6 of the EC Water Framework Directive. Valid long-term tests regarding the substance’s effects on the food stages algae, amphipods and fish are compiled, and the most sensitive of these values is selected. However, as organisms in nature may be even more sensitive than those used to perform the laboratory tests, this smallest figure is divided by a compensating factor in order to calculate the environmental quality standard. If valid long-term toxicity tests are available for all stages, this factor is generally 10. If data is missing, it will be 100 or more.

Some environmental quality standards have very low values. For measurements within the matrix “water”, therefore, the detection limits of the most common substances sometimes exceed the environmental quality standard. In such cases, compliance with the environmental quality standard cannot be verified, and levels may either exceed or comply with the environmental quality standard. For this reason, in Germany environmental quality standards for accumulable substances are primarily defined for the matrix “materials in suspension” (**Table 7**).

Table 7: Environmental quality standards (EQS) for river basin-specific pollutants to determine ecological status

Substance	CAS no.	EQS for watercourses and lakes
Metals, soluble concentration in µg/l or materials in suspension/sediment in mg/kg (Chapters 5.2.3 and 7.2.3)		
Arsenic (As) (materials in suspension/sediment)	7440-38-2	40
Chromium (Cr) (materials in suspension/sediment)	7440-47-3	640
Copper (Cu) (materials in suspension/sediment)	7440-50-8	160
Selenium (Se)	7782-49-2	3
Silver (Ag)	7440-22-4	0.02
Thallium (Tl)	7440-28-0	0.2
Zinc (Zn) (materials in suspension/sediment)	7440-66-6	800
Industrial pollutants, concentration in total water samples in µg/l or in materials in suspension/sediment in µg/kg (Chapters 5.2.4 and 7.2.4)		
1,1,1-Trichloroethane	71-55-6	10
1,1,2,2-Tetrachloroethane	79-34-5	10
1,1,2-Trichloroethane	79-00-5	10
1,1,2-Trichlorotrifluoroethane	76-13-1	10
1,1-Dichloroethane	75-34-3	10
1,1-Dichloroethylene (vinylidene chloride)	75-35-4	10
1,2,4,5-Tetrachlorobenzene	95-94-3	1
1,2-Dibromoethane	106-93-4	2
1,2-Dichloro-3-nitrobenzene	3209-22-1	10
1,2-Dichloro-4-nitrobenzene	99-54-7	10
1,2-Dichlorobenzene	95-50-1	10
1,2-Dichloroethene	540-59-0	10
1,2-Dichloropropane	78-87-5	10
1,2-Dimethylbenzene	95-47-6	10
1.3-Dichloro-4-nitrobenzene	611-06-3	10
1.3-Dichlorobenzene	541-73-1	10
1,3-Dichloropropane-2-ol	96-23-1	10
1,3-Dichloropropene	542-75-6	10
1,3-Dimethylbenzene	108-38-3	10
1,4-Dichloro-2-nitrobenzene	89-61-2	10
1,4-Dichlorobenzene	106-46-7	10
1,4-Dimethylbenzene	106-42-3	10
1-Chloro-2,4-dinitrobenzene	97-00-7	5
1-Chloro-2-nitrobenzene	88-73-3	10
1-Chloro-3-nitrobenzene	121-73-3	1
1-Chloro-4-nitrobenzene	100-00-5	10
1-Chloronaphthalene	90-13-1	1
2,3,4-Trichlorophenol	15950-66-0	1
2,3,5-Trichlorophenol	933-78-8	1
2,3,6-Trichlorophenol	933-75-5	1
2,3-Dichloroaniline	608-27-5	1
2,3-Dichloropropene	78-88-6	10
2,4-&2,5-Dichloraniline		2
2,4,5-Trichlorophenol	95-95-4	1
2,4,6-Trichlorophenol	88-06-2	1
2,4-Dichloroaniline	554-00-7	1
2,4-Dichlorophenol	120-83-2	10
2,5-Dichloroaniline	95-82-9	1
2,6-Dichloroaniline	608-31-1	1
2-Amino-4-chlorophenol	95-85-2	10
2-Chloro-4-nitrotoluene	121-86-8	1

Continuation of table 7

Substance	CAS no.	EQS for watercourses and lakes
2-Chloro-6-nitrotoluene	83-42-1	1
2-Chloroaniline	95-51-2	3
2-Chloroethanol	107-07-3	10
2-Chlorophenol	95-57-8	10
2-Chloro-p-toluidine	615-65-6	10
2-Chlorotoluene	95-49-8	1
2,4,5-Trichlorophenol	609-19-8	1
3,4-Dichloroaniline	95-76-1	0.5
3,5-Dichloroaniline	626-43-7	1
3-Chloro-4-nitrotoluene	38939-88-7	1
3-Chloroaniline	108-42-9	1
3-Chloropropene (allyl chloride)	107-05-1	10
3-Chloro-o-toluidine	87-60-5	10
3-Chlorophenol	108-43-0	10
3-Chloro-p-toluidine	95-74-9	10
3-Chlorotoluene	108-41-8	10
4-Chloro-2-nitroaniline	89-63-4	3
4-Chloro-2-nitrotoluene	89-59-8	10
4-Chloro-3-methylphenol	59-50-7	10
4-Chloro-3-nitrotoluene	89-60-1	1
4-Chloroaniline	106-47-8	0.05
4-Chlorophenol	106-48-9	10
4-Chlorotoluene	106-43-4	1
5-Chloro-2-nitrotoluene	5367-28-2	1
5-Chloro-o-toluidine	95-79-4	10
Aniline	62-53-3	0.8
Benzidine	92-87-5	0.1
Benzyl chloride (α-chlorotoluene)	100-44-7	10
Benzylidene chloride (α,α-dichlorotoluene)	98-87-3	10
Biphenyl	92-52-4	1
Chloral hydrate	302-17-0	10
Chlorobenzene	108-90-7	1
Chloroacetic acid	79-11-8	10
Chloronaphthalenes (techn. mixture)		0.01
Chloroprene (2-Chlorobuta-1,3-diene)	126-99-8	10
Cyanide	57-12-5	10
Cyanuric chloride (2,4,6-Trichloro-1,3,5-triazine)	108-77-0	0.1
Dibutyl tin cation (materials in suspension/sediment)	14488-53-0	100
Dibutyl tin cation (alternatively)	14488-53-0	0.01
Dichlorobenzidines	91-94-1	10
Dichlorodiisopropylether	108-60-1	10
Diethylamine	109-89-7	10
Dimethylamine	124-40-3	10
Epichlorohydrine	106-89-8	10
Ethylbenzene	100-41-4	10
Hexachloroethane	67-72-1	10
Isopropylbenzene	98-82-8	10
Nitrobenzene	98-95-3	0.1
PCB-28 (materials in suspension/sediment)	7012-37-5	20
PCB-28 (alternatively)	7012-37-5	0.0005
PCB-52 (materials in suspension/sediment)	35693-99-3	20
PCB-52 (alternatively)	35693-99-3	0.0005

Continuation of table 7

Substance	CAS no.	EQS for watercourses and lakes
PCB-101 (materials in suspension/sediment)	37680-73-2	20
PCB-101 (alternatively)	37680-73-2	0.0005
PCB-118 (materials in suspension/sediment)	31508-00-6	20
PCB-118 (alternatively)	31508-00-6	0.0005
PCB-138 (materials in suspension/sediment)	35065-28-2	20
PCB-138 (alternatively)	35065-28-2	0.0005
PCB-153 (materials in suspension/sediment)	35065-27-1	20
PCB-153 (alternatively)	35065-27-1	0.0005
PCB-180 (materials in suspension/sediment)	28655-71-2	20
PCB-180 (alternatively)	28655-71-2	0.0005
Phenanthrene	85-01-8	0.5
Tetrabutyl tin (materials in suspension/sediment)	1461-25-2	40
Tetrabutyl tin (alternatively)	1461-25-2	0.001
Toluene	108-88-3	10
Tributyl phosphate (phosphoric acid tributyl ester)	126-73-8	10
Vinylchloride (chloroethylene)	75-01-4	2
Pesticides, concentrations in total water samples in µg/l or in materials in suspension/sediment in µg/kg (Chapters 5.2.5 and 7.2.4)		
Fungicides		
Epoxiconazole	133855-98-8	0.2
Propiconazole	60207-90-1	1
Triphenyl tin cation (materials in suspension/sediment)	668-34-8	20
Triphenyl tin cation (alternatively)	668-34-8	0.0005
Herbicides		
2,4,5-T	93-76-5	0.1
2,4-D	94-75-7	0.1
Ametryn	834-12-8	0.5
Bentazone	25057-89-0	0.1
Bromacil	314-40-9	0.6
Bromoxynil	1689-84-5	0.5
Chlortoluron	15545-48-9	0.4
Dichlorprop	120-36-5	0.1
Diflufenican	83164-33-4	0.009
Hexazinone	51235-04-2	0.07
Linuron	330-55-2	0.1
MCPA	94-74-6	0.1
Mecoprop	7085-19-0	0.1
Metazachlor	67129-08-2	0.4
Methabenzthiazuron	18691-97-9	2
Metolachlor	51218-45-2	0.2
Metribuzin	21087-64-9	0.2
Monolinuron	1746-81-2	0.1
Picolinafen	137641-05-5	0.007
Propanil	709-98-8	0.1
Pyrazone (chloridazone)	1698-60-8	0.1
Terbuthylazine	5915-41-3	0.5
Insecticides		
Azinphos-ethyl	2642-71-9	0.01
Azinphos-methyl	86-50-0	0.01
Chlordane (cis and trans)	57-74-9	0.003
Coumaphos	56-72-4	0.07
Demeton (Total of Demeton-o and -s)		0.1

Continuation of table 7

Substance	CAS no.	EQS for watercourses and lakes
Demeton-o	298-03-3	0.1
Demeton-s	126-75-0	0.1
Demeton-s-methyl	919-86-8	0.1
Demeton-s-methyl-sulphone	17040-19-6	0.1
Diazinon	333-41-5	0.01
Dichlorvos	62-73-7	0.0006
Dimethoate	60-51-5	0.1
Disulfoton	298-04-4	0.004
Etrimphos	38260-54-7	0.004
Fenitrothion	122-14-5	0.009
Fenthion	55-38-9	0.004
Heptachlorine	76-44-8	0.1
Heptachloroepoxide	1024-57-3	0.1
Malathion	121-75-5	0.02
Methamidophos	10265-92-6	0.1
Mevinphos	7786-34-7	0.0002
Omethoate	1113-02-6	0.1
Oxydemeton-methyl	301-12-2	0.1
Parathion-ethyl	56-38-2	0.005
Parathion-methyl	298-00-0	0.02
Pirimicarb	23103-98-2	0.09
Prometryn	7287-19-6	0.5
Triazophos	24017-47-8	0.03
Trichlorfon	52-68-6	0.002
Veterinary pharmaceuticals		
Phoxim	14816-18-3	0.008

Source: Federal Environment Agency in accordance with the Surface Waters Ordinance, 2011

4.2.3 Chemical status

Chemical status is determined from the defined EU-wide environmental quality standards for the 33 priority substances currently listed in the EC Water Framework Directive and 8 other substances regulated on a European-wide basis under the old Directive on water pollution by discharges of certain dangerous substances (formerly: Directive 76/464, now: 2006/11/EC) and the action value for nitrate under the EU Nitrates Directive (**Table 8**). The provisions of the Environmental Quality Standard (EQS) Directive 2008/105/EC and the Nitrates Directive were adopted into Annex 7 of the Surface Waters Ordinance in 2011. The environmental quality standards Directive was updated on 12 August 2013 (2013/39/EU), and now regulates a total of 45 priority substances, which will be adopted by the Surface Waters Ordinance. The environmental quality standards for the 12 new priority substances will come into force in 2018. If the action value of 50 mg nitrate/l is exceeded, measures must be taken to reduce this level. There are two classes of chemical status. If the environmental quality standards is complied with, the status is "good", otherwise it is "not good". "Good chemical status" as an environmental objective applies to both "natural" as well as "artificial" and "heavily modified" waterbodies. These are labelled blue for “good chemical status” and red for “not good chemical status”.

Priority substances must be measured if there are any emissions. The annual average is always monitored, hence the abbreviation AA-EQS (annual average - environmental quality standard). For selected pollutants with acute high toxicity, a maximum allowable concentration (MAC-EQS) is additionally specified, and this must not be exceeded. A MAC-EQS is considered necessary where the ratio of acute to chronic toxicity is less than 12. For hexachlorobenzene, hexachlorobutadiene and mercury, which indicate high levels of accumulation within the food chain, an environmental quality standard for biota was additionally defined. The Member States are at liberty to specify a further environmental quality standard for water corresponding to this biota figure for analytical monitoring. Germany has defined an environmental quality standard for water with respect to HCB and hexchlorobutadiene, but not for mercury due to methodological problems.

The environmental quality standards for chemical status makes allowance for the protection of aquatic organisms (including accumulation in the food chain) and human health. The environmental quality standard for coastal waters and seas were calculated using the test results for marine organisms as well. The marine protection conventions prompted the objective of phasing out emissions of priority hazardous substances within one generation.

The EC Water Framework Directive stipulates that the priority substances listed in Annex 6, should be revised every four years. Updates to Annex X and the environmental quality standards Directive (2008/105/EC) were therefore adopted by Directive 2013/39/EU as regards priority substances in the field of water policy. It also extended the period for updating the list of substances to 6 years in accordance with the management plans. The number of priority substances was increased from 33 to 45, 21 of which are prioritized as hazardous. The standards for eleven "old" substances have been amended (see **Table 9**). The new Directive has reduced the level of monitoring required for the so-called ubiquitous, widespread substances, including mercury and dioxins. Also new is the mandatory watch list with a maximum of 14 substances, including diclofenac and the two hormones E2 and EE2. The watch list must be updated every 2 years, and a substance must not remain on the list for more than 4 years.

Table 8: Environmental quality standard (EQS) for priority substances and other substances relating to chemical status

Substance	CAS number	Priority hazardous substance	AA-EQS in µg/l	AA-EQS in µg/l	MAC-EQS in µg/l	MAC-EQS in µg/l	Biota EQS in µg/kg wet weight
			Watercourses and lakes	Transitional and coastal waters	Watercourses and lakes	Transitional and coastal waters	Surface waters
Nutrients (chap. 5.2.2)							
Nitrate (NO_3)			50,000				
Heavy metals (Chapters 5.2.3 and 7.2.3), soluble concentration in µg/l							
Lead (Pb) and lead compounds	7439-92-1		7.2	7.2	N.a.	N.a.	
Cadmium (Cd) and cadmium compounds (dep. on water hardness class) [1]	7440 43 9	X	≤ 0.08 (class 1) 0.08 (class 2) 0.09 (class 3) 0.15 (class 4) 0.25 (class 5)	0.2	≤ 0.45 (class 1) 0.45 (class 2) 0.6 (class 3) 0.9 (class 4) 1.5 (class 5)	≤ 0.45 (class 1) 0.45 (class 2) 0.6 (class 3) 0.9 (class 4) 1.5 (class 5)	
Nickel (Ni) and nickel compounds	7440-02-0		20	20	N.a.	N.a.	
Mercury (Hg) and mercury compounds	7439-97-6	X	0.05	0.05	0.07	0.07	20
Industrial pollutants (Chapters 5.2.4 and 7.2.4)							
Anthracene	120-12-7	X	0.1	0.1	0.4	0.4	
Benzene	71-43-2		10	8	50	50	
Brominated diphenyl ether [2, 3] **(BDEs)**	32534-81-9	X [12]	0.0005	0.0002	N.a.	N.a.	
C10-13 chloro-alkanes	85535-84-8	X	0.4	0.4	1.4	1.4	
1,2-Dichloroethane	107-06-2		10	10	N.a.	N.a.	
Dichloromethane	75-09-2		20	20	N.a.	N.a.	
Bis(2-ethyl-hexyl)phthalate (DEHP)	117-81-7		1.3	1.3	N.a.	N.a.	
Fluoranthene	206-44-0		0.1	0.1	1	1	
Hexachlorobenzene [3] **(HCB)**	118-74-1	X	0.01	0.01	0.05	0.05	10[4]
Hexachlorobutadiene	87-68-3	X	0.1	0.1	0.6	0.6	55[5]
Naphthalene	91-20-3		2.4	1.2	N.a.	N.a.	
Nonylphenol (4-Nonylphenol)	84852-15-3[6]	X	0.3	0.3	2	2	
Octylphenol ((4-(1,1',3,3'-Tetramethylbutyl)-phenol))	140-66-9		0.1	0.01	N.a.	N.a.	
Pentachlorobenzene [3]	608-93-5	X	0.007	0.0007	N.a.	N.a.	
Pentachlorophenol	87-86-5		0.4	0.4	1	1	
Polycyclic aromatic hydrocarbons (PAH) [7, 3]	N.a.	X	N.a.	N.a.	N.a.	N.a.	
Benzo[a]pyrene	50-32-8	X	0.05	0.05	0.1	0.1	
Benzo[b]fluoranthene	205-99-2	X	∑ = 0.03	∑ = 0.03	N.a.	N.a.	
Benzo[k]fluoranthene	207-08-9	X					
Benzo[g,h,i]perylene	191-24-2	X	∑ = 0.002	∑ = 0.002	N.a.	N.a.	
Indeno[1,2,3-cd]pyrene	193-39-5	X					
Tetrachloroethylene	127-18-4		10	10			
Carbon tetrachloride	56-23-5		12	12			
Trichlorobenzenes [8]	12002-48-1		0.4	0.4	N.a.	N.a.	
Trichlorethylene	79-01-6		10	10			
Trichloromethane	67-66-3		2.5	2.5	N.a.	N.a.	

Continuation of table 8

Substance	CAS number	Priority haz-ardous sub-stance	AA-EQS in µg/l	AA-EQS in µg/l	MAC-EQS in µg/l	MAC-EQS in µg/l	Biota EQS in µg/kg wet weight
			Watercourses and lakes	Transitional and coastal waters	Watercourses and lakes	Transitional and coastal waters	Surface waters
Pesticides (Chapters 5.2.5 and 7.2.4)							
Alachlor	15972-60-8		0.3	0.3	0.7	0.7	
Atrazine	1912-24-9		0.6	0.6	2	2	
Chlorfenvinphos	470-90-6		0.1	0.1	0.3	0.3	
Chlorpyrifos (chlorpyrifos-ethyl)	2921-88-2		0.03	0.03	0.1	0.1	
DDT overall [9] (total DDT)	N.a.		0.025	0.025			
4,4-DDT	50-29-3		0.01	0.01			
Diuron	330-54-1		0.2	0.2	1.8	1.8	
Cyclodiene pesticides (total of aldrin, dieldrin, endrin, isodrin)	309-00-2 60-57-1 72-20-8 465-73-6-6		∑ = 0.01	∑ = 0.005			
Endosulfan [10]	115-29-7	X	0.005	0.0005	0.01	0.004	
Hexachloro-cyclohexane [11] (HCHs)	608-73-1	X	0.02	0.002	0.04	0.02	
Isoproturon	34123-59-6		0.3	0.3	1	1	
Simazine	122-34-9		1	1	4	4	
Tributyl tin compounds (tributyl tin cation) [3] (TBT)	36643-28-4	X	0.0002	0.0002	0.0015	0.0015	
Trifluralin	1582-09-8		0.03	0.03	N.a.	N.a.	

N. a.: Not applicable

1 For cadmium and cadmium compounds, the environmental quality standard depends on the water hardness, which is reflected in five class categories (class 1: <40 mg CaCO3/l, class 2: 40 to <50 mg CaCO3/l, class 3: 50 to <100 mg CaCO3/l, class 4: 100 to < 200 mg CaCO3/l and class 5: >= 200 mg CaCO3/l). The environmental quality standard of the hardness class derived from the 50 percentile of the water hardnesses calculated parallel to the cadmium concentrations is used to assess the annual average concentration of cadmium and cadmium compounds.

2 Environmental quality standard refer for the sum of congeners of numbers 28 (CAS no. 41318-75-6), 47 (CAS no. 5436-43-1), 99 (CAS no. 60348-60-9), 100 (CAS no. 68631-49-2), 153 (CAS no. 68631-49-2) and 154 (CAS no. 207122-15-4).

3 The total content may also be calculated from measurements of the materials in suspension content. The total content refer in this case to
1. sampling by centrifuge to total sampling;
2. sampling by box to a fraction < 63 µm.

4 As an alternative for the water phase 0.0004 µg/l

5 As an alternative for the water phase 0.003 µg/l

6 4-nonylphenol (branched); synonyms: 4-nonylphenol, branched, nonylphenol, technical mixture

7 In the group of polycyclic aromatic hydrocarbons (PAH), each individual quality standard is applicable, i.e. the environmental quality standard for benzo(a)pyrene, the environmental quality standard for the sum of Benzo(b)fluoranthene and benzo(k)fluoranthene and the environmental quality standard for the sum of benzo(g,h,i)perylene and indeno(1,2,3-cd) pyrene, must be met.

8 The environmental quality standard refer to the sum of 1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene and 1,3,5-trichlorobenzene.

9 Total DDT comprises to the sum of 1,1,1-trichloro-2,2-bis-(p-chlorphenyl)ethane (CAS no. 50-29-3; EU no. 200-024-3), 1,1,1-trichloro-2(o-chlorophenyl)-2-(p-chlorophenyl)ethane (CAS no. 789-02-6; EU no. 212-332-5), 1,1-dichloro-2,2-bis-(p-chlorophenyl)-ethylene (CAS no. 72-55-9; EU no. 200-784-6) and 1,1-dichloro-2,2-bis-(p-chlorophenyl)ethane (CAS no. 72-54-8; EU no. 200-783-0).

10 The environmental quality standard refer to the sum total of the two (stereo-)isomers alpha-endosulfan (CAS no. 959-98-8) and beta-endosulfan (CAS no. 33213-65-9).

11 The environmental quality standard refers to the sum of the isomers alpha-, beta-, gamma-, and delta-HCH.

12 Refer only Pentabrominated diphenyl ether (CAS no. 32554-81-9).

Source: Surface Waters Ordinance 2011

Table 9: Amendments and additions to the environmental quality standards Directive

Name of substance	CAS number	Priority hazardous substance	AA-EQS in µg/l	AA-EQS in µg/l	MAC-EQS in µg/l	MAC-EQS in µg/l	Biota EQS in µg/kg wet weight
			Watercourses and lakes	Transitional and coastal waters	Watercourses and lakes	Transitional and coastal waters	Surface waters
Heavy Metals (Chapters 5.2.3 and 7.2.3), soluble concentration in µg/l							
Lead (Pb) and lead compounds	7439-92-1		**1.2**	**1.3**	**14**	**14**	
Nickel (Ni) and nickel compounds	7440-02-0		**4**	**8.6**	**34**	**34**	
Mercury (Hg) and mercury compounds	7439-97-6	X			0.07	0.07	20
Industrial pollutants (Chapters 5.2.4 and 7.2.4)							
Anthracen	120-12-7	X	0.1	0.1	**0.1**	**0.1**	
Brominated diphenylether (BDEs)	32534-81-9	X			**0.14**	**0.014**	**0.0085**
Dioxins		**X**					**0.0065 µg/kg TEQ** [2]
Fluoranthene	206-44-0		**0.0063**	**0.0063**	**0.12**	**0.12**	**30**
HBCDD		**X**	**0.0016**	**0.0008**	**0.5**	**0.05**	**167**
Hexachlorobenzene (HCB)	118-74-1	X			0.05	0.05	10
Hexachlorobutadiene	87-68-3	X			0.6	0.6	55
Naphthalene	91-20-3		**2**	**2**	**130**	**130**	
PFOS	**1763-23-1**	**X**	**0.00065**	**0.00013**	**36**	**7.2**	**9.1**
Polycyclic aromatic hydrocarbons (PAH) [3]	N.a.	X	N.a.	N.a.	N.a.	N.a.	
Benzo(a)pyrene	50-32-8	X	**0.00017**	**0.00017**	**0.27**	**0.27**	**5**
Benzo(b)fluoranthene	205-99-2	X			**0.017**	**0.017**	
Benzo(k)fluoranthene	207-08-9	X			**0.017**	**0.017**	
Benzo(g,h,i)perylene	191-24-2	X			**0.00082**	**0.000082**	
Indeno(1,2,3-cd)pyrene	193-39-5	X			N.a.	N.a.	
Pesticides (Chapters 5.2.5 and 7.2.4)							
Aclonifen	**74070-46-5**		**0.12**	**0.012**	**0.12**	**0.012**	
Bifenox	**42576-02-3**		**0.012**	**0.0012**	**0.04**	**0.004**	
Cybutryne	**28159-98-0**		**0.0025**	**0.0025**	**0.016**	**0.016**	
Cypermethrin	**52315-07-8**		**0.00008**	**0.000008**	**0.0006**	**0.00006**	
Dichlorvos	**62-73-7**		**0.0006**	**0.00006**	**0.0007**	**0.00007**	
Dicofol	**115-32-2**	**X**	**0.0013**	**0.000032**	**N.a.**	**N.a.**	**33**
Heptachlor and heptachlor epoxide	**76-44-8/ 1024-57-3**		**0.0000002**	**0.00000001**	**0.0003**	**0.00003**	**0.0067**
Quinoxyfen	**124495-18-7**	**X**	**0.15**	**0.15**	**2.7**	**0.54**	
Terbutryn	**886-50-0**		**0.065**	**0.0065**	**0.34**	**0.034**	

N.a.: Not applicable
Grey: environmental quality standard to be deleted
Bold: Substance to be included in the daughter directive "Environmental Quality Standard", and/or environmental quality standard has changed
1) Unless otherwise stated, the biota environmental quality standard refers to fish fauna. An alternative biota taxonomy or another matrix may be monitored instead of this, provided the environmental quality standard used offers an equivalent level of protection. For fluoranthene and PAH, the biota environmental quality standard refers to crustaceans and molluscs.
2) PCDD: Polychlorinated dibenzo-p-dioxins; PCDF: polychlorinated dibenzofurans; PCB-DL: dioxin-like polychlorinated biphenyls; TEQ: toxicity equivalent according to the WHO toxicity equivalence factors of 2005.
3) In the group of polycyclic aromatic hydrocarbons (PAH), the biota environmental quality standard and the corresponding annual average environmental quality standard in water refers to the concentration of benzo(a)pyrene, on whose toxicity this is based. Benzo(a)pyrene is considered a marker for the other PAHs; as such, only benzo(a)pyrene is to be monitored for comparison with the biota environmental quality standard and the corresponding annual average environmental quality standard in water.

Source: Federal Environment Agency in accordance with Directive 2013/39/EU

4.3 Monitoring programmes

4.3.1 Monitoring networks

Article 8 of the EC Water Framework Directive obligates the European Union Member States to prepare programmes for monitoring the status of waterbodies in order to obtain a cohesive and comprehensive overview of the status of waterbodies in river basins. The fundamental requirements governing the monitoring of surface waters (rivers, lakes, transitional and coastal waters) are set out in Annex V to the EC Water Framework Directive. Key aspects here include the monitoring types and objectives, the choice of monitoring sites, the quality elements to be monitored, and the required monitoring frequencies (Annex V 1.3). LAWA drew up the "framework concept for the preparation of monitoring programmes and for evaluating the status of surface waters" (RAKON) to ensure the coherent structuring of monitoring programmes in Germany. The provisions of the EC Water Framework Directive and several provisions from this framework concept were incorporated into the 2011 Surface Waters Ordinance.

The EC Water Framework Directive monitoring network should be designed in such a way as to facilitate European-wide comparability of the analysis results and an overview of the ecological and chemical status of surface waters in the river basins. Essentially, the monitoring programmes pursue the following objectives:

- Reviewing compliance with environmental targets
- Creating the essential foundations for the planning of measures, reporting and monitoring the success of measures implemented
- Monitoring long-term natural and anthropogenic developments
- Determining the magnitude and impacts of unintentional contamination.

These objectives necessitate various forms of monitoring, which will differ in terms of the density of monitoring sites, the number of parameters to be analysed and the required measurement frequency, depending on their intended purpose. We distinguish between the following forms of monitoring:

- Surveillance monitoring
- Operational monitoring
- Investigative monitoring.

Surveillance monitoring is primarily intended to assess the overall status in each catchment area or sub-catchment area of a river basin. The results should serve to supplement and review the analysis of pressures and provide an insight into long-term changes in the natural and anthropogenic conditions in a river basin. The surveillance monitoring network may be wide-meshed (with a catchment area of up to 2,500 km² per monitoring site), but must be representative of the assigned hydrological unit and must be permanent. The selected monitoring sites are designed to provide an integrative view of the overall status of the assigned hydrological unit and enable researchers to gauge target achievement in the region. As well as an analysis of pressures, therefore, surveillance monitoring also provides the foundations for higher-resolution operational monitoring. The Länder have defined some 400 surveillance monitoring sites in surface waters. These monitoring sites are generally located in the larger rivers, in the estuaries of significant tributaries and in the larger lakes. Generally speaking, surveillance monitoring sites are required to monitor all quality elements specified in the EC Water Framework Directive.

Table 10: Overview of the number of monitoring sites for the various forms of monitoring and waterbody categories of surface waters in Germany

Monitoring type	Rivers	Lakes	Transitional waters	Coastal waters
Surveillance monitoring	290	67	5	32
Operational monitoring	7,252	449	20	100
Investigative monitoring	375	0	0	0

Source: Federal Environment Agency; data supplied by LAWA, data source: Reporting tool WasserBLicK/BfG, as of 22 January 2010

Operational monitoring evaluates the status of those waterbodies which might fall short of the EC Water Framework Directive's environmental objectives or into which priority substances or significant quantities of specific pollutants are discharged. Operational monitoring is also used to monitor the success of any measures implemented. As operational monitoring is based on pressures and becomes more close-knit as the pressures increase, depending on the waterbody status, the monitoring network may become less dense if the status improves. The Länder have defined a total of 7,855 monitoring sites in surface waters. This monitoring network is comparatively close-knit: On average, watercourses have a monitoring site every 20 kilometres, and there may be several monitoring sites in each waterbody. Whereas surveillance monitoring incorporates all quality elements, operational monitoring only requires the monitoring of those quality elements which react most sensitively to pressures in the body of surface water. Biological quality elements are the most frequently analysed.

Investigative monitoring becomes necessary if it is not known why a waterbody has failed to meet a target, or in order to determine the extent and impacts of unintentional contamination in the waterbody. This type of monitoring is fairly flexible. For example, it is also used in the event of incidents with unforeseen pollutant emissions or sudden fish mortality in waterbodies. For this reason, there are relatively few (375) of these types of monitoring sites in river basins.

4.3.2 Monitoring frequency

The effects of pressures on the existing organisms often only become apparent much later. For this reason, status is generally reviewed at least every 3 years. For macrozoobenthos, at least one sampling per year is sufficient, and for fish and aquatic plants one to two samplings per year. Due to its pronounced annual cycle, phytoplankton must be sampled at least 6 times per year. Monitoring frequencies are increased if considered necessary for a reliable and accurate statement on status (see **chapter 2.3**). The quality elements listed in **Table 5** should be monitored depending on requirements. A quality element in a given type may be exempt from assessment if it proves impossible to define reliable reference conditions due to the high degree of natural variability.

For specific pollutants that are emitted in significant quantities, sampling should be carried out at least every three months, and for pollutants relevant to chemical status at least once a month, unless higher frequencies are required for a reliable and precise assessment of status (see **chapter 2.3**). If the environmental quality standard is exceeded, the substances will remain in the monitoring programme.

5 Watercourses

5.1 Basis for assessment

5.1.1 Watercourse types

Our watercourses are distinguished by their characteristic biotic communities and their sensitivity to anthropogenic influences. For example, different aquatic biotic communities occur in the mountains than in the lowlands. The geological, morphological and hydrological characteristics of the watercourses are indicative of the differences. Based on these characteristics, we currently distinguish some 25 watercourse types (with further sub-types) in Germany (cf. **Table 11**):

- Four for the eco-region of the Alps and Alpine foothills
- Eight for the Central German Highlands (*Mittelgebirge*)
- Nine for the North German Lowlands and
- Four further watercourse types that are distributed among various ecoregions as “ecoregion-independent types”.

Among individual types, further sub-types have been designated that are relevant for assessment purposes, e.g. due to differences along their length. Descriptions of the watercourse types have been drawn up in the form of "profiles", including a brief characterisation of the morphological conditions and the biotic communities of the organism groups used for evaluation purposes (biological quality element).

Table 11: Biocoenotically relevant watercourse types in Germany

Types in the Alps and the Alpine foothills
Type 1: Alpine streams
• Sub-type 1.1: Small rivers of the Calcareous Alps
• Sub-type 1.2: Mid-sized rivers of the Calcareous Alps
Type 2: Streams in the Alpine foothills
• Sub-type 2.1: Small rivers in the Alpine foothills
• Sub-type 2.2: Mid-sized rivers in the Alpine foothills
Type 3: Streams in the Pleistocene sediments of the Alpine foothills
• Sub-type 3.1: Small rivers in the Pleistocene sediments of the Alpine foothillss
• Sub-type 3.2: Mid-sized rivers in the Pleistocene sediments of the Alpine foothills
Type 4: Large rivers in the Alpine foothills
Types from the Central German Highlands
Type 5: Coarse substrate-dominated, siliceous small highland rivers
Type 5.1: Fine substrate-dominated, siliceous small highland rivers
Type 6: Fine substrate-dominated, calcareous small highland rivers
• Sub-type 6_K: Fine substrate-dominated, calcareous small highland rivers in the Keuper
Type 7: Coarse substrate-dominated, calcareous small highland rivers
Type 9: Fine to coarse substrate-dominated, siliceous, mid-sized highland rivers
Type 9.1: Fine to coarse substrate-dominated, calcareous, mid-sized highland rivers
• Sub-type 9.1_K: Fine to coarse substrate-dominated, calcareous, mid-sized highland rivers in the Keuper
Type 9.2: Large highland rivers
Type 10: Gravel-dominated, very large rivers
Types in the North German lowlands
Type 14: Sand-dominated small lowland rivers
Type 15: Sand and loam-dominated mid-sized lowland rivers
Type 15_g: Sand and loam-dominated large lowland rivers
Type 16: Gravel-dominated small lowland rivers
Type 17: Gravel-dominated mid-sized lowland rivers
Type 18: Loess and loam-dominated small lowland rivers
Type 20: Sand-dominated very large rivers
Type 22: Marshland streams of the coastal plains
• Sub-type 22.1: Waters of the marshes
• Sub-type 22.2: Rivers of the marshes
• Sub-type 22.3: Very large rivers of the marshes
Type 23: Baltic Sea tributaries influenced by backflow or brackish waters
Ecoregion-independent types
Type 11: Organic substrate-dominated small rivers
Type 12: Organic substrate-dominated mid-sized rivers
Type 19: Small streams in riverine floodplains
Type 21: Lake outflows
• Sub-type 21_N: Lake outflows in the North German lowlands (north)
• Sub-type 21_S: Lake outflows in the Alpine foothills (south)

Source: Federal Environment Agency in accordance with the Surface Waters Ordinance

5.1.2 Biological quality elements

The biological quality elements used for assessment include invertebrates, fish fauna, macrophytes and phytobenthos, which are combined into one quality element, and phytoplankton. The most important parameters identified to describe the status of groups of organisms are the composition of the biotic community with regard to the species occurring and the frequency of individual species, plus additionally in the case of fish fauna the age structure of the population, and in the case of phytoplankton the biomass of the algae. This biologically-oriented assessment procedure under the Water Framework Directive comprises a broad spectrum of different pressures such as organic saprobic contamination or structural depletion. **Table 12** contains brief descriptions of the techniques used in Germany to evaluate biological quality elements in watercourses and the indicated pressures.

Intercalibration results

The Water Framework Directive stipulates that the results of national assessment methods should be compared and harmonised with one another by way of an intercalibration process. This is designed to ensure comparability between the assessment yardsticks used by individual Member States. Almost all techniques used in Germany for the ecological assessment of watercourses have been successfully intercalibrated. **Table 13** provides an overview of the results following completion of the first (2005-2007) and second (2008-2011) intercalibration phases. The results referring to international intercalibration types have been assigned to German watercourse types.

5.1.3 Hydromorphological quality elements

The hydromorphological quality elements listed in Annex V to the Water Framework Directive, such as continuity, hydrological regime and morphology, support the classification of waterbodies into an ecological status by defining normative reference conditions for

Table 12: Biological quality elements for assessing the ecological status of watercourses and brief description of the assessment method

Biological quality element	Brief description of the assessment method	Indicated pressures	Reference literature
Aquatic flora			
Phytoplankton* (algae species and cyanobacteria suspended freely in the water)	**PHYTOFLUSS** Parameter: Species composition, biomass; (algae biomass, relative proportion of selected algae groups and type-specific index value for potamoplankton (TIP index))	Eutrophication	Mischke, U. & H. Behrendt (2007)
Macrophytes (aquatic plant visible to the naked eye) and phytobenthos (algae species growing on substrate)	**PHYLIB** Parameter: Species composition, species frequency; (reference species, disturbance indicators, acidification indicators, trophic, saprobic and halobic index)	Eutropication, structural degradation, acidification (especially phytobenthos), salification (especially phytobenthos)	Schaumburg et al. (2006)
Aquatic fauna			
Macrozoobenthos (invertebrates, visible to the naked eye, that live in or on the waterbed)	**PERLODES** Parameter: Species composition, species frequency, disturbance-sensitive species, diversity; (multimetric assessment method with the following modules: "Saprobic condition" (saprobic index), "general degradation" (stream type-specific multimetric index), "acidification" (acidification index)	General and structural degradation, pressures on the oxygen balance, acidification, accumulation of iron hydroxide	Meier, C., P. Haase, P. Rolauffs, K. Schindehütte, F. Schöll, A. Sundermann & D. Hering (2006)
Fish	**FiBS** Parameter: Species composition, species frequency, age structure; multimetric assessment method	General and structural degradation, lack of passability	Verband Deutscher Fischereiverwaltungsbeamter und Fischereiwissenschaftler e.V (2009)

* Only assessed in watercourses rich in plankton

Source: Federal Environment Agency

Table 13: Ecological quality quotients of intercalibrated national assessment methods

Intercalibrated assessment method (biological quality element or sub-element in brackets)	Intercalibrated national waterbody type	Ecological quality quotients	
		Limit high / good status	Limit good / moderate status
FiBS – (fish fauna)	1-3, 5-9, 11-19	1.086	0.592
PERLODES – (macrozoobenthos)	2, 3, 5, 5.1, 14, 15	0.80	0.60
PHYLIB – (macrophytes and phytobenthos - macrophytes module)	14	0.745	0.495
	5, 5.1	0.80	0.55
	15, 17	0.575	0.395
PHYLIB – (macrophytes and phytobenthos - diatom module)	1	0.735	0.540
	5, 5.1, 14	0.67	0.43
	15, 17 (D 12.2)*	0.61	0.43
	15,17 (D 13.1)**	0.73	0.55
	10, 20	0.725	0.545

*= Watercourses of diatom type D 12.2 (=calcareous or alkaline-rich, organic substrate-dominated small and mid-sized rivers of the north German lowlands with catchment area < 1,000km)
**= Watercourses of diatom type D 13.1 (=calcareous or alkaline-rich, organic substrate-dominated large rivers of the north German lowlands)

Source: Federal Environment Agency in accordance with Resolution 2013/480/EU

what constitutes a high status. In all other classes, the hydromorphological quality elements are classified via biology.

Additionally, in Germany, the status of a waterbody's morphological structure is determined using an established assessment method developed in Germany ahead of the Water Framework Directive's entry into force. A mapping technique is used to ascertain the degree of deviation of the current morphological structure from its potential natural form. The potential natural state corresponds to the status which would arise while retaining irreversible changes (e.g. silting up of lakes, formation of alluvial loam due to deforestation in the river basin) if artificial structures were removed, water body maintenance and usage were discontinued, and the rivers were able to develop their own natural dynamics. This potential natural status corresponds to the hydromorphological reference conditions used as a "yardstick" for gauging the status of the quality element "morphology".

The measured deviation from the potential natural state is assigned to a structural category based on a 7-point scale. Waterbodies which indicate no or only slight changes to their natural structure and dynamics are classified as structural category 1. At the other end of the scale, water bodies in structural category 7 are considered to have been completely altered (**Table 14**).

Table 14: Structural classes of waterbodies

Class	Degree of change	Brief description
1	unchanged	The water body structure corresponds to the potential natural state
2	slightly changed	The water body structure is influenced only minimally by isolated, small-scale interventions.
3	moderately changed	The water body structure is influenced only moderately by several small-scale interventions.
4	distinctly changed	The water body structure is significantly influenced by various interventions e.g. in the bed, bank, by backflow and/or uses in the flood plain
5	obviously changed	The water body structure is impaired by a combination of interventions e.g. into its routing, as a result of bank obstruction, transverse structures, dam regulation, flood alleviation installations and/or use in the flood plain.
6	strongly changed	The water body structure is heavily impaired by a combination of interventions e.g. into its routing, as a result of bank obstruction, transverse structures, dam regulation, flood alleviation installations and/or use in the flood plain.
7	completely changed	The water body structure has been completely transformed as a result of various interventions into its routing, bank obstruction, transverse structures, dam regulation, flood alleviation installations and/or use in the flood plain.

Source: LAWA

On small to medium-sized watercourses, the morphological structure is assessed using either the "overview method" or the "on-site method", whereby both methods are currently being revised and will be merged in future. Whereas the overview procedure assessment is based primarily on aerial pictures and thematic maps, the on-site method, is based on collecting data from the site. Both methods are based on the recording of certain parameters. These parameters represent those structural elements of a watercourse with particular relevance to assessment and which have certain indicator properties that characterise the water body's ecological functional capacity. For example, most lowland waterbodies develop a meandering course which entails cutting off meanders and oxbows. The structural quality of a lowland river can therefore be described in terms of how much its course meanders. If this is inadequately developed or has been altered by means of straightening measures, the assessment will be poorer. Individual assessments are aggregated at various functional levels and ultimately combined to form a structural class.

For reporting under the Water Framework Directive, with effect from the second management cycle, a set of 18 individual morphological parameters (**Table 15**) is used to mathematically calculate the assessment of the hydromorphological quality element "morphology". It is calculated as an average for all watercourse sections in a given waterbody. The individual parameter results obtained in this way for a given waterbody are combined into one overall index, likewise derived from the average of all 18 index figures. Assessment uses a 5-point classification based on an equidistant transformation of the 7-point structural quality method into 5 categories: The results of classification for

Table 15: Individual parameters and aggregation levels under the on-site procedure for small and medium-sized watercourses. Individual parameters highlighted in bold are used for reporting under the Water Framework Directive.

Area	Main parameter	Functional unit	Individual parameter
riverbed	Course development	Meandering	**Meandering**
			longitudinal banks
			special run structures
		Mobility	**Meandering erosion**
			profile depth
			bank obstruction
	Longitudinal profile	Natural longitudinal profile elements	**Transverse banks**
			flow diversity
			depth variance
		Anthropogenic barriers	Transverse structures
			piping
			openings
			backflow
	Bed structure	Nature and distribution of substrate	Substrate type
			substrate diversity
			specialised structures
		Bed obstruction	Bed obstruction
Bank	Cross-section	Profile depth	**Profile depth**
		Width development	**Width erosion**
			width variance
		Profile shape	Profile shape
	Bank structure	Typical features of the natural area	**Special bank structures**
		Plant growth typical of the natural area	**Bank growth**
		Bank obstruction	**Bank obstruction**
Land	Surrounding area	Riparian buffer strips	**Riparian buffer strips**
		Foothills	Land use, other surrounding structures

Source: LAWA

the quality element "morphology" were compared with the respective ecological status categories using sample data records from waterbodies in the various Länder. It emerged that in around 80 % of cases, the classification of morphology and ecological status on the 5-point scale was comparable.

5.1.4 General physico-chemical quality elements

Annex V of the Water Framework Directive lists visibility, temperature, oxygen, conductivity, acidification and nutrient conditions as general physico-chemical quality elements for watercourses. In a "high status", the defined type-specific background levels of the general physico-chemical quality components must be adhered to. In a "good status", the values must be within a range which guarantees correct functioning of the type-specific ecosystem and type-specific population with at least a good biological quality classification ("threshold values"), otherwise the ecological status is no more than "moderate"; classification must not contradict the biological assessment (cf. **Chapter 4.2.1**). These quality elements have no bearing on classification into the inferior status classes "poor" and "bad". The type-specific threshold values (good status/ good ecological potential) for temperature are included in the Surface Waters Ordinance.

5.1.5 Other assessment methods

As well as the legally binding environmental quality standard of the Surface Waters Ordinance, the 7-point chemical water quality classification provides an important basis for assessing the pollution of inland surface waters in Germany. The water quality classification was developed by the Federal Government and Länder in Germany prior to the Water Framework Directive's entry into force. As long as there are no binding values for classification of a good ecological status (e.g. for nutrients), Germany will continue to use the holistic chemical water quality classification, which also takes into account remote effects in the oceans (this extends to reporting under the EU Nitrates Directive). The substance concentrations corresponding to quality class I characterise a status that is free from anthropogenic impairments. For nutrients, quality class II contains values derived from previous assessment procedures.

Table 16: Chemical quality classification for nutrients (comparison value: 90 percentile)

Quality class	Total P in mg/l	NO_3-N in mg/l	NH_4-N in mg/l	Total N in mg/l
I	≤ 0.05	≤ 1.0	≤ 0.04	≤ 1.0
I-II	≤ 0.08	≤ 1.5	≤ 0.10	≤ 1.5
II	≤ 0.15	≤ 2.5	≤ 0.30	≤ 3.0
II-III	≤ 0.30	≤ 5.0	≤ 0.60	≤ 6.0
III	≤ 0.60	≤ 10	≤ 1.20	≤ 12
III-IV	≤ 1.20	≤ 20	≤ 2.40	≤ 24
IV	> 1.20	> 20	> 2.40	> 24

Source: LAWA

5.1.6 Network of monitoring points for reporting

The LAWA network of monitoring points has been set up in Germany for the purposes of reporting on European Directives and reporting to the European Environment Agency. In 2008, the LAWA network of monitoring points for "watercourses" was extended to include monitoring points in the surveillance monitoring network, and currently comprises some 257 representative monitoring points, primarily surveillance monitoring points but also monitoring points in the operative monitoring network, monitoring points for investigative purposes, and reference monitoring points on watercourses, transitional waters and one river-lake (cf. also **chapter 4.3.1**). The data from these monitoring points provides the basis for the assessments in **chapters 5.2.2-5.2.6** and **5.2.8**.

5.2 Status monitoring

5.2.1 Hydromorphology

The structure and dynamics of rivers are determined by the climatic and geological conditions and by the relief of the catchment area. The temporal and spatial sequence of flooding and drought, of erosion, transportation and sedimentation and a mobile riverbed, which may develop across the entire width of the valley, create close links between the river and floodplain, forming a continuum that ranges from the source to the mouth. The quality and proper functioning of this complex system is expressed in the hydromorphological quality of the water body.

Figure 19: Watercourses in the alpine upper reaches (left) and in the lowland lower reaches (right)

Source: Federal Environment Agency

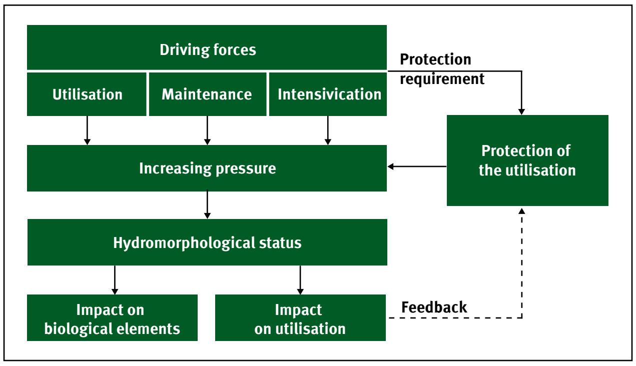
The interactions between gradient, transport processes, soils and bedrock, together with discharge dynamics, leads to the creation of typical large-scale structures such as meander zones in the lowlands. These macro-structures are characterised by a mosaic of typical surface forms such as gravel banks and sandbanks, pools, steep slopes, bayous and side arms, flood channels etc. which are subject to a high level of dynamic. The diversity of current conditions, including extreme water levels, and the morphological structures of the river bed and riparian zones are a pre-requisite for the occurrence of site-typical flora and fauna communities which are linked to one another via complex food webs and flow of matter. Under natural conditions, rivers and their flood plains are therefore ecosystems with the greatest richness of species in Central Europe. They are known as “hotspots” of biodiversity.

Developing waterbodies for certain uses, and structuring them to allow more effective and reliable usage, i.e. as independent as possible from natural processes, opposes the dynamics in the river and floodplain landscapes. Interventions into watercourses designed to facilitate human use are essentially aimed at the following, consistently similar purposes:

- To compensate for natural fluctuations in water flow, both at minimum and maximum levels
- To make a defined volume of water or a defined water level available, largely independently of natural discharge fluctuations
- To remove land from the river, to limit the course of the river to a defined riverbed, to stabilise and fix the riverbed, and
- To regulate the groundwater level in adjacent areas.

Key uses of our water bodies involving intervention include urbanisation, navigation, the use of hydropower, agriculture and forestry, water supply, and the use of waterbodies for leisure and relaxation. The need to protect human settlements, uses and investments, particularly flood alleviation measures, entails further pressures on the riverine landscape. The constant intensification of uses also leads to escalating pressure. Alleviating the adverse consequences of hydraulic engineering measures on existing use, for example, entails measures designed to prevent deep erosion, which was often triggered in the first place by usage-related intervention into the waterbody. Our past failure to significantly reduce the hydromorphological pressures on waterbodies is also partly due to preservation of the developed state via on-going maintenance and repair of anthropogenic structures.

Figure 20: Uses and hydromorphological pressures as factors influencing the status of surface waters



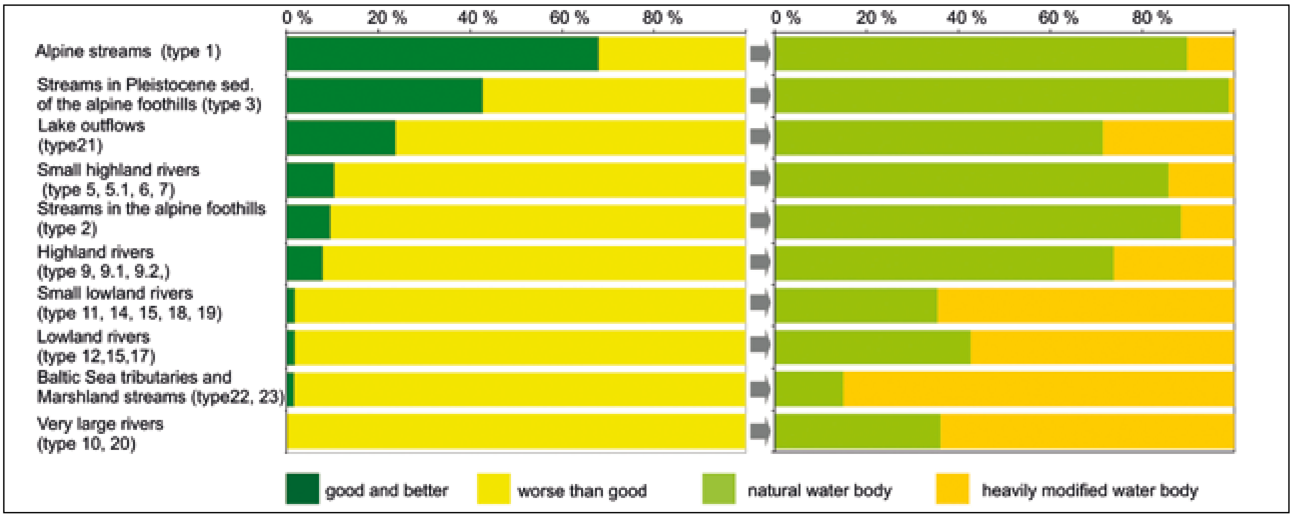
Source: Federal Environment Agency

Hydromorphological pressures are the consequence of human activities in the catchment area of a water body and the result of measures and intervention on and in the water body itself in order to facilitate or maintain uses. In highly developed countries, these non-material pressures have a significant influence on the waterbody status. They not only alter the appearance of the landscape, but often also remove the habitats of aquatic organisms and therefore threaten their survival.

Assessment of the quality element "hydromorphology"

Given the diverse correlations between abiotic and biotic environmental factors, the impairment of a water body's hydromorphological function influences the existence and composition of site-typical biotic communities, and hence the ecological status of a body of surface water. The hydromorphological quality element, comprised of hydrological regime, river continuity and morphology, must be in a condition which allows the water body to be populated in a manner typical of the natural area. In Germany, at present only 10 % of watercourses show a “high” or “good ecological status" (cf. Chapter 5.2.7). This low level is primarily attributable to hydromorphological degradation. At present, only 8 % of the watercourse sections analysed in Germany indicated a hydromorphological status of good or above (structural mapping of waterbodies). As a general rule, the hydromorphological

Figure 21: Left-hand diagram: Assessment of the hydromorphological status of various watercourse types (excluding artificial waterbodies); right-hand diagram: Classification into natural and heavily modified waterbodies (reference: proportion of watercourse length)



Source: Federal Environment Agency; data supplied by LAWA, data source: Reporting tool WasserBLicK/BfG, as of 22 March 2010

quality of watercourses in the small rivers of the Alps and the central highlands is better than in the lowlands and in large rivers.

As a result of usage intensity and associated hydromorphological impairments, 33 % of the watercourse length of former natural watercourses in Germany has now been designated as “heavily modified” (HMWB). This primarily affects waterbodies in the lowlands, the impounded Baltic Sea inlets, the marsh waters and large rivers.

Figure 22: Proportions of natural (NWB), heavily modified (HMWB) and artificial waterbodies (AWB) among watercourse sections in Germany

Source: Federal Environment Agency; data supplied by LAWA, data source: Reporting tool WasserBLicK/BfG, as of 22 March 2010

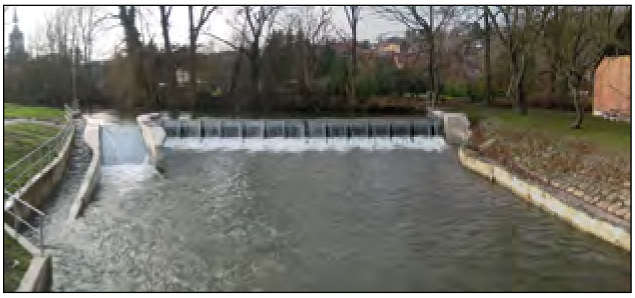
Quality element "Hydrology"

The natural discharge regime in our watercourses is influenced in a multitude of different ways by water abstractions and diversion, water storage, rain elutriation and river engineering measures such as straightening and damming. The resultant changes in the discharge height and dynamic in turn lead to changes and impairments to the hydromorphological status of a watercourse. This occurs, firstly, by dampening the discharge level by capping flood peaks at average flood events, raising the low-water discharge in dry periods, or by channelling off and abstracting in certain sections of river. Secondly, rapid precipitation discharge from the land due to land sealing and drainage in conjunction with damming, straightening and the removal of retention space leads to an acceleration of flood waves and also increases discharge peaks. An independent, uniform nationwide assessment of the quality element hydrology is not possible at the present time.

Quality element "Continuity"

A watercourse that has been left in its natural state is generally freely passable to migrating aquatic organisms in an upstream and downstream direction, but also perpendicular to the flow into the adjacent floodplains, and solid and dissolved matter is transported unhindered following the gradient. This is known as river continuity. The continuity of watercourses is interrupted by numerous technical structures.

Figure 23: Transverse structure on the Ilm with modern hydropower plant allowing water to flow over and under it, and technical fish pass.

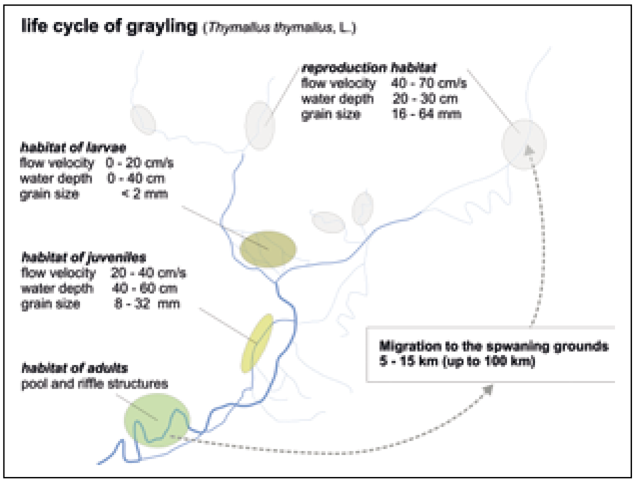


Source: Federal Environment Agency

These transverse structures are used for drinking water abstraction, irrigation, hydropower use, shipping, bank support or the creation of artificial reservoirs for recreational purposes. There are currently thought to be some 200,000 transverse structures in Germany. In relation to the overall length of Germany's network of watercourses of around 400,000 km, therefore, the continuity of the rivers is interrupted every second kilometre by a technical structure. Overall, the installation of transverse structures in a waterbody has significant consequences for biological and morphodynamic continuity.

Over the course of evolution, many fish species have developed a migration pattern that allows them to make optimum use of different habitats. For example, reproduction places provide different requirements on environmental factors such as flow, temperature and substrate than feeding, maturation or winter dormancy. For this reason, native species migrate within connected water systems to find the optimum conditions for their current life phase (**Figure 24**). These species are dependent on the continuity of their river and its links to all required sub-habitats. For this reason, the fragmentation of watercourses is reflected primarily in an assessment of the status of fish fauna. At present, only 37 % of the watercourse sections analysed indicated a species composition, frequency and age class distribution that could be described as "good". Within the context of the German Länder Initiative on Core Indicators (LIKI), continuity is regularly evaluated by the Länder according to the fish passability indicator. The indicator is defined as the proportion of transverse structures that are passable to fish versus the total number of transverse structures in water bodies > 100 km². At present, nationwide (excluding Bavaria), around 45 % of transverse structures in the migration routes of potamodromous and diadromous fish species are passable in an upstream direction. In these particularly significant water bodies, the aim should be to ensure the passability of all transverse structures for fish wherever possible.

Figure 24: Habitats in the lifecycle of the grayling (*Thymallus thymallus L.*)



Source: Federal Environment Agency

Figure 25: Gravel bank in an alpine water body

Source: Federal Environment Agency

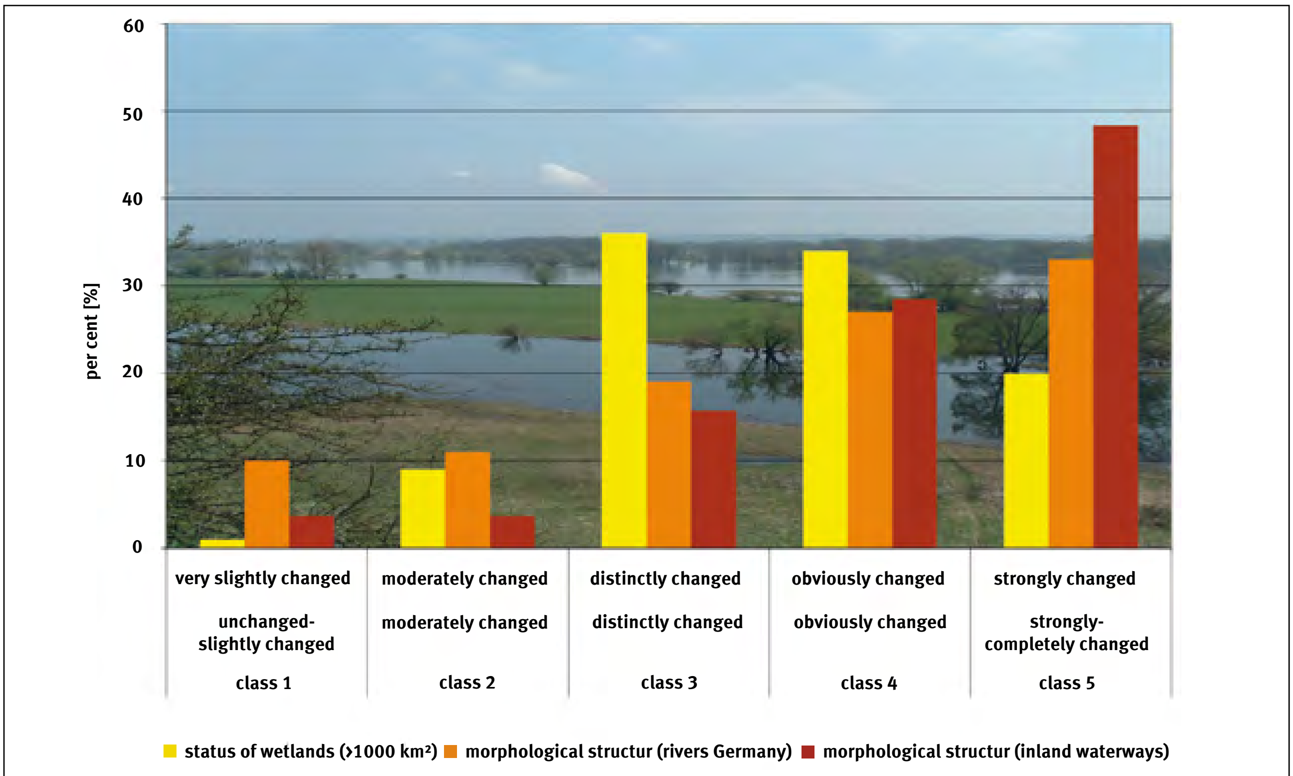
The transportation of sediments is impaired by a lack of morphodynamic continuity. The sediment content of a watercourse is characterised by the type and quantity of the material transported, together with the interactions between erosion, transportation and sedimentation. It is closely related to the natural conditions in the catchment area of a watercourse.

Hydrological changes, interruptions to the river continuum and alteration of the morphological conditions influence the sediment regime. The erosion, relocation and depositing of bed materials is then no longer balanced, and the transportation of sediment loses its natural dynamic. Sediment retention in reservoirs and the prevention of side erosion by hydraulic engineering measures to reinforce watercourses leads to a lack of coarser material in the lower reaches. As a result, valuable habitats are lost. The river is only able to compensate for this deficit of sediments by gathering material from the bottom, causing it to "dig into" the landscape more extensively along certain sections. As a result of such erosion, for example, the Rhine has become up to 7 m deeper, the Isar up to 8 m, and the Elbe up to 1.7 m deeper. The trend towards further deepening is continuing. The majority of rivers in Germany are thought to exhibit unnaturally high levels of erosion. This process is often masked and displaced downstream by the retrospective installation of transverse structures to reinforce the river bed. As a result, the river breaks its banks less frequently, and the groundwater level in the adjacent floodplain falls. The naturally linked ecosystems of the river and floodplains become disconnected.

Quality element "morphology"

Influences on the hydrological regime and morphodynamic continuity of watercourses, in addition to direct river engineering intervention, also have a decisive effect on the characteristics of the river morphology (i.e. structure). Watercourse structure refers collectively to all spatial and material differentiations in the riverbed, riparian area and surrounding land which affect hydraulics, morphology and hydrobiology and which are significant to the ecological functioning of the river and its floodplain. The structure of the riverbed and its riparian environment is also directly modified by various hydraulic engineering intervention measures such as dyke construction, straightening, damming or embankment.

Figure 26: Distribution of floodplain status assessments (rivers with a catchment area > 1,000 km²), the structural quality of watercourses (33,000 km as at 2001), and the structural quality of Federal waterways

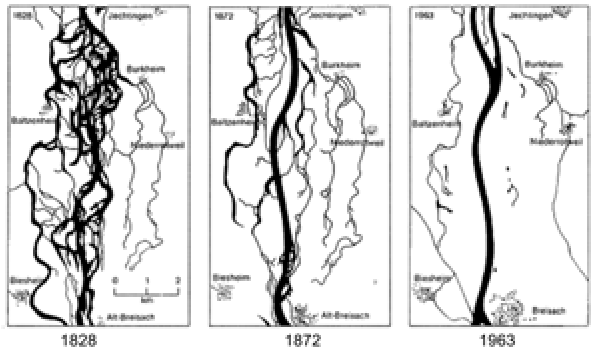


Source: Compiled by the Federal Environment Agency using figures supplied by LAWA and the BfN

The 7-stage watercourse structure map first published in December 2002 provides an overview of the morphological status of rivers and streams in Germany (cf. also **chapter 5.1.3**). Acording to this, of the mapped watercourse sections (approximately 33,000 km), 21 % are classified as "moderately changed" to "unchanged" (quality class 3 and above), while 33 % are classified as "strongly changed" or "completely changed" (quality class 6 and 7) (cf. **Figure 26**). The Länder have since extended the watercourse structure map to cover the Water Framework Directive reporting network, and assessed a far greater number of watercourse sections. The results of this assessment are published on a regular basis as the LIKI indicator "Structure of watercourses". This suggests that, on average, Germany's natural watercourses are classified as "strongly changed" (class rating 4.35), and its heavily modified watercourses as "very strongly changed" (average of structural class 5.39) (figures exclude Bavaria).

As a general rule, most large rivers have been technically modified with weirs and locks for the benefit of navigation and hydropower use. Furthermore, large parts of their flood plains have been separated off from the river and restricted by dykes. This explains their considerable structural deficits and predominant allocation to the classes "strongly changed" to "completely changed", and underscores the particular significance of semi-natural sections on large rivers, as in the free-flowing Danube below the Isar estuary. Installations and interventions aimed at flood alleviation may exert significant pressures on hydromorphology. There is evidence dating back to the Middle Ages of dyke structures on the Rhine and Elbe and of cuts of meanders, but these often did not last long against the power of the water. Today nearly all sections of the major rivers have dykes. The building of dykes resulted in the loss of floodplains as retention spaces for flood water. For example, the development of the Upper Rhine resulted in a river bed up to 12 km wide giving way to a channel between 200 and 250 m in width; the Rhine floodplains between Basel and Karlsruhe decreased by 87 %. Overall, the natural floodplain area of the Upper Rhine was reduced by 60 % or 130 km², which in turn necessitated considerable expenditure to counteract the increased risk of flooding in downstream areas.

Figure 27: Loss of structural diversity and retention space as a result of development measures, as illustrated by the Upper Rhine near Breisach: In 1828 before regulation, in 1872 after correction by Tulla, and in 1963 after further canalisation.



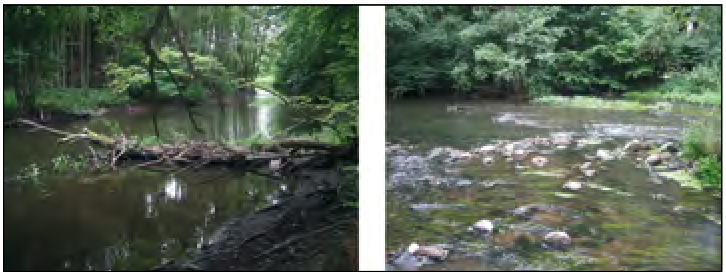
Source: IKSR (International Commission for the Protection of the Rhine).

All major rivers in Germany are in a similar situation, as verified by the BfN's report on floodplain status. Consequently, only 10-20 % of the former floodplains on major rivers are now available to retain flooding. Only 10 % of the floodplains analysed in river basins > 1,000 km² can be described as slightly or moderately changed (cf. **Figure 26**). Most of the rivers covered by floodplain mapping are Federal waterways. The usage pressure on the major rivers is also reflected in their structural quality. Over 90 % of Federal watersways have had their natural structure "distinctly" to "completely changed" (structure classes 4-7, cf. **Figure 26**).

Most of the smaller rivers and streams in the Central German Highlands (Mittelgebirge), downs and lowlands have been modified in the past to accommodate hydropower, to protect settlements or transport routes, or for agricultural use. They are regularly maintained, which prevents morphodynamic processes. For the vast majority of these rivers and streams, the morphological status has been distinctly to completely changed.

Unchanged to moderately changed sections of streams and rivers can still be found in the Alps and pre-Alpine regions, in the granite and gneiss landscapes of the Bavarian Forest, in the upper reaches of the Central German Uplands, in the heathland landscapes of the North German lowlands and in the landscapes of Mecklenburg-Western Pomerania that were shaped by the ice age. In these areas, river engineering measures and the melioration of the surrounding land is largely absent.

Figure 28: Woody debris (left) and bed material from the terminal and ground moraine (right) as key structural elements in the lowland rivers (example: Warnow).



Source: Federal Environment Agency

5.2.2 Nutrients

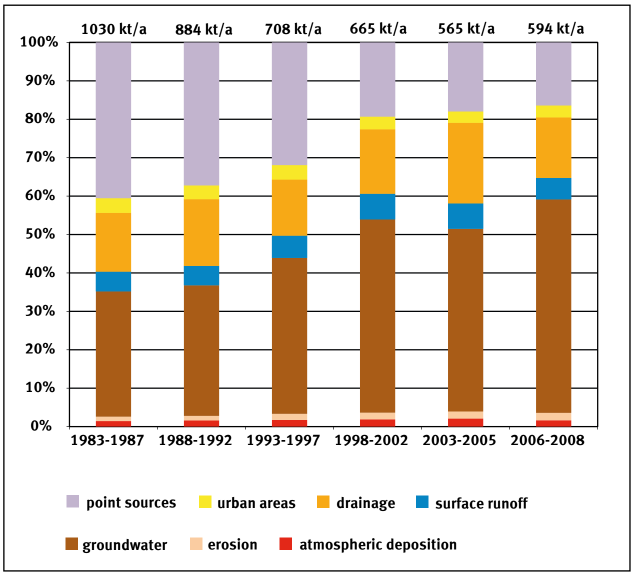
Total phosphorus and nitrogen inputs into Germany's watercourses have been substantially reduced thanks to the introduction of phosphate-free detergents, the closure of production facilities in the new Länder, the construction and modernisation of municipal and industrial wastewater treatment plants (construction of phosphate precipitation plants), and the greater number of households connected to wastewater treatment facilities. Today, agriculture is the principal source of nutrient loads in waterbodies, together with municipal wastewater treatment plants, power plants, transport and industrial operations.

In 2006-2008, nitrogen inputs into Germany's surface waters totalled 593,800 t/a, a decrease of 436,000 t/a (42 %) against the comparison year 1983-1987 (cf. **Figure 29**). The 42 % reduction achieved between 1983-1987 and 2006-2008 was primarily due to the significant decrease in nitrogen inputs from point sources (municipal wastewater treatment plants and direct industrial dischargers) (77 %). As a result, the proportion of point sources among total inputs was reduced to 16 % in 2006-2008, primarily thanks to improvements in the purification performance of wastewater treatment plants. By contrast, the decrease in nitrogen inputs from diffuse sources was only 23 %. Inputs via the groundwater were the overall dominant pathway for Germany in 2006-2008, accounting for a share of 56 %. Nitrogen inputs from agriculture account for around 80 % of total nitrogen inputs.

Phosphorus inputs into Germany's surface waters totalled around 26,000 t/a in 2006-2008 (**Figure 30**). Phosphorus inputs were significantly reduced by around 55,000 t/a (68 %) against the comparison year 1983-1987. The reduction in phosphorus inputs is likewise primarily attributable to the reduction in inputs from point sources (86 %). Despite this significant reduction in inputs from point sources, they were still the dominant pathway in 2006-2008, accounting for 30 % of total inputs. Overall, diffuse phosphorus inputs were only reduced by 32 %, primarily thanks to the reduction in inputs from urban land (combined sewer overflows and separate sewer systems, residents not connected to a municipal wastewater treatment plant or sewer system (67 %). Among diffuse sources of phosphorus, inputs via the groundwater account for 23 % of total inputs, followed by inputs via erosion at 22 %. Phosphorus inputs from agriculture account for around 60 % of total phosphorus inputs.

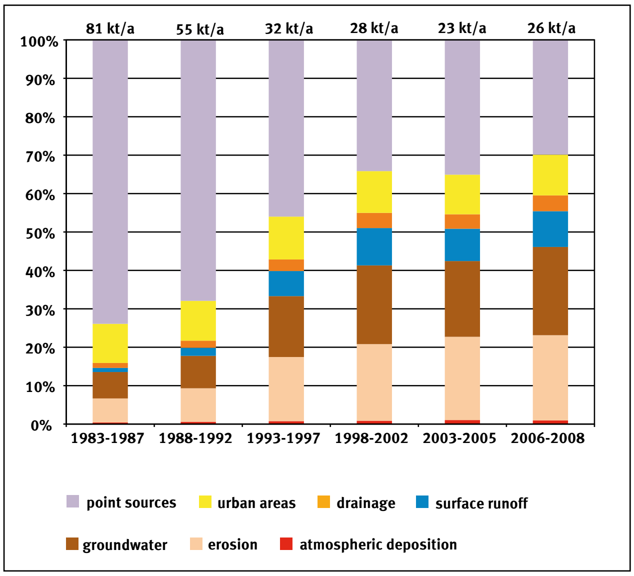
The reduction in inputs is reflected in decreased concentration levels, as illustrated by a comparison of mean 90-percentile values for the periods 1991-2000

Figure 29: Nitrogen inputs from point and diffuse sources into Germany's surface waters



Source: Federal Environment Agency (MoRE), as at: June 2013

Figure 30: Phosphorus inputs from point and diffuse sources into Germany's surface waters

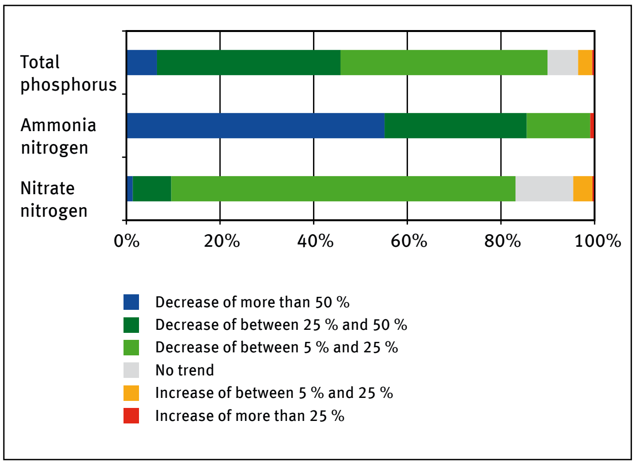


Source: Federal Environment Agency (MoRE), as at: June 2013 and 2001-2010 at LAWA monitoring points for which data is available (around 200 monitoring points, cf. **Figure 31**). This comparison reveals that

- For total phosphorus, concentration levels decreased at 91 % of monitoring points, showed no trend at 5 %, and increased at 4 %.
- For ammonia nitrogen, concentration levels decreased at 98 % of monitoring points and showed no trend or an increase at 1 % respectively
- For nitrate nitrogen, concentration levels decreased at 86 % of monitoring points, showed no trend at 9 %, and increased at 5 %.

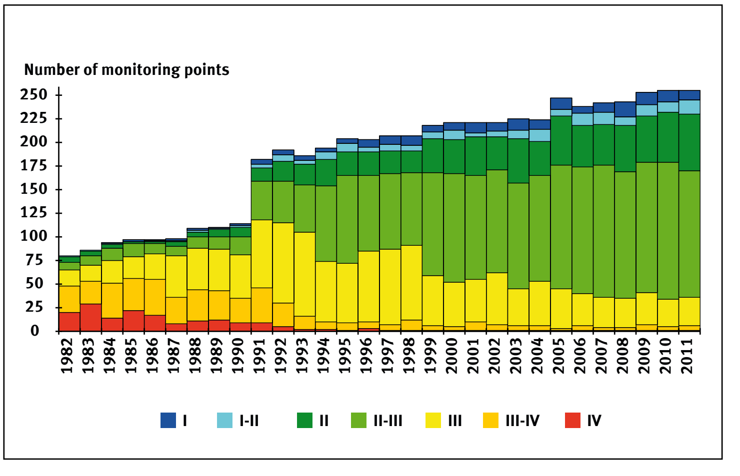
The development of total phosphorus and nitrogen concentrations at these LAWA monitoring points is shown in **Figures 32-34**. While the decrease in concentration levels began in the early 1990s for total phosphorus and ammonia nitrogen, for nitrate nitrogen a decrease did not become apparent until the mid-1990s, and was not as pronounced as for total phosphorus and ammonia nitrogen. However, phosphorus and nitrogen concentrations are still too high. For nitrate, in addition to the "target value" of 2.5 mg N/l, there is also an action value of 50 mg NO_3/l (see **chapter 4.2.3**, corresponds to 11.3 mg/l nitrate nitrogen). Although the action value was met by all LAWA monitoring points in 2011, only 15 % of them (257 points) reported nitrate nitrogen concentration levels below the target value.

Figure 31: Change in concentration levels of total phosphorus, ammonia nitrogen and nitrate nitrogen, 2001 – 2010 versus 1991–2000 (basis: LAWA network of monitoring points; mean 90-percentile for the years)



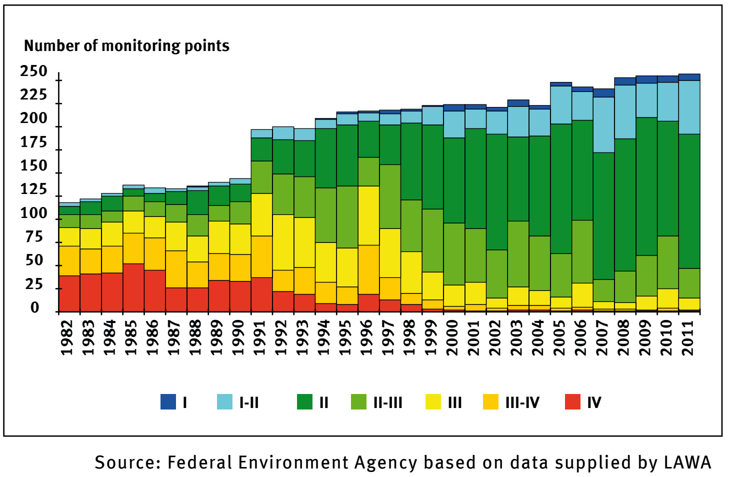
Source: Federal Environment Agency based on data supplied by LAWA

Figure 32: Quality classification for total phosphorus, 1982-2011 (LAWA monitoring points)



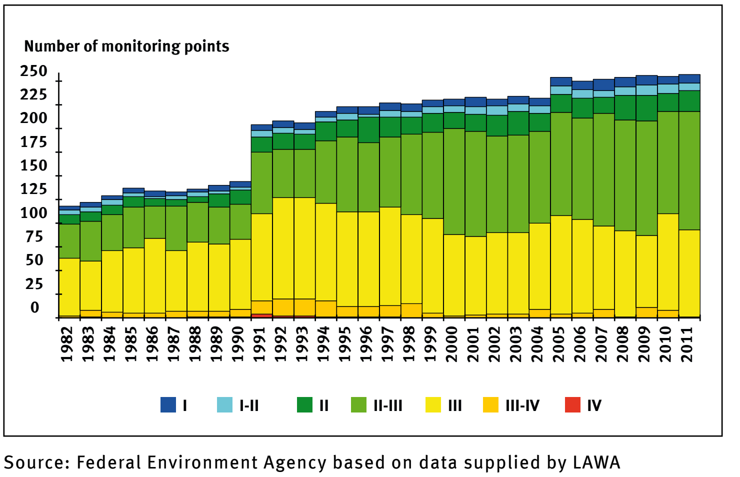
Source: Federal Environment Agency based on data supplied by LAWA

Figure 33: Quality classification for ammonia nitrogen, 1982-2011 (LAWA monitoring points)



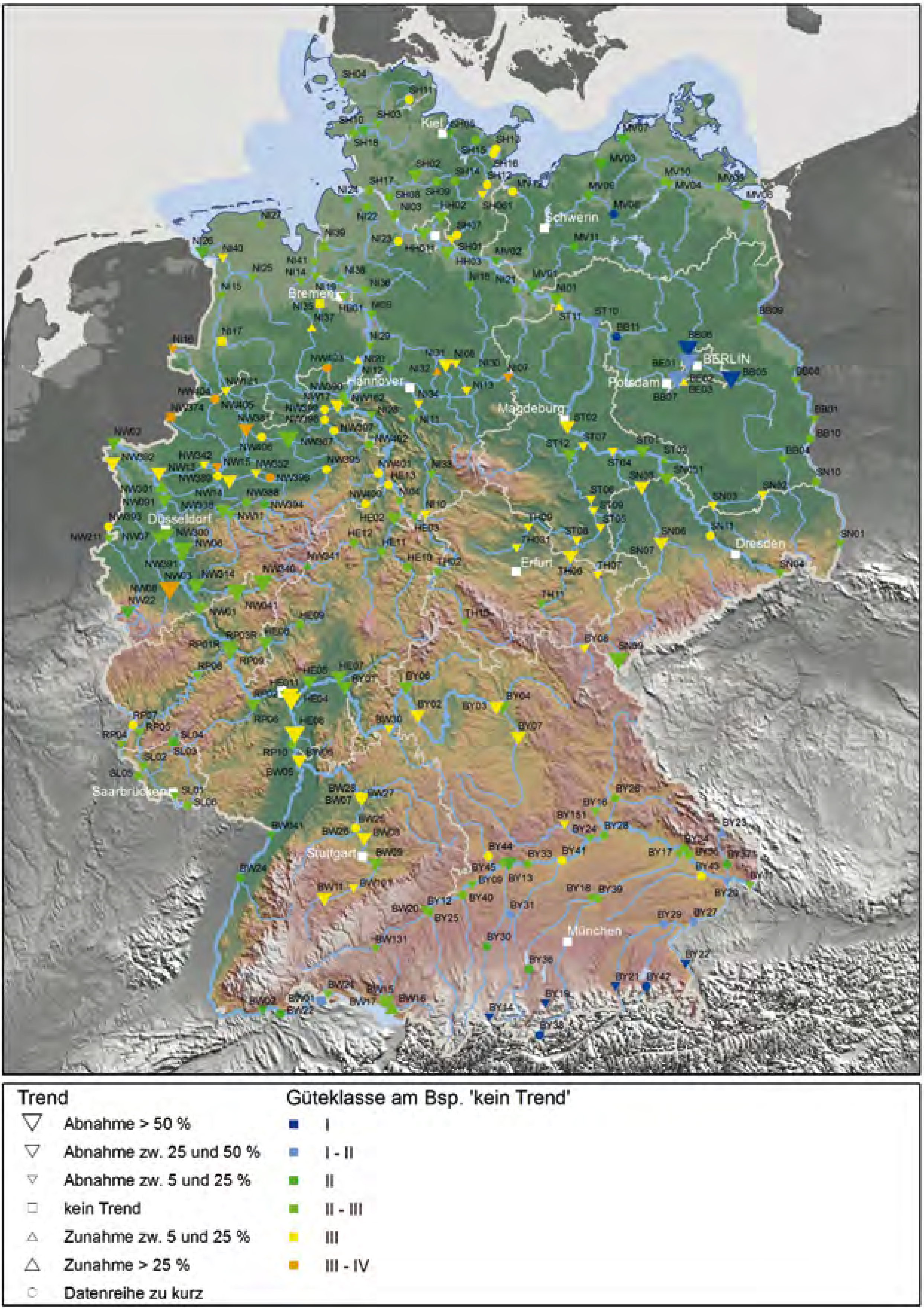
Source: Federal Environment Agency based on data supplied by LAWA

Figure 34: Quality classification for nitrate nitrogen 1982-2011 (LAWA monitoring points)



Source: Federal Environment Agency based on data supplied by LAWA

Figure 35: Trend and quality classification, 2010 – nitrate nitrogen



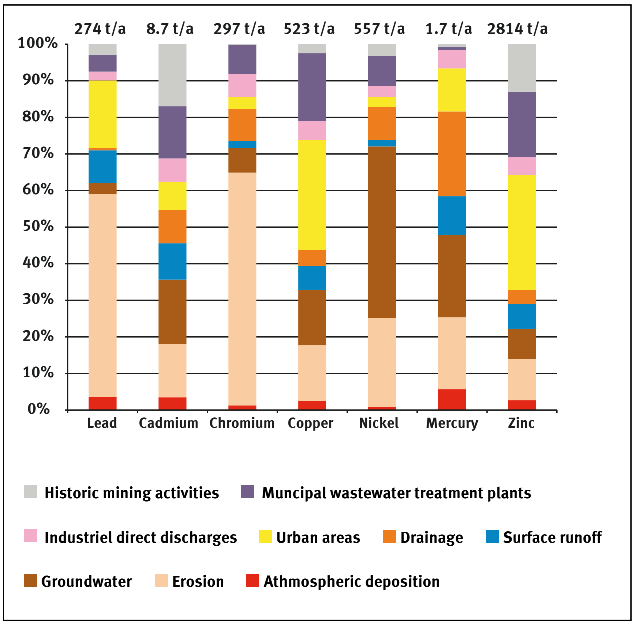
Source: Federal Environment Agency based on data supplied by LAWA

5.2.3 Heavy metals and metalloids

Inputs of metals into surface waters have been significantly reduced, thanks to the construction and modernisation of municipal and industrial wastewater treatment plants.

The reduction in inputs ranges from 38 % in the case of nickel to 94 % in the case of mercury, and is primarily attributable to a dramatic reduction in direct industrial discharges (point sources) ranging from 91 % for lead to 99 % for mercury. Measures in industry prompted by statutory requirements have been instrumental in helping to reduce environmental pollution, coupled with a decrease in industrial production in the new German Länder since 1990. In 2006-2008, direct industrial dischargers played only a subordinate role, accounting for between 2 % (lead) and 6 % (cadmium, chromium) of total inputs. Although inputs from municipal wastewater treatment plants (point sources) remain high, in the years 2006-2008 water pollution was dominated by diffuse inputs, whose proportions ranged from 62 % (cadmium) to 93 % (mercury) depending on the heavy metal. The principal diffuse pathways were erosion, groundwater and urban land (mostly sewer systems and households not connected to the municipal sewer system). In particular, the metals chromium (64 %) and lead (55 %) are emitted into surface waters as a result of erosion. In the case of nickel (47 %), geogenic input via the groundwater is the dominant pathway. Mercury is emitted into surface waters via erosion (20 %), groundwater (23 %) and drainage (23 %). With the exception of nickel and chromium, a high proportion of heavy metal inputs from surface waters also originates from urban land, including inputs from combined and separate sewer systems. Zinc (31 %), copper (30 %) and lead (19 %) account for particularly high proportions of total inputs. As a significant portion of precipitation run-off is transported to the wastewater treatment plant in combined systems, the level of heavy metal water contamination from this source is lower than in the separate sewer system (**Figure 36**). In the case of zinc, cadmium, copper, nickel, lead and arsenic, historical mining (old tunnels) may also account for a high proportion of total inputs.

Figure 36: Heavy metal inputs (lead, cadmium, chromium, copper, nickel, mercury, zinc) from point and diffuse pathways into Germany's surface waters, 2006 -2008

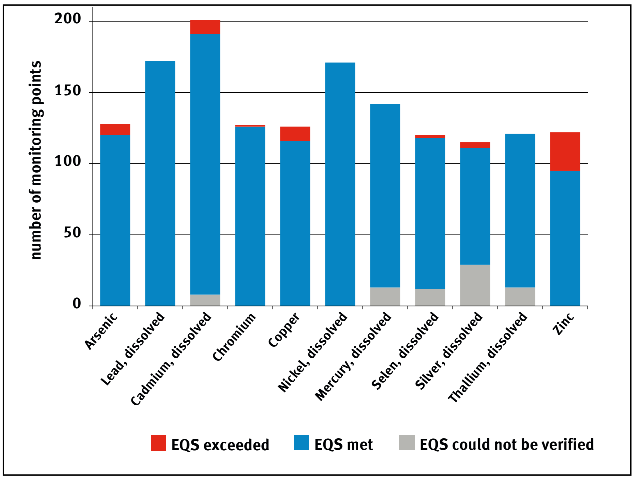


Source: Federal Environment Agency (MoRE), as at: June 2013

The assessment of metals is based on dissolved concentrations (lead, cadmium, nickel, mercury, selenium, silver, thallium), materials in suspension (arsenic, chromium, copper, zinc) and biota (mercury) (cf. **chapters 4.2.2** and **4.2.3**). Whereas data for the assessment of materials in suspension and dissolved concentrations is available from a large number of LAWA monitoring points, there is currently only limited data available for biota.

In 2009-2011, the environmental quality standards for materials in suspension were exceeded in some cases. In terms of the number of monitoring points where the environmental quality standard was exceeded, zinc was the most common, followed by copper, arsenic and chromium. The environmental quality standard for dissolved concentrations were likewise exceeded at several monitoring points in the case of cadmium, silver and selenium (in ascending order according to the number of monitoring points where the environmental quality standard was exceeded) (**Fig. 37**).

Figure 37: Comparison of annual means in 2009-2011 with the environmental quality standard (EQS) for selected metals (LAWA monitoring points)



Source: Federal Environment Agency based on data supplied by LAWA

5.2.4 Industrial organic pollutants

Industrial and municipal wastewater treatment has led to a shift in the focus of industrial pollutant inputs from point inputs to diffuse inputs.

The high proportion of diffuse inputs is elucidated by the example of PAHs. During the period 2006-2008, an average of 16,700 kg of PAH per annum was emitted into Germany's surface waters. The bulk of this entered our surface waters via urban systems, followed by surface water run-off and atmospheric deposition onto water surfaces (cf. **Table 17**).

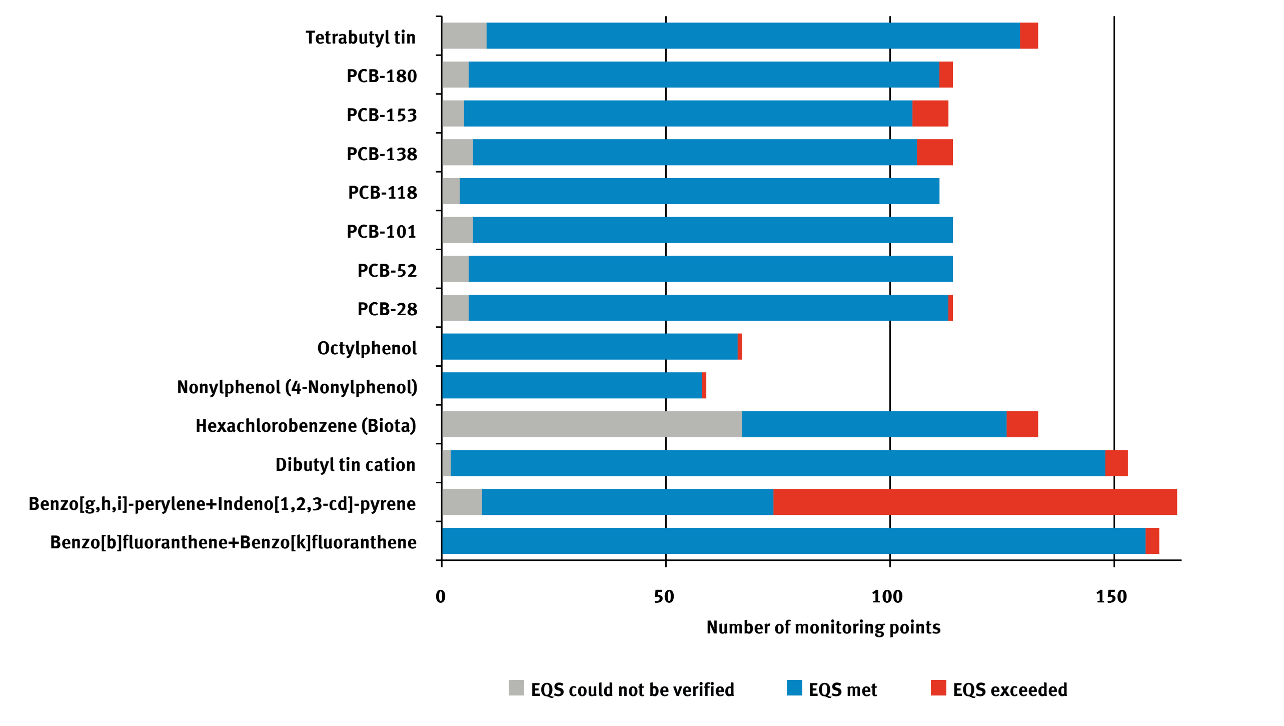
Table 17: PAH discharges into Germany's surface waters (2006-2008)

Discharge path	∑ EPA-PAH$_{16}$ [kg/a]
Atmospheric deposition	2,076
Erosion	1,497
Groundwater inflow	385
Direct industrial dischargers	180
Inland shipping	1,346
Surface run-off	4,505
Drainage	28
Urban systems	5,612
Municipal wastewater treatment plants	1,082
Total	**16,711**

Source: Federal Environment Agency (MoRE), as at: June 2013

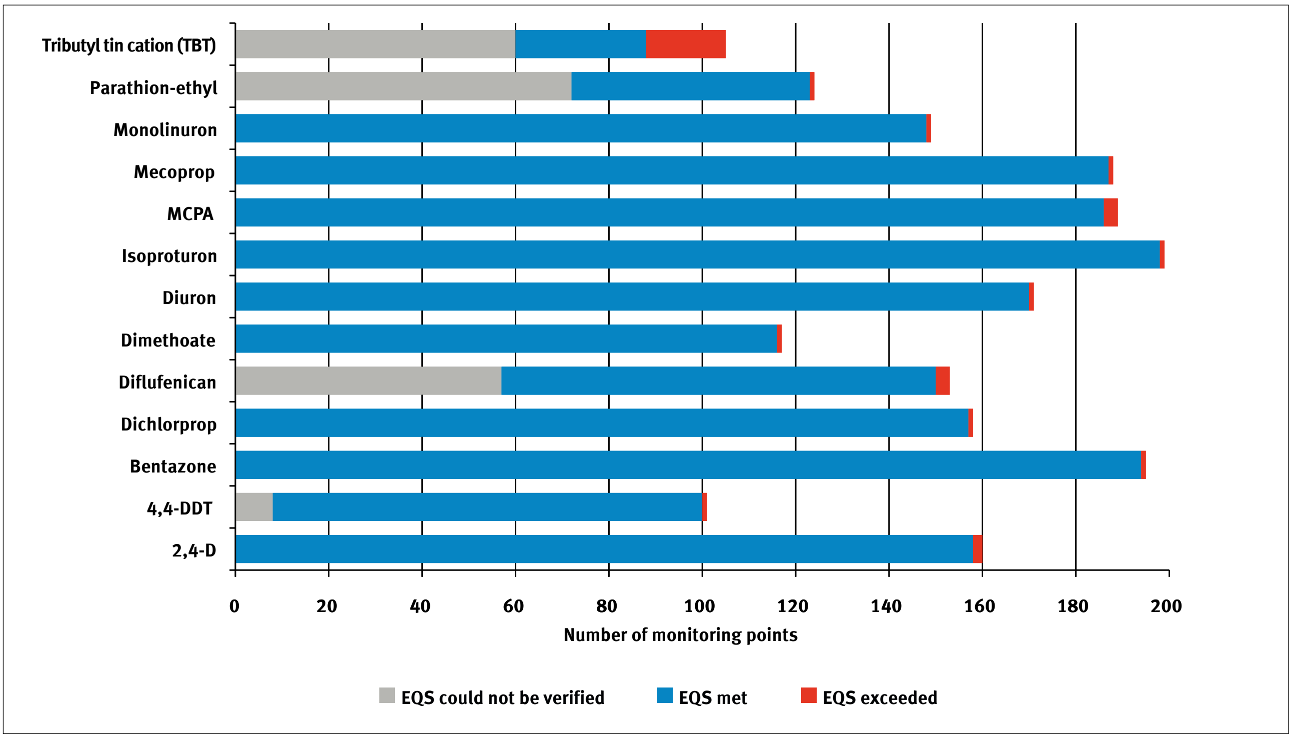
Comparing the environmental quality standard (cf. **chapters 4.2.2** and **4.2.3**) with the annual means for 2009-2011 at LAWA monitoring points reveals a number of isolated incidents where the sum total of benzo[b]fluoranthene & benzo[k]fluoranthene, nonylphenol, dibutyl tin cation, octylphenol, some polychlorinated biphenyls and tetrabutyl tin was exceeded. The levels were exceeded more frequently in the case of sum total benzo[g,h,i]perylene & indeno[1,2,4-cd] pyrene and hexachlorobenzene (total water sample, protected natural resource: biota). The environmental quality standard for maximum allowable concentration was exceeded in a number of isolated incidents in 2009-2011 for nonylphenol, benzo[a]pyrene, fluroanthene and HCB. Several environmental quality standard (e.g. for polybrominated diphenyl ether) could not be verified at many monitoring points because the limit of quantification exceeds the environmental quality standard. **Figure 38** shows an analysis of industrial pollutants which exceeded the environmental quality standard at least once in 2009-2011.

Figure 38: Comparison of annual means in 2009-2011 with the environmental quality standard (EQS) for selected industrial pollutants (LAWA monitoring points)



Source: Federal Environment Agency based on data supplied by LAWA

Figure 39: Comparison of annual means in 2009-2011 with the environmental quality standard (EQS) for selected pesticides (LAWA monitoring points)



Source: Federal Environment Agency based on data supplied by LAWA

5.2.5 Pesticides

Pesticides and biocides are discharged into water-bodies primarily via diffuse sources. Comparing the environmental quality standard (cf. **chapters 4.2.2** and **4.2.3**) with the annual means for 2009-2011 at LAWA monitoring points reveals isolated incidences of the levels being exceeded for 2,4-D, 4,4-DDT, sum total of DDT, bentazone, dichlorprop, diflufenican, dimethoate, diuron, isoproturon, MCPA, mecoprop, monolinuron and parathion-ethyl. The environmental quality standards are exceeded more frequently in the case of tributyl tin cation. The environmental quality standard for maximum allowable concentration was exceeded in isolated incidences in 2009-2011 in the case of isoproturon and hexachlorocyclohexanes, and more frequently in the case of TBT. Several environmental quality standard (e.g. for dichlorvos) could not be verified at many monitoring points because the limit of quantification exceeds the environmental quality standard. **Figure 39** shows an analysis of pesticides which exceeded the environmental quality standard at least once in 2009-2011.

5.2.6 Pharmaceuticals

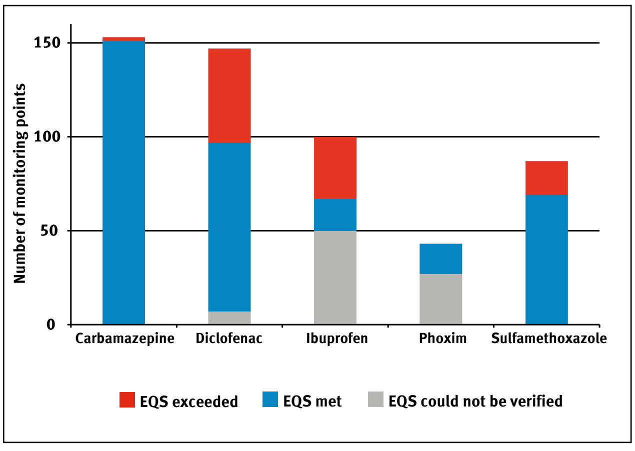
Until now, no environmental quality standards have been specified in the Surface Waters Ordinance for human pharmaceuticals. However, environmental quality standard proposals have been drafted at both European and national level. Comparing the environmental quality standard proposals with the annual means for 2009-2011 at LAWA monitoring points reveals isolated incidences where these levels were exceeded in the case of the human pharmaceuticals carbamazepine (environmental quality standard proposal = 0.5 µg/l), ibuprofen (environmental quality standard proposal = 0.01 µg/l) and sulfamethoxazole (environmental quality standard proposal = 0.1 µg/l). The environmental quality standard are exceeded more frequently in the case of diclofenac (environmental quality standard proposal = 0.1 µg/l). For the veterinary medicine phoxim, there are problems with the limit of quantification. **Figure 40** shows an analysis of these parmaceuticals.

5.2.7 Ecological status

Rivers with a catchment area of more than 10 km² for which reporting is mandatory under the Water Framework Directive have a watercourse length of around 127,000 kilometres. They have been divided into 9,070 water bodies.

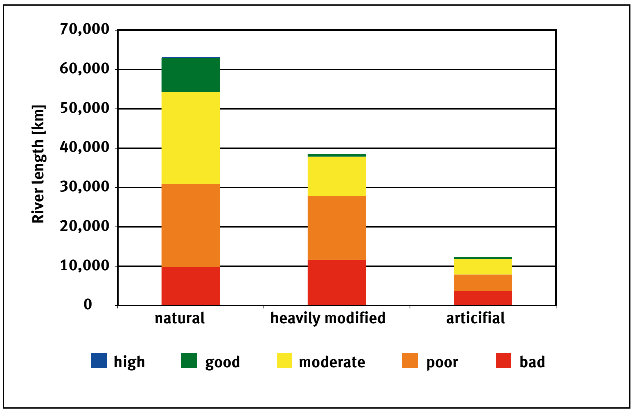
The watercourse length of all natural watercourses totals 74,506 km, corresponding to just under 59 % of the total watercourse length. The proportion of heavily modified waterbodies (HMWB) is 31 %, while artificial waterbodies (AWB) account for just under 10 % (cf. **Figure 41**). The Water Framework Directive is applicable to all water bodies, including those with a catchment area of less than 10 km².

Figure 40: Comparison of annual means in 2009-2011 with the environmental quality standard (EQS) proposals for pharmaceuticals (LAWA monitoring points)



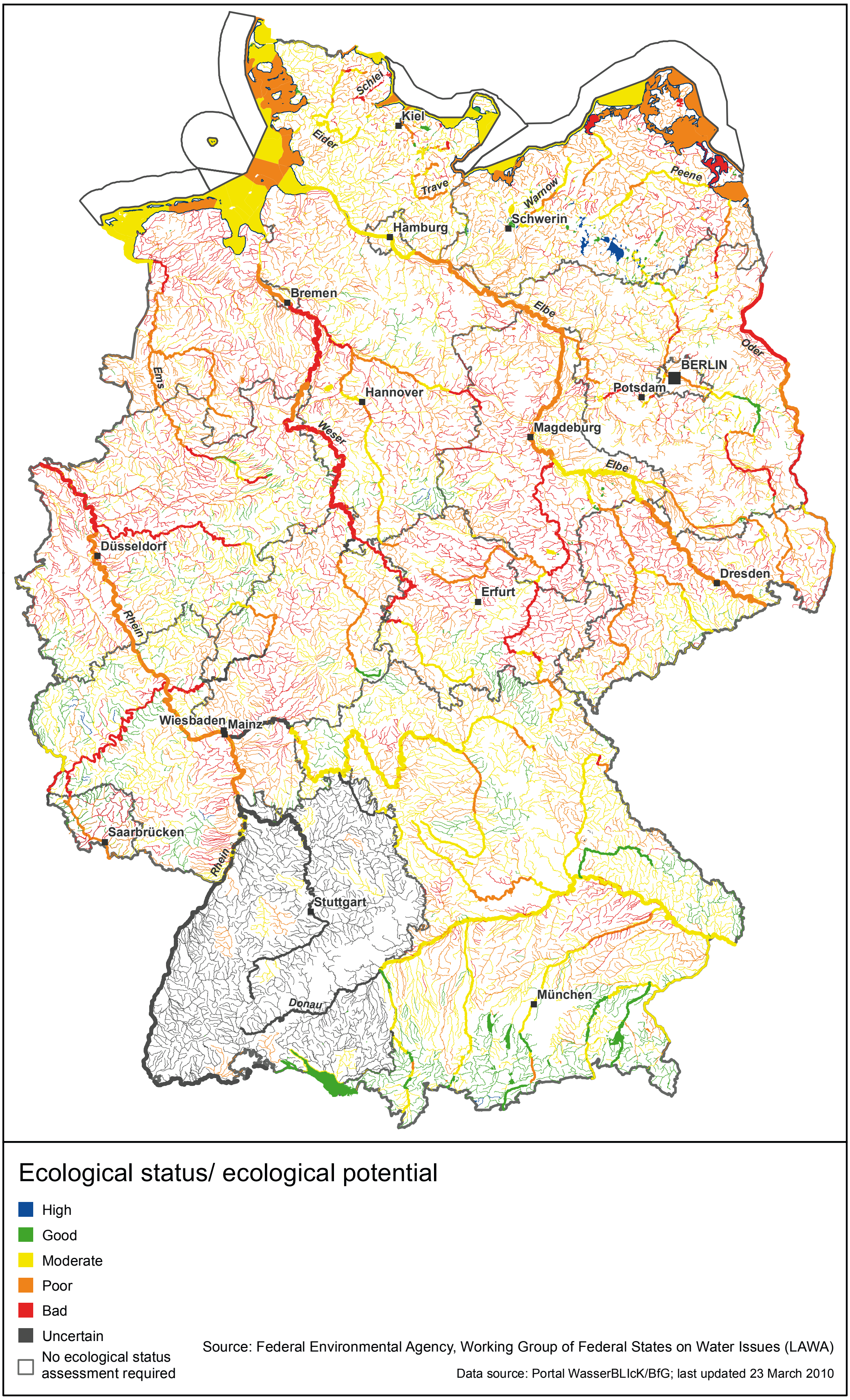
Source: Federal Environment Agency based on data supplied by LAWA

Figure 41: Ecological status of natural watercourses and ecological potential of heavily modified and artificial watercourses in Germany (reference: proportion of watercourse length, 9.9 % of watercourse length not evaluated)



Source: Federal Environment Agency; data supplied by LAWA, data source: Reporting tool WasserBLicK/BfG, as of 22 March 2010

Figure 42: Ecological status/ecological potential of surface water bodies in Germany



An assessment of natural watercourses (in relation to watercourse length) reveals that:

- 0.24 % exhibit a "high" ecological status
- 14 % exhibit a "good" status
- 37 % exhibit a "moderate" ecological status
- 34 % exhibit a "poor" ecological status
- 15 % exhibit a "bad" ecological status

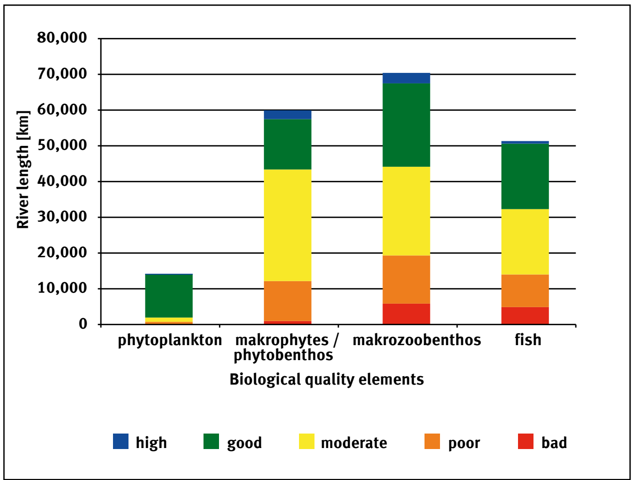
The most common reason for failing to achieve a "good ecological status" are changes in hydromorphology in natural watercourses, and the high levels of nutrient load originating from human activities, which is reflected in changes to the natural aquatic community of that area.

Figure 43 shows a breakdown of the individual ecological status classes into watercourse length and the four biological quality elements that are relevant for rivers. The different bar heights indicate that not all quality elements were assessed simultaneously in the individual sections of watercourse. Macrozoobenthos was recorded in almost 95 % of the total watercourse length of all natural watercourses, while fish and macrophytes/phytobenthos were only recorded in 69 and 80 % respectively, and phytoplankton only in around 20 %.

Status assessment at the level of biological quality elements indicates an almost identical picture for macrozoobenthos and fish (cf. **Figure 44**). For both elements, the proportion of watercourses with a "good" and "high" status is around 37 %, while 35 % were classified as "moderate". In the case of macrozoobenthos, the "poor" and "bad" status class applies to 19 % and 8 % respectively, and for fish 18 % and 9 % respectively. These more or less identical assessment results indicate that the quality elements respond in a similar way to the pressure factors acting upon them. In both cases, the hydromorphological changes and lack of longitudinal and lateral river continuity are the principal factors in failing to meet a "good" ecological status.

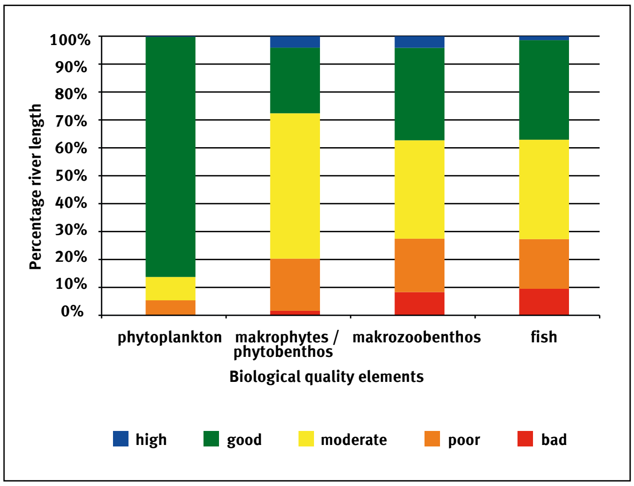
In the case of the quality element "macrophytes/phytobenthos", the proportion of watercourses in a "good" and "high" status is only 27 %, with 52 % classified as "moderate". Around 19 % are classed as "poor", and less than 2 % as "bad". Both macrophytes and phytobenthos respond primarily to nutrient contamination of waters. However, structural degradation is also reflected in the composition of the macrophyte biotic community. Unlike all other biological quality elements, more than 86 % of the phytoplankton in the watercourse sections analysed is in a "good" status. By contrast, the quality element macrophytes/phytobenthos (aquatic flora) indicates excessively high nutrient loads in 71 % of natural watercourse sections.

Figure 43: Ecological status of biological quality elements in Germany's natural watercourses (reference: proportion of watercourse length (approximately: 74,500 km, of which 15.3 % not assessed)



Source: Federal Environment Agency; data supplied by LAWA, data source: Reporting tool WasserBLicK/BfG, as of 22 March 2010

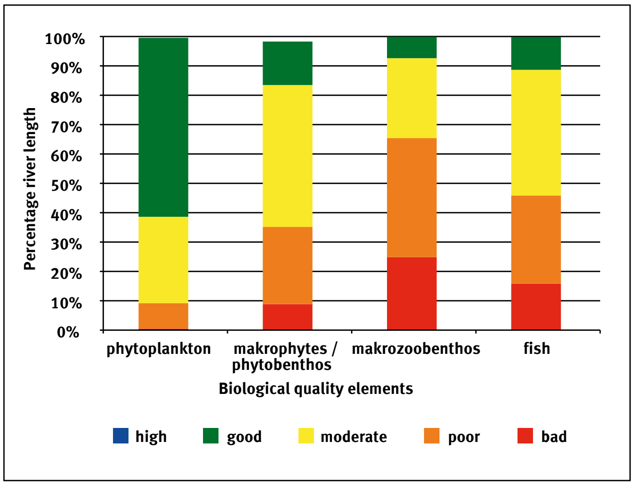
Figure 44: Percentage distribution of the ecological status classes of biological quality elements in Germany's natural watercourses (reference: proportion of watercourse length (approximately 74,500 km, of which 15.3 % not assessed))



Source: Federal Environment Agency; data supplied by LAWA, data source: Reporting tool WasserBLicK/BfG, as of 22 March 2010

In HMWB, too, the proportion of watercourse length with a good ecological potential for macrophytes/phytobenthos, macrozoobenthos and fish fauna is very low (**Figure 45**). In each case, the proportions are just under 15 % for macrophytes/phytobenthos, just over 7 % for macrozoobenthos, and just over 11 % for fish. The biological quality element “macrozoobenthos” is assessed as poor or bad in more than 65 % of watercourse length in HMWB.

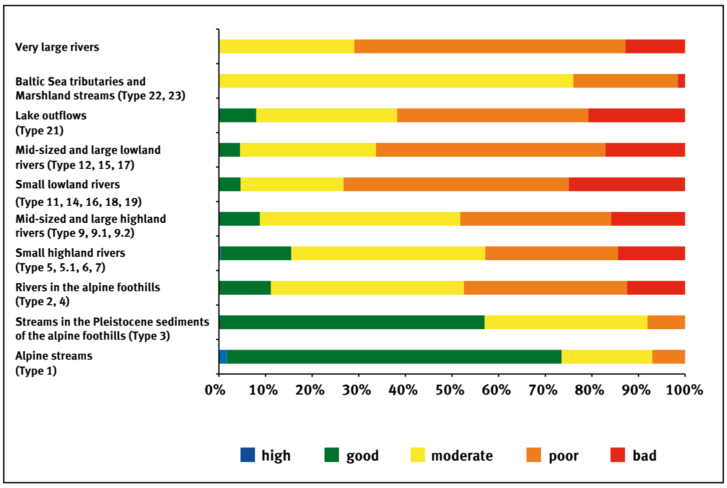
Figure 45: Percentage distribution of ecological potential classes for biological quality elements in Germany’s HMWB (reference: proportion of watercourse length (approximately: 39,647 km, of which 3 % not assessed))



Source: Federal Environment Agency; data supplied by LAWA, data source: Reporting tool WasserBLicK/BfG, as of 22 March 2010

The ecological status of Germany’s watercourses indicates significant differences between individual watercourse types with regard to their natural environment. 60 % or more of the natural watercourses of the Alps and of the Pleistocene sediments in the Alpine foothills indicate a status of at least “good”. Of the other watercourse types of the Alpine foothills and Central German Highlands, 20 % are classed as having a "good" status, while 30 to 50 % are classed as "moderate". Among North German lowland streams and rivers, the proportion of good status is generally well below 10 %. Generally speaking, the ecological status of more than 70 % of the watercourse length in many lowland watercourse types is worse than "moderate" (cf. **Figure 46**).

Figure 46: Percentage distribution of ecological status classes in natural watercourses per watercourse type.



Source: Federal Environment Agency; data supplied by LAWA, data source: Reporting tool WasserBLicK/BfG, as of 22 March 2010

Among assessed watercourse sections, 1.6 % of HMWBs and 4.5 % of artificial waterbodies achieved a good ecological potential in 2010. Just over one-quarter of all HMWBs were classed as "moderate". The proportion of watercourses with a "poor" ecological potential was around 42 %, while around 30 % were classed as "bad". Artificial waterbodies indicate similar assessment results: just under 32 % were classed as having a "moderate" ecological potential, 34 % as "poor" and just under 30 % as "bad" (cf. **Figure 41**).

5.2.8 Chemical status

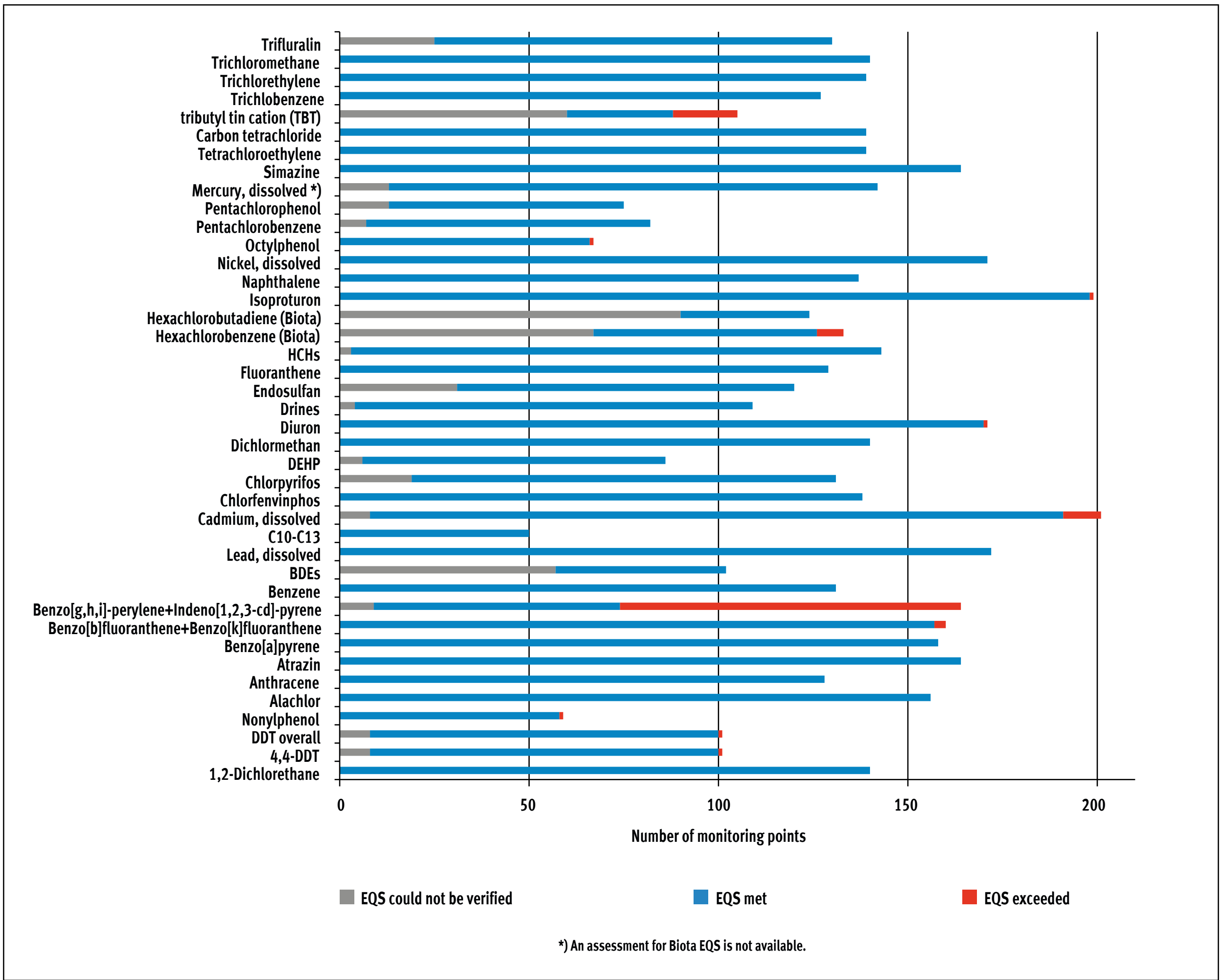
In Germany, the chemical status was classed as "good" in 88 % of surface waters (as at: 22 March 2010). If the environmental quality standards from the Environmental Quality Standards Directive are applied, 100 % of water bodies are expected to fall short of the target of a "good chemical status".

For the period 2009-2011, isolated incidences of the environmental quality standard being exceeded were ascertained for benzo[b]fluoranthene & benzo[k]fluoranthene, cadmium, 4,4-DDT, sum total of DDT, diuron, isoproturon, nonylphenol and octylphenol. The environmental quality standard were exceeded more frequently in the cases of benzo[g,h,i]perylene & indeno[1,2,3-cd]pyrene, hexachlorobenzene (total water sample, protected natural resource: biota) and tributyl tin cation. The environmental quality standard for maximum allowable concentration is exceeded in isolated cases for cadmium, nonylphenol, benzo[a]pyrene, fluoranthene, isoproturon, hexachlorobenzene, hexachlorocyclohexanes and mercury in the period 2009 to 2011, and more frequently for tributyl tin cation.

Data analysis indicates a need for improved analysis techniques in order to review the environmental quality standard for selected substances (cf. **chapter 2.2**). At many monitoring points, the environmental quality standard cannot be verified for substances such as tributyl tin cation, because the limit of quantification is above the environmental quality standard.

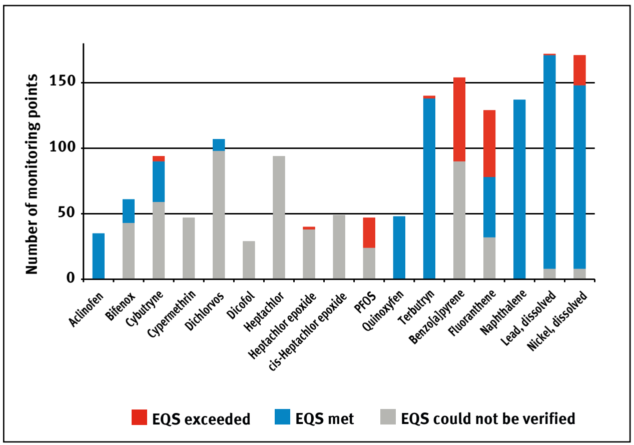
If the amendments and additions to the Environmental Quality Standards Directive (cf. **chapter 4.2.3**) are applied, the environmental quality standard are exceeded occasionally for lead, cybutryne and terbutryn, and more frequently for benzo[a]pyrene, fluoranthene, nickel and PFOS (cf. **Figure 48**). The environmental quality standard for the maximum allowable concentration are exceeded for benzo[a] pyrene, bifenox, cybutryne, cypermethrin, dichlorvos, fluoranthene, heptachlor, heptachlor epoxide and PFOS. For hexabromocyclododecane (HBCDD), dioxins (environmental quality standard for biota) and brominated diphenyl ether (environmental quality standard for biota), compliance with the environmental quality standard cannot be assessed at present.

Figure 47: Assessment of the environmental quality standard (EQS) of the water phase (LAWA monitoring points, 2009-2011)



Source: Federal Environment Agency based on data supplied by LAWA

Figure 48: Assessment of the revised environmental quality standards (EQS) and environmental quality standards (EQS) for newly identified substances for the water phase (LAWA monitoring points, 2009-2011)



Source: Federal Environment Agency based on data supplied by LAWA

For the substances listed in Annex 7 of the Surface Waters Ordinance (cf. **chapter 4.2.3**), § 4 of the Ordinance requires the preparation of an inventory of emissions, discharges and losses. Emissions into water bodies have not been reported for all these substances, highlighting the fact that diffuse sources are also responsible for emissions of the substances regulated by the Environmental Quality Standard Directive (cf. also **chapters 5.2.3** and **5.2.4**). **Table 18** contains an overview of direct discharges into water bodies reported to the PRTR (**P**ollutant **R**elease and **T**ransfer **R**egister) in 2011 (known as emissions into water, cf. also Part 1, **chapter 5.1.2**).

Table 18: Reported emissions into water for substances listed in Annex 7 to the Surface Waters Ordinance, reporting year 2011

Substance	Emissions into water	Unit
1,2-dichloroethane	97.10	kg/a
Benzene	209.00	kg/a
Lead and compounds	7291.40	kg Pb/a
Cadmium and compounds	410.26	kg Cd/a
Di-(2-ethylhexyl)phthalate (DEHP)	736.34	kg/a
Dichloromethane	126.90	kg/a
Dioxins and furans	0.002582	kg TEQ/a
Diuron	1.38	kg/a
Endosulfan	3.00	kg/a
Fluoranthene	1.80	kg/a
Hexachlorobenzene (HCB)	1.50	kg/a
Hexachlorocyclohexane	5.82	kg/a
Isoproturon	12.10	kg/a
Nickel and compounds	27829.20	kg Ni/a
Nonylphenol and its ethoxylates	201.40	kg/a
Ocytlphenols and octylphenol ethoxylates	33.93	kg/a
PAH	34.80	kg/a
Mercury and compounds	166.31	kg Hg/a
Trichloromethane	1079.30	kg/a

TEQ = Toxic Equivalency Factor

Source: Federal Environment Agency from the Pollutant Release and Transfer Register (PRTR), as at: 2013

6 Lakes and reservoirs

6.1 Basis for assessment

6.1.1 Lake types

Unlike watercourses, a comprehensive biocoenotic characterisation of lakes has not yet been carried out. The typology used for standing waters in Germany follows an approach based initially on abiotic factors. The following criteria were used to demarcate the individual lake types:

- Ecoregion
- Geology
- Size of lake
- Influence of the catchment area and
- Stratification properties (cf. **Table 19**).

Research work is currently ongoing to identify the specific reference biocoenoses (see **chapter 6.1.2**). When determining the reference trophic level, for many lake types, it is expedient to distinguish sub-types based on the phytoplankton assessment (see phytoplankton sub-types in **Table 24**).

Table 19: Lake types in Germany

Ecoregions 4 and 9: The Alps and Pre-Alpine region
Type 1: Pre-Alpine lakes: Calcareous[1], relatively large catchment area[2], unstratified
Type 2: Pre-Alpine lakes: Calcareous, relatively large catchment area, stratified[3]
Type 3: Pre-Alpine lakes: Calcareous, relatively small catchment area, stratified
Type 4: Alpine lakes: Calcareous, relatively small or large catchment area, stratified
Ecoregions 8 and 9: Central German Highlands
Type 5: Central German Highlands region: Calcareous, relatively large catchment area, stratified
Type 6: Central German Highlands region: Calcareous, relatively large catchment area, unstratified
Type 7: Central German Highlands region: Calcareous, relatively small catchment area, stratified
Type 8: Central German Highlands region: Siliceous, relatively large catchment area, stratified
Type 9: Central German Highlands region: Siliceous, relatively small catchment area, stratified
Ecoregions 13 and 14: North German lowlands
Type 10: Lowland region: Calcareous, relatively large catchment area, stratified
Type 11: Lowland region: Calcareous, relatively large catchment area, unstratified, water residence time > 30 d
Type 12: Lowland region: Calcareous, relatively large catchment area, unstratified, water residence time < 30 d
Type 13: Lowland region: Calcareous, relatively small catchment area, stratified
Type 14: Lowland region: Calcareous, relatively small catchment area, unstratified
Special types (all ecoregions)
Special type for natural lakes: e.g. peat lakes, beach lakes
Special type for artificial lakes: e.g. excavation lakes (dredged lakes, lakes in former open cast mines)

1 Calcareous lakes: $Ca^{2+} \geq 15$ mg/l; siliceous lakes: $Ca^{2+} < 15$ mg/l
2 Relatively large catchment area: Ratio of the area of the overground catchment area (with lake area) to the volume of the lake (volume ratio VQ) > 1.5 m^2/m^3; relatively small catchment area: VQ ≤ 1.5 m^2/m^3
3 A lake is classified as stratified if the thermal stratification at the deepest point of the lake remains stable for at least 3 months

Source: Federal Environment Agency in accordance with Annex 1 of the Surface Waters Ordinance

6.1.2 Biological quality elements

The biological quality elements for assessing the ecological status of lakes are invertebrate fauna, fish fauna and aquatic flora. Macrophytes and phytobenthos have been combined into one assessment element. Phytoplankton represents the second floristic element. In order to describe the status of organism groups, the identified species occurring and the individuals of each species are counted. In the case of fish fauna, the age structure of the population is additionally determined, and in the case of phytoplankton, the biomass of the algae. The various organism groups with their specific habitat requirements can detect a broad spectrum of different pressure factors such as eutrophication or structural depletion (cf. **Table 20**).

Table 20: Biological quality elements to assess the ecological status of lakes

Biological quality element	Brief description of assessment methods and parameters recorded	Indicated pressures	Reference literature
Aquatic flora			
Phytoplankton (algae freely suspended in water)	**Phyto-See-Index** (PSI) Parameter: Biomass and algae classes; Phytoplankton-Taxa-See-Index (PTSI) and Profundal-Diatom-Index (DIPROF)	Eutrophication	Mischke, U. & Nixdorf, B. (editors) (2008)
Macrophytes (aquatic plant visible to the naked eye) and phytobenthos (algae species growing on substrate)	**PHYLIB** Parameter: Species composition, species frequency of macrophytes and phytobenthos via reference species, disturbance indicators, trophic index (in lakes only analysis of diatoms)	Eutrophication, structural degradation	Schaumburg et al. (2007)
Aquatic fauna			
Macrozoobenthos (invertebrates, visible to the naked eye, that live in or on the lake bottom)	**AESHNA** (lake type-specific multimetric assessment method) Parameter: Species composition, species frequency, disturbance-sensitive species, diversity	Structural degradation	Brauns, M., Böhmer, J, Pusch, M. (2010) , Miler, O., Brauns, M., Böhmer, J., Pusch, M. (2011 and 2013)
Fish	**SITE-method** (assessment of lakes in the Alpine region, modelling of historical reference community and current fish community for every lake**)** **TYPE-method** (assessment of lakes in North German lowlands, lake type-specific multimetric assessment method, practical testing method) Parameter: Species composition, species frequency, age structure	Eutrophication, structural degradation	Ritterbusch, D. & Brämick, U. (2010)

Source: Federal Environment Agency

Intercalibration results

In accordance with the procedure for watercourses (cf. chapter 5.1.2), the results of the national assessment methods for lakes were likewise compared with one another and harmonised in an intercalibration process. **Table 21** provides an overview of the results following completion of the first (2005-2007) and second (2008-2011) intercalibration phases. The results referring to the international intercalibration types were assigned to the German lake types. For the biological quality element fish fauna, only the method for assessing lakes in the Alpine region (SITE method) has been intercalibrated to date. Intercalibration of the method for North German lowland lakes (TYPE method) is still outstanding.

6.1.3 Hydromorphological quality elements

The hydromorphological quality elements for lakes are hydrological regime and morphology. The hydromorphological quality elements are used for the reference status (= high status), while in the other four

Table 21: Ecological quality quotients for intercalibrated national assessment methods

Intercalibrated national classification systems (biological quality element or sub-element in brackets)	Intercalibrated national waterbody type	Ecological quality quotients	
		Limit high/ good status	Limit good/ moderate status
DELAFI_SITE – (fish fauna)	2, 3, 4	0.85	0.69
AESHNA – (eulittoral macrozoobenthos)	2, 3, 4, 10, 11, 13	0.80	0.60
PSI (Phyto-See-Index) – (phytoplankton)	2, 3, 4, 10, 11, 13	0.80	0.60
PHYLIB – (macrophytes and phytobenthos – macrophytes module)	2, 3, 4	0.76	0.51
	10, 11, 13	0.80	0.60
PHYLIB – (macrophytes and phytobenthos – macrophytes & phytobenthos modules)	2, 3	0.74	0.47
PHYLIB – (macrophytes and phytobenthos – phytobenthos module)	10, 11, 13	0.80	0.55

Source: Federal Environment Agency in accordance with Resolution 2013/480/EU ecological classification groups, hydromorphological degradation is recorded via biology (cf. **Chapter 4.2.1**).

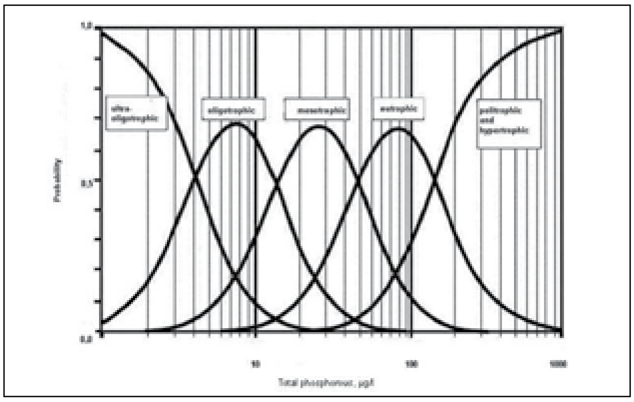
For the quality element "morphology", a uniform national method is currently under development for recording and assessing the shore structures of natural lakes. This will necessitate the identification of biologically effective structural parameters currently recorded under the structural quality mapping methods used in Germany.

The exposed substrate, the shore morphology determined by lake genesis and exposure to the erosive effects of waves have a decisive influence on the formation of lake shores. Based on these influencing factors, for example, in Mecklenburg-West Pomerania we distinguish three different lake shore types – moraine, sand and peat. During mapping, a total of 19 different morphologically relevant individual parameters are logged, and subdivided into three water body zones: shallow water zone (littoral zone), shore zone, and riparian zone. In each zone, the uses, damage structures and special structures are mapped, and an overall assessment is derived from the mean assessment of the shallow water zone, shore zone and riparian zone. There is also a shore assessment technique developed by the International Commission for the Protection of the Waters of Lake Constance (IGKB) and the so-called "HMS technique" (hydromorphological overview mapping and classification of lake shores), both of which originate from the assessment of lake shores from a nature conservation perspective.

6.1.4 General physico-chemical quality elements

In recent decades, lakes in Germany were assessed primarily according to their trophic situation, which describes pollution with nutrients and how plankton algae respond to this nutrient supply. Increased nutrient loads and concentrations lead to an increase in plant biomass production, particularly phytoplankton. In this respect, phosphorus plays a key role as a limiting factor for the primary production of phytoplankton. The first quantification of the effects of increased nutrient discharges was carried out by Vollenweider in 1975, and was tested on various water types within the context of a 1982 OECD study (cf. **Figure 49**).

Figure 49: Probability distribution of the trophic classes of a lake depending on total phosphorus levels (annual means), after Vollenweider.



Source: Vollenweider 1979

This classification system forms the basis for the assessment system of lakes in Germany, which was published in 1999 by LAWA. On the basis of these LAWA guidelines, trophic classification is implemented primarily according to the parameters total phosphorus (TP) concentration, chlorophyll a and water transparency (cf. **Table 22**).

Conversion of the existing nutrients into plant biomass depends not only on the nutrient concentrations, but also on the shape and position of the lake basin and on the hydrology. Thus deep lakes with stable summer temperature stratification, a small catchment area and little water exchange are naturally not very productive (the reference condition is oligotrophic (= low in nutrients)), whereas shallow, constantly mixed lakes tend to convert nutrients more effectively (greater algae production) (the reference condition is eutrophic (= rich in nutrients)). The LAWA assessment system

Table 22: Total phosphorus and chlorophyll a concentration, limit of visibility and trophic levels according to LAWA (1999) – using stratified lakes as an example

Total phosphorus concentration in spring in µg P/l	Total phosphorus concentration in summer in µg P/l	Chlorophyll a in µg/l in epilimnion	Limit of visibility [m]	Trophic level
≤ 11	≤ 8	≤ 3.0	≥ 5.88	Oligotrophic
> 11 – 58	> 8 – 45	> 3.0 – 9.7	< 5.88 – 2.40	Mesotrophic
> 58 – 132	> 45 – 107	> 9.7 – 17	< 2.40 – 1.53	Weakly eutrophic
> 132 – 295	> 107 – 250	> 17 – 31	< 1.53 – 0.98	Highly eutrophic
> 295	> 250	> 31 – 56	< 0.98 – 0.63	Weakly polytrophic
> 500	> 500	> 56 – 100	< 0.63 – 0.40	Highly polytrophic
		> 100	< 0.40	Hypertrophic

Source: LAWA, 1999

makes allowance for this by allocating a quality class based on the deviation of the actual trophic status from the potential natural trophic status (i.e. the status which would occur without (further) anthropogenic influence). The 7-point scale ranging from class 1 (no nutrient pollution) to class 7 (an excessively high level of nutrient pollution) has since been converted to an 8-point scale, prompted by the latest biological analysis results (sub-division of the trophic level "mesotrophic" (cf. **Table 23**).

Table 23: LAWA index 1999, trophic classes and abbreviations

LAWA index	Trophic class	Abbreviation
0.5 – 1.5	oligotrophic	o
> 1.5 – 2.0	mesotrophic 1*	m1
> 2.0 – 2.5	mesotrophic 2*	m2
> 2.5 – 3.0	eutrophic 1	e1
> 3.0 – 3.5	eutrophic 2	e2
> 3.5 – 4.0	polytrophic 1	p1
> 4.0 – 4.5	polytrophic 2	p2
> 4.5	hypertrophic	h

* Sub-dividing the trophic level "mesotrophic" deviates from the original LAWA system (1999), but can probably be differentiated and justified by biological findings.

In future, the recording of a broad spectrum of biological indicators required by the EC Water Framework Directive will facilitate a more differentiated and comprehensive assessment of the lakes. Supplementary to this, limit ranges for total phosphorus concentration for the reference status and good status have been defined for the various trophic levels (cf. **Table 24**). Compliance with the guideline values, particularly with regard to total phosphorus, may positively affect the biological quality elements fish, macrophytes and phytobenthos diatoms and macrozoobenthos, but will not necessarily lead to a "good" status for these bio-elements, since the corresponding assessment techniques may be calibrated to other ecologically effective stressors.

6.1.5 Network of monitoring points for reporting

The LAWA network of monitoring points has been set up in Germany for the EU Nitrates Directive and for reporting to the European Environment Agency. The LAWA network of monitoring points for standing waters currently comprises 68 representative sites, including surveillance monitoring points and sites in the operative monitoring network (cf. **chapter 4.3.1**). The data from these monitoring points provides the basis for the evaluations outlined in **chapter 6.2.2** below.

6.2 Status assessment

6.2.1 Hydromorphology

In terms of the earth's history, lakes are surface forms that exist for a comparatively short period. Lake morphology is directly linked to the genesis of the lake, and influences the substance balance in the water. In deep lakes with steep edges, the small volume of surface water compared to deep water reduces productivity (oligotrophy), as the degradation process in deep water outweighs the production of organic substance in surface water. This lake shape is characteristic of the Maar lakes in the Eifel region, for example. By contrast, in lakes with extended shallow water areas, a high level of productivity (eutrophy) is typical. The grain size of the sediment can also influence the lake shape. Fine-grained, clay sediment may be very stable and encourage the formation of steep slopes, whereas coarse-grained sediment such as sand or gravel leads to shallow slopes. The immediate bank form is also shaped by the lake genesis and protruding sediment.

Figure 50: Morphologically effective interventions into the bank area such as bathing and mooring areas can influence the water biology

Source: Federal Environment Agency

However, the fundamental relationship between basin morphology and the productivity of lakes has been disturbed by urbanisation and agricultural use in the catchment area and the associated discharge of nutrients into the lake waterbody, so that in many lakes eutrophication is accelerated. Less is known about the impacts of hydrological and morphological changes in the littoral zone on the habitats of macrozoobenthos (invertebrates in the water bed), aquatic plants, fish fauna and aquatic birds. Relevant hydromorphological pressures for lakes also include changes in the water regime associated with regulation and water abstractions. The hydromorphological quality elements (cf. **chapter 6.1.3**) of water regime (water level dynamics, water residence time, link to groundwater body) and morphological conditions (depth variation, structure and substrate of the lake bed, structure of the shore zone) have a supporting effect on a good status of water body biology.

Table 24: Class limits of the high (reference) and good ecological status for the parameter "total phosphorus" (mean of the vegetation period); some of the figures given are provisional and will be validated during the course of ongoing research projects.

Ecoregion	LAWA lake type (MATHES et al. 2002)	Phytoplankton lake subtypes or type groups	Maximum trophic level in reference status (LAWA index)	Limit ranges of total phosphorus – seasonal average (µg/l)	
				Upper limit of reference status	Upper limit of good status
Pre-Alpine	1	1	mesotrophic 1 (1,75)	(10-15)	(20-26)
Pre-Alpine	2, 3	2+3	mesotrophic 1 (1,75)	10-15	20-26
Alps	4	4	(very) oligotrophic (1,25)	6-8	9-12
Central German Highlands	5, 7, 8, 9	7+9***	mesotrophic 1 (1,5)	8-12	14-20
Central German Highlands	6	6.1	mesotrophic 2 (2,25)	18-25	30-45
Central German Highlands	6	6.2	mesotrophic 2 (2,5)	25-35	35-50
Central German Highlands	6	6.3	eutrophic 1 (2,75)	30-40	45-70
Central German Highlands	5, 7, 8, 9	5+8***	oligotrophic (1,75)	9-14	18-25
Lowlands	10	10.1	mesotrophic 1 (2,0)	17-25	25-40
Lowlands	10	10.2	mesotrophic 2 (2,25)	20-30	30-45
Lowlands	11	11.1	mesotrophic 2 (2,5)	25-35	35-45
Lowlands	11	11.2*	eutrophic 1 (2,75)	28-35	35-55
Lowlands	12	12**	eutrophic 1 (3,50)	40-50	60-90
Lowlands	13	13	mesotrophic 1 (1,75)	15-22	25-35
Lowlands	14	14	mesotrophic 2 (2,25)	20-30	30-45

* In the very shallow lake type 11.2 (IC type LCB 2), in the reference status and in largely unpolluted lakes, phosphorus re-dissolution processes may lead to significantly higher concentrations.

** Lakes in river-lake systems with a high retention capacity (e.g. lakes at the start of a chain of lakes) may indicate very high trophic levels in the reference status, in some cases extending far into the eutrophic class. In such lakes, total phosphorus (TP) concentrations may range between 40 and around 100 µg/l as a seasonal average.

*** In lakes heavily influenced by humic substances, higher TP levels may occur, particularly as a result of degraded peatlands in the catchment area. Light limitation caused by the brown discoloration and elevated levels of degradable organic carbon (DOC) may significantly promote heterotrophic phytoplankton species. Under such conditions, the P limits of the phytoplankton will be undermined, and cases of elevated phytoplankton biomass may occur, despite lower TP concentration levels.

Source: Riedmüller et al. (2009, 2013)

Hydromorphological pressures on lakes in Germany were recorded as part of the analysis of pressures and impacts pursuant to Article 5 of the EC Water Framework Directive. The pressures were identified according to the following features:

- Anthropogenic influences on the water level
- Changes to the shore structure (obstruction, build-up, bank inclination),
- Changes in the structural conditions (use, construction work) in the immediate vicinity of the lake
- The absence of riparian buffer strips of land to act as a buffer zone between the surrounding land and the lake.

Changes to the shore structure are relevant to the ecological status of a lake if they affect significant portions of the shore length. A good ecological status is considered to be at risk if 70 % of the shore's length fails to exhibit the typical characteristics of that waterbody. For lakes in Germany, it has been ascertained that nutrient discharges into the water body pose a greater threat to target achievement than hydromorphological pressures. As part of the structural mapping of lakes in Mecklenburg-West Pomerania, almost one-third of lake shores were assigned to structural class 2 (semi-natural with restrictions) and almost half to class 3 (moderately impaired). Where the shores are heavily obstructed, ecological deficits may apply even if the water quality is good. Lake Constance is a case in point. In the Baden-Wuerttemberg part of the upper lake, 39 % of the shore length has been classified as unnatural or heavily altered, 20 % as impaired, and 41 % as natural or semi-natural. This poses a threat to the good ecological status of the shallow water zone.

There is currently no uniform mapping and classification method for structural quality that is applicable to all lake types in Germany. Consequently, unlike watercourses, there is no nationwide mapping of hydromorphological variables in lakes. It is hoped that current research projects will rectify this deficit. In an initial stage, a uniform nationwide method will be developed for classifying the shore structure of the entire lake. Biologically effective structural quality parameters will also be formulated which are closely linked to the structure-indicating bio-elements macrozoobenthos and macrophytes. It is hoped that this will facilitate the use of type-specific hydromorphological variables as a supporting criterion for the assessment of ecological status and (if applicable) potential.

6.2.2 Nutrient and trophic status of lakes

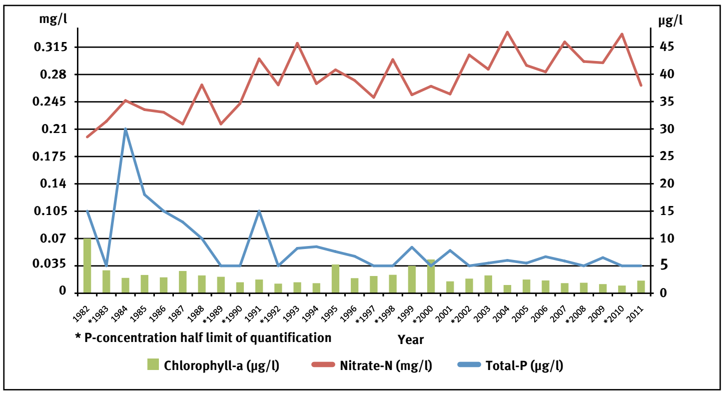
The biggest problem for lakes in Germany remains the excessive inputs of nutrients and the resulting over-fertilisation (eutrophication) of the lakes. High concentrations of the nutrients phosphorus and nitrogen may accelerate algal growth in stagnant waters. Possible adverse consequences include high turbidity, oxygen deficits, fish mortality, restrictions on use for drinking water, and allergic reactions in bathers. The limiting nutrient for algal development is usually phosphorus. During high summer, however, nitrogen limitation may also occur in lakes. Under such conditions, there is the possibility of the mass development of blue-green algae, which are capable of absorbing nitrogen from the air. The influence of wastewater as a source of pollution has decreased considerably in recent years, thanks to improved wastewater treatment technology and the introduction of phosphate-free detergents. The diagrams below illustrate the annual concentrations of chlorophyll, nitrate and phosphorus in selected lakes.

The Alpine and pre-Alpine lakes are examples where phosphorus concentrations have been reduced as a result of improved wastewater treatment technology.

In **Lake Constance**, total phosphorus concentrations increased almost fivefold between 1960 and 1980, while the biomass of plankton algae quadrupled over the same period. Thanks to improved wastewater treatment methods and the introduction of phosphate-free detergents, there has been a marked reduction in phosphorus concentrations since then, and they are now below the specified limit range for total phosphorus (cf. also Water Resources Management in Germany, Part 1).

Starnberger See, which was low in nutrients until around 1950, recorded rising levels of nutrient pollution from the mid-to late 1960s as a result of wastewater discharges. The perimeter sewage system constructed in two stages in the 1970s helped to relieve nutrient pollution. Further efforts are aimed at minimising emissions from agriculture as a result of extensification. A significant reduction in phosphorus levels inside the lake was not seen until around the mid-1980s, due to the long retention period; by the late 1990s, total phosphorus concentrations had been reduced to below 10 µg/l.

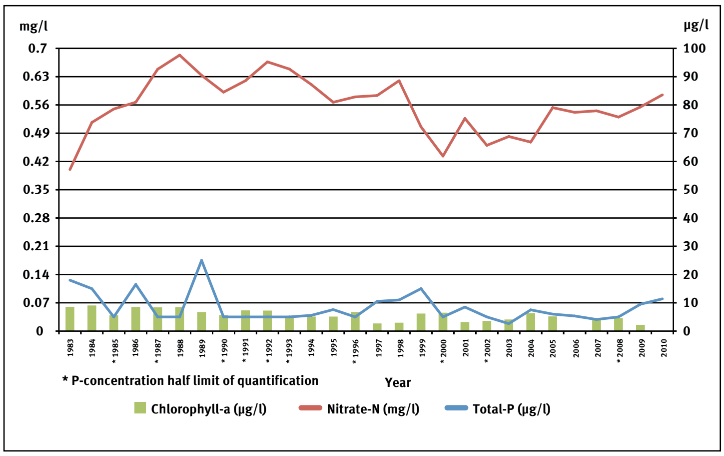
Figure 51: Starnberger See (annual means 1982-2011, chlorophyll-a, nitrate-N and phosphorus)



Source: Federal Environment Agency based on data supplied by the Bayerisches Landesamt für Wasserwirtschaft (Bavarian Water Resource Management Agency)

Chiemsee indicates a similar development to Starnberger See (**Figure 52**). Although this is Germany's third-largest lake, unlike Starnberger See it has only a relatively short retention period of one year. Thanks to good water mixing and a shallow depth, the nutrient situation improved quickly. Wastewater was discharged into the lake until the late 1980s. Thanks to improved wastewater treatment technology and the construction of a perimeter sewage system, the lake status became weakly eutrophic. At present, the lake is in the process of transition to a mesotrophic status. As in Starnberger See, phosphorus is the limiting factor.

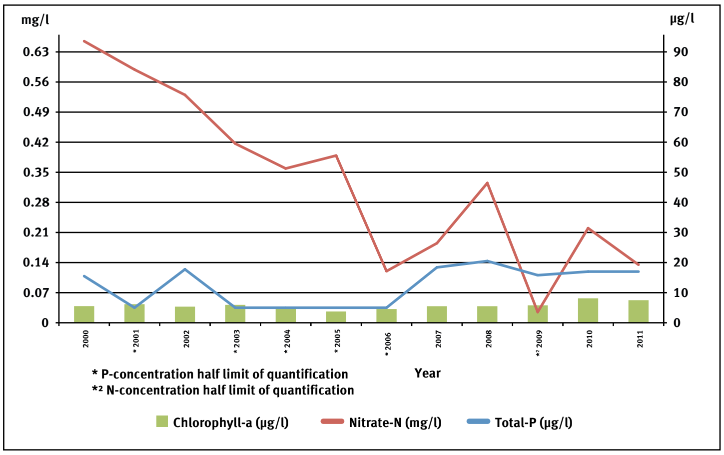
Figure 52: Chiemsee (annual means 1982-2011, chlorophyll-a, nitrate-N and phosphorus)



Source: Federal Environment Agency based on data supplied by the Bayerisches Landesamt für Wasserwirtschaft (Bavarian Water Resource Management Agency)

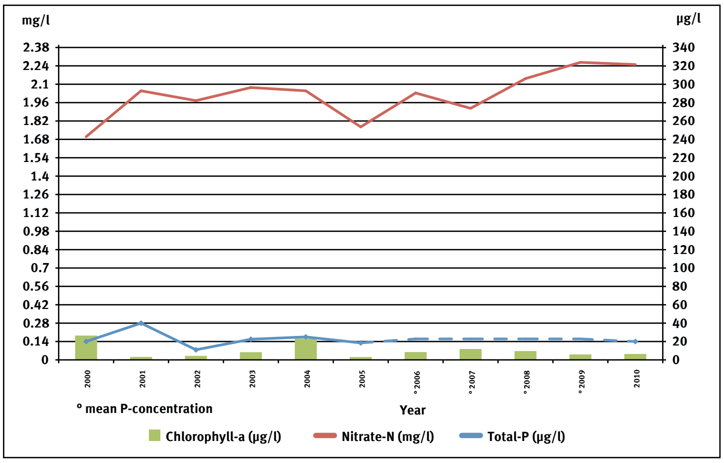
In some of the lakes of the Central German Highlands, improvements have likewise become apparent in recent years, as illustrated by the examples of **Brombachsee** (**Figure 53**) and **Edersee Reservoir** (**Figure 54**). Brombachsee, a reservoir lake in the Franconian lake district, is phosphorus-limited. In 1994, a wastewater treatment plant was built near Brombachsee and a perimeter sewage system constructed to prevent untreated wastewa--ter from entering the lake. Over the past ten years, the status of the lake has shown a marked improvement. Annual average nitrate levels are now in the region of 0.15 mg N/l. The lake is an important local recreation facility for the Nuremberg conurbation area, and also serves as a flood defence for the Altmühl valley.

Figure 53: Brombachsee (annual means 2000-2011, chlorophyll-a, nitrate-N and phosphorus)



Quelle: Zusammenstellung des Umweltbundesamtes nach Angaben des Bayerischen Landesamtes für Wasserwirtschaft

Figure 54: Edersee Reservoir (annual means 2000-2010, chlorophyll-a, nitrate-N and phosphorus)

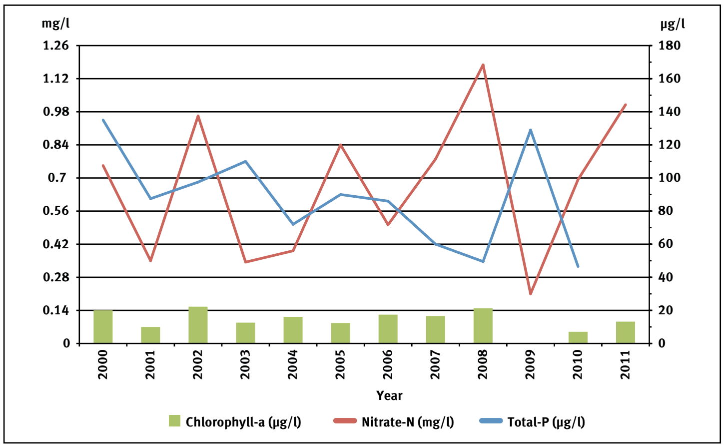


Source: Federal Environment Agency based on data supplied by by the Hessian State Agency for Environment and Geology

The **Edersee Reservoir**, a reservoir lake in Hesse, supplies water to the Mittelland Canal and the Oberweser, and is also used as a local recreation facility and to generate hydropower. Once again, for many years, wastewater and emissions from adjacent agricultural land were discharged into this water body. Nitrate concentration levels remain unchanged at a high average level of 2.2 mg/l.

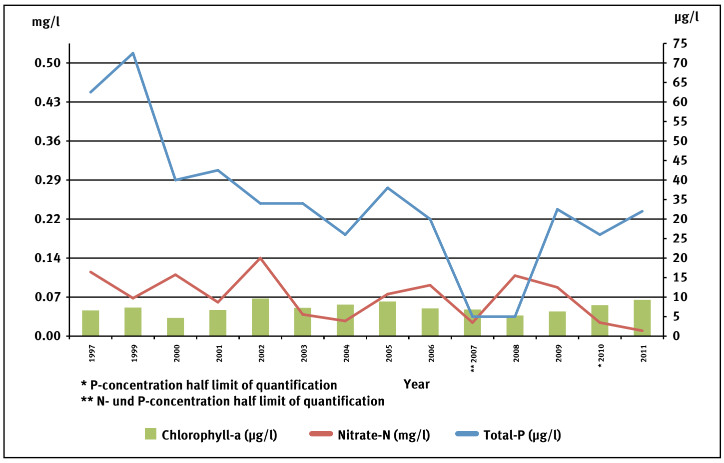
In the past, the lakes of the North German lowlands, particularly in the new Federal States, were heavily polluted with nutrients resulting from inadequate wastewater technology and diffuse emissions from agriculture. However, the influence of wastewater as the cause of eutrophication has diminished considerably in recent years. **Figures 55** and **56** illustrate conditions in **Kummerower See** and **Plauer See**.

Figure 55: Kummerower See (annual means 2000-2011, chlorophyll-a, nitrate-N and phosphorus)



Source: Federal Environment Agency based on data supplied by the Mecklenburg-Western Pomerania State Agency for Environment, Nature Conservation and Geology

Figure 56: Plauer See (annual means 2000-2011, chlorophyll-a, nitrate-N and phosphorus)



Source: Federal Environment Agency based on data supplied by the Mecklenburg-Western Pomerania State Agency for Environment, Nature Conservation and Geology

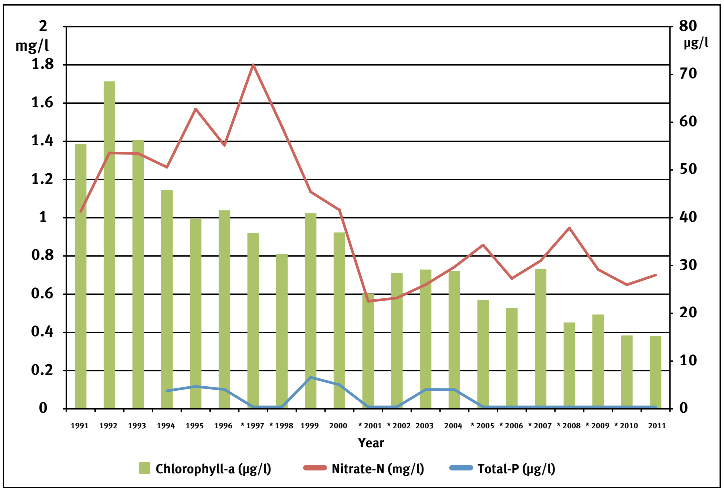
Both of these are shallow lakes with an average depth of 6 metres (Plauer See) and 8 metres (Kummerower See) respectively, and a short retention period. Agricultural use predominates over a large catchment area (around 1,200 km² in each case). The trout farming practised in Plauer See since the 1970s has contributed to the lake's eutrophication. Today, Plauer See is nitrogen-limited.

The **Upper Havel** (**Figure 57**) is a lake-like extension of the river Havel in Berlin, which absorbs discharge from Tegeler See. As a result of the heavy eutrophication of Tegeler See due to sewage irrigation practices in the 1970s and 1980s, phosphorus concentrations in the Upper Havel remained high throughout the 1990s. The phosphate precipitation plant constructed in the 1980s in the inflow to Tegeler See (Tegeler Fließ) substantially improved conditions in Tegeler See and the Havel. The depth aeration system constructed in Tegeler See in 1995 actually caused total phosphorus levels to deteriorate, since circulation in the deep water of the lake during the summer distributed phosphates throughout the lake. Nitrogen levels have improved in the past 15 years and now average at 0.7 mg/l. The lake is phosphorus-limited.

Zeuthener See (**Figure 58**), on the border between the states of Berlin and Brandenburg, is a nitrogen-limited shallow lake. This is a nutrient-rich, polytrophic lake with a high level of phytoplankton production. The low nitrate levels of 0.7 mg/l are attributable to the limiting of nitrogen. The reference status of the lake is eutrophic.

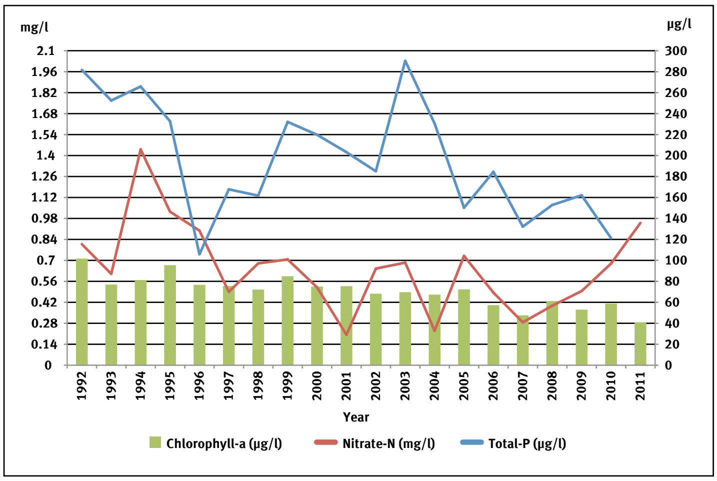
In **Schweriner See** (**Figure 59**), phosphorus pollution levels have also been reduced since 1994 by diverting the city of Schwerin's wastewater out of the lake's catchment area, and by improving wastewater treatment in a number of local communities. As well as acute oxygen problems with the formation of hydogen sulphide in deep water, eutrophication in the lake, with phosphorus concentrations in the milligram range during peak periods, was also manifested in the regular appearance of blue-green algal bloom, the extinction of certain oxygen-loving fish, some cases of acute fish mortality, and the appearance of filamentous green algae in the riparian zone. Overall, the status of Schweriner See remains very unstable to this day.

Figure 57: Upper Havel (annual means 1991-2011, chlorophyll-a, nitrate-N and phosphorus)



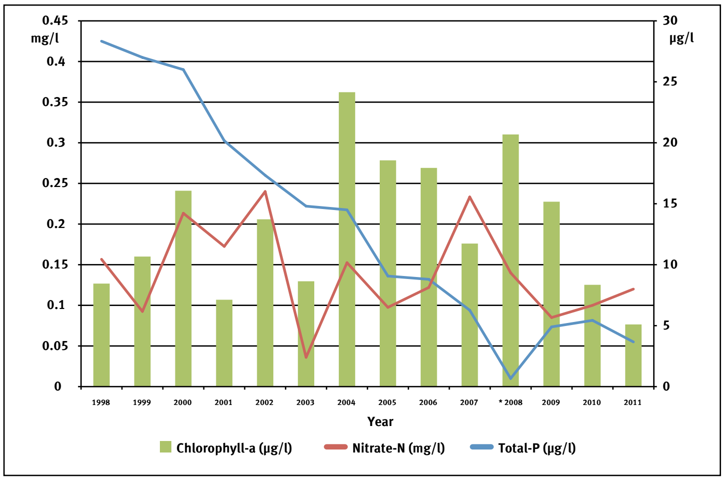
Source: Federal Environment Agency based on data supplied by the Senate Department for Urban Development and the Environment, Berlin

Figure 58: Zeuthener See (annual means 1992-2011, chlorophyll-a, nitrate-N and phosphorus)



Source: Federal Environment Agency based on data supplied by the Senate Department for Urban Development and the Environment, Berlin

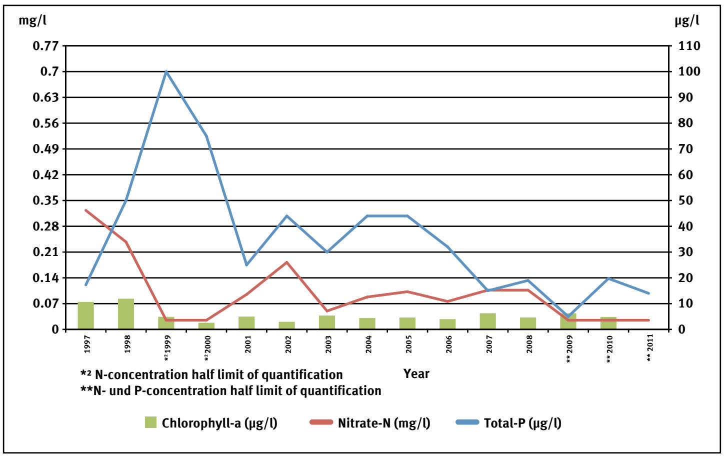
Figure 59: Schweriner See (annual means 1998-2011, chlorophyll-a, nitrate-N and phosphorus)



Source: Federal Environment Agency based on data supplied by the Mecklenburg-Western Pomerania State Agency for Environment, Nature Conservation and Geology

Germany's second-largest lake, the **Müritz** in the Mecklenburg Lakes region, is likewise nitrogen-limited. The high phosphorus levels associated with the discharge of wastewater and intensive agricultural activity in the past have improved since the 1980s, and continue to do so. Today, the Müritz is classed as mesotrophic to weakly eutrophic, although the bays still indicate elevated nutrient concentrations. It can be assumed that large quantities of phosphorus are still fixed in the lake sediment, and could be re-released as the oxygen concentrations decrease.

Figure 60: Müritz (annual means 1997-2011, chlorophyll-a, nitrate-N and phosphorus)



Source: Federal Environment Agency based on data supplied by the Mecklenburg-Western Pomerania State Agency for Environment, Nature Conservation and Geology

Despite persistently high nutrient pollution levels in many areas of the lowland lakes, improved wastewater treatment has led to a significant reduction in phosphorus concentrations in recent years. In future, measures to reduce eutrophication must focus in particular on diffuse nutrient emissions from agriculture. For some types of lakes, however, additional restoration measures will be needed to reduce the trophic level. However, such internal measures (deep water aeration, sediment treatment, calcite precipitation etc.) rely on a dramatic reduction in nutrient emissions from the catchment area in order to be effective.

The following table (**Table 25**) lists the trophic assessment for selected lakes since 1990. The graduation of actual status to reference status is colour-coded as per the key. Assessment indicates that in almost all lakes, the actual status is at least one trophic class higher than the reference status.

However, the list also shows that the trophic assessment based on one year's data only partially reflects the biological water status. For example, in the Müritz and Plauer See, the strong fluctuations in most parameters and the very different phytoplankton and zooplankton successions from year to year indicate that the status of these lake ecosystems changes from one year to the next.

Owing to the morphology of their lake basin (very deep, steep sides, high hypolimnion/epilimnion ratio), many **former mine lakes** offer favourable parameters for the development of clear, low-nutrient lakes. For the transition from empty excavation to filled mining lake, it is preferable to flood with external water from rivers rather than allowing them to fill with rising groundwater, for a number of reasons. Rapid flooding reduces the risk of landslips, and especially of soil liquefaction, at the sides of the mining lake. Another aim is to equalise the water deficit in the whole of the post-lignite mining landscape, and especially the deficit in the groundwater balance (cf. **chapter 3.2**), more quickly by flooding the excavations with surface water. The quality requirements governing the water used to flood the lake should prevent excessive eutrophication. LAWA in collaboration with the Federal Environment Agency has drawn up quality recommendations for mining lakes and their inflows and outflows (LAWA brochure "Tagebaurestseen – Anforderungen an die Wasserqualität", 2001).

Table 25: Trophic assessment of selected lakes in Germany

Trophic condition							
Lake	Reference	1990	1995	1996	1997	1998	1999
Ammersee	oligotrophic	m	m	m	m	m	m
Arendsee	oligotrophic	-	-	e1	e1	e1	e1
Bodensee	oligotrophic	m	m	m	m	m	m
Brombachsee	oligotrophic	-	-	-	-	-	-
Chiemsee	oligotrophic	e1	m	m	m	m	m
Dobersdorfer See	mesotrophic	e2	-	-	-	-	p1
Edersee Reservoir	oligotrophic	-	-	-	-	-	-
Goitzschesee	oligotrophic	-	-	-	-	-	-
Großer Müggelsee	mesotrophic	p1	e1	e1	e1	e2	e2
Großer Plöner See	oligotrophic	-	-	-	-	e1	e1
Kochelsee	oligotrophic	-	-	-	-	-	-
Königssee	oligotrophic	-	-	-	-	-	-
Kummerower See	mesotrophic	-	-	-	-	e1	e2
Laacher See	oligotrophic	e1	e1	e1	e1	e1	e1
Langbürgner See	oligotrophic	-	-	-	-	-	-
Muldestausee	mesotrophic	-	-	-	-	-	-
Müritz (Outer Müritz)	mesotrophic	-	-	-	m	e1	m
Müritz (Inner Müritz)	mesotrophic	-	-	-	m	e1	m
Upper Havel	weakly eutrophic	-	-	-	-	-	-
Ostersee	oligotrophic	-	-	-	-	-	-
Plauer See	mesotrophic	-	-	-	e1	m	m
Rappbode Reservoir	oligotrophic	-	-	-	-	-	-
Sacrower See	mesotrophic	-	e1	e1	e1	e1	e1
Scharmützelsee	mesotrophic	-	e2	e2	e2	e2	e1
Schweriner See (Outer Lake)	mesotrophic	-	-	-	-	e1	e1
Schweriner See (Inner Lake)	mesotrophic	-	-	-	-	e1	e1
Staffelsee	oligotrophic	-	-	-	-	-	-
Starnberger See	oligotrophic	m	m	m	m	m	m
Stechlinsee	oligotrophic	-	-	o	o	o	o
Steinhuder Meer	weakly eutrophic	p2	p2	p2	p2	p2	e2
Tegernsee	oligotrophic	-	-	-	-	-	-
Unterbacher See	mesotrophic	-	-	-	e1	e1	e1
Walchensee	oligotrophic	-	-	-	-	-	-
Wörthsee	oligotrophic	-	-	-	-	-	-
Zeuthener See	weakly eutrophic	-	-	-	-	-	-

reference status [1]	oligotrophic (o)	mesotrophic (m)	weakly eutrophic (e1)	highly eutrophic (e2)	weakly polytrophic (p1)	highly polytrophic (p2)	hypertrophic (h)
oligotrophic							
mesotrophic							
weakly eutrophic							
highly eutrophic							
weakly polytrophic							

[1] Highly polytrophic and hypertrophic conditions result from human pressures and thus cannot be used as a reference status.

Source: Federal Environment Agency based on data supplied by LAWA, 2012

	Trophic											
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	m	m	m	m	m	m	m	m	m	m	m	m
	e1	e1	e1	e2	e2	e2	e2	e2	e1	e2	e1	e1
	m	m	m	m	m	m	m	m	m	m	m	m
	m	m	m	m	m	m	m	m	m	m	m	m
	m	o	m	o	m	m	m	m	m	m	m	m
	e2	e2	p1	e2	e2	e2	e2	e2	-	-	-	-
	m	m	m	m	m	m	e1	e1	e1	m	m	m
	-	-	-	-	-	-	-	-	m	m	o	o
	e1	e2	e1	e2	e1	e2	e1	e1	e1	e1	e1	e1
	m	e1	e1	m	m	m	m	m	m	-	-	-
	o	m	-	m	-	-	-	o	-	-	-	-
	o	-	-	-	-	-	-	-	-	-	-	-
	e2	e1	p1	e2	e2	e2	e2	e2	-	-	-	-
	-	-	-	-	-	m	-	-	m	-	m	m
	-	-	-	-	-	o	-	-	-	-	-	-
	-	-	e2	e2	e1	e2	e1	m	e1	m	m	m
	m	m	m	m	m	m	m	m	m	-	-	-
	m	m	m	m	m	m	m	m	m	-	-	-
	-	-	-	-	-	-	e2	e2	e2	e2	e2	e2
	-	m	-	-	o	-	-	-	m	-	-	-
	m	m	m	m	m	m	m	m	m	-	-	-
	-	-	e1	e1	m	m	m	m	m	m	m	m
	e2	e1	e1	e2	e1	e1	e1	e1	e1	-	-	-
	m	e1	e2	m	m	m	m	m	m	-	-	-
	p1	e1	e2	e2	e2	e1	e1	e1	e1	-	-	-
	e1	e1	e2	e2	e2	e1	e1	e1	e1	-	-	-
	m	m	-	-	m	-	-	m	-	-	m	m
	m	o	m	m	o	o	m	o	o	o	o	o
	o	o	o	o	o	o	o	o	o	-	-	-
	e2	e1	e1	p2	p1	-	-	-	-	-	-	-
	o	-	-	-	-	-	-	-	o	-	-	-
	e1	e1	e1	e1	e1	e1	e1	e1	e1			
	o	o	-	o	-	-	o	-	o	-	-	-
	o	m	m	m	-	o	-	-	o	-	-	-
	e2	e2	e2	e2	e2	e2	e2	e2	e2	e2	e2	e2

6.2.3 Ecological status

Among lakes in Germany with an area of more than 0.1 km² (of which there are almost 2,000), 871 are assessed under the mapping provisions of the EC Water Framework Directive (lakes with an area of more than 0.5 km²). As a result, to date 553 lake water bodies (75.9 %) have been assessed as natural, 89 (12.2 %) as heavily modified waterbodies and 87 (11.9 %) as artificial waterbodies (cf. **Figure 61**).

Among the natural lakes,

- 12 % are assessed as having a "high" status
- 27 % as "good"
- 39 % as "moderate"
- 18 % as "poor", and
- 4 % as "bad".

Among heavily modified lakes,

- 28 lakes are assessed as "good and above"
- 41 as "moderate", and
- 20 as "poor".

Artificial lakes are classed as "good and above" (42 lakes), "moderate" (39), "poor" (5) and "bad" (1) (cf. **Figure 61**).

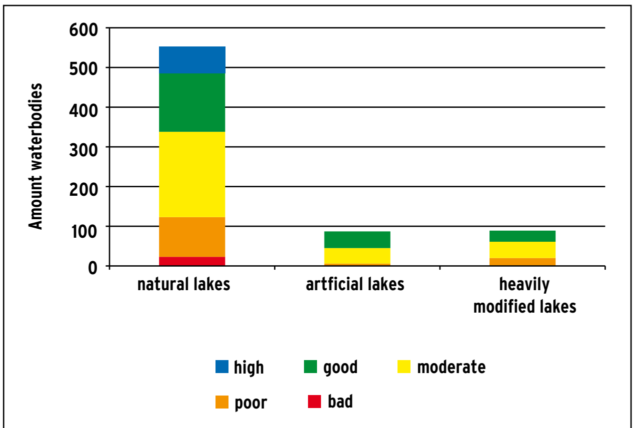
Excessively high nutrient inputs are the main reason why lakes fall short of "good ecological status" or "good ecological potential". The Alpine and pre-Alpine lakes exhibit the best quality, with a good or even high status exhibited almost throughout. Among lakes in the North German lowlands, approximately half of the deep, stratified lakes (types 10 and 13, cf. **chapter 6.1.1**) exhibit a good or better status, but this is only true of 15 % (types 12 and 14) and 30 % (type 11) respectively of the shallower, unstratified lakes (cf. also **Figure 62**).

The good and high ecological status of the pre-Alpine lakes is attributable to the early reduction of phosphorus concentrations, thanks to improved wastewater treatment technology and the installation of a perimeter sewage system in the mid-1970s. The comparatively shallow lakes of the North German lowlands, however, have large catchment areas generally characterised by agricultural use, and merely reducing nutrient emissions from point discharges alone will not be sufficient. In the new Länder, where many of these shallow lakes are located, nutrient emissions were not reduced until the early 1990s when wastewater treatment technology was improved, and the trophic levels of most lakes tend to respond to such nutrient reductions with a delay.

The ecological status of lakes was generally determined on the basis of phytoplankton and macrophytes or phytobenthos (cf. **chapter 6.1.2**).

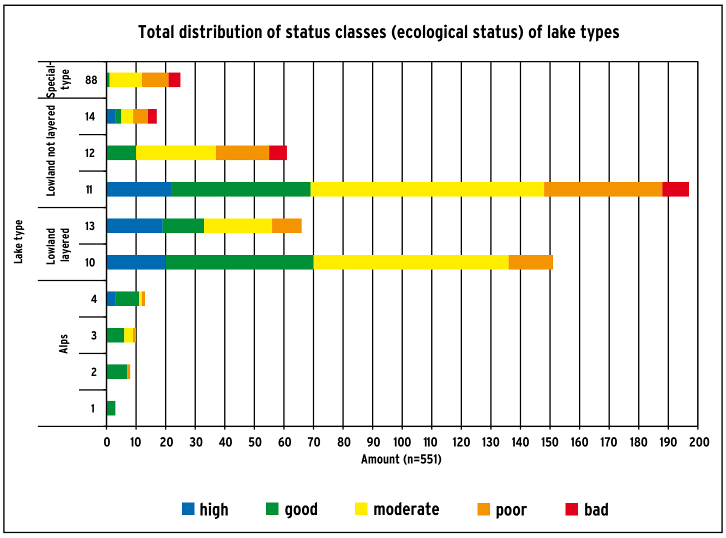
The phytoplankton community is particularly responsive to nutrient pollution levels in lakes. For half of natural lakes, the status of phytoplankton was evaluated as "good" or "high" (**Figure 63**). For macrophytes, a similar assessment was only achieved by 37 % of lakes. The poorer macrophyte status could be

Figure 61: Ecological status of natural lakes (n=553) and ecological potential of artificial (n=87) and heavily modified (n=89) lake waterbodies in Germany (number of water bodies not assessed: 142)



Source: Federal Environment Agency; data supplied by LAWA, data source: Reporting tool WasserBLicK/BfG, as of 22 March 2010

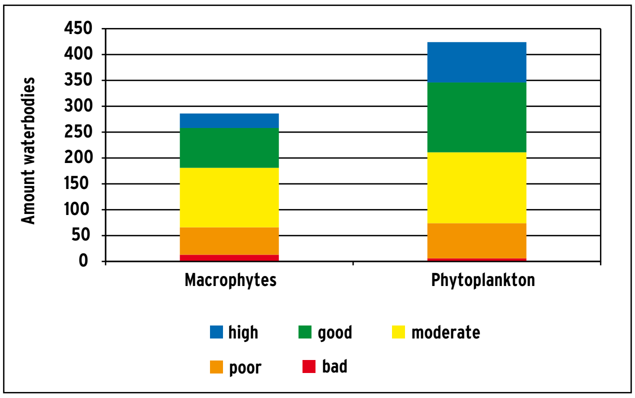
Figure 62: Ecological status of natural lakes, divided according to lake types in Germany (number of water bodies not assessed: 82)



Source: Federal Environment Agency; data supplied by LAWA, data source: Reporting tool WasserBLicK/BfG, as of 22 March 2010

attributable to the higher nutrient and pollutant levels in the lake sediment compared with the open waters, together with structural-morphological pressures, to which macrophytes respond sensitively. Furthermore, aquatic plants do not naturally re-establish themselves until phytoplankton biomass has been reduced over a period of several years.

Figure 63: Ecological status of the biological quality elements macrophytes/phytobenthos and phytoplankton for natural lake waterbodies



Source: Federal Environment Agency; data supplied by LAWA, data source: Reporting tool WasserBLicK/BfG, as of 22 March 2010

6.2.4 Chemical status

92 % of the waterbodies in Germany's lakes achieve a "good" chemical status (as at 22.3.2010). In isolated cases, the environmental quality standards are exceeded for certain heavy metals, pesticides and PAH. If the environmental quality standards from the Environmental Quality Standards Directive are applied, 100 % of waterbodies would probably fall short of the target of a "good chemical status".

7 Transitional, coastal and marine waters

7.1 Basis for assessment

Under the Water Framework Directive, the ecological status of transitional and coastal waters (up to 1 nautical mile) is assessed on the basis of biological, hydromorphological, chemical and general physico-chemical quality elements (**chapter 4.2.1**). Additionally, the Habitats Directive assesses selected rare species and habitat types and designates protected areas for them also in coastal and marine waters. The European regulations were completed in 2008 with the adoption of the EU Marine Strategy Framework Directive (MSFD). This directive requires the Member States to undertake an initial assessment of coastal and marine waters by mid-2012. The regional conventions on the protection of the marine environment (such as OSPAR, HELCOM) evaluate biological parameters and the overall ecological status of the North and Baltic Seas, too. As the EC Water Framework Directive, EU Marine Strategy Framework Directive, Habitats Directive and regional conventions overlap in their application areas, it is important to develop harmonised assessment methods and to review existing procedures for their general applicability.

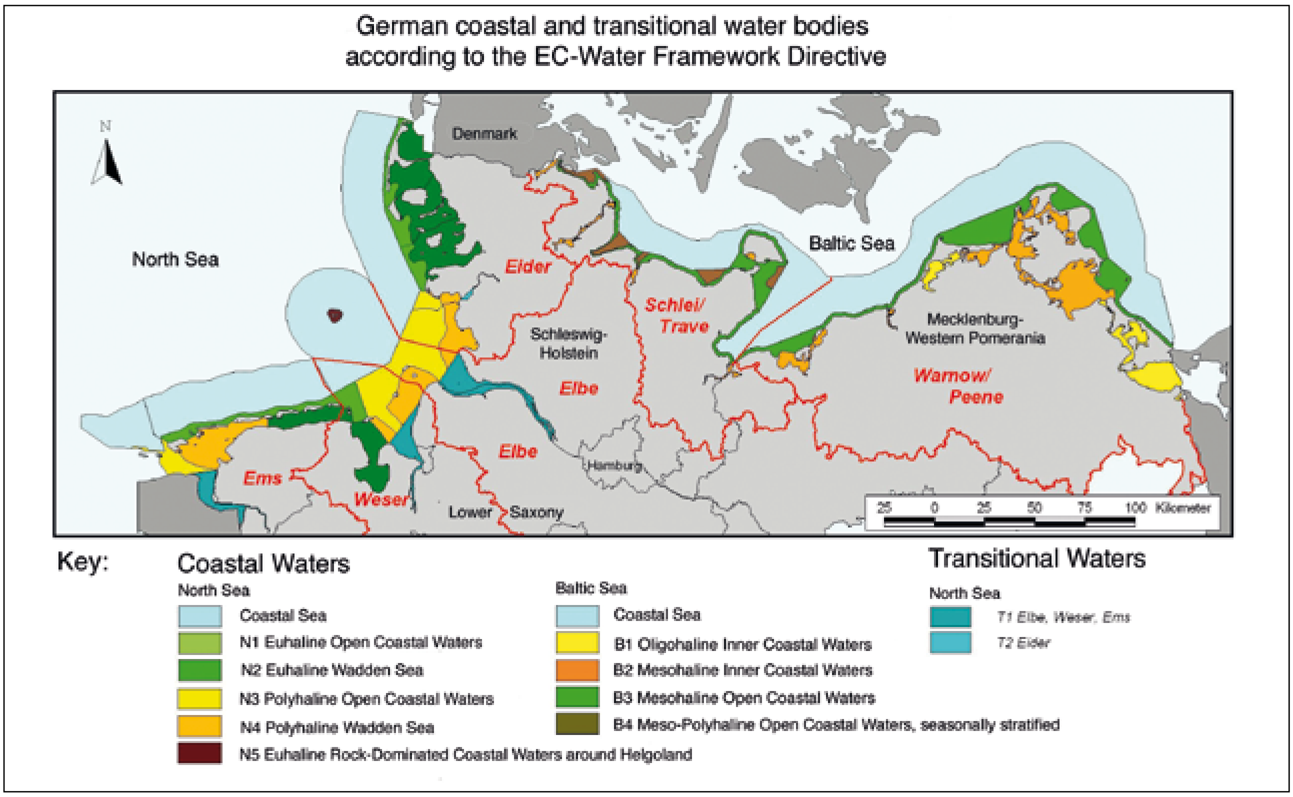
7.1.1 Assessment methods under the Water Framework Directive

Types of transitional and coastal waters

Transitional waters are divided into two types (type T1: transitional waters Elbe, Weser, Ems; type T2: transitional waters Eider).

The characterisation of coastal waters is based on the obligatory factors of geographical latitude, geographical longitude, salt content and depth, together with the optional physico-chemical factors current velocity, wave exposure, water temperature and fluctuation range, the composition of the substrate and turbidity (visibility). Along the German Baltic Sea coast, four main types B1 to B4 (**Figure 64**) and six sub-types (not shown on the map), delineated by salt content, are distinguished. Germany's North Sea coast is divided into five types of coastal waters (N1 to N5), with salt content and sediment composition used as typology criteria (**Figure 64**). As a general rule, the Wadden Sea coast is demarcated from the more exposed outer coasts. The coastal waters around Helgoland have been designated a separate type. The types of transitional and coastal waters are listed in Annex 1 to the Ordinance on Surface Waters.

Figure 64: Types of transitional and coastal waters



Source: LAWA

Table 26: Assessment methods used for biological quality elements

Quality element	Area	Assessment techniques and parameters	Bibliography
Phytoplankton (microalgae)	North Sea	**NEA GIG** Parameters: Biomass (Chl a), Phaeocystis	European Union (2008) DÜRSELEN et al. (2006)
	Baltic Sea	**Baltic GIG** Phytoplankton indicators for the ecological classification of Germany's Baltic Sea coastal waters Parameters: Biomass (Chl a)	European Union (2008) SAGERT et al. (2008)
Macrophytes (large algae and angiosperms)	Transitional waters	**Site-typification methods (STIM) acc. to Adolph** Parameters: Species diversity, abundance, expansion, zoning ▸ Emerse vegetation ▸ Brackish and salt meadows ▸ Opport. algae	STILLER (2005) STILLER (2007) ARENS (2006)
	North Sea	**Techniques according to Reise, Adolph, Arens** Parameters: Species diversity, coverage, zoning ▸ Seagrass meadows ▸ Opport. algae ▸ Brackish and salt meadows	DOLCH et al. (2009) JAKLIN et al. (2007) ADOLPH at al. (2007) ARENS (2006)
	Helgoland	**HPI (Helgoland Phytobenthic Index)** Parameters: Species diversity, expansion, depth limit	KUHLENKAMP et al. (2009)
	Baltic Sea, outer waters	**BALCOSIS** Parameters: Depth limit, seagrass & Fucus, opport. algae	SCHORIES et al. (2009) FÜRHAUPTER UND MEYER (2009)
	Baltic Sea, inner waters	**ELBO** Parameters: Depth limit, characeae and spermatophytes, loss of plant communities	SCHUBERT et al.(2003) SELIG et al. (2008)
Macrozoobenthos (Benthic invertebrates)	Transitional waters	**Estuary typology techniques (AeTV)** Parameters: Abundance, sensitive taxa, tolerant taxa	KRIEG (2005)
	North Sea	**M-AMBI** Parameters: AMBI index, species diversity, diversity	MUXIKA et al. (2007) HEYER (2006, 2009)
	Helgoland	**Helgoland MarBIT module** Parameters: Species diversity, sensitive taxa, tolerant taxa	Boos et al. (2009)
	Baltic Sea	**MarBIT – Baltic Sea macrozoobenthos classification system for the WFD** Parameters: Species diversity, abundance, sensitive taxa, tolerant taxa	MEYER et al. (2005) MEYER et al (2008)
Fish	Transitional waters	**FAT-TW** Parameters: Species spectrum, abundance, indicator species	Bioconsult (2006)

Source: Federal Environment Agency based on the German Marine Monitoring Programme BLMP, 2010

Biological quality elements

The basis for assessment has already been outlined in detail in **chapter 4**. This is the reason why below, focus is on selected aspects of the ecological assessment of coastal waters. The EC Water Framework Directive assesses ecological status on the basis of four biological quality elements. Tried and tested assessment methods are now available for the biological quality components phytoplankton (microalgae), macrophytes (large algae, flowering plants), macrozoobenthos (invertebrate bottom-dwellers) and fish (only in the transitional waters of Ems, Weser, Elbe and Eider) (cf. **Table 26**).

Intercalibration results

Table 27 provides an overview of the results of intercalibration following completion of the second (2008-2011) intercalibration phase for assessment methods used for transitional and coastal waters of the North and Baltic Seas. The table includes all successfully and conclusively intercalibrated assessment methods (assessment methods from Annex I of the new Intercalibration Decision). According to the latest Intercalibration Decision, all pending intercalibrations must be completed by 2016.

Hydromorphological quality elements

Annex V of the Water Framework Directive lists "morphological conditions" and "tidal regime" as hydromorphological quality elements for classifying the ecological status of transitional and coastal waters. These quality elements have a supporting effect in the classification of ecological status/ecological potential, in that they help to determine the reference conditions (high status or maximum ecological potential) (see **chapter 4.2.1**).

General physico-chemical quality elements

Annex 6 of the Ordinance on Surface Waters specifies type-specific concentration ranges for salinity, total nitrogen, inorganic nitrogen, nitrate nitrogen, total phosphorus and orthophosphate phosphorus, which apply to classification in the "high" status, as reference conditions for the general physico-chemical quality elements (cf. **chapter 4.2.1**).

Table 27: Ecological quality quotients of the intercalibrated national assessment methods

Intercalibrated national classification systems (biological quality element or sub-element in brackets)	Intercalibrated national waterbody type	Ecological quality quotients	
		Limit high/good status	Limit Good/moderate status
Phytoplankton (biomass parameter: Chlorophyll a)	North Sea: N1 and N2	0.67	0.44
SG - Assessment system for sea grass of the coastal and transitional waters implementing the EC Water Framework Directive in Germany	North Sea: N3 and N4	0.80	0.60
FAT – TW - Fish-based assessment tool for transitional waters of the North German estuaries	North Sea transitional waters: T1	0.84	0.62
Benthic invertebrates: MarBIT – Marine Biotic Index Tool	Baltic Sea: National types B3 and B4 in Schleswig-Holstein from the Danish border to Dahmeshöved.	0.80	0.60
Phytoplankton (biomass parameter: Chlorophyll a)	Baltic Sea: National type B3 in Mecklenburg-West Pomerania from Darßer Ort to the Polish border.	0.80	0.60
Phytoplankton (biomass parameter: Chlorophyll a)	Baltic Sea: National types B3 and B4 in Schleswig-Holstein from the Danish border to Dahmeshöved.	0.80	0.60
Macroalgae and angiosperm (depth limit of ***Zostera marina***)	Baltic Sea: National types B3 and B4 in Schleswig-Holstein from the Danish border to Dahmeshöved.	0.90	0.74

Source: Federal Environment Agency following Resolution 2013/480/EU

7.1.2 Assessment methods under the Habitats Directive

The Habitats Directive, which entered into force in 1992, is designed to safeguard and protect wild species, their habitats, and the Europe-wide linking of such habitats. One of the central pillars of this Directive is the creation of a coherent network of protected areas, "NATURA 2000", which also includes protected areas under the Birds Directive of 1979 (79/409/EC). Its second pillar comprises species conservation provisions for endangered species throughout Europe that cannot be preserved by protected areas, for example because they are to be found over large areas in certain habitats. For marine ecosystems, nine habitat types had been identified as particularly worthy of protection, including two sea habitats that are far from the coast (reefs, sandbanks). Marine species listed in the Habitats Directive and to be found in Germany are mammals (porpoise, common seal, grey seal), various species of birds, and six species of fish, none of which is exclusively sea dwelling. These are migratory species spawning in fresh water (anadrome species), like the salmon. The conservation status of species is assessed using four parameters: current range, population, species habitat, and future prospects. For habitat types, the parameters are current range, current area, specific structures and functions, and future prospects. Each parameter is assessed for a given species or habitat using specified criteria with limits and threshold values, and allocated to one of three assessment levels: favourable (green), unfavourable/inadequate (amber) and unfavourable/bad (red) (so-called "traffic-light" system). If the data does not facilitate a precise assessment of the parameters, they are classified as unknown (grey). The parameter with the poorest assessment determines the overall result.

7.1.3 Assessment methods under the Marine Strategy Framework Directive

The EU Marine Strategy Framework Directive requires the regular assessment of coastal waters as well as marine waters in the Exclusive Economic Zone (EEZ). A first initial assessment was published in 2012. The current marine status of individual marine regions was recorded and assessed, and the "good environmental status" to be achieved was described and defined using 11 descriptors (cf. **Table 28**). These are outlined and more precisely defined with the aid of characteristics (EU Marine Strategy Framework Directive: Annex III, Table 1) and pressures/impacts (EU Marine Strategy Framework Directive: Annex III, Table 2) listed in the Directive. Two descriptors refer to marine biology, and one to the integrity of the seabed (habitat). The remaining eight descriptors primarily refer to the anthropogenic pressures resulting from specific uses. A decision by the EU Commission defines the criteria and methodological standards (2010/477/EU) as the basis for a harmonised European-wide assessment of "good environmental status", and specifies a total of 56 indicators. Whereas the initial assessment of Germany's marine waters in 2012 was primarily based on assessments under the EC Water Framework Directive, Habitats Directive, OSPAR and HELCOM, it is important

Table 28: Overview of descriptors of good environmental status (EU Marine Strategy Framework Directive)

Qualitative descriptors for determining good environmental status
1. Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.
2. Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.
3. Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
4. All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.
5. Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.
6. Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected
7. Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
8. Concentrations of contaminants are at levels not giving rise to pollution effects.
9. Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.
10. Properties and quantities of marine litter do not cause harm to the coastal and marine environment.
11. Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

Source: EU Marine Strategy Framework Directive, Annex I, 2008 that the next assessment in 2018 will review and, where necessary, operationalise the indicators in the Commission's Decision of 2010 for their applicability to the North and Baltic Seas. Moreover, a suggestion that the EU Marine Strategy Framework Directive should require an overall assessment of environmental status incorporating all descriptors is currently under debate. Such overall assessment could be guided by a grouping of descriptors into "status related descriptors" (3 descriptors: biodiversity D1, food web D4 and ocean floor D6) and "pressure related descriptors" (8 descriptors of anthropogenic pressures and their impacts).

Whereas sophisticated assessment methods for certain pressures (such as eutrophication, contaminants and sub-aspects of fishing) and their impacts on organisms and populations are already well-documented, for other less investigated factors such as noise contamination of the oceans and inputs of litter, suitable assessment methods are still at the development stage.

For macrozoobenthos, fish fauna, phytoplankton and macrophytes, assessment methods have already been developed and tested during the course of implementing the EC Water Framework Directive (cf. **Table 26**). However, corresponding methods are still lacking for an assessment of avifauna, zooplankton, sea birds and marine mammals. It is therefore advisable to begin with the methods of the Water Framework Directive available and to successively (where necessary) supplement these with methods from the Habitats and Birds Directives, from OSPAR and HELCOM etc.

7.1.4 Assessment methods under the international marine conventions (OSPAR, HELCOM)

The regional conventions on the protection of the marine environment of the North-East Atlantic (OSPAR Convention) and the Baltic Sea (Helsinki Convention) address the assessment of environmental status for the respective Convention waters, and in recent years have extended this to a comprehensive holistic overall assessment. The corresponding work at OSPAR and HELCOM has in part led to harmonised procedures that the Marine Strategy Framework Directive can now build on.

With its Baltic Sea Action Plan, HELCOM pursues the vision of a "healthy Baltic Sea environment with balanced biological elements" based on a hierarchical strategy comprising four segments: eutrophication, hazardous substances, biodiversity and maritime activities. There are a number of ecological objectives assigned to each of these areas, achievement of which is assessed according to a series of parameters to be measured.

2010 saw the publication of the first ever holistic assessment of the marine environment of the Baltic Sea (HELCOM HOLAS), evaluating data from 2003-2007. The assessment is based on the ecosystem approach and considers a number of relevant pressures and their impacts on marine organisms, and includes the current status of the ecosystem as well as trends. Like the Water Framework Directive, it uses a five-point evaluation scale. However, the results of this assessment differ from the Water Framework Directive because it uses different assessment methods, among other things.

OSPAR, meanwhile, focuses on thematic strategies in the areas of biodiversity, eutrophication, hazardous substances, radioactive substances, and offshore oil and gas extraction. The OSPAR assessment, unlike HELCOM and the Water Framework Directive, only uses a three-point scale, but like the Water Framework Directive is also guided by reference values reflecting the status of the ecosystem uninfluenced by humans. The assessment systems for eutrophication, hazardous substances and radioactive substances are well-developed, whereas assessment and monitoring of biodiversity is still in its infancy.

Supplementary to its thematic strategies, OSPAR has developed a series of ecological quality objectives intended to facilitate a holistic evaluation of the seas based on the ecosystem approach. The quality objectives characterise specific anthropogenic pressures (fishing, marine litter etc.). They were derived from the objectives of the thematic strategies (hazardous substances, nutrients), and function as superordinate indicators of the status of marine ecosystems (e.g. healthy seal populations). Compliance with the quality targets was reviewed for the first time in the Quality Status Report 2010. The Quality Status Report 2010 provides an overview of the status of the North-East Atlantic and its principal pressures, evaluates the success of management measures, and prioritises future measures. This is the second Quality Status Report covering the entire North-East Atlantic. Earlier reports (1987, 1993) were confined to the North Sea. As well as ecological quality objectives, the Quality Status Report 2010 trials a second approach for the holistic assessment of marine ecosystems, incorporating the principal pressures and their cumulative effects. Experiences with this approach reveal that extensive development work is still needed in this area, particularly with regard to implementation of the Marine Strategy Framework Directive.

The Marine Strategy Framework Directive's entry into force radically transformed the role of the regional conventions on the protection of the marine environment. HELCOM and OSPAR increasingly function as coordination platforms for the implementation of the Marine Strategy Framework Directive, and their work currently focuses on the development of regional core indicators, used, for example, in the Baltic Sea to implement both the Baltic Sea Action Plan and the Marine Strategy Framework Directive.

7.1.5 Quality assurance in marine monitoring

A Quality Assurance Panel at the Federal Environment Agency has been charged with ensuring the quality and comparability of analytical results in the German Marine Monitoring Programme of the North and Baltic Seas (GMMP). This is an independent panel not directly involved in the monitoring. Quality management systems based on DIN EN ISO/IEC 17025 are to be introduced throughout all institutions involved in marine monitoring by 2014. A template of a quality management manual tailored to the specific needs of the GMMP and templates of standard operating instructions for selected biological methods have been made available by the Quality Assurance Panel to the institutions involved in the GMMP.

The use of reference materials (RMs) and certified reference materials (CRMs) is an important measure of internal quality assurance. RMs and CRMs represent homogeneous and stable materials of which the content of certain chemicals is known exactly. In the case of CRMs, the concentrations have been established with a high degree of accuracy using internationally recognised methods, and confirmed in a certificate. RMs and CRMs may be used to calibrate a measurement device or to evaluate a measurement method (validation, verification).

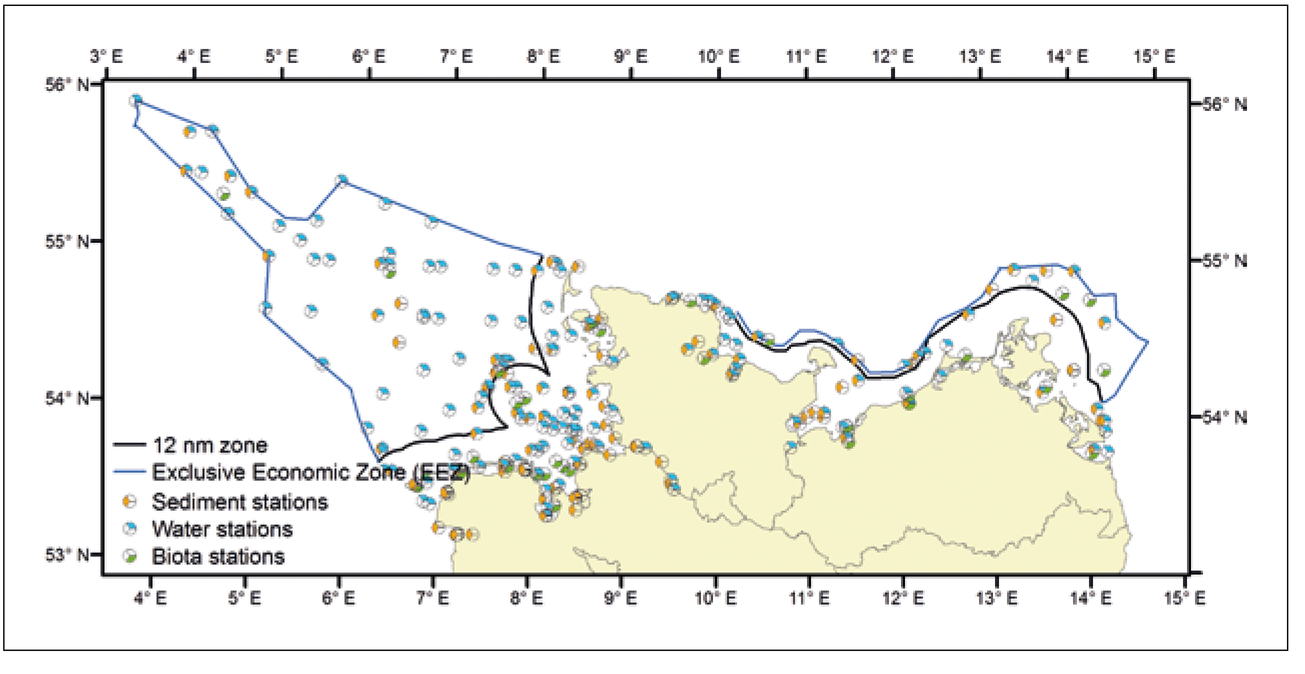
Proficiency tests and laboratory intercomparisons are the most important measures of external quality assurance. For chemical measurements, QUASIMEME (Quality Assurance of Information for Marine Environmental Monitoring in Europe) is the leading proficiency testing provider in marine monitoring. It offers proficiency tests for many parameters on a regular basis, e.g. the determination of nutrients, heavy metals and a wide range of organic pollutants in seawater, marine sediment, and biota samples.

Laboratory comparisons for biological parameters have been found to be feasible and expedient as well. They can be used to identify deficits in data quality. For example, such comparisons might be used to evaluate the taxonomical expertise of the participating laboratories with regard to species identification and accuracy of counting organisms. This helps to ensure comparability of data collected within the GMMP, and to detect potential problem areas regarding the identification of certain organism groups.

7.1.6 Monitoring networks in the North and Baltic Seas

The marine environmental database MUDAB is the central database of the BLMP. It is operated by the Federal Institute of Hydrology (Bundesanstalt für Gewäs-

Figure 65: German stations for monitoring of biota, sediments and water in the North and Baltic Seas (2008-2011)



Source: MUDAB, BfG, 2012

serkunde, BfG) in Koblenz on behalf of the Federal Environment Agency. MUDAB contains data for water, sediment and biota obtained for defined monitoring sites in the BLMP (**Figure 65**).

Data on the accumulation of heavy metals and organic pollutants in biota of the North and Baltic Seas is based on data from the Federal Environmental Specimen Bank.

7.2 Status monitoring

7.2.1 Hydromorphology

The coastal region is characterised by hydrodynamics and morphology. Driving forces include, on the one hand, astronomical and meteorological effects which control the tides and waves; and on the other – with a significantly longer time scale of more than one hundred years – climate change and rising sea levels. Man interferes with this system via a diverse range of activities, leading to changes in morphology which, for their part, invoke changes in hydrodynamics with reciprocal influences on morphology.

Quality element "morphological conditions"

The morphology of the coastal waters is subject to a high level of natural dynamics, broad sections of which are only exposed to minimal human influence. Depending on the acting hydrodynamic forces, shore areas expand or are eroded. Tidal inlets alter their position and the height level of the tidal areas changes.

The morphology of transitional and coastal waters is influenced, inter alia, by the following anthropogenic interventions:

- Dredging in estuaries and in coastal waters
- Flood barriers in estuaries (such as the Ems and Eider)
- Structures at sea, shipyards and harbours
- Land reclamation and polders
- Offshore wind farms, transformer substations etc.
- Sand and gravel extraction
- Beach nourishment, sand replenishment and similar coastal protection measures
- Bottom-trawling and
- Dams and diversion structures.

Since dyke construction first began in the 11th century, the transitional and coastal waters – like virtually every other habitat in Central Europe – have become increasingly removed from their natural status as a result of human intervention.

In some areas, over the centuries man has exerted a significant influence on morphological development. For example, solid structures have been raised to protect islands in the North Sea, particularly on what were once dynamically-changing flow channels. Whereas in the past, the location, shape and size of the islands changed constantly, their position has been fixed by the construction of revetments and groins since approximately the mid-19th century, and the natural dynamics have been suppressed as a result.

However, these structures have failed to contain the acting hydrodynamic forces, as a result of which these areas tend to be affected by erosion, which is counteracted by further reinforcement of the structures, and since around the 1950s, by artificial beach nourishment. As a result of this human intervention, the dynamics in the transitional zone of the tidal areas to the open sea have been restricted, while in the areas behind and at the side of an island, natural processes continue to act comparatively uninfluenced.

A far more severe human intervention with considerable impacts on the morphodynamics of the coastal and transitional waters has occurred as a result of the expansion of the navigable channels of the rivers Ems, Jade, Weser and Elbe since the 19th century. As a result of dredging and the construction of stream deflectors and groins, the position of the shipping lane was fixed, preventing the previously potential dynamic shifts. For example, in the Ems estuary, the Geise stream deflector extends across approximately 12 km in the vicinity of the Dollart, while the other seaward part of the transitional water is not influenced by such structures. In the case of the Weser, groins and stream deflectors extend across the entire transitional water into the coastal water, and restrict natural morphodynamic development. From the beacon "Kugelbake" in Cuxhaven, a long stream deflector in the river Elbe extends seawards. In addition to these larger measures, various local encroachments have occurred, such as beach replenishment or the reinforcement of smaller harbours.

The construction of flood barriers in river estuaries represents a massive encroachment. Along the German North Sea coast, the Eider and Ems flood barriers are particularly worth mentioning. These two structures pursue different objectives. The Eider flood barrier is intended to protect against storm flooding of the inland area and to safeguard the navigability of the Eider. The Ems flood barrier, however, as well as pursuing the same protective purposes, is primarily intended to ensure the flexibility of the Ems shipping lane (transit of large cruise ships from the ship yard in Papenburg to the North Sea). Both structures entail a range of ecological impacts such as loss of salt meadows and tidal flats, lowering of the groundwater level with consequences for i.a. the avifauna, and changes in the courses of rivers as e.g. increasing siltation and oxygen depletion in deeper areas, with associated consequences for flora and fauna.

Quality Element "tidal regime"

The transitional and coastal waters of the North Sea are characterised by the rhythm of tides. The tidal wave from the North Sea runs along the coast from west to east and into the estuaries with an average period of 12 hours and 25 minutes. The incoming tidal wave changes shape in its temporal characterisation and amplitude as it interacts with the relief, as a result of which the low tide becomes lower and the high tide higher. For example, the average tidal range off Borkum is around 2.2 m and increases by around 60 cm along the coast, and by a further 80 cm into the estuaries.

Sea level deflections caused by the passing tidal wave create horizontal water movements so-called tidal flows. The characteristics of high and low tide vary locally as a result of interactions with the relief. In the open seas, high tide runs in a west/east direction, and low tide in an east/west direction. Close to the coast and in the Wadden Sea, the currents vary over a small area in terms of speed, duration and direction according to the morphological structure of the region. Additionally, tidal flows are superimposed with wind-induced drift flows and barrier effects.

The EU Water Framework Directive also cites wave exposure as a further parameter regarding the quality element “tidal regime”. The sea state is created by the influence of the wind on the water’s surface. If acting upon the surface directly, it is known as wind sea, while the undulations that follow after the wind has subsided are known as swell. The energy-rich sea state of the open North Sea is subject to strong interactions with morphology due to decreasing water depths as it spreads along the coast. The flow field induced by the sea state is also deformed, which in turn impacts the wave movements on the surface.

In coastal waters, tidal events are relatively uninfluenced by direct anthropogenic impacts. However, there are small-scale influences as in the tips of islands secured by groins, since they divert the flows in their immediate environment.

Considerably stronger impacts are created by the structural measures in the estuaries of the rivers Ems, Weser and Elbe, where tidal conditions have changed significantly over the past 150 years. The river Weser is a good example. In the municipality of Bremen, the tidal range was just under 20 cm before construction work began on the Lower and Outer Weser at the end of the 19th century. Today, Bremen has the largest tidal range on the entire German North Sea coast, at over 4 m. As these types of changes have a lasting ecological effect, the transitional waters of the rivers Ems, Weser and Elbe were characterised as "heavily modified waterbodies" (HMWB).

The development of wave exposure in the coastal and transitional waters has not changed on a large scale. However, at local level it is influenced by the construction of groins, stream deflectors etc. Similarly, the fixing of the East Friesian flow channels has largely eliminated former spatial variations. Analogous conclusions apply to the proximity of artificial shipping channels in the estuaries.

In the first Water Framework Directive’s management plan, all transitional waters were designated as "heavily modified", with hydromorphological degradation cited as the reason for their failure to meet a good status. By contrast, out of the 67 bodies of coastal surface waters in Germany, only a few (5) are "heavily modified”, while 13 are rated as "not good" due to hydromorphological degradation.

7.2.2 Eutrophication

Eutrophication refers to the accumulation of nutrients (phosphorus, nitrogen) in the water as a result of human activities. This leads to the accelerated growth of microscopic algae (phytoplankton) and macrophytes (large, sessile algae and seagrass), causing undesirable disturbances to the biocoenoses in the water and the quality of the water itself. Over-fertilisation of the sea may lead to greater algal growth, shifts in species composition and lack of oxygen due to the bacterial decomposition of dead algae. This lack of oxygen impairs bottom-dwelling fauna and leads to fish mortality. What is more, it also leads to the development of toxic hydrogen sulphide and to the release of nutrients, which in turn amplify the eutrophication effects. Elevated nutrient inputs originate primarily from the fertilisation of agricultural land and from public and industrial wastewater, and are discharged into the oceans via the rivers. Atmospheric nitrogen emissions also play a role (e.g. emissions from agriculture, shipping, transport, power plants and industry).

7.2.2.1 Inputs

Nutrient loads are ascertained both directly in the rivers via measured substance concentrations and flow rates, and as nutrient inputs into the surface waters of the North and Baltic Seas calculated using the model approach (MoRE). In order to calculate the inputs from land into the North Sea, anthropogenic substance inputs from point and diffuse sources throughout the entire North Sea catchment area are quantified using the MoRE model (data as per the end of 2008). In the model results outlined below, retention in the water bodies is disregarded, in other words, the calculated inputs are higher than the recorded loads.

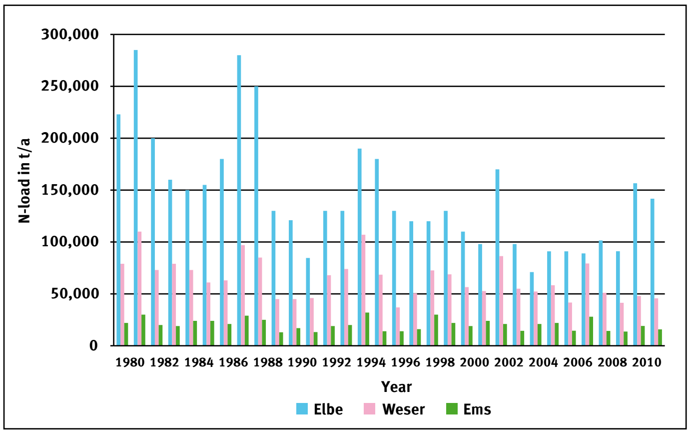
Inputs into the North Sea

The calculated nutrient loads at the mouths of the rivers Ems, Weser, Elbe and Eider are based on data series since 1980. Of these, the river Elbe accounts for the largest portion of nutrient inputs into the North Sea. The current trend is characterised by a constant reduction in nutrient loads (cf. **Figures 66** and **67**).

Phosphorus and nitrogen demonstrate pronounced behaviour depending on the water flow. Unlike phosphorus compounds (high level of soil binding), higher quantities of precipitation lead to increased leaching and run-off of nitrogen compounds from agricultural soils. In the case of nitrogen, allowing for run-off adjustments in the individual river basins, virtually no reduction in nitrogen loads between 1980 and 2011 has been observed. Only the river Elbe indicates an approximate 60 % decrease in nitrogen loads for the period 1990 to 2011, despite the influence of varying water flow rates. In the case of phosphorus, by contrast, since 1990, levels have clearly settled at a lower level than in the preceding years. The average reduction in phosphorus inputs into the North Sea via the rivers Elbe, Weser and Ems was around 70 % during the period 1990 to 2011.

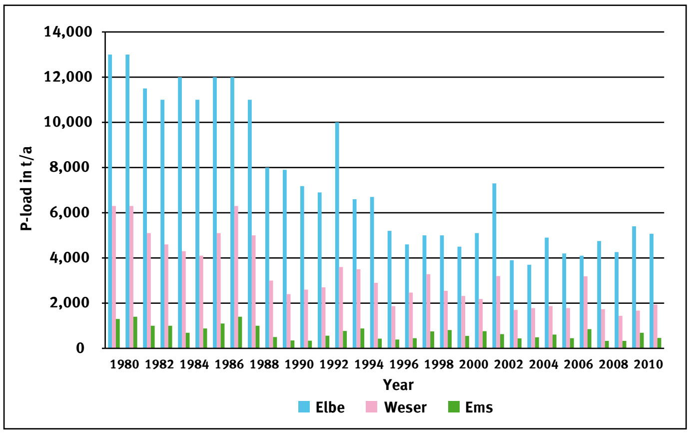
Between 1983-1987 and 2006-2008, nutrient inputs into the surface waters in the German North Sea catchment area were reduced from 804,038 t/a to 450,980 t/a in the case of nitrogen, and from 67,164 t/a to 20,517 t/a in the case of phosphorus. This translates into a 44 % input reduction in the case of nitrogen and of 69 % in the case of phosphorus in 2006-2008 compared with the period 1983-1987. The 44 % overall reduction in nitrogen inputs was achieved primarily due to the sharp decline (77 %) in nitrogen emissions from point sources. As a result of this, the proportion of nitrogen emissions from point sources was reduced to around 20 % of total emissions in 2006-2008 (cf. **Figure 68**). By contrast, nitrogen emissions from diffuse sources were only reduced by approximately 20 % by 2006-2008. Compared with 1995, there was even an increase in inputs from agriculture (groundwater, erosion, surface run-offs of mainly agricultural land and drainage). In 2006-2008, around 77 % of the total nitrogen inputs originated from agriculture, with inputs via the groundwater (54 %) and via drainage (16 %) playing a pivotal role. Nitrogen inputs via atmospheric deposition and erosion, accounting for 1 % and 2 % respectively, and surface run-offs from mainly agricultural land, at around 5 %, only account for a small proportion of the overall inputs into surface waters.

Figure 66: Total nitrogen inputs via Germany's inlets into the North Sea, 1980-2010



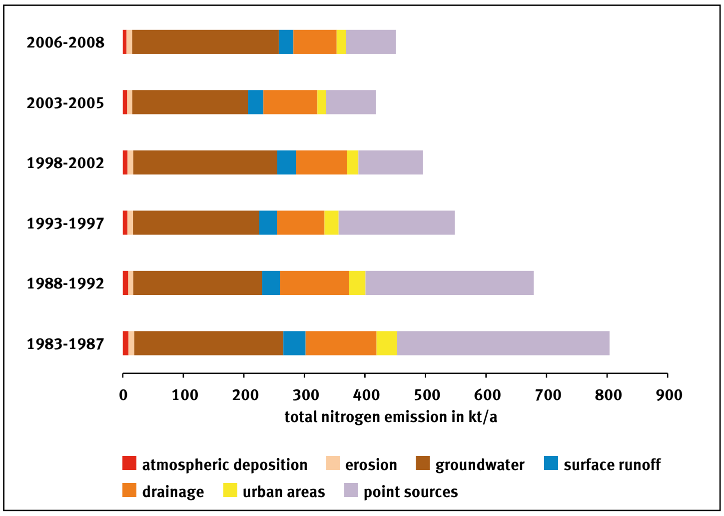
Source: Federal Environment Agency using data supplied by the Länder for reporting under OSPAR, as of 2011

Figure 67: Total phosphorus inputs via Germany's inlets into the North Sea, 1980-2010



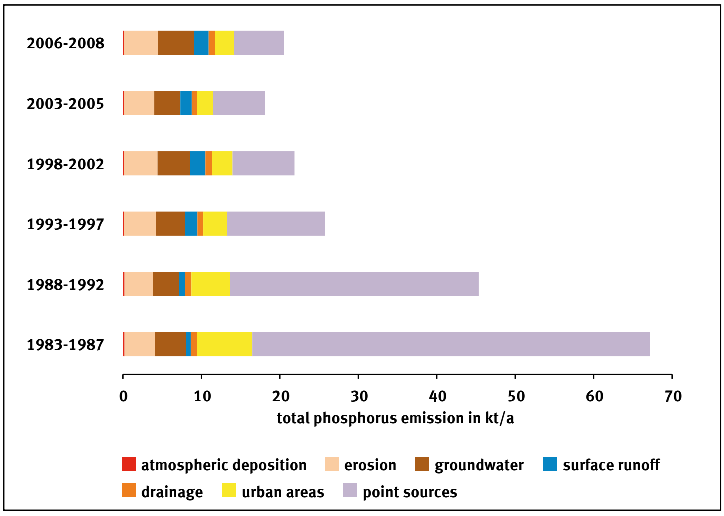
Source: Federal Environment Agency using data supplied by the Länder for reporting under OSPAR, as of: 2011

Figure 68: Nitrogen inputs into surface waters in the German catchment area of the North Sea



Source: Federal Environment Agency (MoRE), as of June 2013

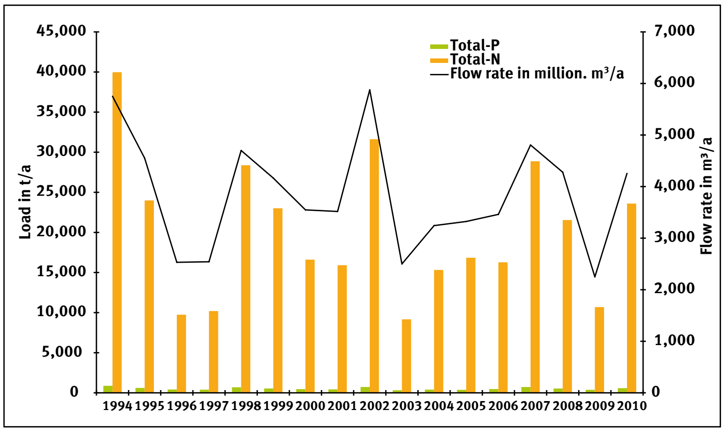
Figure 69: Phosphorus inputs into surface waters in the German catchment area of the North Sea



Source: Federal Environment Agency (MoRE), as of June 2013

The 69 % reduction in phosphorus inputs is likewise primarily attributable to the 87 % (approximate) reduction in phosphorus emissions from point sources. The huge reduction in phosphorus inputs from point sources meant that emissions from diffuse sources were dominant in 2006-2008, accounting for approximately 70 % ; around 57 % of these emissions are attributable to agriculture alone (groundwater, erosion, surface run-off and drainage) (cf. **Figure 69**). By contrast, phosphorus inputs from diffuse sources decreased only by 14 % in 2006-2008 compared with 1983-1987. This development was primarily due to the reduction in phosphorus inputs from surface run-off from (66 %) and from atmospheric deposition (26 %) which continued for the duration of the study. Conversely, inputs from agriculture have increased again. Overall, in 2006-2008, inputs via erosion represented the dominant diffuse pathway (21 % of total emissions).

Figure 70: Development of nutrient inputs via German rivers into the Baltic Sea, 1994-2010.



Source: Federal Environment Agency using data supplied by the Länder for reporting under HELCOM, as of 2011

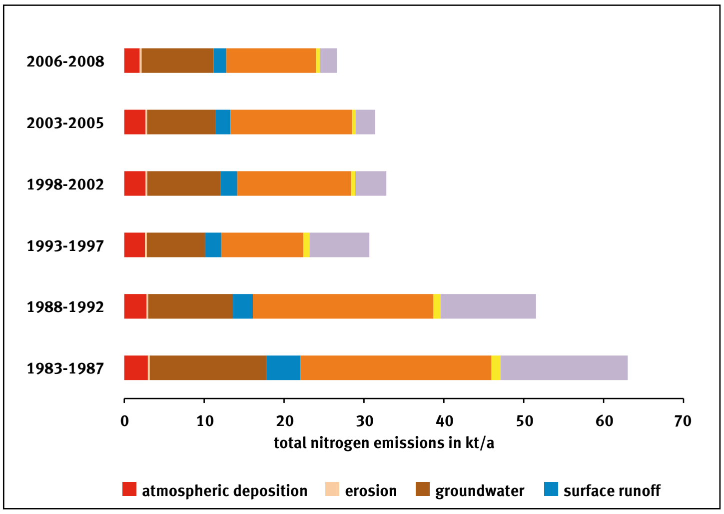
Inputs into the Baltic Sea

The loads of phosphorus and nitrogen compounds from German inflows into the Baltic Sea have been declining for many years (cf. **Figure 70**). However, there are some very sharp fluctuations from year to year, as a result of variations in flow rate. In 2010, around 24,000 t of nitrogen and 600 t of phosphorus were discharged into the Baltic Sea.

Between 1983-1987 and 2006-2008, nitrogen inputs into the surface waters of the German Baltic Sea catchment area were reduced from 63,018 t/a to 26,616 t/a, and phosphorus inputs from 3,645 t/a to 1,000 t/a. This translates into nitrogen reductions of 58 % and phosphorus reductions of 72 % (phosphorus) respectively in 2006-2008 compared with the period 1983-1987 (cf. **Figures 71** and **72**).

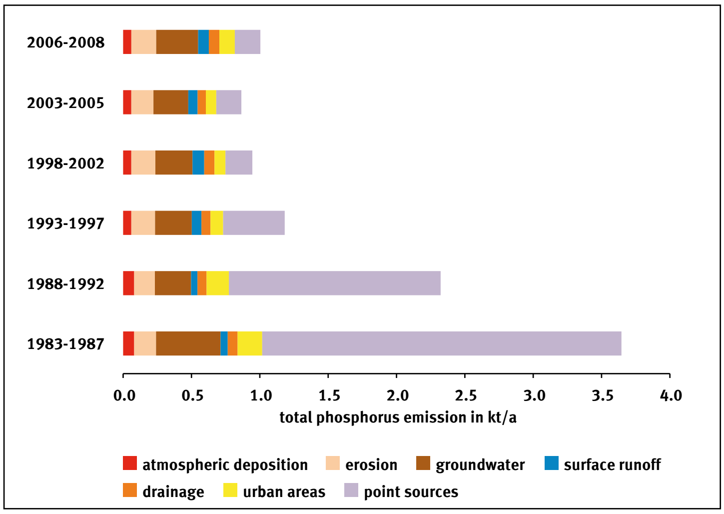
The 58 % reduction in nitrogen inputs was primarily due to the sharp decrease of approximately 85 % in nitrogen emissions from point sources. The share of nitrogen emissions from point sources decreased from 25 % to 8 % during the period under review. In comparison, diffuse sources gained in importance, with inputs from agriculture being the principal pathway (82 %). Overall, nitrogen emissions from diffuse sources were reduced by around 48 %. The dominant diffuse input pathways of the overall inputs were drainage (42 %) and groundwater (33 %).

Figure 71: Nitrogen inputs into surface waters in the German catchment area of the Baltic Sea



Source: Federal Environment Agency (MoRE), as of June 2013

Figure 72: Phosphorus inputs into surface waters in the German catchment area of the Baltic Sea



Source: Federal Environment Agency (MoRE), as of June 2013

The approximate 72 % reduction in phosphorus inputs is likewise primarily attributable to the 93 % reduction in emissions from point sources. The sharp reduction in phosphorus emissions from point sources meant that these no longer represented the dominant emission pathway from 2006 to 2008, accounting for 18 % as against 72 % in 1985. In 2006-2008, phosphorus emissions from diffuse sources accounted for 81 % of total phosphorus emissions, around 64 % of which were attributable to agriculture. Overall, phosphorus emissions from diffuse sources decreased by 20 % during the period under review, primarily due to the reduction in phosphorus emissions from run-off from sealed surfaces (37 %) and groundwater (35 %). Inputs from erosion and drainage increased. At the same time, there was a significant rise in inputs from elutriation from mainly agricultural land. Among diffuse sources, groundwater (30 %) and erosion (18 %) accounted for the bulk of total emissions.

7.2.2.2 Eutrophication of the North Sea

Besides fishing eutrophication represents the biggest threat to the North and Baltic Seas, and therefore plays a major role in marine protection. In order to combat eutrophication, a detailed survey of the eutrophication status is required before measures are initiated. For this purpose, an eutrophication assessment ("Common Procedure for the Identification of the Eutrophication Status of the OSPAR Maritime Area" (COMP)) was developed and harmonised between the Contracting Parties to the OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic. This is also one of the key components of the 2010 OSPAR strategy for tackling eutrophication, which aims to achieve and maintain a healthy environment devoid of eutrophication by 2020 at the latest. Despite a significant reduction in nutrient inputs via the rivers that flow into the North Sea, this ambitious target remains a challenge.

The COMP procedure comprises a set of assessment criteria designed to facilitate a harmonised assessment of eutrophication in marine areas. The method evaluates the degree of nutrient enrichment as well as the direct and indirect effects of eutrophication (cf. **Table. 29**). Based on this assessment, the areas are divided into problem areas (PA), potential problem areas (PPA) and non-problem areas (NPA). This designation approach has proven effective in practice, but must be adapted to accommodate new challenges (such as climate change).

The first application of the harmonised OSPAR eutrophication assessment was published in 2003. This report classified the inner German Bight, including the Wadden Sea, as a problem area. This is connected offshore to a transitional zone classified as a potential problem area. The results of the assessment for the remainder of the North Sea indicate that the southern North Sea is particularly affected by eutrophication, together with some large areas along the Norwegian and Swedish coasts and a number of British estuaries. The results of the second application of the COMP procedure were presented in June 2008. The OSPAR report revealed that the strategic objective of a healthy marine environment devoid of eutrophication has only been partially met to date. Of the 204 areas assessed, OSPAR classified 106 waters, usually close to the coast, as problem areas, including all coastal waters of the North Sea (cf. **Figure 73**). Compared with the status report of 2003, there was no significant change

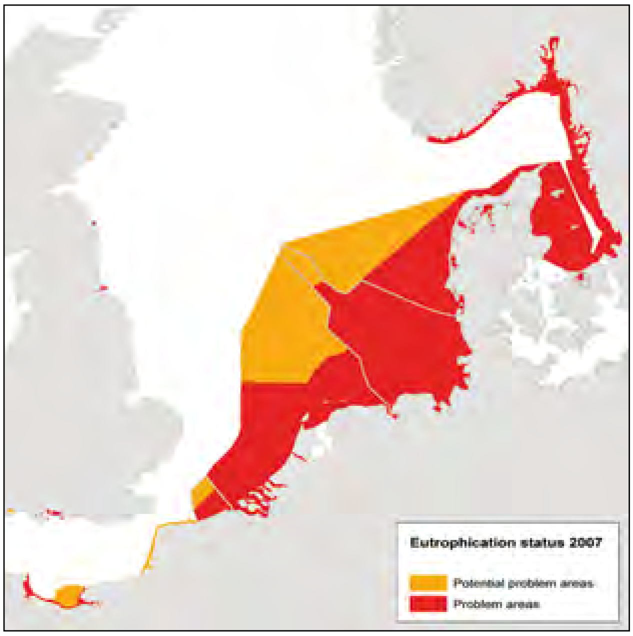
Table 29: Criteria for assessing the physico-chemical and biological parameters of eutrophication

Category	Assessment parameter
I	**Degree of nutrient enrichment**
	1 Riverine inputs and direct discharges (area-specific) Elevated inputs and/or increased trends of total N and total P (compared with previous years)
	2 Nutrient concentrations Elevated levels (defined as concentration > 50 % above salinity-related and/or region-specific background concentrations) of winter DIN and/or DIP and total nitrogen and phosphorus
	3 Winter N/P ratio (Redfield N/P = 16) Elevated in relation to natural Redfield ratio (> 50 % deviation: > 25)
II	**Direct effects of nutrient enrichment (during growing season)**
	1 Chlorophyll a concentration (area-specific) Elevated maximum and mean levels or 90 percentile (defined as concentration > 50 % of regional (e.g. open sea) background concentrations)
	2 Phytoplankton indicator species (area-specific) Elevated levels of nuisance/toxic phytoplankton indicator species (and increased duration of blooms)
	3 Macrophytes including macroalgae (area-specific) Shifts from long-lived to short-lived nuisance species (e.g. *Ulva*) Elevated levels (biomass or area covered) especially for opportunistic green macroalgae
III	**Indirect effects of nutrient enrichment (during growing season)**
	1 Oxygen deficiency Decreased levels (< 2mg/l: acute toxicity, 2- 6 mg/l: deficiency) and lowered % oxygen saturation
	2 Zoobenthos and fish Kills (in relation to oxygen deficiency and/or toxic algae) Long-term area-specific changes in zoobenthos biomass and species composition
	3 Organic carbon/organic matter (area-specific) Elevated levels (in relation to oxygen deficiency, relevant in sedimentation areas)
IV	**Other possible effects of nutrient enrichment (during growing season)**
	1 Algal toxins Incidence DSP / PSP mussel infection events

DSP = Diarrhetic Shellfish Poisoning
PSP = Paralytic Shellfish Poisoning

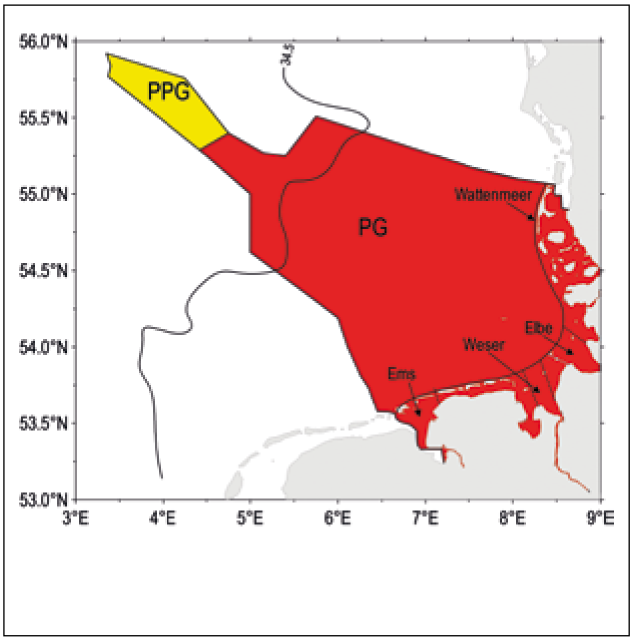
Source: OSPAR Commission, 2008

Figure 73: OSPAR eutrophication status of the North Sea, 2007 (assessment period 2001-2005)
Red zones = problem areas (PA)
Yellow zones = potential problem areas (PPA)
National boundaries of competence are indicated by grey lines.



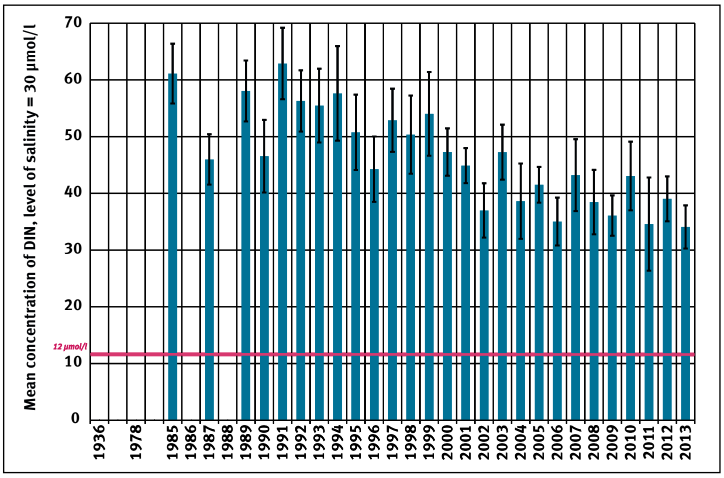
Source: OSPAR Commission, 2008

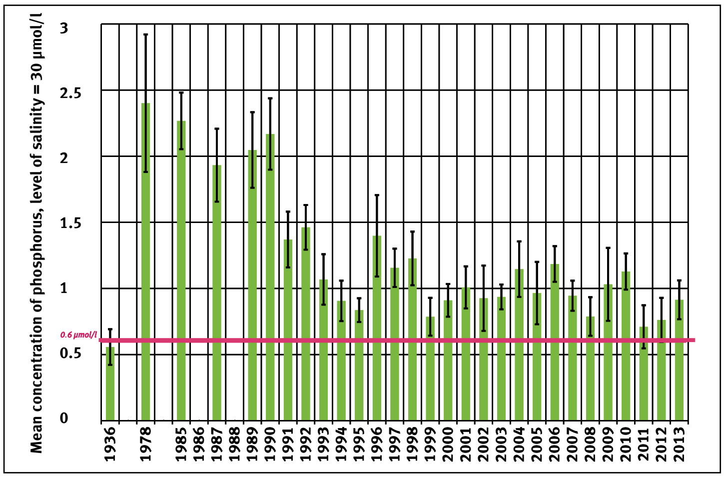
Figure 74: Eutrophication status of the German Bight and the German Exclusive Economic Zone (2007)
PPA = Potential problem area,
PA = problem area,
Wattenmeer = Wadden Sea



Source: OSPAR Commission, 2007

Figure 75: Time series of the concentrations of both dissolved inorganisc nitrogen, DIN (left figure) and phosphate concentrations (right figure) as well as standard errors in winter in the waters of the German Bight in comparison to OSPAR benchmarks





Source: Federal Maritime and Hydrographic Agency, 2013

in the eutrophication status of the North Sea by 2005. Although nutrient concentrations along the coast have fallen, thanks to some significant reductions in nutrient discharges via the rivers, this trend is not yet reflected in a decrease in phytoplankton concentrations (calculated as chlorophyll content). The southern North Sea, Kattegat and Skagerrak remain some of the most heavily eutrophied regions of the North-East Atlantic. The third application of the COMP procedure is scheduled for 2016, and shall therefore guarantee its use in the follow-on assessment under the EU Marine Strategy Framework Directive scheduled for 2018.

The OSPAR Contracting Parties had undertaken to reduce emissions of nitrogen and phosphorus by 50 % compared with 1985 levels. Whilst this reduction target was already met a long time ago for phosphorus by virtually all littoral states, further efforts are still needed by most Contracting Parties (with the exception of Denmark, the Netherlands and Germany) for nitrogen. Reduction scenarios aided by ecosystem models have shown that the aspired target of cutting 50 % of nutrient inputs via rivers will not be sufficient to eliminate eutrophication in the problem areas. Depending on the area, it may be necessary to reduce nitrogen by up to 90 %. Another problem is the time-delayed response of the marine ecosystem to reduced nutrient inputs. Scientists estimate that it could take 10 to 30 years for the eutrophication status of an affected region to significantly improve.

OSPAR has recognised that the blanket goal setting practised in the past was a good and important joint first step towards tackling eutrophication. Individual targets are now being set for the individual problem areas already identified and will incorporate nutrient emissions from neighbouring marine regions which may not themselves indicate any symptoms of eutrophication, as well as atmospheric nutrient emissions, into the balance sheets.

The German North Sea coast and the German Exclusive Economic Zone (EEZ) have been classified as problem areas with respect to eutrophication (cf. **Figure 74**). The main reason for the eutrophication of the German Bight are nutrient inputs from rivers, together with remote transportation from the British coast, the English Channel and the Dutch coast, with the counter-clockwise principal flow direction of the North Sea and atmospheric nitrogen emissions. Eutrophication problems decrease as nutrient concentrations become increasingly diluted towards the high seas. Eutrophication effects in the German North Sea include an elevated phytoplankton biomass, regular summer oxygen deficiency in the estuaries and frequently in the bottom waters of the German Bight, restricted water transparency (secchi depth), restricted spread of macrophytes, and changes to the populations of bottom-dwelling organisms (zoobenthos). Oxygen deficiency and phytoplankton eutrophication indicator species have even been observed from time to time in the open North Sea (outer Entenschnabel / "Duck's Bill").

Long-term studies of nutrients and plankton in the German Bight indicate that phosphate induced eutrophication of the German Bight began as early as the 1960s, partly as a result of the large-scale use of detergents containing phosphates. Average winter phosphate concentrations near Helgoland increased sharply until the mid-1970s. They remained at this level for around a decade and then fell again (**Figure 75**) as a result of measures to reduce phosphate, such as the introduction of phosphate-free detergents and the installation of phosphate elimination systems in industrial and public wastewater treatment plants. Winter nitrate concentrations started to increase sharply in the 1980s, and concentration levels have decreased since 1990, but to a much smaller extent than phosphate (**Figure 75**). Whereas the benchmark for phosphate of 0.6 µmol/l or 0.06 mg/l has almost been met, the benchmark for nitrate (12 µmol/l or 0.74 mg/l) is still exceeded more than three times, and concentrations have stagnated at this high level in recent years. For this reason, the situation is still far from satisfactory regarding the ecological impacts of eutrophication.

Blooms of the slimeball or "foam algae" *Phaeocystis globosa* are particularly noticeable in the Wadden Sea (**Fig. 76**). When these algal cells die off, the waves beat the layer of gelatine into foam, which is then blown ashore in large quantities by the wind.

Figure 76: Foam algae on Spiekeroog beach

Source: Federal Environment Agency

Since the early 1980s, oxygen deficiency has repeatedly been observed in the near-ground water layers of the German Bight during summer. The occurrence of this widespread phenomenon followed unusual phytoplankton blooms in spring. With descended biomass being reduced due to microbial decomposition, under certain hydrographical and meteorological conditions (stratified water bodies), oxygen depletion can occur in bottom waters. Depending on the geographical extent and duration of the oxygen deficiency, benthic organisms may be impaired to a greater or lesser extent. Adapted, robust and opportunistic species withstand this situation better than more sensitive species such as starfish and sea urchins. Some fish may flee the area and therefore have significantly higher rates of survival than sedentary organisms.

On the North Sea coast, the Wadden Sea represents a special habitat, also with regard to eutrophication, because organic matter is imported and degradation processes can exceed the primary production output. The littoral states Denmark, Germany and Netherlands had classified the Wadden Sea as a eutrophication problem area in 2000-2005 following the application of the OSPAR COMP. In the Wadden Sea, eutrophication has led to algal bloom (foam algae Phaeocystis and green macroalgae), a reduction in the seagrass population, and oxygen deficiency in the sediments. There are regional differences in the level of eutrophication, with the southern Wadden Sea generally being more severely affected by eutrophication.

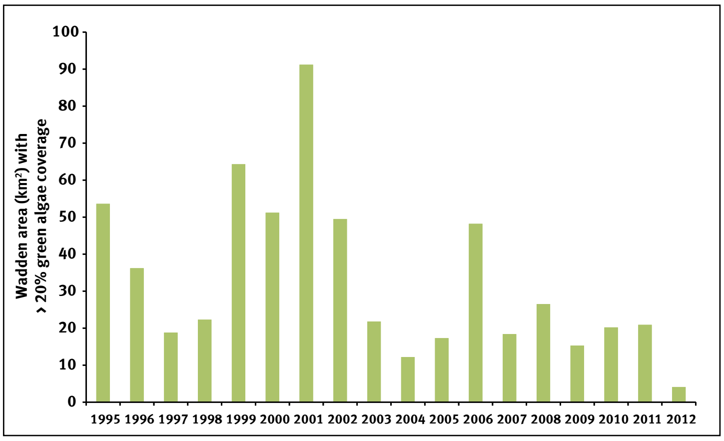
Elevated cell densities of potentially toxic *Dinophysis* species repeatedly occur in the Lower Saxony Wadden Sea. They form a toxin which can cause diarrhoea and vomiting in humans (DSP, diarrhetic shellfish poisoning). It is absorbed by eating mussels, which can accumulate this toxin after ingesting Dinophysis. If the DSP limits in mussel flesh are exceeded, common mussels are prohibited from sale in Germany. Macroscopically visible carpets of green algae occurred for the first time over a large area in the Wadden Sea around twenty years ago, and are an indicator of advancing eutrophication (**Figure 77**). They impair both the benthic fauna of the Wadden Sea and seagrass meadows in the tidal area. The overlaid benthic organisms die as a result of oxygen deficiency or possible sulphide poisoning. The occurrence of green algal mats has conspicuously changed the summer Wadden area landscape. These green algae mats in the Schleswig-Holstein Wadden Sea have tended to become less extensive since the 1990s, but with major fluctuations (**Figure 78**). The extent of green algae mats in the Lower Saxony Wadden Sea has likewise decreased significantly.

Figure 77: Green algae on Wadden area

Source: Federal Environment Agency

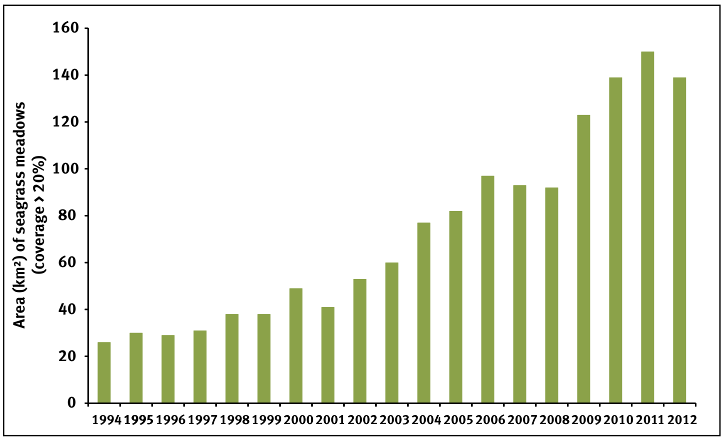
The increase in seagrass meadows in the Schleswig-Holstein Wadden Sea is seen as an indication of decreasing eutrophication, as a constant spread has been observed since 1994 (> 20 % coverage) (**Figure 79**). In August 2011, seagrass beds in the North Frisian Wadden Sea achieved their greatest extension to date (150 km² or 16 % of the Wadden area). Overall, seagrass beds in the tidal zone of the Lower Saxony coast had decreased significantly by 2000-2002. The most recent mapping in summer 2008 indicates that stocks have spread by now, but this does not affect all

Figure 78: Wadden area (km²) with > 20% green algae coverage following aerial surveillance of the Schleswig-Holstein Wadden Sea in sommer time between 1995 and 2012. The figures given are seasonal maximums



Source: Landesamt für Küsten- und Naturschutz Tönning (State Agency for the Protection of Coast and Nature Tönning), 2012

Figure 79: Area (km²) of seagrass meadows (coverage > 20%) on North Friesian Wadden area following aerial surveillance in August or September between 1978 and 2012.



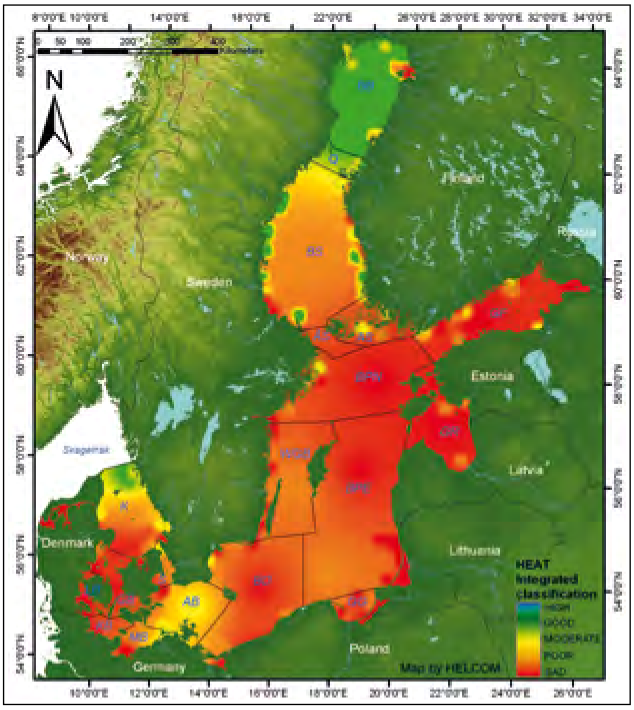
Source: Landesamt für Küsten- und Naturschutz Tönning, (State Agency for the Protection of Coast and Nature Tönning) 2012

areas of the Lower Saxony coast. For example, stocks of Zostera marina in the river Ems estuary have almost been extinguished.

7.2.2.3 Eutrophication of the Baltic Sea

HELCOM has refined the OSPAR eutrophication assessment method and, similar to the Water Framework Directive, introduced a five-point scale. Throughout the entire Baltic Sea, of the 189 areas analysed during the assessment period 2001-2006, only 13 were classified by HELCOM as "not eutrophied", including the open Bottenwiek and the north-eastern Kattegat (**Figure 80**). In the German Baltic Sea, Mecklenburg Bight (oxygen deficiency) and Fehmarn-Belt (limited occurrence of macrophytes) are classified as poor, while Wismar Bight (oxygen deficiency, high populations of phytoplankton), Lübeck Bight (limited occurrence of macrophytes), Kiel Bight and Flensburg Fjord (limited occurrence of macrophytes) are even classified as bad. The ecosystems in the Arkona Basin and in the outer Darß-Zingst waters were classified as moderate due to the high phytoplankton populations.

Figure 80: HELCOM classification of the eutrophication status of the Baltic Sea
Green = High status, i.e. areas not affected by eutrophication; **Yellow** = Moderate status; **Orange** = Poor status; **Red** = Bad status
HEAT = HELCOM Eutrophication Assessment Tool.



Source: HELCOM, 2009

The Baltic Sea Action Plan of 2007 sets out concrete reduction targets for the Baltic Sea littoral states. These had been revised on the basis of improved models and scientifically derived targets. New targets for nutrient reduction were adopted at the HELCOM Ministerial Meeting in Copenhagen on 3 October 2013. For the first time, airborne nutrient inputs were regarded as well. In the Ministerial Declaration, Germany undertook to reduce nutrient inputs by 7,670 t and phosphorus inputs by 170 t till 2016. Measures for reducing nutrient inputs include the reduced use of fertilisers in agriculture, the cultivation of intercrops to prevent soil erosion, the establishment of wetlands and buffer zones to collect nutrients, improved wastewater treatment, and initial attempts to reduce exhaust gas emissions in shipping. Above and beyond this, scientists have established that overfishing likewise contributes to eutrophication. For example, as a result of the decline in the predator cod, populations of sprat, which feed on zooplankton, are increasing. Fewer zooplankton means that less phytoplankton is consumed, which in turn leads to increased eutrophication.

Because of the direct inflows from rivers, the Mecklenburg coastal waters and inner bays are far more heavily polluted with nutrient inputs than the Baltic Sea off the 1 nautical mile zone. Whereas phosphate levels are generally two to three times higher than on the outer coast, nitrate concentrations can exceed the levels of the offshore Baltic Sea by a multiple. This is particularly the case in the rivers Innere Schlei and Unterwarnow, in the lagoon Kleines Haff and in the Pomeranian Bight. Nutrient concentrations in the inner coastal Bodden waters have decreased substantially, whereas in outer coastal waters there has been no significant decrease since 1997. This is thought to be due to the remobilisation of large quantities of phosphate from the oxygen-deficient sediment. For Saaler Bodden, for example, an external phosphorus input of 17 t contrasts with an internal load of 88 to 212 t. For the open Baltic Sea, longer data series indicate a rise in nitrate concentrations up until the late 1980s, followed by a continuous decrease. Phosphate concentrations follow this trend but have shown pronounced fluctuations in recent years.

One well-known effect of eutrophication is increased algal growth and the associated, aforementioned potential adverse impacts on the ecosystem. Trend analyses since 1979 indicate a significant increase in dinoflagellates and a decrease in diatoms (gravel algae) for the Baltic Sea. Severe blue-green algal bloom occurs periodically, and huge carpets of algae drift onto the beaches of Mecklenburg-West Pomeraia and Schleswig-Holstein (**Figure 81**). The algal bloom reduces water transparency (secchi depth), e.g. to less than 0.5 m in the estuaries of the rivers Oder and Warnow.

Oxygen deficiency is a naturally occurring phenomenon in the Baltic Sea. However, the frequency, strength and spread of low-oxygen and oxygen-free zones (dead zones) caused by excessive nutrient inputs have increased substantially as a result of human activity. In the coastal waters of Schleswig-Holstein and Mecklenburg-Western Pomerania, as off the Danish coast, oxygen deficits in bottom water occur every year during summer and autumn. Oxygen deficiency in summer stratified waters has been identified in Mecklenburg Bight, Lübeck Bight, Kiel Bight and neighbouring bights and inlets. A recent survey of oxygen levels in the western Baltic Sea indicates that 68 % of all measured values from stations with more than 15 m water depth are to be attributed to the categories bad or unsatisfactory, which means that the water contains less than 1-2 mg oxygen per litre. Bottom-dwelling organisms are heavily impaired by the lack of oxygen. It can take macrozoobenthos up to 4 years to recover from oxygen deficiency events. The underwater vegetation responds very sensitively to high nutrient inputs. The associated increased turbidity of the water column leads to a deterioration in the underwater light conditions and hence to a reduction in habitats suitable for colonisation. Large algae and flowering plants are displaced from the deeper sections to the shallow

Figure 81: Algal bloom on the beach at Glowe/Rügen

Source: W. Leujak

water zones of the coastal waters. The historical spread depths for seagrass (10 m) and bladderwrack (20 m) are no longer matched today. Recent studies suggest that there is very little bladderwrack remaining along the coast of Mecklenburg-Western Pomerania. Seagrass meadows in the Prerow Bight are overgrown with thread-like algae that have become established due to overfertilisation and which suppress the seagrass.

7.2.3 Heavy metals

Metals are present in the environment as a result of natural processes such as weathering, volcanism and gas liberation. Metal concentrations originating from such natural emissions are known as background concentration levels. Emissions associated with human activities have led to heavy metal concentrations in the marine environment that are generally far higher than the background levels. Rivers and the atmosphere are the principal emission pathways. The toxicity of heavy metals is dependent on a large number of factors. In descending order of toxicity, they can be roughly ranked as follows: mercury, cadmium, zinc, nickel. The compounds in which the metals are present are the decisive factor here. Many metals are harmful to human health. They accumulate in the food chain and thus enter the human body. In the marine environment, heavy metals are regularly measured in water, sediment and organisms (biota).

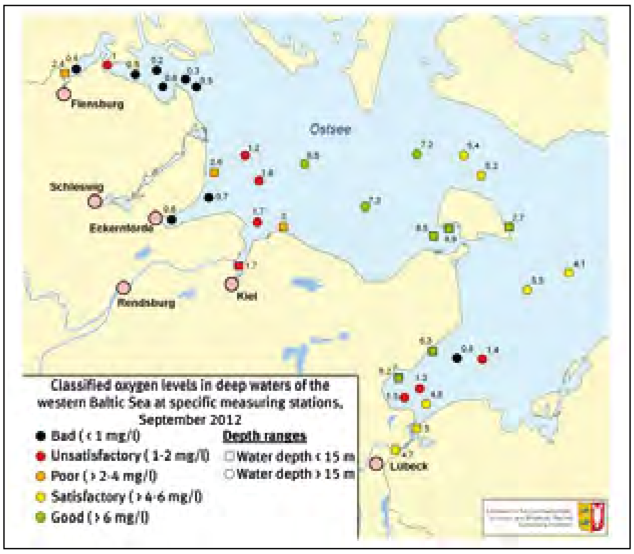
7.2.3.1 Inputs

Inputs into the North Sea

Mercury and cadmium inputs into the North Sea via the rivers Elbe, Weser and Ems have been decreasing for many years. In 2010, they had fallen to 12 % (mercury) and 38 % (cadmium) of input levels in the reference year 1990 (cf. **Figure 83**).

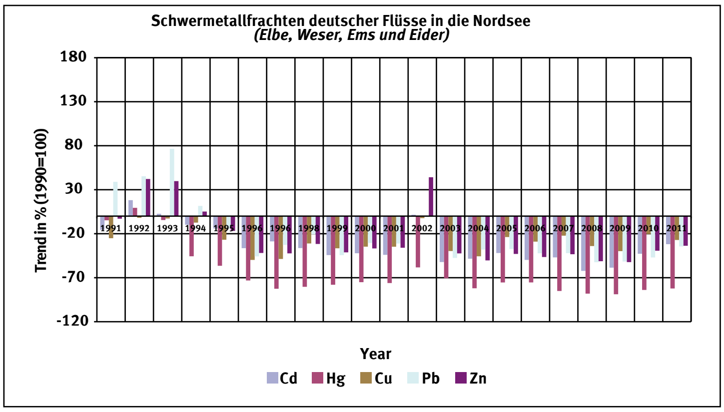
Measures such as modernised wastewater treatment techniques have played a decisive role in reducing

Figure 82: Classified oxygen levels in deep waters of the western Baltic Sea at specific measuring stations, September 2012



Source: Landesamt für Landwirtschaft, Umwelt und ländliche Räume Schleswig-Holstein (State Agency for Agriculture, Environment and Rural Areas)

Figure 83: Heavy metal inputs via German inflows into the North Sea between 1990 and 2010



Source: Federal Environment Agency using data supplied by the Länder for reporting under OSPAR, as of 2011

heavy metal inputs. Nevertheless, elevated concentration levels are still measured from time to time, particularly following periods of heavy precipitation followed by floods (e.g. in 2002). Such floods mobilise the pollutants that have accumulated in the river sediment and therefore leads to a greatly increased input of heavy metals into coastal waters.

Between 1983-1987 and 2006-2008, inputs of heavy metals into the German North Sea catchment area declined significantly (see **Table 30**).

Nickel inputs have seen the smallest reduction (42 %), because the non-influencable geogenic portion (groundwater pathway (45 % of total inputs)) is fairly high. The greatest reductions were achieved for mercury (96 %) and cadmium (87 %) inputs. These results are attributable primarily to the dramatic reduction in direct industrial discharges (point sources), ranging from 95 % for lead to 99 % for mercury. This reduction of environmental impacts was largely due to measures by industry prompted by a tightening in the statutory requirements, coupled with the scaling down of industrial activities in the new German Länder since 1990 (Elbe river basin). In 2006-2008, direct industrial discharges played only a subordinate role in heavy metal inputs, accounting for between 0.5 and 9 % of total inputs. Although the significance of discharges from public wastewater treatment plants (point sources) remains high, in the years 2006-2008 water pollution was dominated by diffuse sources. The most significant emission pathways are urban areas (particularly sewer systems and residents not connected to the sewer system), erosion and groundwater.

Urban areas, including emissions from combined and separate sewer systems, are a key source of heavy metal emissions into surface waters. These combined wastewater discharges and precipitation runoff from separate systems are responsible for between 3 and 30 % of total heavy metal inputs. The levels of zinc (32 %), copper (31 %) and lead (20 %) are particularly high. Since combined sewer systems transport a considerable proportion of stormwater runoff to the wastewater treatment plant, they cause less heavy metal pollution than separate sewer systems. In particular, the metals chromium (60 %) and lead (54 %) enter surface waters as a result of erosion. There are significant differences in pollution levels between the individual river basins, particularly as a result of differences in land use and outflow events.

Inputs into the Baltic Sea

In some cases, inputs of heavy metals via German inflows into the Baltic Sea have decreased noticeably since 1994. For some heavy metals, pollutant loads increase in proportion to increased discharge volumes during years with heavy precipitation, as would be expected. By contrast, the dramatic 96 % decrease in mercury loads from 1994 to 2010 indicates that emissions of anthropogenically emitted metals have significantly and continuously declined since the early 1990s. (cf. **Figure 84**).

Table 30: Inputs of mercury, nickel, cadmium, lead, zinc, copper and chromium from point and diffuse sources in the German catchment area of the North Sea in t/a

	atmospheric deposition [t/a]	historical mining activities [t/a]	erosion [t/a]	groundwater [t/a]	direct industrial dischargers [t/a]	surface runoff [t/a]	drainage [t/a]	urban areas [t/a]	municipal wastewater treatment plants (WWTP) [t/a]	Total [t/a]
	Mercury inputs into surface waters, rounded									
1983-1987	0.64	0.010	0.24	0.28	22	0.78	0.30	2.3	2.5	**29**
1998-2002	0.063	0.010	0.25	0.29	0.13	0.13	0.31	0.53	1.2	**2.9**
2006-2008	0.067	0.013	0.25	0.29	0.084	0.11	0.30	0.17	0.012	**1.3**
	Nickel inputs into surface waters, rounded									
1983-1987	9.7	17	98	192	179	11	38	71	125	**740**
1998-2002	2.9	17	97	197	18	8.0	39	19	68	**466**
2006-2008	2.7	18	101	193	16	6.0	38	13	39	**428**
	Cadmium inputs into surface waters, rounded									
1983-1987	7.4	2.0	0.91	1.1	21	3.1	0.59	11	6.2	**53**
1998-2002	0.21	2.0	0.94	1.2	0.42	0.73	0.62	1.4	1.9	**9.4**
2006-2008	0.21	1.5	0.99	1.1	0.54	0.51	0.60	0.57	1.1	**7.1**
	Lead inputs into surface waters, rounded									
1983-1987	54	9.0	108	6.2	125	157	1.2	253	51	**763**
1998-2002	8.5	9.0	108	6.4	14	16	1.2	70	25	**258**
2006-2008	7.0	7.8	114	6.3	6.4	15	1.2	43	11	**211**
	Zinc inputs into surface waters, rounded									
1983-1987	210	371	222	170	2814	344	80	1268	822	**6300**
1998-2002	63	371	228	174	99	194	84	980	419	**2612**
2006-2008	47	365	240	171	120	122	81	741	405	**2292**
	Copper inputs into surface waters, rounded									
1983-1987	36	14	55	58	398	41	17	156	135	**911**
1998-2002	8.2	14	57	60	32	41	18	133	101	**463**
2006-2008	8.0	13	59	59	27	24	17	132	83	**421**
	Chromium inputs into surface waters, rounded									
1983-1987	2.7	0.26	126	15	442	10	19	38	106	**759**
1998-2002	0.82	0.26	127	15	16	3.3	20	9.1	31	**222**
2006-2008	2.3	0.32	134	15	18	3.9	20	8.4	22	**223**

Source: Federal Environment Agency (MoRE), as of June 2013

Between 1983-1987 and 2006-2008, inputs of heavy metals into the German Baltic Sea catchment area declined sharply overall (see **Table 31**). The general reduction is primarily attributable to the dramatic decrease in discharges from industry, reflected in reduced direct industrial discharges, as well as inputs via atmospheric deposition, urban land and public wastewater treatment plants (indirect industrial discharges). Technological measures prompted by a tightening of statutory requirements played a key role in this achievement, combined with the collapse of industrial activities in the German Oder river basin since 1990.

Discharges from public wastewater treatment plants (point sources) ranging from 0 % (mercury) to 8 % (copper) are of minimal importance in relation to total inputs to the Baltic Sea. In 2006-2008, water pollution was dominated by diffuse sources. The most significant emission pathways are urban land (particularly sewer systems and residents not connected to the sewer system), erosion and groundwater.

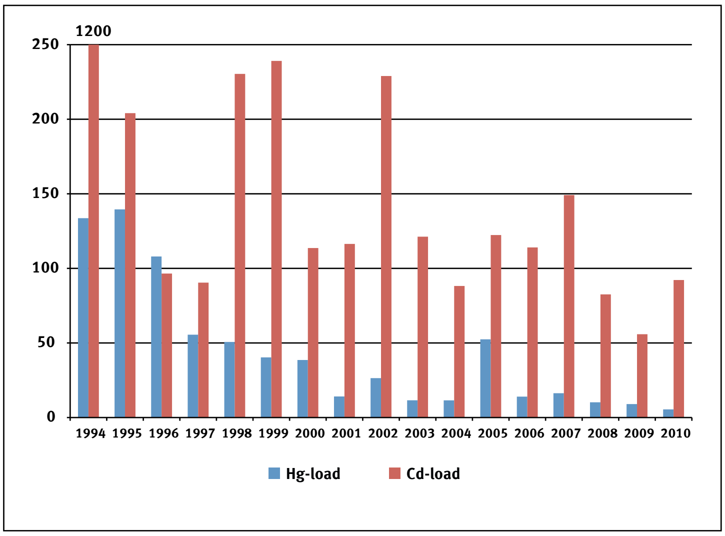
Urban land, including discharges from combined and separate sewer systems, is a principal source of heavy metal inputs into surface waters. These combined sewage discharges and storm water runoff from separate systems are responsible for between 3 and 42 % of total heavy metal inputs. The levels of zinc (42 %), copper (34 %) and lead (32 %) are particularly high. Since combined sewer systems transport a considerable proportion of storm water runoff to the wastewater treatment plant, they cause less pollution than separate sewer systems. In particular, the metals chromium (23 %) and lead (24 %) enter surface waters as a result of erosion. Compared to the North Sea region, the importance of this emission pathway is diminishing. For example, in the case of mercury in the Baltic Sea region, inputs via drainage systems are a more significant source, accounting for 47 % of total inputs, and in the case of lead, the same is true of atmospheric deposition (21 %). In the case of nickel, geogenic inputs via the groundwater are the predominant pathway (52 %), followed by inputs via drainage systems (29 %). In the North Sea region, on the other hand, the erosion pathway plays a major role for nickel, alongside groundwater. Significant regional differences in pollution levels arise as a result of differences in land use and outflow events.

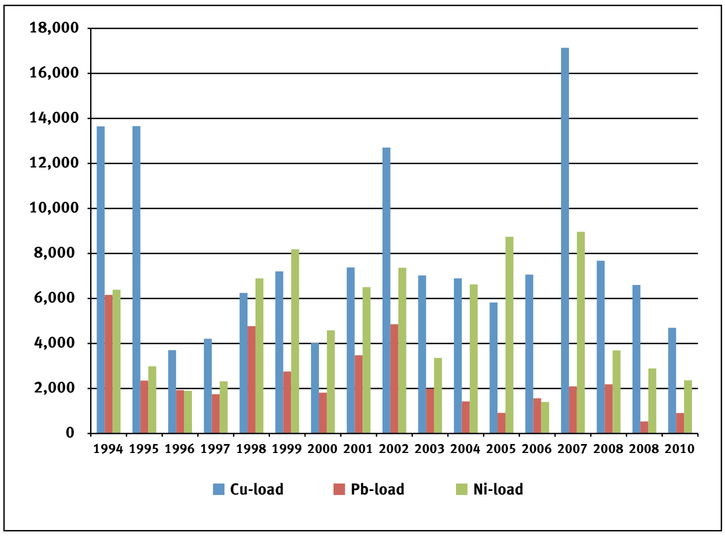
Table 31: Inputs of mercury, nickel, cadmium, lead, zinc, copper and chromium from point and diffuse sources in the German catchment area of the Baltic Sea

	atmospheric deposition [t/a]	historical mining activities [t/a]	erosion [t/a]	groundwater [t/a]	direct industrial dischargers [t/a]	surface runoff [t/a]	drainage [t/a]	urban areas [t/a]	municipal wastewater treatment plants (WWTP) [t/a]	Total [t/a]
	Mercury inputs into surface waters, rounded									
1983-1987	0.34	0	0.005	0.026	0.001	0.077	0.050	0.13	0.041	**0.66**
1998-2002	0.022	0	0.005	0.018	0.001	0.009	0.052	0.030	0.012	**0.15**
2006-2008	0.019	0	0.005	0.018	0.001	0.009	0.053	0.007	0	**0.11**
	Nickel inputs into surface waters, rounded									
1983-1987	6.1	0	1.0	17	0	1.2	6.3	4.1	4.1	**40**
1998-2002	1.2	0	1.0	12	0.32	0.56	6.6	1.1	1.0	**24**
2006-2008	1.1	0	1.1	12	0.21	0.42	6.7	0.80	0.85	**23**
	Cadmium inputs into surface waters, rounded									
1983-1987	5.9	0	0.014	0.10	0	0.31	0.10	1.0	0.41	**7.9**
1998-2002	0.077	0	0.016	0.071	0.022	0.052	0.10	0.084	0.027	**0.45**
2006-2008	0.068	0	0.017	0.072	0.018	0.040	0.11	0.033	0.011	**0.36**
	Lead inputs into surface waters, rounded									
1983-1987	24	0	1.9	0.56	0.18	16	0.20	14	2.0	**58**
1998-2002	2.5	0	2.0	0.39	0.89	1.0	0.21	4.4	0.32	**12**
2006-2008	1.8	0	2.1	0.39	0.11	1.1	0.21	2.7	0.10	**8.5**
	Zinc inputs into surface waters. rounded									
1983-1987	111	0	3.6	15	0	35	14	71	9.9	**259**
1998-2002	25	0	3.9	11	9.5	13	14	61	5.5	**143**
2006-2008	17	0	4.3	11	4.2	9.4	14	47	5.5	**113**
	Copper inputs into surface waters, rounded									
1983-1987	20	0	1.1	5.3	0	4.3	2.8	6.9	3.3	**44**
1998-2002	3.3	0	1.2	3.6	0.22	2.7	3.0	7.8	2.3	**24**
2006-2008	3.3	0	1.3	3.7	0.26	1.8	3.0	8.0	2.0	**23**
	Chromium inputs into surface waters, rounded									
1983-1987	1.24	0	1.7	1.3	18	1.4	3.3	1.9	3.1	**32**
1998-2002	0.32	0	1.8	0.92	0.11	0.29	3.4	0.55	0.28	**7.6**
2006-2008	0.93	0	1.9	0.93	0.01	0.30	3.5	0.53	0.28	**8.3**

Source: Federal Environment Agency (MoRE), as of June 2013

Figure 84 a-b: Inputs of selected heavy metals via German rivers into the Baltic Sea in t/a, between 1994 and 2010





Source: Federal Environment Agency using data supplied by the Länder for reporting under HELCOM, as of 2011

7.2.3.2 Heavy metal pollution

Heavy metal concentrations in water

In the period 2008 to 2011, there were no cases of the Environmental quality standards (EQS) being exceeded for lead (annual average EQS = 7.2 µg/l), mercury (annual average EQS = 0.05 µg/l) or cadmium (annual average EQS = 0.2 µg/l) in the water phase of the Baltic and North Seas. For stations located outside of the 12 nautical mile zone, the levels were generally lower than inside the zone. This suggests that an important share of the inputs originate from rivers and increasingly diluted with unpolluted seawater offshore.

Heavy metal concentrations in sediment

The results of cadmium, lead and mercury pollution in sediment are illustrated below (**Figures 85-87**). Environmental quality standards as they exist for the water phase are not currently available for the heavy metals cadmium, lead and mercury in sediment. The diagrams below show the concentrations levels in three categories, as per the assessment system used by OSPAR in its 2010 Quality Status Report. Concentrations that are approaching the Background Assessment Concentration (BAC) are shown in blue, while concentrations that are above the Effect Range Low (ERL) are shown in red. Concentration levels that are not thought to cause harmful effects in organisms are shown in green. During the period from 2008 to 2011, less than five measurements were not assessed (white circle). Very little data is available for the Baltic Sea, and for this reason no assessment was undertaken. In the North Sea, the measured concentrations for mercury and lead, in particular, were in the critical range.

Heavy metals in marine organisms

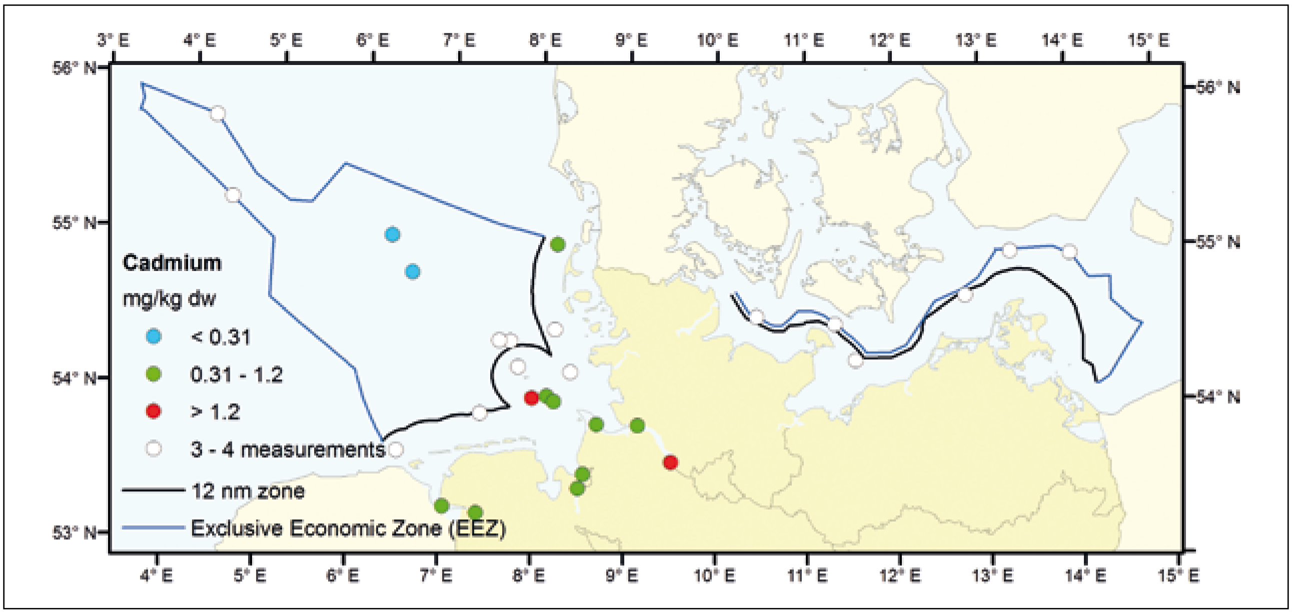
North Sea

In the period 1985 to 1993, common mussels taken from the Jade Estuary (near Eckwarderhörne) in the North Sea indicated significantly higher levels of lead, cadmium and mercury than mussels from Sylt-Römö-Watt (List/Königshafen). Over subsequent years (1994 to 2011), these differences were reduced, since contamination levels in mussels from Jade Estuary have tended to decrease, whilst those in mussels from Sylt-Römö-Watt have remained roughly the same or increased slightly. Only lead indicated a statistically significant decrease in concentration levels in common mussels.

The natural background concentration levels of metals in common mussels determined by OSPAR for the entire North-East Atlantic (including the North Sea) are 0.07-0.11 mg/kg for cadmium, 0.01-0.19 mg/kg for lead and 0.005- 0.010 mg/kg for mercury, each in relation to wet weight (ww). In the case of cadmium, only common mussels from Eckwarderhörne indicate concentrations above or at the upper limit of the background level. Mercury concentrations in common mussels from both North Sea sampling points have declined since the late 1980s, but remain significantly above the background concentration.

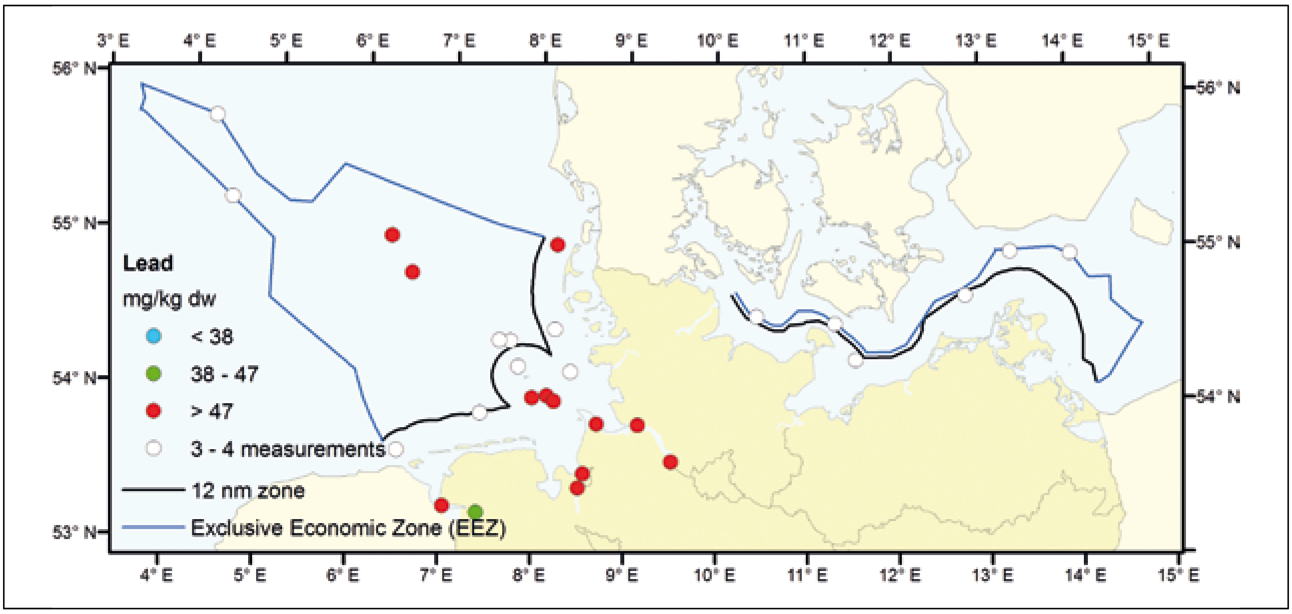
The maximum concentrations in food of mercury (0.5 mg/kg wet weight mussels), lead (1.5 mg/kg wet weight mussels) and cadmium (1.0 mg/kg wet weight mussels) as specified by the European Commission were significantly exceeded by common mussels in the area of the German North Sea coast.

Figure 85: Mean cadmium levels in sediments in the German North and Baltic Sea areas (2008-2011)
Sampling sites are represented by circles. Only sampling sites with at least 5 samples available from the analysis period were assessed. The colour indicates the measured concentration range.



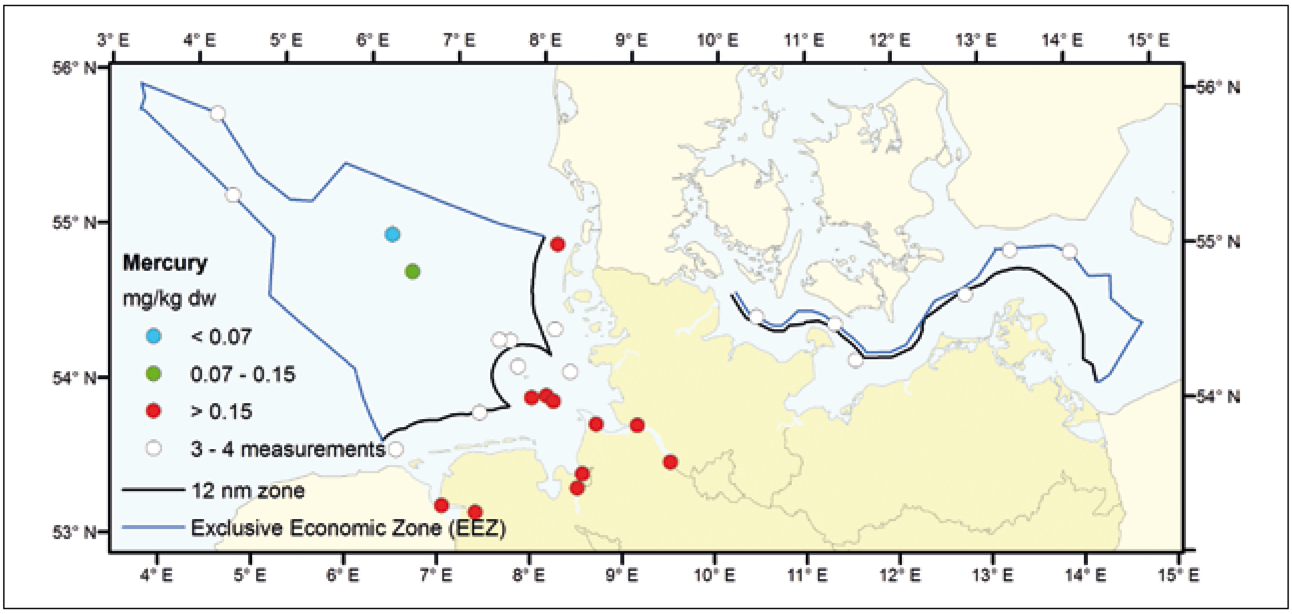
Source: MUDAB (Marine Environmental Data Base), BfG, 2012

Figure 86: Mean lead levels in sediments in the German North and Baltic Sea areas (2008-2011)
Sampling sites are represented by circles. Only sampling sites with at least 5 samples available from the analysis period were assessed. The colour indicates the measured concentration range.



Source: MUDAB (Marine Environmental Data Base), BfG, 2012

Figure 87: Mean mercury levels in sediments in the German North and Baltic Sea areas (2008-2011)
Sampling sites are represented by circles. Only sampling sites with at least 5 samples available from the analysis period were assessed. The colour indicates the measured concentration range .



Source: MUDAB (Marine Environmental Data Base), BfG, 2012

In order to assess the chemical status, an environmental quality standard of 20 µg/kg wet weight for mercury in biota was defined in the Ordinance for the Protection of Surface Waters. The mercury concentrations found in common mussels from Jade Estuary and Sylt-Römö-Watt are within this range. However, the mercury concentrations measured in the musculature of eelpout from the Varel-Mellum transect and Meldorf Bight are at least three times higher than 20 µg/kg. There was no evidence of a decrease in the mercury concentrations in eelpout musculature during the analysis period 1994 to 2011.

Mercury contamination in seabird eggs generally reflects local-level pollution, as during the formation of eggs, mercury is ingested by the females via food found in the immediate vicinity of the breeding ground. The fact that the mercury levels in silver gull eggs from the island of Trischen (Wadden Sea in Schleswig-Holstein) are 2 to 3 times higher than in eggs from the island of

Mellum (Wadden Sea in Lower Saxony) is indicative of the high level of riverine inputs from the river Elbe compared with that from the rivers Jade and Weser. The time series for mercury concentrations in silver gull eggs from the island of Trischen between 1988 and 2001 indicate a significant decrease in mercury contamination.

Baltic Sea

Contamination of common mussels in the German coastal Baltic Sea region with mercury, lead and cadmium is lower than in the North Sea coastal area. No significant pollution hot spots have been identified. In the sampling year 2011, common mussels (2.6 µg/kg wet weight) showed mercury concentrations around eight times lower than in organisms from the North Sea). The contamination of mussels from Darßer Ort with lead (0.1 mg/kg wet weight) and cadmium (0.09 mg/kg wet weight) is almost identical to that of mussels from Königshafen on the North Sea coast. For these three heavy metals, in recent years, only lead has seen a decreasing trend in common mussels. Mercury levels in biota are significantly below the environmental quality standard of 20 µg/kg wet weight in common mussels. Mercury concentration levels measured in the musculature of eel-pout during the period 1994 to 2011 exceed these environmental quality standard by a factor of 2, on average. This exceedance is rather low compared with environmental quality standards exceeded in fish from inland waters and the North Sea.

7.2.4 Organic environmental chemicals

Polycyclic aromatic hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons are produced during the incomplete combustion of organic material such as wood, coal, petroleum and oil, and are contained in fossil raw materials (cf. also **chapter 5.2.4**). Many polycyclic aromatic hydrocarbons are persistent, toxic, bioaccumulating and have been found to be widespread in the environment. In numerical terms alone, the group of polycyclic aromatic hydrocarbons represents a significant pollutant class, hundreds of compounds of which have already been detected in the environment. These substances are taken up by humans e.g. via food and by inhalting contaminated air from car exhaust fumes or tobacco smoke. Numerous polycyclic aromatic hydrocarbonsare carcinogenic in humans. Furthermore, they are teratogenic and can impair fertility.

There are no measurements of the polycyclic aromatic hydrocarbons on the list of priority substances exceeding environmental quality standards (cf. **Table 8**) in water.

Polychlorinated biphenyls

Polychlorinated biphenyls are toxic, carcinogenic chemical chlorine compounds which were used primarily in transformers, electrical capacitors, as hydraulic fluid in hydraulic systems and as softeners in paints, sealing masses, insulating materials and plastics until the 1980s. They have spread throughout the world; they are found in the atmosphere, in waterbodies and in soil. Polychlorinated biphenyls are among the twelve persistent organic pollutants known as the "dirty dozen" addressed by the Stockholm Convention of 22 May 2001.

A survey conducted by the environmental specimen bank to determine the geographical and temporal distribution of organic pollutants in common mussels, eelpout and silver gulls' eggs found that polychlorinated biphenyls are the main contaminants in marine organisms in both the North Sea and Baltic Sea coastal regions.

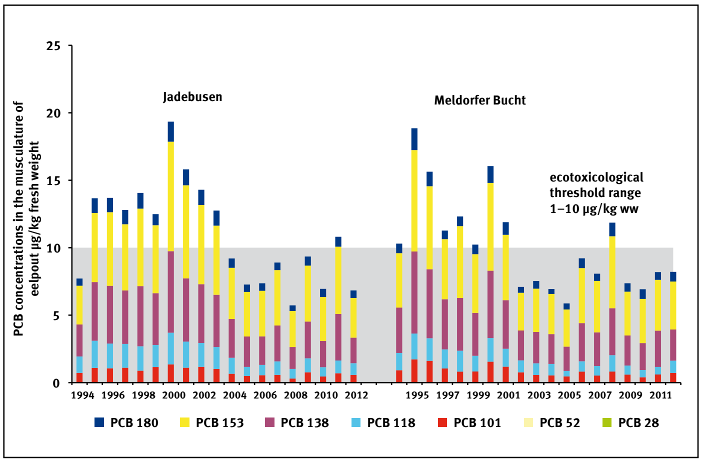
The assessment criterion used by OSPAR for the sum total of the seven polychlorinated biphenyls congeners (∑ PCB7: IUPAC No. PCB28, PCB52, PCB101, PCB118, PCB138, PCB153, PCB180) is based on ecotoxicological (tolerable) threshold ranges of 1 to 10 µg/kg wet weight for fish and 5 to 50 µg/kg dry weight for common mussels. The concentrations of ∑ PCB7 found in eelpout musculature from the Jade Estuary area (6.8 µg/kg wet weight) and the Meldorfer Bucht area (8.2 µg/kg wet weight) in 2012 were at the upper limit of this ecotoxicological threshold range (**Figure 88**). Over the monitoring period 1994 to 2012, ∑ PCB7 concentrations fluctuated widely, with a significant downward trend since the turn of the millennium (**Figure 88**).

In contrast to the German North Sea region, contamination with organic pollutants in the German Baltic Sea region tends to be characterised by diffuse emissions from agriculture and point source emissions from contaminated industrial sites, rather than inputs via large rivers. Common mussels and eelpout from the sampling area near Darßer Ort are significantly less contaminated with PCB than samples from the North Sea.

Hexachlorobenzene

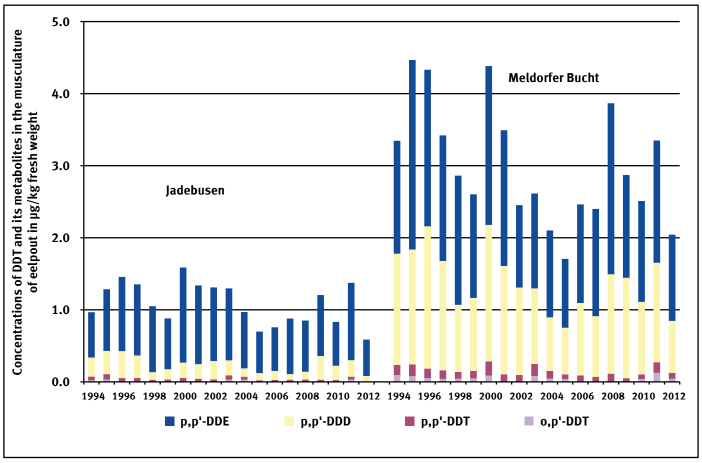
Hexachlorobenzene is a chlorinated hydrocarbon that was used primarily as a fungicide in the treatment of seeds and as wood preservatives. In the Federal Republic of Germany, pesticides containing hexachlorobenzene were banned in 1981; the German Democratic Republic followed suit and banned hexachlorobenzene in 1984. Since the Stockholm Convention entered into

Figure 88: PCB concentrations in the musculature of eelpout in the North Sea (Jade Estuary and Meldorfer Bucht)



Source: Federal Environment Agency – Federal Environmental Specimen Bank, 2013

Figure 89: Concentrations of DDT and its metabolites in the musculature of eelpout in the North Sea (Jade Estuary and Meldorfer Bucht)



Source: Federal Environment Agency– Federal Environmental Specimen Bank, 2013

force in 2004, the use of hexachlorobenzene has been banned worldwide except as a chemical intermediate and as a solvent for pesticides.

Hexachlorobenzene concentrations in the water phase of the Baltic Sea and the North Sea do not exceed the annual average environmental quality standard of 0.01 µg/l.

Dichlorodiphenyl trichloroethane (DDT)

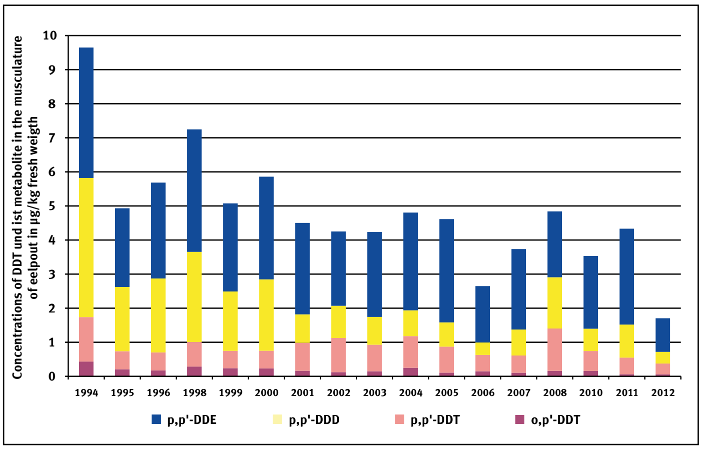
DDT is a persistent and strongly acting insecticide. In 1963, around 100,000 tonnes of it were manufactured and used worldwide. Due to its solubility in fat, DDT accumulates in the fatty tissue of fish, birds and humans. DDT degrades very slowly in the environment, and is thought to be a carcinogen. The manufacture and distribution of DDT has been prohibited in the Federal Republic of Germany since 1 July 1977. Since the Stockholm Convention's entry into force in 2004, the use of DDT worldwide has been restricted to the control of disease-carrying insects.

In comparison to 2002, slightly elevated levels of p,p'-DDT and o,p'-DDT were measured for DDT (and its degradation products DDE and DDD) in eelpout musculature from Meldorfer Bucht and Jade Estuary in the North Sea in 2003. This is thought to be due to increased DDT discharges from the river Elbe flood in August 2002 (**Figure 101**). Over the following two years, concentrations of DDT and its metabolites DDE and DDD fell significantly to below pre-flood levels.

However, the measured concentrations fluctuated considerably from year to year, and since 2006, concentration levels have tended to rise again (**Figure 89**).

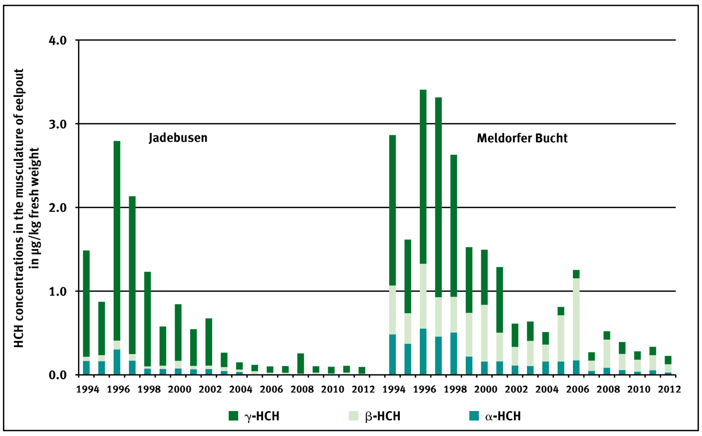
DDT contaminates organisms in the Baltic Sea to a far greater extent than in the North Sea, particularly compared with measurements in Jadebusen. Alongside the decomposition products (DDD and DDE) of the pesticide DDT, high proportions of the original compound DDT are still very much in evidence (**Figure 90**), suggesting that this pesticide is still being used in the catchment area of the Baltic Sea, even though it has been banned.

Figure 90: Concentrations of DDT and its metabolites in the musculature of eelpout in the Baltic Sea (Darßer Ort)



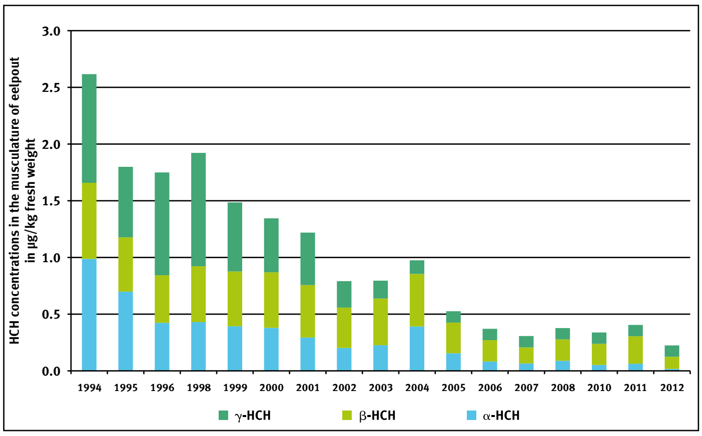
Source: Federal Environment Agency – Federal Environmental Specimen Bank, 2013

Figure 91: HCH concentrations in the musculature of eelpout in the North Sea (Jade Estuary and Meldorfer Bucht)



Source: Federal Environment Agency – Federal Environmental Specimen Bank, 2013

Figure 92: HCH concentrations in the musculature of eelpout in the Baltic Sea (Darßer Ort)



Source: Federal Environment Agency – Federal Environmental Specimen Bank, 2013

Hexachlorocyclohexane (HCH)

Hexachlorocyclohexane (HCH) was originally manufactured as a technical mixture comprised of various HCH isomers (α-, β-, γ-, δ-hexachlorocyclohexane). The γ-isomer, known as lindane, is an effective insecticide. The individual HCH isomers vary in their degree of toxicity. It is a stomach, inhalation and contact insecticide. The Federal Republic of Germany banned the use of technical HCH in 1997, while the use of lindane has been prohibited throughout the EU since 2002. Lindane is a proven carcinogen.

The environmental quality standard for the chemical status for the sum total of hexachlorocyclohexane (annual average of the environmental quality standard = 0.002 µg/l) is generally met in both the Baltic Sea and the North Sea. The introduction of an EU-wide ban on lindane has therefore been a verifiable and successful measure.

The musculature of eelpout from Meldorfer Bucht indicated a rising trend for β-HCH, leading to the highest measured concentrations ever in 2006 (**Figure 91**). As α-HCH likewise demonstrated a rising trend for this limited period, increased input via the river Elbe is assumed to be responsible. Large quantities of contaminated river sediment were released due to flooding in the Bitterfeld region (Saxony-Anhalt), which may have reached the German Bight via the rivers Mulde and Elbe. By contrast, in Jadebusen, the pronounced downward trend for α-, β- and γ-HCH (lindane) in eelpout continued during the monitoring period 1996 to 2012. Meldorfer Bucht likewise recorded a significant decrease in concentration levels over the same period.

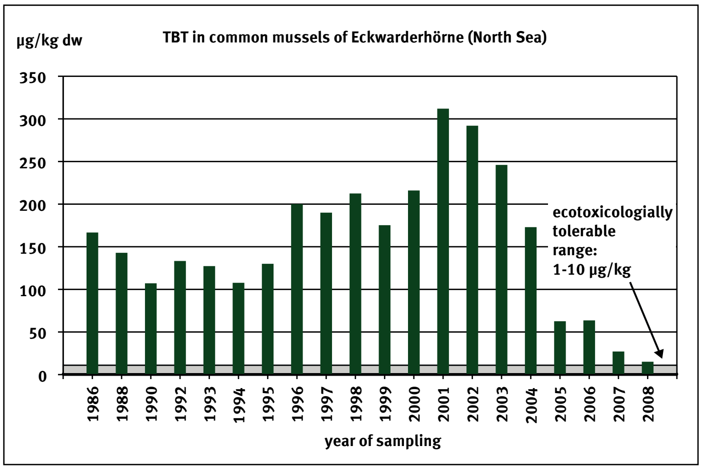
Contamination with hexachlorocyclohexane in the Baltic Sea is similar to that at the Meldorfer Bucht sampling site in the North Sea. During the monitoring period (1994 to 2012), HCH concentrations in eelpout musculature decreased significantly, the sharpest decreases being measured for α-HCH and γ-HCH (> 90%), whereas β-HCH levels decreased by around 70 % (**Figure 92**).

Tributyl tin

The organic tin compound tributyl tin was used predominantly as a biocide (active agent for killing living organisms) in the manufacture of underwater ship's paints. These so-called antifouling paints prevent the growth of mussels, barnacles and algae on the ship's hull, which are killed upon contact with the toxic paint. The toxic, poorly degradable tributyl tin released from the paints today contaminates many rivers and seas, partly as a result of its unintentional effect as an environmental hormone on mussels and molluscs. The extensive damage caused to marine organisms by organic tin compounds became evident in the early 1980s, and was manifested primarily in the fact that the reproductive capabilities of molluscs and oysters were reduced or eliminated entirely.

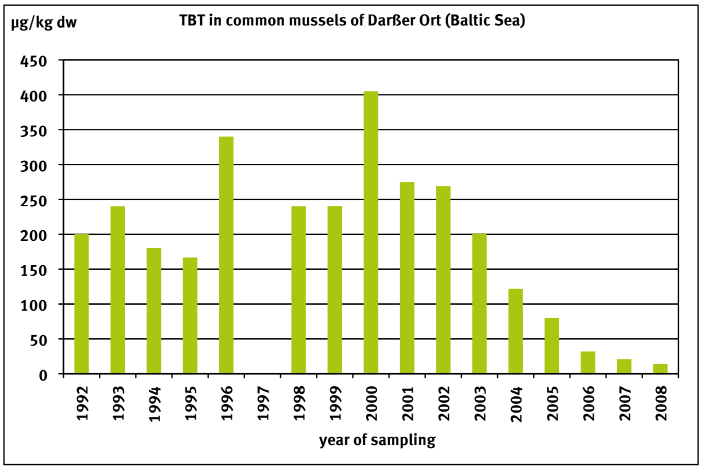
Analyses by the environmental specimen bank revealed relatively constant concentrations of tributyl tin in common mussels and eelpout from the mid-1980s to the end of the 1990s, followed by a significant increase towards the turn of the millennium, and a sharp drop in tributyl tin concentrations since 2004.

Figure 93: Tributyl tin in common mussels in the North Sea (Eckwarderhorne)



Source: Rüdel H. et.al.

Figure 94: Tributyl tin in common mussels in the Baltic Sea (Darßer Ort)



Source: Federal Environment Agency – Federal Environmental Specimen Bank, 2009

The assessment criterion for tributyl tin in common mussels used by OSPAR is an ecotoxicologically tolerable range of 1 to 10 µg/kg dry weight. Tributyl tin concentrations in common mussels from Eckwarderhörne exceeded this indicator level for potential problem areas 10 to 20 times over for the monitoring period 1986 to 2000, and 30 times over in the years 2001/2002 (**Figure 93**). In subsequent years, tributyl tin concentrations decreased continuously to levels only just above the threshold range in 2008.

In some cases tributyl tin concentrations in common mussels from Darßer Ort in the Baltic Sea during the monitoring period 1992 to 2000 were significantly higher than the concentrations found in mussels from the North Sea coast (**Figure 94**). Thereafter, there was an approximation in concentration levels, and the decrease in tributyl tin in mussels from the North and Baltic Seas showed a virtually parallel development from 2002 onwards, as a positive effect of the global agreement banning ship's coatings containing tributyl tin which came into force in 2001.

7.2.5 Marine litter

The term “marine litter” refers to all long-lasting, manufactured or processed durable materials that enter the marine environment because they are discarded or as ownerless commodities, where they pose a potential threat to fauna and habitats, and impair the leisure value of our coastlines. At present, there is no adequate system for assessing the ecological impacts of marine litter. Descriptor 10 of the Marine Strategy Framework Directive states that a good environmental status has been achieved if the properties and quantities of marine litter and their decomposition products do not cause harm to marine creatures and habitats.

Small pieces of plastic litter on the ocean's surface can already be quantified using the existing, tried-and-tested OSPAR EcoQO "Plastic litter in the stomachs of Northern fulmars". To meet this objective, a good environmental status for North Sea areas would be achieved if less than 10 percent of the Northern fulmars used as indicators had less than 0.1 g of plastic particles in their stomachs. However, further evaluation is needed to determine whether the current objective of this indicator satisfies the requirements of the EU Marine Strategy Framework Directive.

Apart from the ecological consequences, existing and new litter entering the marine environment should not pose a direct or indirect threat to human health and should not lead to significant financial losses for industrial uses and coastal communities.

It is estimated that each year, some 20,000 tonnes of litter enter the North Sea, of which 15 % remain in the water, 70 % on the ocean floor and 15 % on the beaches. On average, on the beaches in the southern North Sea region 236 pieces of litter per 100 metres of coastline are to be found. Shipping and the fishing industry have been identified as the principal sources of beach littering along the German North Sea coast. Comparable quantities are found on heavily littered beach sections along the German Baltic Sea coast. Although a comprehensive inventory has not yet been conducted for the Baltic Sea, initial surveys indicate however that litter in the Baltic region is likewise dominated by plastics. Whereas littering from fishing and aquaculture in the North-East Atlantic rose sharply in the years 2000 to 2006, an analysis of other litter sources indicated that levels have remained stable. Standardised beach litter monitoring has been carried out along the German North Sea coast since 2002. Three-quarters of the litter found on the beaches between 2002 and 2008 consisted of plastic and/or polystyrene. The most commonly found items, accounting for 30 % of the total litter volume, were ropes, lines and nets. A further 28 % comprised various packaging materials, while plastic items of unknown origin accounted for 16 %. It is estimated that 600,000 m³ of litter is located on and in the ocean floor of the North Sea alone. Studies of the Northern fulmar, which is native to the North Sea, found plastic in nearly all of the stomachs examined (97 %). During the last survey period, an average of 25.8 particles of plastic litter weighing 0.39 g were discovered. A Northern fulmar weighs approximately 700 g.

An initial analysis of beach littering on the Baltic Sea coasts was carried out by the "Marine Litter Project" under the auspices of HELCOM. On average, plastic waste accounted for 30-60 % of the litter weight or litter products, the bulk of which were plastic bottles and plastic bags. In the Baltic Sea littoral states, the quantities of litter found varied between 2 and 328 kilograms (4-181 pieces) per 500 metres of coastline. The highest quantities of litter were between 700 and 1,200 pieces per 100 m of coastline, comparable with the quantities found on beach sections in the northern North Sea.
In 1996, litter on the ocean floor of the western Baltic Sea was quantified by means of dragnet analyses. With 1.26 ± 0.82 pieces per hectare, the figures were comparable with the results obtained from the North Sea.

Extensive flights over the German North and Baltic Seas have identified high densities of litter and a correlation between the density of vessels and the density of litter. Increased importance must therefore be given to litter separation on board, inspections at sea and the provision of standardised port collection facilities for the onshore disposal of ship-generated waste.

7.2.6 Underwater noise

Underwater noise has a particular status among the various energy emissions in the North and Baltic Seas, because unlike heat, light or electromagnetic energy, which generally have a local impact, it is spread over a large geographical area. Water is a good transport medium for sound, because acoustic waves propagate four times faster in water than in the air. In particular, impulsive sound emissions may cause damage to marine species. Continuous noise sources, on the other hand, have different effects, such as disturbance (causing the affected species to move away) or masking of biologically important signals. Natural noise sources such as wind and wave movements form the background noise in the ocean. This natural "acoustic landscape" is supplemented by continuous anthropogenic noise emissions, primarily from shipping. In the frequency range of 10-300 Hz, the natural noise level is raised by 20-30 dB from shipping (even long distances away). Additionally, temporary impulsive noise emissions, such as those caused by pile-driving during the construction of offshore wind farms, can temporarily increase the noise pollution in a marine region. Temporary noise emissions in the form of impulsive signals should not induce physical damage to marine organisms. Current scientific knowledge suggests that a temporary threshold shift (TTS) occurs at a sound exposure level (SEL) of 164 dB re 1µ2Pa2s (unweighted), with an associated sound pressure level (SPL) of 199 dB (peak-peak) re 1µPa in porpoises. By way of comparison, the auditory threshold of a diver at 1 kHz is 67 dB re 1µPa. Please note that the decibel (dB) characterises the logarithm of ratios - for example, a tenfold increase in the output as energy variable means a change of 10 dB.

Underwater noise emissions may be divided into impulsive and continuous signals. Whereas continuous emissions permanently increase the natural ambient noise level, impulsive signals cause a temporary increase in a marine region's noise level. Relevant sources of impulsive underwater noise emissions in the German North Sea include the use of various types of sonar, noise-intensive construction work associated with offshore wind farms, seismic activities, explosions (e.g. from dumped munitions) and the use of acoustic deterrent devices e.g. in fishing. Shipping, sand and gravel extraction and the operation of offshore wind farms are the principal sources of continuous noise emissions.

Sonar and echo-sounders

Vertical echo-sounders, as used in commercial and leisure shipping, are essential for navigation safety, but their numbers are not recorded. So-called fishing sonar continues to be used on fishing vessels. The German navy reportedly has a number of mid-frequency sonar systems in use, which can achieve long ranges. Military activities with sonar occur primarily in designated exercise regions in the German Bight. This is supplemented by the use of various active noise sources for scientific purposes, such as ocean floor analysis for wind farms, cable-laying or gas pipelines.

Offshore wind farms

The test field "alpha ventus" with 12 wind turbines has been brought into service in the German North Sea. Since 2010, the first commercial wind farm

BARD Offshore 1 is being constructed and the already installed turbines are generating electricity. Measurements conducted during the construction of the test field "alpha ventus" revealed that the 160 dB re 1 µPa sound exposure level at a distance of 750 metres from the pile-driving site was typically exceeded by between 10 and 14 dB re 1 µPa, the maximum deviation being 19.1 dB re 1 µPa when driving the piles for the first 15 turbines at the BARD Offshore 1 wind farm. Acoustic deterrent devices used to dispel marine mammals for their own safety from areas where pile-driving work is imminent can represent a significant, if temporary, noise source at local level during the construction of offshore wind farms.

Seismic studies

During the most recent relevant seismic study in 2007 at Doggerbank, peak noise levels of 263 dB re 1 µPa were emitted.

Explosions

Experts estimate that there are still up to 1.6 million tonnes of conventional munitions remaining in German waters in the North and Baltic Seas, including some 1,300,000 tonnes in the North Sea region alone. There are also some 90 tonnes of chemical warfare agents in German marine waters off Helgoland. No figures are available regarding the number and intensity of munitions explosions in this area. Additionally, the German navy carries out controlled explosions in German waters for materials testing and training purposes, and also in order to remove residual warfare equipment.

Deterrent devices

The use of acoustic deterrent devices has been mandatory since 2004 (EU Regulation 812/2004) for certain types of fishing (which use tangle nets, gillnets or drift nets), to prevent the by-catch of small cetaceans. Other acoustic deterrent devices specifically for seals are used, for example, prior to pile-driving in the construction of offshore wind farms.

Navigation

Shipping is the principal continuous source of underwater noise. Some of the world's most intensively travelled shipping lanes are found in the North Sea. In 2005, in the German Bight alone, there were more than 68,000 recorded movements by vessels more than 50 metres in length. It is estimated that at any given time, there are between 1,800 and 2,000 vessels in the Baltic Sea.

Sediment extraction

Areas for the extraction of sediment can be found throughout the German North Sea. For example, continuous sand extraction takes place in the authorized field "Westerland II", with hopper-dredgers producing continuous broadband noise by using a jet vane.

Until now, there has been insufficient data available on the natural and anthropogenic noise pollution of the German North and Baltic Seas regions to enable an initial assessment to be made. According to OSPAR and HELCOM, anthropogenic underwater noise is considered one of the most important pressure factors, and adverse effects on marine life are clearly indicated. There is an acknowledged need for measures to reduce this. OSPAR confirms a high and growing level of noise pressure for Region II (Greater North Sea) as a result of intensive human use, and reiterates the need for cumulative record-keeping of the effects of rising emissions from various sources, and the development of assessment techniques to adequately quantify the biological effects.

Table 33: Classification of the ecological status / ecological potential of German surface waterbodies of transitional and coastal waters

Quality element		Phytoplankton						Macrophytes						Benthic invertebrates						Ecological Status			
Area	Number of water bodies	Bad	Poor	Moderate	Good	High	Uncertain	Bad	Poor	Moderate	Good	High	Uncertain	Bad	Poor	Moderate	Good	High	Uncertain	Bad	Poor	Moderate	Good
North Sea	28	0	8	13	1	0	6	1	6	11	1	0	9	1	0	19	6	1	1	1	9	18	0
Baltic Sea	44	5	19	16	4	0	0	2	16	16	3	0	7	4	9	20	8	0	3	7	22	14	1

Source: Federal/Länder Measurement Programme of the North and Baltic Seas

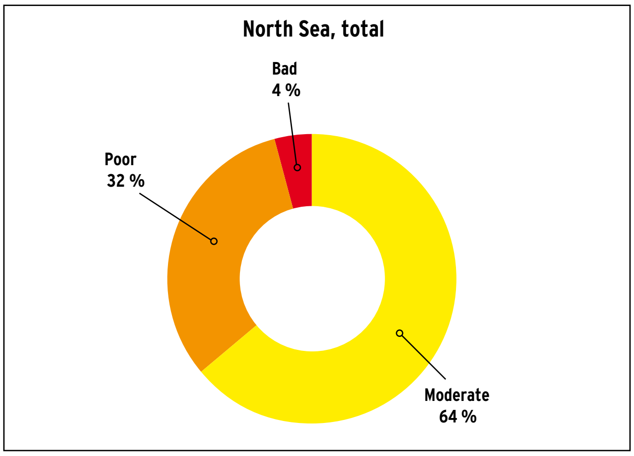
7.2.7 Ecological status

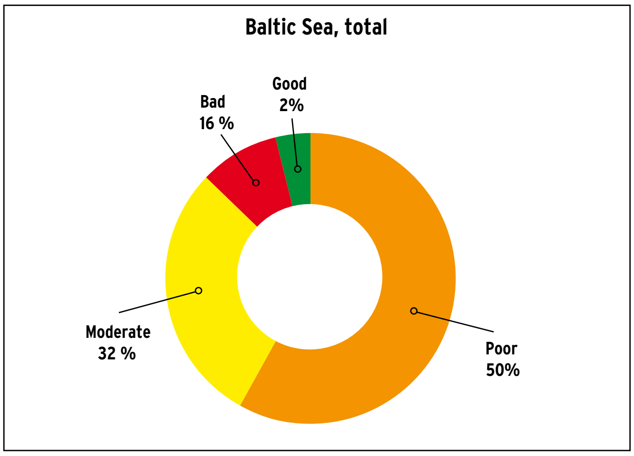
7.2.7.1 Assessment under the EG Water Framework Directive

In 2008, at European level intercalibrated assessment procedures were used for the first time for coastal waters (**Chapter 7.1.1**). The results of the assessment of the ecological status/ecological potential in German transitional (estuarine) and coastal waters are summarised in **Table 33**. **Figure 95** gives an up to date overview.

The results of the 2004 inventory of pressures have been largely confirmed. The vast majority of coastal water bodies in the North and Baltic Seas are in a moderate to bad status; and suitable measures must be adopted to improve them. Whilst the coastal waters of the North Sea are for the most part rated as "moderate", the coastal waters of the Baltic Sea are predominantly in a "poor" or even "bad" status. For the German North Sea coast, out of a total of 28 surface water bodies assessed, 18 were classified as “moderate”, 9 as “poor” and one (lower river Ems) as “bad” (**Figure 96**). In the German Baltic Sea, of the 44 designated water bodies, 7 were assessed as “bad”, 22 as “poor", 14 as “moderate” and only one as “good” (**Figure 96**). Most of the German Baltic Sea coastal waters assessed as “bad” are water zones with low water exchange rates or long retention periods (river Peenestrom, Kleiner Jasmunder and Barther Bodden, rivers Untere Trave and Travemünde, Innere and Mittlere Schlei).

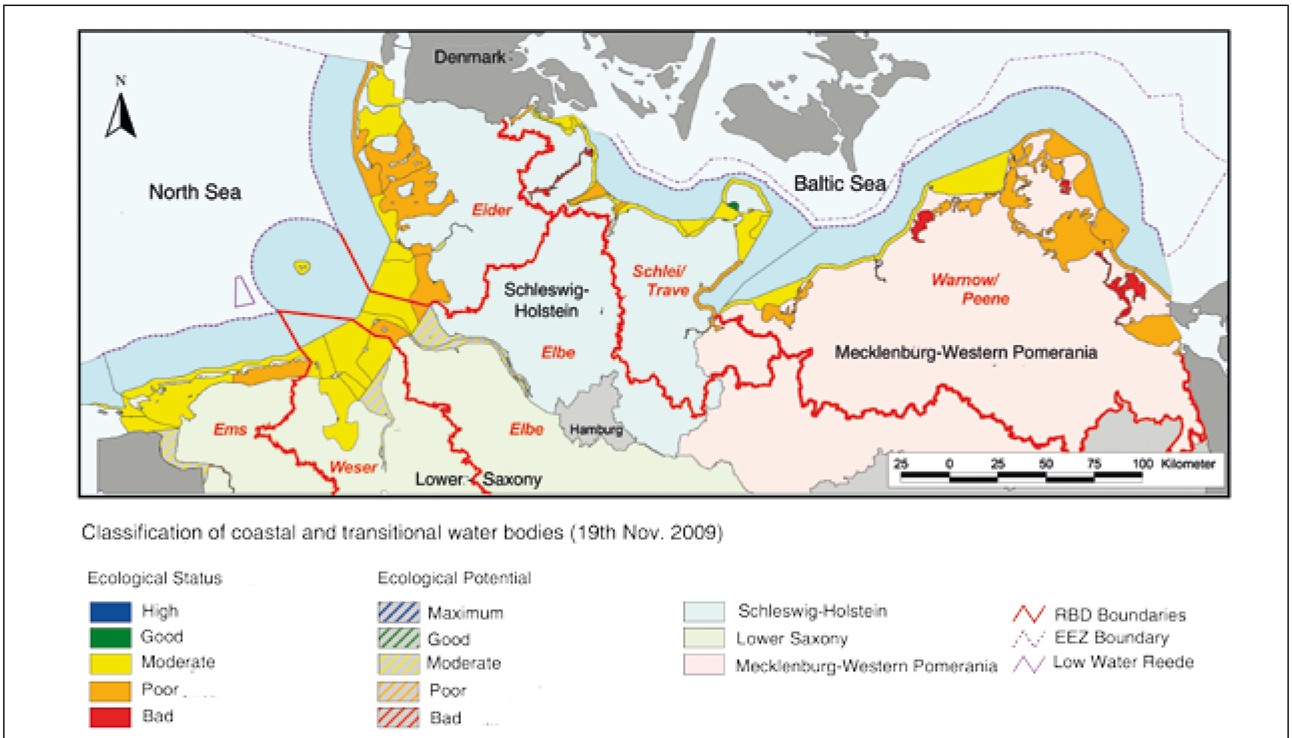
Figure 96: Summary of the ecological status/ecological potential of all water bodies in the North Sea (n = 28) and Baltic Sea (n = 44)





Source: Federal/Länder Measurement Programme of the North and Baltic Seas

Figure 95: Assessment of the ecological status oftransitional and coastal waters of the North and Baltic Seas



Source: H.C. Reimers, State Agency for Agriculture, Environment and Rural Areas (Landesamt für Landwirtschaft, Umwelt und ländliche Räume)

The assessment results obtained for the biological quality elements "phytoplankton" and "macrophytes" (including large algae/seagrass) are the main reason for failing to achieve a good ecological status. For example, in the river basin of the Eider and Elbe, phytoplankton assessments were generally the decisive factor. Phytoplankton and macrophytes react sensitively to the excessive input of nutrients from the waters flowing into them (see **chapter 7.2.2**). The classification of surface waters into "poor", "moderate" and "bad" is therefore particularly common in the areas influenced by estuaries and bights, firths and inner bays characterised by low water exchange. Measures to improve the status must therefore focus on reducing diffuse nutrient discharges from agriculture in particular.

The status of bottom-dwelling fauna was rather classified as "moderate", and in some cases as "good", with the exception of the lower river Ems, where the ecological status of the benthic invertebrate fauna was classified as bad. Summer oxygen deficiency, caused by the degradation of organic compounds, was regularly observed in the estuaries of the rivers Elbe, Weser and Ems as well as in the Mecklenburg Bight, Lübeck Bight, Kiel Bight and neighbouring bights and firths. The inflow of low-oxygen water into the German Bight also affects the coastal waters (see **Chapter 7.2.2**).

The quality element "fish" was disregarded in **Table 33** as assessment was only necessary in the five estuaries. Its ecological classification produced a “moderate potential” for the rivers Eider, Elbe, Weser and Ems.

7.2.7.2 Assessment under the Habitats Directive

The second National Report (reporting period 2001-2006) was the first comprehensive report on the conservation status of the habitat types and species listed in the Habitats Directive. In this report, the conservation status of habitat types as well as of fauna and flora species were assessed based on the best available information. In view of the very deficient data situation, a number of species and habitat types were classified as unknown. Among those that were assessed, the conservation status was predominantly classified as “bad” (**Table 34**). Only the tide area and the seal populations of the German North Sea are in a “favourable” conservation status.

Table 34: Overall assessment of the conservation status of species and habitat types according to the Habitats Directive for the period 2001-2006

Habitat types/species	North Sea	Baltic Sea
Sandbanks slightly covered by seawater all the time	Unknown	Unknown
Estuaries	Unfavourable-bad	Unfavourable-bad
Mudflats and sandflats not covered by seawater at low tide	Favourable	Unfavourable-inadequate
Coastal lagoons	Unfavourable-bad	Unfavourable-bad
Large shallow inlets and bays	Unknown	Unfavourable-inadequate
Reefs	Unfavourable-inadequate	Unknown
Grey seal	Unfavourable-inadequate	Unfavourable-bad
Harbour porpoise	Unfavourable-inadequate	Unfavourable-bad
Common seal	Favourable	Unfavourable-bad

Source: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, BMU)

7.2.7.3 Assessment under the EU Marine Strategy Framework Directive

An initial assessment of the environmental status of the entire German North and Baltic Sea region under the EU Marine Strategy Framework Directive (2008/56/EC) was carried out in 2012 and comprised an assessment of key features and pressures, together with an analysis of socio-economic aspects. This assessment was primarily based on a summary of existing analyses and assessments from other Directives (Habitats Directive, EC Water Framework Directive) and regional Conventions, although the latter do not currently cover all aspects of the EU Marine Strategy Framewok Directive. The findings indicate that the German North and Baltic Seas currently fall short of a good environmental status (cf. http://www.meeresschutz.info/index.php/berichte.html). **Figure 97** provides a simplified, summarising overview of the initial assessment under the EU Marine Strategy Framework Directive for Germany's marine waters.

Based on the results of the initial assessment, the following seven environmental objectives have been defined for the German North and Baltic Seas:

- Seas unimpacted by anthropogenic eutrophication (see also **chapter 7.2.2**).
- Seas unpolluted by contaminants (see also **chapters 7.2.3** and **7.2.4**).

- Seas without impacts from human activities on marine species and habitats
- Seas with sustainably and ecologically-sound used resources
- Seas not polluted with litter (see **chapter 7.2.5**)
- Seas unimpacted by anthropogenic energy inputs (see **chapter 7.2.6**)
- Seas with natural hydromorphological characteristics (see **chapter 7.2.1**)

These will serve as a general, overarching guideline for the achievement of a good environmental status by 2020. They provide a framework which is currently being fleshed out by specific operational objectives and will be defined in greater detail by relevant indicators. Within the context of implementing the EU Marine Strategy Framework Directive, specific programmes of measures must be prepared by 2015 with a view to attaining and/or maintaining a "good environmental status" and which must be guided by the environmental objectives.

7.2.7.4 Assessment under OSPAR and HELCOM

The 2010 OSPAR Quality Status Report asserts that the majority of ecological quality objectives in the North Sea have not yet been met, and that further efforts are needed to improve the status. However, there are signs that contamination with chemicals and oil and the associated impacts on organisms are decreasing,

Figure 97: Summarising overview of the 2012 initial assessment under the EU Marine Strategy Framework Directive for Germany's marine waters. **Green** = good environmental status met, **Red** = good environmental status not met

Features, pressures and impacts	North Sea		Baltic Sea	
Biotope types	Not good		Not good	
Phytoplankton	Not good		Not good	
Zooplankton	Not assessed		Not assessed	
Macrophytes	Not good		Not good	
Macrozoobenthos	Not good		Not good	
Fish	Not good		Not good	
Marine mammals	Not good		Not good	
Seabirds	Not good		Not good	
Complete coverage with sediment	Not assessed		Not assessed	
Sealing	Not assessed		Not assessed	
Changes in siltation	Not assessed		Not assessed	
Abrasion	Not assessed		Not assessed	
Selective abstraction	Not good		Not assessed	
Underwater noise	Not assessed		Not assessed	
Marine litter	Not good		Not assessed	
Changes in the temperature profile	Not assessed		Not assessed	
Changes in the salinity profile	Not assessed		Not assessed	
Input of synthetic and non-synthetic compounds	EC Water Framework Directive	OSPAR	EC Water Framework Directive	HELCOM
Input of radio nuclides	gut		gut	
Contaminants in food	Not good		gut	
Systematic and/or intentional release of substance	EC Water Framework Directive	OSPAR	EC Water Framework Directive	HELCOM
Accumulation of nutrients and organic material	Not good		Not good	
Input of microbial pathogens	Good		Good	
Occurrence of non-native species	Not assessed		Not assessed	
By-catch	Not good		Not assessed	
Cumulative and synergetic effects	Not assessed		Not assessed	
Overall environmental status	**Not good**		**Not good**	

Source: Federal Ministry for the Environment, Nature Protection and Nuclear Safety, 2012 whilst intensive fishing continues to adversely affect commercial fish stocks, and the large quantities of litter in the North Sea are disastrous for seabirds in particular. The principal pressures and their cumulative effects concern eight groups of organisms and habitats. According to this classification, only selected deep sea habitats and seal populations are in a good status in the extended North Sea, whereas shallow fine sediment habitats, in particular, indicate a poor status and are also exposed to the greatest pressures. Bottom trawling is the principal culprit.

For the extended North Sea, the 2010 Quality Status Report concludes that the region continues to be exposed to major anthropogenic pressures as a result of high usage pressure (intensive fishing, heavily used shipping routes and high population density along the coast). In the future, these pressures will intensify, for example because shipping will increase further, and offshore wind farms will take up large areas. Eutrophication remains a major problem for the region, and major efforts are needed to reduce this, particularly as agricultural activities are poised to intensify in future. The stocks of 40 commercially fished species are declining, and many of these populations are outside of safe biological limits. However, there are indications that the size composition of ground-dwelling populations has improved. Additionally, the growing practice of bottom-trawling damages and destroys benthic habitats and causes high rates of by-catch, which are decimating the populations of rays, porpoises and sharks, *inter alia*. Industrial fishing also has massive impacts on fish stocks and the seabirds that feed on them. Litter in the North Sea proves fatal for many Northern Fulmars; 94 % of the birds examined were found to have plastic particles in their stomachs. Climate change leads to shifts in the dispersal area of some species and accelerates the decrease in cod populations. Future marine planning which reduces or halts these ecological effects would be a means of harmonising the diverse usage pressures more effectively with the aim of achieving or conserving a good status of the marine environment.

As part of a pilot study, the Helsinki Commission conducted the first holistic assessment (HOLAS) of the status of the Baltic Sea based on data from the years 2003-2007. It concludes that none of the Baltic Sea basins currently has a good environmental status. Most areas are impaired by eutrophication and/or hazardous substances and/or have an unfavourable conservation status for certain species. Bothnian Bay, Bothnian Sea and parts of northern Kattegat at least indicate a moderate status, whereas the open Gulf of Finland, the northern central Baltic Sea, the eastern Gotland basin, the coastal waters of both Kattegat and Arkona Basin and the Belt Sea, as well as the Kiel and Mecklenburg Bights show significant deviations from a good status. If anthropogenic pressures are ranked in order of severity, inputs of nutrients and organic material and the impacts of fishing (reduction of fish stocks and destruction of habitats by bottom trawling), together with inputs of pollutants (such as lead), rank among the top 10. These pressures currently impair the ecosystem of the Baltic Sea to such an extent that it is incapable of providing key environmental services (fishing, leisure, climate, species diversity etc.). The HELCOM report concludes that further efforts are needed throughout the Baltic Sea to attain a good environmental status, and identifies the following measures among others: Reducing nutrient inputs, restoring intact food webs, particularly by increasing the proportion of top predators, reducing the inputs of contaminants, reducing oil contamination, restoring natural habitats (particularly reefs and wetlands close to the coast), and reducing physical habitat impairments by fishing equipment.

The biodiversity of the open Baltic Sea is mainly under threat from eutrophication and fishing, whereas on the coasts, physical disturbances (sand and gravel extraction, construction of harbours, bridges, wind farms etc.) additionally play an important role. Over the last 30 to 40 years, biodiversity has changed significantly. The species composition of phytoplankton communities has changed, macrophytes (large algae, seagrasses) have disappeared from some areas, particularly in southern coastal regions, bottom-dwelling organisms are declining in terms of numbers and species diversity, and the fish communities of the Baltic Sea are now dominated by sprat rather than codfish. Populations of dunlin, eider and long-tailed duck are decreasing rapidly. There are only several hundred harbour porpoises still living in the Baltic Sea, and populations of ringed seal are in a poor condition. Some 59 species in the Baltic Sea are currently classed as endangered. The biodiversity status of just 17 % of the assessed coastal regions can be classified as good or high, while the remaining 83 % is in a moderate to poor status. Among the Baltic Sea basins, the central Baltic Sea, Riga Bight and the Gulf of Finland have the poorest biodiversity status, while only the Bothnian Sea is in a good status.

The assessment of biodiversity aspects currently being undertaken by HELCOM is a first step towards an assessment of the environmental status in accordance with the EU Marine Strategy Framework Directive. In future, consideration must be given to ecological structures and functions in addition to protected species.

7.2.7.5 Status assessment for the Wadden Sea

In June 2009, the German and Dutch part of the Wadden Sea was declared a UNESCO world heritage site, highlighting the uniqueness of this ecosystem and acknowledging efforts to date to protect it. Although Germany, Denmark and the Netherlands have been endeavouring to protect this exceptional landscape since 1982 as part of the Trilateral Wadden Sea Convention, the 2009 Quality Status Report indicates that the ecosystem is still exposed to a diverse range of human pressures, primarily eutrophication, contaminants, marine litter and fishing. Efforts to reduce nutrient discharges and emissions have achieved a notable degree of success. The continuing extensive fishing of stocks that migrate between the open reaches of the North Sea and the Wadden Sea leads to reduced population sizes of commercially fished species (sole, dab, cod, whiting), which in turn causes changes in the food web and overall impairments to the ecosystem of the Wadden Sea. In particular, large fish species such as the thornback ray, stingray and various species of shark have become rare. Fishing in the Wadden Sea is confined to prawns (common shrimp or sand shrimp) and common mussel farming. Natural populations of common mussel have decreased sharply since the 1990s. The aim of the Wadden Sea Agreement to increase the size of the mussel banks has not yet been achieved. Domestic common mussels must now also compete with non-native pacific oysters introduced by human mariculture activities. Litter originating primarily from fishing and shipping continues to be washed onto the shores of the Wadden Sea in large quantities. The number of non-native species in the Wadden Sea is continuously rising, changing the species composition of the Wadden Sea organisms, and undermining efforts to restore natural biodiversity. The Wadden Sea is also under major threat from climate change. Rising sea temperatures are forcing many species of young fish out of their breeding grounds in the Wadden Sea, and the mudflats cannot grow fast enough to match up to the rise of the sea level. As a result, this habitat faces the threat of further irreparable losses. Restoring degraded habitats and conserving natural habitats are the basis for adapting the Wadden Sea ecosystem to advancing climate change. The Quality Status Report recommends artificial sand replenishment to enable the Wadden Sea to keep pace with rising sea levels. Further research is needed to ensure that this is achieved in a selective, eco-friendly manner.

7.2.8 Chemical status

Substances which are not biodegradable (**p**ersistent), accumulate in living beings (**b**io-accumulative) and **t**oxic (**PBT** substances as defined in Annex 13 of REACH) play a particularly important role when assessing pollution of the marine environment with hazardous substances. Under the EU Water Framework Directive, substances with PBT characteristics are classed as priority hazardous substances alongside other equally hazardous substances such as certain metals and dioxins. For these substances, the aim is to achieve concentrations close to zero (xenobiotics) or background levels (heavy metals) in coastal waters within one generation.

For the priority and selected other pollutants listed in Annex 7 to the Ordinance on the Protection of Surface Waters, the chemical status of transitional and coastal waters (12 nautical mile zone) must be ascertained. If only one of the environmental quality standards of these substances is exceeded, the status is classed as “not good”. In the first management plan, of five surface waterbodies in transitional waters, two are considered to have a "good chemical status", together with almost all (98 %) coastal waters. However, it should be noted that the Directive on environmental quality standards in the field of water policy had not yet been applied at this point. In the second management plan, good chemical status is unlikely to be achieved in the majority of cases, due to the standardised requirements of the Directive on environmental quality standards in the field of water policy.

8 Summary and conclusions

The EC Water Framework Directive (WFD) formulates ambitious environmental objectives for the protection of groundwater and surface waters that can only be achieved gradually over a period of many years. The initial management plans pursuant to Article 13 of the EC Water Framework Directive presented by the end of 2009 document the progress achieved with waterbody pollution control, but also underscore the need for extensive action if we are to achieve the target of a "good status" of waterbodies. Only 10 % of surface waterbodies are currently in a good ecological status. Among inland waters, this corresponds to around 14 % of the total length of rivers and streams. The most common causes for an inferior status class are changes in the morphological structure and a lack of passability for fish and smaller organisms. Other reasons include a high level of pollution with nutrients, particularly from diffuse sources, and (in selected cases) with river-specific pollutants. For lakes, the result is rather better – 215 bodies of lakewater (39 %) achieve a good ecological status, and 70 (40 %) a good ecological potential. The results for transitional and coastal waters, on the other hand, are not as good, and only one waterbody (out of a total of 72) is already in a good ecological status. Here, nutrients are the principal pressure factor, because they lead to eutrophication in these predominantly standing waters. The chemical status of waterbodies, measured in terms of compliance with environmental quality standards, is consistently not good, due partly to the fact that the environmental quality standard for mercury in biota is exceeded throughout Europe. Differentiated representations are therefore required in order to show which of the priority substances are currently problematic and which are not. Among groundwater bodies, only 63 % achieve "good chemical status". The main reason for failure to achieve this is an excessive nitrogen load. On the whole, quantitative status is at least good (96 % of groundwater bodies).

Measures within the context of the initial management plans must focus primarily on hydromorphology, while in a material sense, it is crucial to reduce emissions of nutrients, metals and pesticides.

Measures that improve the dynamic of riverflow result in a significantly better hydromorphological status. These include the removal of bed and bank fortifications, the connection of bayous, or the relaying of dykes and the raising of beds. Measures to create linear passability and thereby provide aquatic fauna with access to functioning habitats can often be achieved without restricting usage. Careful waterbody maintenance can help to improve ecological status with a diverse range of small-scale measures. It is advantageous to "let the water run its course”, provided no disadvantageous impacts on usage are anticipated. In the longer term, only those hydromorphological changes which are necessary in order to maintain ecologically compatible uses should be retained.

The concentrations of nitrate in groundwater, and of phosphorus and nitrogen in surface waters, have decreased to varying degrees, but nevertheless remain too high, and are an important factor in failing to achieve a good status. The largest proportion of inputs comes from soil material eroded from farmland in the case of phosphorus, and from inputs of agricultural nitrogen losses via the groundwater in the case of nitrogen. These are also the areas with the greatest reduction potential.

Even if the positive trend of decreasing nutrient inputs continues, the eutrophication effects in marine ecosystems will only gradually disappear with a delayed effect. In the Wadden Sea and in many regions of the Baltic Sea in particular, historical nutrient deposits in sediment will persist for a long time to come. Moreover, in future, eutrophication processes could be further encouraged by climate change, because as the surface water is warmed up, stratification in waterbodies intensifies. New problem areas might emerge as a result of this.

In the case of groundwater, reductions in nitrate and pesticides will only become apparent with a time delay, due to the long flow times of water from the soil surface into the groundwater.

During recent years and decades, overall, the contamination of surface waters with industrial organic pollutants such as hexachlorobenzene and heavy metals such as mercury and cadmium has decreased significantly. Nevertheless, further efforts to reduce substance discharges are still needed for the substances and substance groups cited. This applies in particular to the heavy metals mercury, zinc, copper and cadmium, which currently fall short of the relevant targets to varying degrees. Diffuse sources account for a large proportion of total inputs in the case of heavy metals as well. On average, about half of all diffuse inputs are due to rainwater runoff from streets and roofs in towns and cities. Today the concentrations of nearly all heavy metals are higher in rainwater than in municipal sewage – the “real” wastewater.

Particular attention must be devoted to the contamination of waterbodies with pesticides. In some cases, the environmental quality standards for surface water and the groundwater quality standards are exceeded for these substances. In groundwater close to the surface, around 5 % of more than ten thousand monitoring sites fail to comply with the limit of 0.1 µg/l for at least one active ingredient. Nevertheless, overall, the pollution of groundwater with individual substances such as atrazine and diuron is decreasing.

In watercourses, the environmental quality standards for polycyclic aromatic hydrocarbons (total benzo[g,h,i]perylene and indeno[1,2,4-cd]yrene), hexachlorobenzene, polychlorinated biphenyls and the biocides cybutryn and tributyl tin are frequently exceeded. The environmental quality standard proposed but not adopted by the Commission for the pharmaceutical diclofenac, which is on the watch list of the new EU Environmental Quality Standards Directive, is also exceeded in some cases.

In marine waters, pollution with poorly biodegradable substances such as DDT, polychlorinated biphenyls, hexachlorocyclohexane and hexachlorobenzene persists, despite substance bans and decreasing concentrations. Decreasing concentrations of tributyl tin in mussels from the North and Baltic Seas have been observed since 2002. This is a positive effect of the global agreement banning ship's coatings containing TBT, which came into force in 2001.

The EU Marine Strategy Framework Directive is a marine conservation Directive with an ecological focus. The status of the marine ecosystems and the decisive pressures from invasive species, commercial fishing, eutrophication, pollutants, marine litter and energy inputs (such as cooling water and noise) must be assessed. The overarching objective of this Directive is to achieve or maintain a good environmental status of European marine waters by 2020. An initial assessment of national marine waters was undertaken in 2012. The monitoring programmes must be in place by mid-2014 at the latest. As with the EC Water Framework Directive, the description and assessment of marine ecosystems compared with the type-specific biota occurring in a good status is based on an integrative ecological classification of marine waters. Identification of the relevant pressures will allow targeted programmes of measures to be drafted by mid-2016. The results of the next status assessment of marine waters must then be presented by 2018. The Federal Government and coastal Länder are deploying a joint Secretariat on Marine Protection to coordinate national implementation of the EU Marine Strategy Framework Directive.

Essentially, the EU Marine Strategy Framework Directive pursues identical objectives to the EC Water Framework Directive. Consequently, assessments under both Directives should complement one another. In coastal areas, no waterbodies are in a good status. Ambitious objectives call for ambitious measures, which have already been taken with the first Management Plan under the EC Water Framework Directive. However, there still remains much to do. One thing is clear: far from all waterbodies will be in a good status by 2015. Consequently, the next two management cycles under the EC Water Framework Directive, lasting 12 years in total, will be crucial in determining the extent to which a good waterbody quality can be achieved throughout Europe's seas and inland waters.

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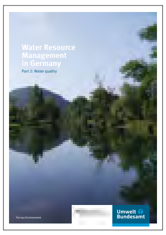

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