



TO

Marjan Datema

FROM

M.J. Baptist

Dear Mrs. Datema,

In this memo I present an overview of the Dutch and German long-term monitoring programmes in the Ems estuary. This overview is based on a previous report of Baptist & Philippart (2015), a memo of 31 October 2018 "Monitoring programmes Ems-Dollard" and additions and comments that have been contributed by colleagues from NLWKN, BfG and RWS, for which I thank them wholeheartedly.

I limited the overview on the monitoring of surface water only, which means I have not included groundwater monitoring. I also limited the overview to mandated long-term (>10 years) monitoring required by EU Directives and other relevant agreements, which means that short term project monitoring (such as Ems-Ästuar Messungen EDoM) are not included.

With kind regards,

M.J. Baptist

Memo

DATE

March 2, 2020

SUBJECT

Update of overview of monitoring programmes Ems-Dollard

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Current monitoring programmes in Germany and The Netherlands

Germany

The monitoring programmes in the Ems estuary that provide data for international conventions, directives and agreements are carried out by different institutions:

1. The "**Gewässerüberwachungssysteme Niedersachsen (GÜN)**" is carried out by the Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz (NLWKN). Since 1980, this monitoring network supplies data on the quantity and quality of precipitation, groundwater, surface waters and coastal waters of Niedersachsen. With regard to coastal waters, this programme is primarily focusing on the requirements for the WFD and is also providing data for the OSPAR Coordinated Environmental Monitoring Program as well as TMAP (NLWKN, 2017).
2. The "**Erfassungsprogramme im Naturschutz**" is a continuous, systematic, long-term monitoring programme in Niedersachsen on flora, fauna and biotopes. The NLWKN is co-ordinating four acquisition series on species and biotopes in which more than 3000 volunteers operate: vegetation, birds, biotopes and all other species. Vegetation maps of coastal biotopes are worked-out following the EU habitat typology (Drachenfels, 2014).
3. The "**Kooperationsprogramm Naturschutz**" is carried out under the responsibility of the Niedersächsisches Ministerium für Umwelt, Energie und Klimaschutz (NMUEK). The programme is financing voluntary measures for nature conservation mainly in Natura-2000 areas of Niedersachsen and is divided in four sections: agricultural land, special habitat types, permanent grassland and northern wintering and migratory birds. The programme results in maps of agricultural buffer strips, conservation areas and biotopes for specific species and habitat types, including those that lie at the border of the Ems estuary (NMUEK, 2014).
4. The "**Niedersächsische Meeresüberwachung**" is operated by NLWKN and the National Park Administration Wadden Sea. It is part of the federal / state-wide monitoring programme for the North and Baltic Sea named "Bund-/ Länder-übergreifenden Messprogramms für die Nord- und Ostsee" (BLMP). Following the requirements of relevant marine directives and agreements, the BLMP is coordinating on monitoring concepts and the allocation of work to the specialized services provided by the federal and local governments. The BLMP was founded on 17 April 1997 at the 34th Conference of Environmental Ministers of northern Germany and reorganized in its basic structure in 2007. The programme is based on the requirements of the EC Water Framework Directive, Marine Strategy Framework Directive, Habitats and Birds Directives, and the marine protection conventions (OSPAR, HELCOM, TMAP) and other regulations. Hence, the seafloor and coastal waters are investigated on biological parameters, physico-chemical parameters, sediment texture, and the contamination of sediments and organisms. These tasks are carried out in individual monitoring programmes of the partners. Detailed information can be found in the BLMP Monitoring Manual (BSH, 2014) or <http://www.blmp-online.de/>.
5. The **Niedersächsischer Landesamtes für Verbraucherschutz und Lebensmittelsicherheit (LAVES)** is responsible for monitoring fish fauna for the WFD. Measurements take place every two years in three locations in the Ems, i.e. at Krummhörn, Oterdum and Terborg with the use of stow nets (NLWKN, 2010). The actual fishing is carried out by a subcontractor, Bioconsult. LAVES is also responsible for seal counts in the Ems estuary.
6. The **Wasser- und Schifffahrtsamt Emden** is responsible for the development and maintenance as well as for the order and security of

shipping traffic on the waterway between Papenburg and Emden and further out to the islands of Borkum to Spiekeroog. Navigational depth in the Ems estuary is measured at least once a year with echosounding. Several fixed water level measurement stations are maintained in the Ems estuary.

7. The **Bundesamt für Seeschifffahrt und Hydrographie (BSH)** is responsible for monitoring physical quantities in the North and Baltic Sea. This is done with permanently installed monitoring networks for temperature, salinity, direction and speed of currents and water levels. The BSH is also determining the (physico-chemical) quality of surface waters and sediment for the BLMP.
8. The **Bundesministerium für Ernährung und Landwirtschaft (BMEL), Johann Heinrich von Thünen-Institut (Bundesforschungsinstitut für Ländliche Räume, Wald und Fischerei)** is responsible for monitoring and sustainable management of fish, crustaceans and molluscs. The Thünen-Institut also deals with questions concerning the conservation and protection of marine mammals and birds, the distribution and effects of pollutants in the sea, and the impact of aquaculture on the aquatic environment.
9. The **Bundesanstalt für Gewässerkunde (BfG)** - in its function as a scientific institution ranking as a supreme federal agency - monitors and documents the status of the German federal waterways. Data is collected for specific questions as well as for permanent monitoring.

The Netherlands

The monitoring programmes in The Netherlands that provide data for international conventions, directives and agreements are carried out or coordinated by different institutions:

1. The "**Monitoring Waterstaatkundige Toestand des Lands**" (**MWTL**) is carried out under the responsibility of Rijkswaterstaat (RWS), which is part of the Ministry of Infrastructure and Water Management. It is a national environmental monitoring programme for hydrochemistry, hydrobiology and geomorphology. In marine waters it focuses on height (lidar) and bathymetry, contaminants in fish, shellfish and bird eggs, chemical parameters in surface water and sediment, phytoplankton, macrozoobenthos, seagrass and birds (Rijkswaterstaat, 2014).
2. The "**Landelijk Meetnet Water**" (**LMW**) is carried out under the responsibility of Rijkswaterstaat. LMW is a facility that is responsible for the acquisition, storage and distribution of abiotic water data. In over 400 locations measurements are made of discharge, water level, wave height and direction, flow velocity and direction and water temperature .
3. The "**Netwerk Ecologische Monitoring**" (**NEM**) is a partnership between government, provinces and the Central Bureau for Statistics (CBS). The major part of the collection of data is carried out by volunteers, under coordination of Private Data Management Organisations (PGOs). The NEM focuses on flora and fauna such as terrestrial mammals, bats, birds, fish, reptiles, amphibians, butterflies, dragonflies, beetles, marine invertebrates, plants, lichens and mushrooms .
4. The "**Wettelijke Onderzoeks Taken**" (**WOT**) is carried out under the responsibility of the Ministry of LNV. Two programme units are relevant for marine waters. The "WOT Natuur & Milieu" ensures the implementation of legal monitoring tasks for Nature & Environment. Since 2014 the unit it is coordinating NEM. The "Centrum voor Visserij Onderzoek (CVO)" provides management advice on fisheries and collection of data on fishing and fish stocks. WOT measurements in the Dutch Wadden Sea focus on seals,

demersal fish, macrozoobenthos in particular shellfish, and salt marshes and are deployed by Wageningen Marine Research.

In The Netherlands there is also the "Subsidy system Nature and Landscape" (SNL), which are provincial subsidies. Owners and nature management organisations receive subsidies for management and nature development of natural and cultural landscapes. Subsidies are also available for monitoring as well and data contributes to Natura2000 monitoring requirements. The focus is on terrestrial ecotopes, but salt marshes are included. There are no long-term records yet that derive from SNL, therefore this monitoring is not included here.

Monitoring in The Netherlands and Germany compared

An overview and comparison of monitoring that is relevant for the Ems estuary is given below.

In this listing, the Ems estuary is subdivided in regions as depicted in **Figure 1** and numbered:

1. Freshwater Unterems.
2. Brackish Unterems.
3. Dollard.
4. Inner estuary.
5. Outer estuary.

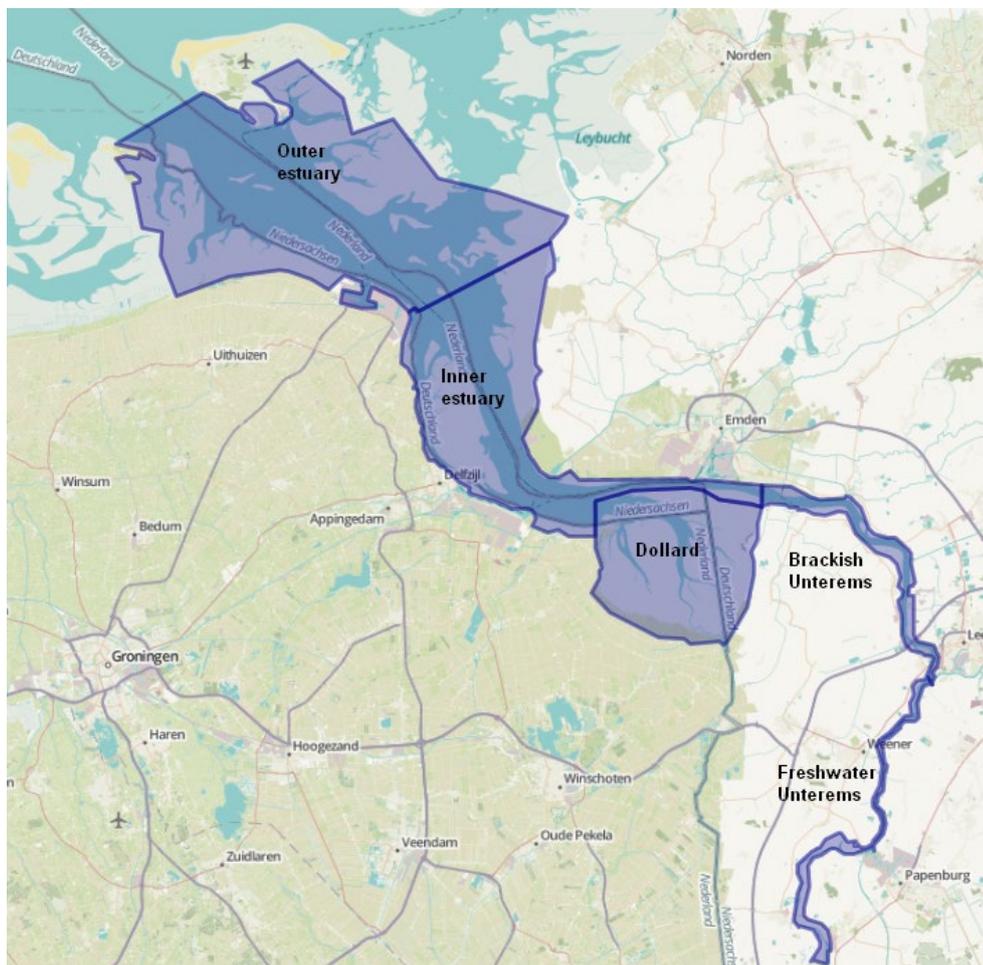


Figure 1. Regions of the Ems estuary.

Netherlands

Germany

Water level

Water level

In the LMW programme several hydrographical parameters (water levels, current velocities, wave heights) are measured from fixed measurement poles or wave buoys.

The Wasserstraßen- und Schifffahrtsamt Emden measures water levels in the Ems estuary at 18 different locations (not all in the study area: four in region 1, five in region 2, two in region 4 and three in region 5). In addition, current velocity and direction, as well as CTD and **oxygen** and **turbidity** are measured on 15 positions usually in the vicinity of gauge stations (seven in region 1, four in region 2, three in region 4 and one in region 5).

Fixed water level stations in the Ems estuary are located at Nieuwe Statenzijl (region 3), Delfzijl (region 4) and Eemshaven (region 5). Wave buoys are all located in region 5: Oude Westereems Zuid, Oude Westereems Noord, Uithuizerwad en Stroommeetpaal Eemshaven.

The BfG has two large hydrographical stations in the Ems at Terborg, Ems-km: 24,60 (region 2) and Knock, Ems-km: 50,85 (region 4). Water level measurements are continuous (5-minute averaged). Additional parameters include **hydrochemistry**: temperature, oxygen, pH, conductivity, turbidity.

Hydrochemistry (also see phytoplankton and zooplankton)

Hydrochemistry (also see phytoplankton and zooplankton)

In the MWTL programme several hydrochemical parameters (suspended matter, nutrients, oxygen, toxic constituents) are determined from samples from surface waters and sediment. In 2014 there were 10 measurement stations existing in the entire Dutch Wadden Sea. Sampling frequency varies from 12 to 19 times per year for surface water. The Ems estuary has four measurement stations that are sampled 19 times annually, Table 3. Sediment is sampled twice in a 3-yearly cycle (Rijkswaterstaat, 2014).

Four NLWKN stations in Ems estuary: one in region 1, two in region 2 and one in region 5. Analysis of nitrite+nitrate, ammonium, ortho-phosphate, silicate, DOC, TP, and TN. Sampling frequency differs between weekly, 2-weekly or once per quarter.

In the 1970s and 1980s there were 33 sample locations in the Ems-Dollard, but since the 1990s the number of measurement stations has been declining (de Jonge et al., 2006; Jager et al., 2009).

Twice a year since 2009 (May to September) surface sampling by pump with a vessel of the WSA-Emden, on a longitudinal transect sailing against the ebb current from Borkum to Herbrum. Continuous measurements of oxygen, conductivity, water temperature, pH, turbidity, chlorophyll. Individual samples are taken on this cruise as well (approx. 20 samples): nutrients (ammonium, nitrite, nitrate, ortho-P, silicate, total P, total-N), TOC, DOC, suspended matter content and LOI, chlorophyll (according to DIN and with HPLC), **phytoplankton** and **zooplankton** (microscopic determination of composition, waste and bio-volumes).

Two to four times per year since 2009 BfG carries out a measurement of vertical distribution at three water depths during one tidal cycle at different stations between Ems km 8 and km 24.

	<p>a. Continuous: oxygen, conductivity, water temperature, pH, turbidity.</p> <p>b. Individual samples approx. 20 samples per measurement: nutrients (ammonium, nitrite, nitrate, ortho-P, silicate, total P, total-N), TOC, DOC, suspended matter content and LOI.</p> <p>BfG does continuous measurements since 2014 in the months April to November at two stations at Ems km 11.8 and km 18.3 in 5 measuring positions above the bed (0.5 m to 3 m) and one near-surface position. Temporal resolution 30 min. values, parameters: oxygen and water temperature</p>
<p>Pollutants</p> <p>Pollutants in water and sediment are monitored in the hydrochemistry programme of MWTL in four stations, Table 1. Rijkswaterstaat is also responsible for measuring pollutants in bird eggs of Oystercatcher or Common tern for TMAP. The analysis of chemical contaminants is carried out by the Institut für Vogelforschung (IfV) in Wilhelmshaven. In the entire Dutch Wadden Sea there are five measurement locations of which one is located in the Ems estuary at the shipping channel of the port of Delfzijl.</p>	<p>Pollutants</p> <p>NLWKN has three (combined) stations for pollutants in sediment: one in region 1 (Herbrum Schleuse Unterwasser), one (three combined) in region 3 (Ems-Dollart Sediment A B C) and one (three combined) in region 5 (Borkum Sediment A B C).</p> <p>BfG uses a Van-Veen sampler to monitor sediment samples each 0.5 kilometre on 114 locations from Papenburg to Knock, measuring different groups of pollutants (organic, anorganic toxic substances).</p> <p>Two stations for pollutants in water are: in region 2 (Terborg Pegel), and in region 4 (Knock Pegel).</p> <p>NLWKN is measuring pollutants in bird eggs for TMAP in sampling station Dollart (region 3). Pollutants in Blue Mussel are monitored at Borkum (region 5).</p>
<p>Radioactivity</p> <p>The water quality stations Dantziggat and Huibertgat Oost of the MWTL programme include radiochemistry.</p>	<p>Radioactivity</p> <p>The measuring location at Terborg is also a warning point for radioactivity as part of the legal task of the BfG according to the Radiation Protection Act 161: Continuous online measurement of total gamma activity.</p> <p>Water and suspended sediment samples for radionuclides are taken at Borkum, Knock, Emden, Oldersum, Terborg, Leerort, Weener, Halt. Determination of alpha, beta and gamma emitters in water and gamma emitters in the suspended matter.</p>
<p>Bathymetry</p>	<p>Bathymetry</p>

The bathymetry of the Dutch Wadden Sea is determined by singlebeam depth soundings every six years in the MWTL programme. The transect width is 200 m. Each year a subarea of the Wadden Sea is surveyed, the Ems-Dollard was covered in 1985, 1990, 1995-1997, 2001-2002, 2008 (Grasmeijer and Pasmans, 2013) and the latest bathymetric survey of the Ems-Dollard took place in 2014. A next survey is planned for 2020. The height of coastal dunes and beaches is determined yearly by a combination of lidar and depth soundings.

Singlebeam and multibeam echosound^{DATE} depth soundings in the sublittoral zone - terrestrial²⁰²⁰ and laser scan surveying in the eulittoral^{PAGE} zone. If possible combined with side-scan-sonar¹⁶ investigations.

A full bathymetric map of the Ems estuary was made by the WSA Ems every five years in 2005, 2010 and 2015. A next survey is planned for 2020.

Substrate

In the SIBES research and monitoring programme sediment is sampled annually since 2008 on a regular grid of 500 x 500 m in the intertidal areas of the Dutch Wadden Sea. Data availability is at the moment restricted to the years 2008-2012.

The substrate composition in the subtidal parts of the Dutch Wadden Sea are determined twice per year in a 3-yearly cycle in the MWTL programme, see the paragraph on hydrochemistry.

Substrate

Sediment is appraised/designated firstly as a supporting parameter in the context of the investigation of benthic biotic communities using grabs, sediment cores and samples taken by divers/dip sampling. Secondly, whole water bodies are mapped with what is practically an area-wide approach using hydroacoustic and remote sensing procedures, as well as targeted in situ sampling.

At present, the surveillance monitoring of substrates in the coastal and transitional waters of Germany's river basin districts does not comply with the prescribed minimum cycles of six years (BSH, 2014).

Both organogenic and clastic components, seabed-physical parameters such as roughness (surface structure) and hardness (density, compaction), the rheological properties of the substrates and, sometimes, suspended load are investigated during the monitoring of the seabed's structure, the substrate and, in transitional waters, the quantity of the substrate.

Phytoplankton

Phytoplankton is determined in the water samples of the MWTL hydrochemical programme, see the paragraph on hydrochemistry. The Ems estuary has four measurement stations, Table 3. Chlorophyll-a concentrations are determined 19 times each year. Phytoplankton counts are determined 14 times per year in summer using flow cytometry and microscopic inspections.

Phytoplankton

One station in Ems estuary Bork_W_1 in region 5 measures phytoplankton monthly during summer. Another station Bork_W_2 in the Osterems (strictly speaking outside the study area) measures toxic phytoplankton.

Phytoplankton is quantified microscopically in sedimentation chambers and Petri dishes (Phaeocystis colonies). Chlorophyll-a content is determined as a measure of biomass.

Transitional waters are characterised by high concentrations of suspended matter and wide fluctuations in salinity, which worsen the growth conditions for phytoplankton. For these reasons, and in accordance with the

	<p>current state of knowledge, it does not appear expedient to monitor the ecological status of a type 1 transitional water area using phytoplankton.' (ARGE Elbe, 2005 and Ad-hoc-Working Group on Nutrients & Phytoplankton).</p>
<p>Seagrass</p> <p>Monitoring of seagrass in the Wadden Sea is part of the MWTL programme of Rijkswaterstaat since 1991. Since 2005, the monitoring consists of a combination of aerial and field surveys. Since 2011 the field survey changed from an area approach to a transect approach, without the aid of aerial photo interpretation. Potential seagrass habitats are systematically monitored in August or September by walking transects of several kilometres. In each 20x20 m grid cell the cover of seagrass is estimated, and this information is used to construct a distribution and cover map of different seagrass species. As from 2011, Rijkswaterstaat reduced the monitoring frequency of seagrass in the Wadden Sea (and on Hond-Paap) to once every 3 years in potential seagrass areas. In the Ems estuary, the largest meadow (300 ha) of intertidal <i>Zostera marina</i> of the Dutch Wadden Sea was found on the Hond-Paap (NL), but it has been decreasing since 2003 and was only scarcely found in 2011 (Jager and Kolbe, 2013).</p>	<p>Seagrass</p> <p>Comprehensive surveying by means of overflights (aerial survey) in combination with field mapping every six years. Next campaign in 2019. The flights are carried out three times a year in summer (if possible in June, July and August) in order to ensure that the maximum seagrass and macroalgae coverage is surveyed in the course of the year to be used for assessment. The aircraft flies at an altitude of 300 to 500 m. During the flight, three independent observers enter the corresponding populations on Wadden Sea maps. Annual sampling in August of selected seagrass meadows (permanent monitoring units) to validate aerial data, and surveying the annual variability of the seagrass within the six-year period and characteristic supporting parameters (including species composition, density, quantity of epiphytic algae, biomass). One station for seagrass (and macroalgae) is located on the Hond-Paap.</p>
<p>Zooplankton</p> <p>There is no monitoring on zooplankton in the Dutch Wadden Sea.</p>	<p>Zooplankton</p> <p>Stations Bork_W_1 and Bork_W_2 in region 5 measure zooplankton monthly from March-October.</p>
<p>Benthos</p> <p><i>Benthos survey Wadden Sea and Ems-Dollard – MWTL.</i> Benthic survey on 9 littoral transects since 1991. Sampling in spring and autumn. Frequency is once every three years, annually in Dollard. Per transect 10-20 samples are taken with a hand corer. The Ems-Dollard transects are located on Heringsplaat, Dollard (region 3).</p> <p><i>Littoral shellfish survey – WOT LNV.</i> Annual inventory of littoral shellfish stocks in the Dutch Wadden Sea (WOT mussel and cockle survey) running since 1990. Various sampling gears are used depending on tidal state: either a specially modified hydraulic dredge (sampling area 0.42 m²), a handheld cockle-</p>	<p>Benthos</p> <p>Eleven stations for benthic sampling are located in the Ems study area (or just outside), both eulittoral and sublittoral: one in section 1 (Ems0), three in section 2 (Ems1, Ems_MZB_6 & Ems2), none in section 3, three in section 4 (EmDo_MZB_2, EmDo_MZB_5, Ems3), and four in section 5 (Bork_MZB_4, Ems4, Bork_MZB_8 and just outside study area Ems5).</p> <p>The BfG samples six stations (Ems0-Ems5) with a Van Veen grab each year in autumn. The samples are sieved over a 500 µm mesh. N.B. According to MUDAB, the monitoring in five out of six BfG stations has ceased in 2005 and 2011, but apparently it has not.</p>

sampling device (sampling area 0.033 m²) or at low tide with a corer (diameter 24.4 cm). All gears sample the top 10 cm, and a total surface area of ~0.8-0.1 m² is taken in each case (multiple samples per stations, depending on gear type). Samples are sieved using a 5 mm sieve, and for each species density and biomass is determined. A stratified sampling grid is used; distance between sampling points is smaller in those places where a higher density of the target species (mussels and/or cockles) is expected. Additional information, for instance on age or size classes, as well as occurrence of other species is collected. Sampling transects are located in the Dutch parts of the Inner Ems estuary (region 4) and on the Dutch mudflats in the estuary mouth (Outer Ems estuary, region 5).

Litoral shellfish banks – WOT LNV.

This survey maps the contours of littoral banks of mussels and oysters in the Dutch Wadden Sea since 1995 for the WOT-programme. Prior to the survey, an inspection flight is carried out to assess the greatest changes in extent. Then a field visit follows. Contours are recorded on foot with a handheld GPS. Coverage percentages to be visually estimated. Banks do not qualify when percent coverage is less than 5%.

A selection of banks is visited annually for detailed analysis on the structure of the banks (age distribution, morphology, vertical layers, etc.). Two or three of these banks are located south of Rottum, just within region 5. The contours of all shellfish banks present are recorded from the Inner Ems estuary (region 4) and on the Dutch mudflats in the estuary mouth (Outer Ems estuary, region 5). No record is known in the Dollard.

SIBES survey - NIOZ. Benthic infauna is sampled on a regular grid of 500 x 500 m with 10% random locations in littoral areas since 2008, Ems-Dollard since 2009. Locations to be visited on foot or by boat. At sites visited by foot one sample per station is taken, with an area of 0.0177 m² to a depth of 25 cm. At sites visited by boat two samples per station are taken, with a total area of 0.0173 m² to a depth of 25 cm. Samples are sieved over a 1 mm sieve. Large shellfish are separated and frozen, the rest of the sample is kept in a 4% formalin solution. Sediment is sampled on a

NLWKN samples four stations twice per year, in spring and autumn. They apply a 1000 µm mesh for the two outer estuary stations and a 500 µm mesh for the two inner estuary stations. Their Unterems station is sampled every three years in May with a mesh of 500/250 µm.

The minimum monitoring frequency for benthic invertebrates under the WFD is three years, yearly is recommended.

Eulittoral: Sediment samples are taken using box corers or piston corers. Sublittoral: Van Veen grab or dredge. In future, greater use should be made of sonar systems/video techniques for supporting purposes.

regular grid of 500 x 500 m (in 2008 1 x 1 km). A sediment core is taken from one sample for each location to a depth of 4 cm. Sampling locations in the Ems-Dollard are located in the Dutch tidal parts of the outer and inner Ems estuary (regions 4 & 5) and Dollard (region 3).

Birds

Monitoring of breeding birds, waders, nesting locations and sleeping locations in the Dutch Wadden Sea is carried out for the Netwerk Ecologische Monitoring (NEM), the Joint Monitoring Project (TMAP), the MWTL programme and the Waterfowl census of Wetlands International, all coordinated by SOVON. In the entire Wadden Sea there are monthly counts at high-tide roosts. Specific programmes in the Ems-Dollard region exist that have focal species such as Common tern and Arctic tern and are coordinated by other parties such as the Vogeltrekstation.

Fish

The most comprehensive monitoring programme for fish in the Dutch Wadden Sea is the Demersal Fish Survey by WMR running since 1969. The Dutch Demersal Fish Survey (DFS) is part of an internationally co-ordinated inshore survey carried out by The Netherlands (DFS), UK (Young Fish Survey-YFS), Belgium (Demersal Young Fish Survey-DYFS) and Germany (DYFS). The DFS aims at monitoring young plaice and sole in their nursery grounds in the North Sea coastal zone, but records every species caught. The Ems estuary, including main channels in the Dollard, is sampled as DFS region 620 (ICES, 2013).

RWS is responsible for monitoring fish fauna for the WFD. Measurements take place every two years in three locations in the Ems, i.e. at Spijk/Krummhörn (region 5), Oterdum (region 4) and Terborg (region 2) with the use of stow nets. Measurements are carried out by a German subcontractor Bioconsult in co-operation with LAVES. **The next campaign takes place in 2020.**

Marine mammals

Monitoring of seals in the Dutch Wadden Sea is carried out by WMR. The monitoring of harbour seals and grey seals is performed by flying over the area at low tide. Surveys of the

Birds

Monitoring of breeding birds, resting birds and beached birds in the Ems estuary is carried out as part of the BLMP by the NLWKN and Nationalpark Niedersächsischen Wattenmeer. The Joint Monitoring of Breeding Birds (JMBB) as part of TMAP started in 1989. It consists of annual surveys of the colonial and rare breeding birds and annual counts in the census areas. Every six years a complete census of all selected species in the entire Wadden Sea during the breeding season is coordinated.

Fish

Data since 1974 of the Demersal Young Fish Survey (DYFS) are available for the German Wadden Sea. These are collected by the Thünen Institute. It is internationally agreed that the Ems estuary, region 620, is monitored by The Netherlands (ICES, 2013).

LAVES is responsible for monitoring fish fauna for the WFD. Measurements take place every two years in three locations in the Ems, i.e. at Spijk/Krummhörn (region 5), Oterdum (region 4) and Terborg (region 2) with the use of stow nets. Measurements are carried out by a German subcontractor Bioconsult in co-operation with RWS. **The next campaign takes place in 2020.**

Marine mammals

Monitoring of seals in the Lower Saxony Wadden Sea is the responsibility of LAVES since 2005. Population size is documented since 1958. The Lower Saxony Wadden Sea is

Dutch area are synchronised with those in Germany and Denmark to produce a count of the total Wadden Sea population. The counts are carried out several times per year and planned according to breeding and moulting season. The complete Ems-Dollard is surveyed.

subdivided in three parts between Emden, Mariensiel and Luneplate. Each aerial survey is executed with three planes simultaneously at low tide. Five simultaneous surveys are carried out in summer and synchronised with international counts.

Porpoise monitoring takes place using CPOD's on four stations at Ems-km 47.2, 54.1, 67.8 (region 4) and 75.6 (region 5).

Salt marshes

The salt marshes in the Dutch Wadden Sea are monitored in the VEGWAD programme of Rijkswaterstaat since the mid-1970s with a mapping frequency of once per six years. Vegetation maps are produced with a scale of 1:5,000 or 1:10,000. Input is from remote sensing (interpretation of stereo false-colour photographs) and fieldwork (ground truthing). For the classification of the vegetation a detailed typology is used (SALT97) that can easily be transformed into the TMAP typology. The salt marshes along the Dollard and Punt van Reide are part of the VEGWAD programme. The latest aerial survey took place in 2012, the next is planned for 2018. Groninger Landschap is responsible for monitoring the accretion and vegetation composition of the Dollard salt marshes since 1983. Sedimentation-erosion bars are surveyed in spring and autumn and vegetation quadrants in autumn.

Salt marshes

The foundation for the monitoring of salt marshes is provided by Sachteleben and Behrens (2010), which was drawn up at the federal level for terrestrial habitat types. The responsibility for habitat monitoring in the Ems lies at NLWKN. An area-wide survey of habitat types is carried out in the course of the six-year reporting cycle to ascertain their range and area. **Next campaign in 2019/2020.** The survey is carried out using aerial images and the biotope mapping keys issued by the Länder and/or the TMAP typology. Selection and permanent specification of representative sample plots or transects is done for detailed surveying of characteristic vegetation structures, functions and species (BSH, 2014).

A spatial overview of long-term monitoring stations in the German and Dutch parts of the outer and inner Ems estuary and Dollard are given in the figures below.

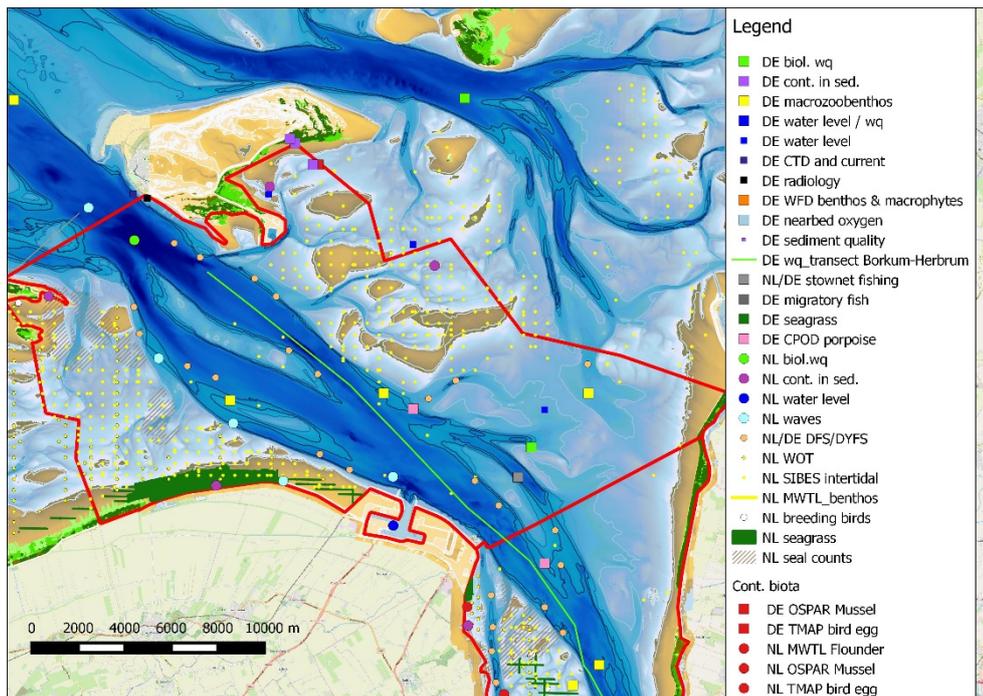


Figure 2. Monitoring stations in the Outer Ems estuary. Squares: German monitoring stations. Circles: Dutch monitoring stations.

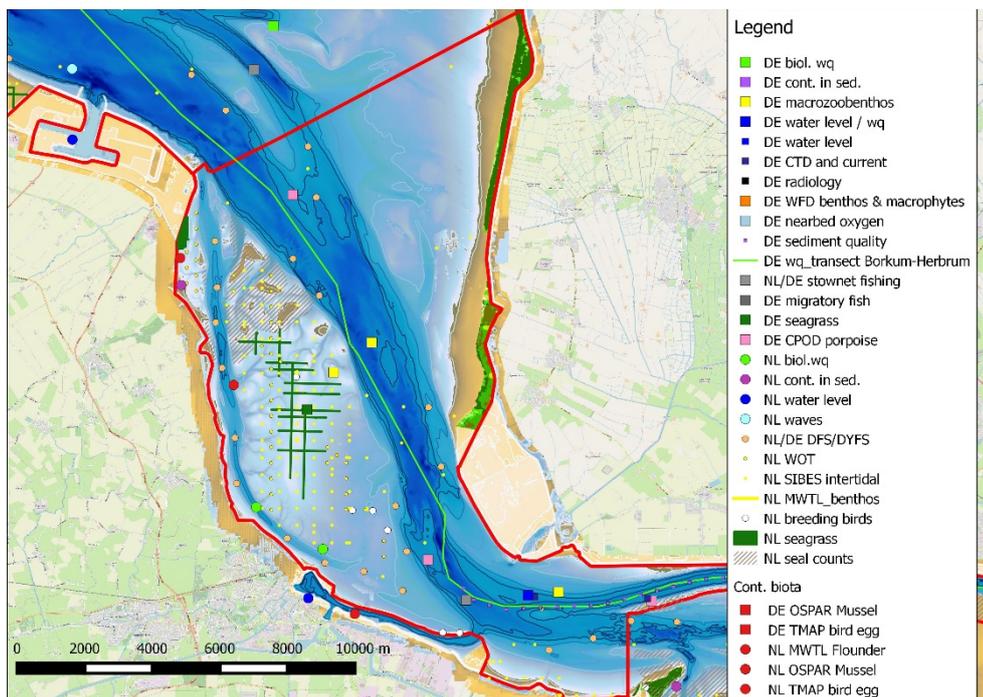


Figure 3. Monitoring stations in the Inner Ems estuary. Squares: German monitoring stations. Circles: Dutch monitoring stations.

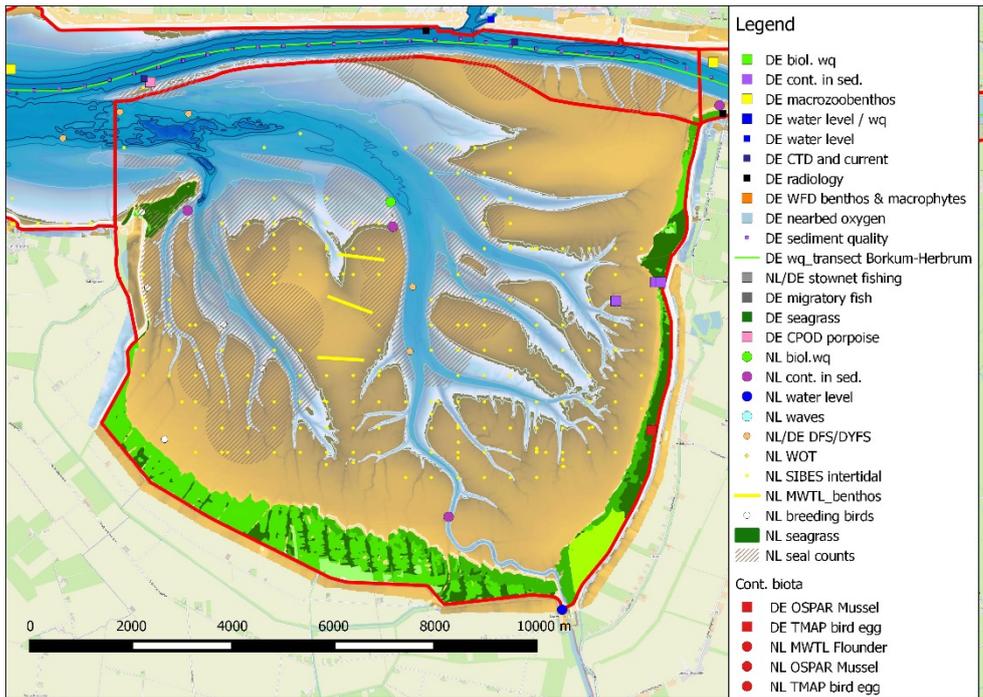


Figure 4. Monitoring stations in the Dollard. Squares: German monitoring stations. Circles: Dutch monitoring stations.

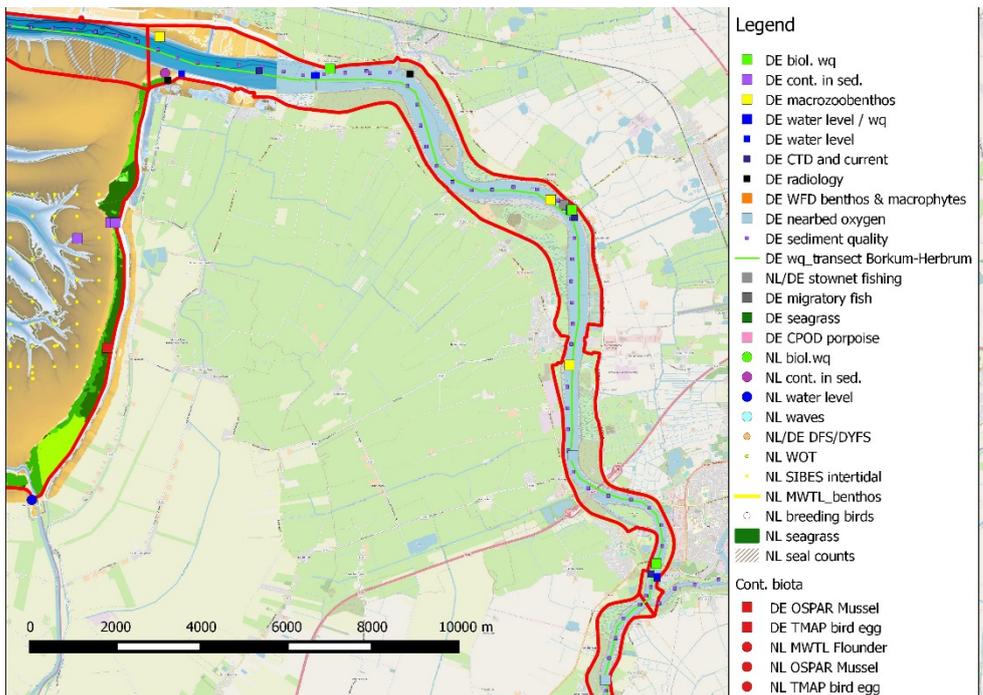


Figure 5. Monitoring stations in region 2, brackish Unterems. Squares: German monitoring stations. Circles: Dutch monitoring stations.

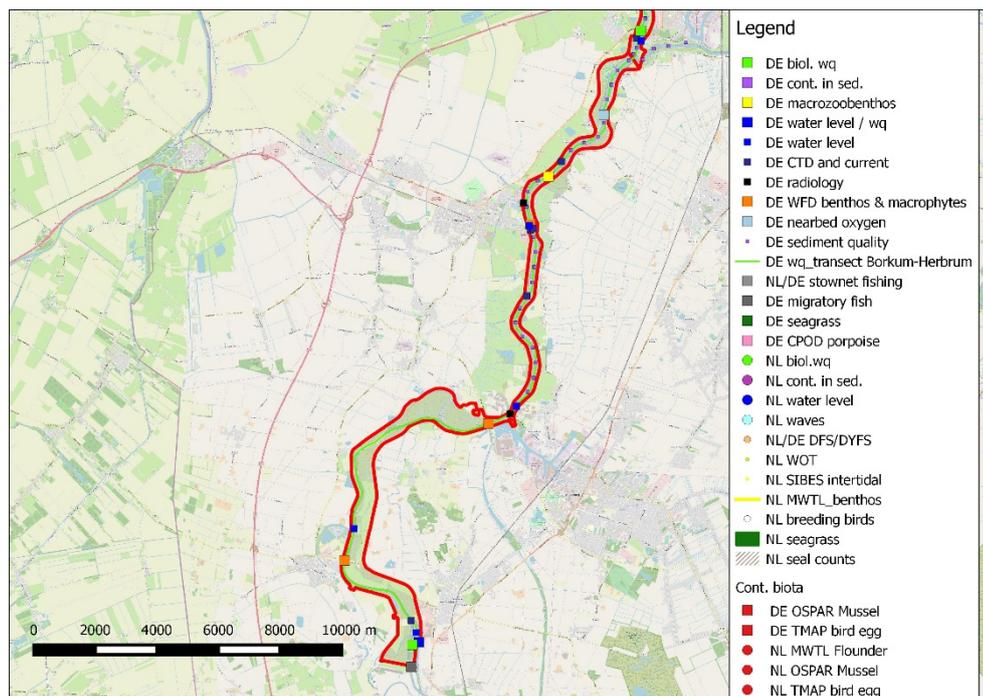


Figure 6. Monitoring stations in region 1, freshwater Unterems. Squares: German monitoring stations. Circles: Dutch monitoring stations.

Table 1. German monitoring stations for contaminants (in sediment, water and Blue Mussel), macrozoobenthos, biological water quality / phyto & zooplankton and water level. Source: Marine Environmental Data Base (MUDAB) Germany.

Area	Station name	Type	Lat.	Lon.
Outer estuary	Bork_S_C	cont. in sed.	53.59833	6.76167
Outer estuary	Bork_S_B	cont. in sed.	53.59667	6.76500
Outer estuary	Bork_S_A	cont. in sed.	53.58833	6.77667
Outer estuary	Bork_MZB_4	macrozoobenthos	53.49991	6.95445
Outer estuary	Bork_MZB_8	macrozoobenthos	53.49714	6.72295
Outer estuary	Bork_W_1	biol. wq / phyto & zooplankton	53.47901	6.91759
Outer estuary (just outside)	Bork_W_2	biol. wq / phyto & zooplankton	53.61400	6.87454
Inner estuary	EM-Ems3	macrozoobenthos	53.39467	6.96133
Inner estuary	EmDo_MZB_5	macrozoobenthos	53.38666	6.94433
Inner estuary	EmDo_MZB_2	macrozoobenthos	53.32797	7.04418
Inner estuary	Knock Pegel	water level / cont. water	53.32716	7.03067
Dollard	EmDo_S_B	cont. in sed.	53.32586	7.26528
Dollard	EmDo_S_C	cont. in sed.	53.32246	7.31172
Dollard	EmDo_S_A	cont. in sed.	53.29481	7.38890
Brackish Unterems	Ems_W_3	biol. wq / cont. in sed.	53.29270	7.39610
Brackish Unterems	Ems_MZB_6	macrozoobenthos	53.29000	7.23500
Brackish Unterems	Ems_W_2	biol. wq	53.29000	7.23667
Brackish Unterems	Terborg Pegel	water level / wq	53.28667	7.22333
Freshw. Unterems	Herbrum Schleuse UW	water level / cont. in sed.	53.03911	7.31830
Freshw. Unterems	Ems_W_1	biol. wq	53.03834	7.31524

Table 2. German WFD stations for macrozoobenthos and macrophytes in the freshwater Unterems (3-yearly monitoring). Source: NLWKN.

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Area	Station name	Type	Lat.	Lon.
Freshw. Unterems	Herbrum = Ems_W_1	macrozoobenthos and macrophytes	53.03834	7.31524
Freshw. Unterems	Rhede	macrozoobenthos and macrophytes	53.06308	7.28239
Freshw. Unterems	Papenburg	macrozoobenthos and macrophytes	53.10321	7.35216
Freshw. Unterems	Weener	macrozoobenthos and macrophytes	53.16152	7.37244

Table 3. Dutch MWTL stations for hydrochemistry / biological water quality (yearly monitoring). Source: Rijkswaterstaat (2014b).

Area	Station name	DONARCODE	Lat.	Lon.
Outer estuary	Huibertgat oost	HUIBGOT	53.55913	6.66120
Inner estuary	Bocht van Watum	BOCHTVWTM	53.35064	6.90996
Inner estuary	Bocht van Watum oost	BOCHTVWTO	53.33948	6.93960
Dollard	Groote Gat noord	GROOTGND	53.30429	7.15666

Table 4. Dutch MWTL stations for sediment quality (three-yearly monitoring). Source: Rijkswaterstaat (2014b).

Area	Station name	DONARCODE	Lat.	Lon.
Outer estuary	Rottumeroog Zuid Oost	ROTTMOZOT	53.53742	6.60587
Outer estuary	Uithuizerwad Eemshaven West	UITHZWEHVWT	53.46418	6.71409
Outer estuary	Borkum Kwelder Zuid	BORKKDZD	53.57983	6.74871
Outer estuary	Blindes Randzelgat Zuid Oost	BLINDRZGZOT	53.54929	6.85517
Inner estuary	Bocht Van Watum Dijkvoet Vka	BOCHTVWTDVVA	53.40992	6.87672
Inner estuary	Bocht Van Watum Oost	BOCHTVWTOT	53.33948	6.93960
Dollard	Reiderplaat Noord	REIDPND	53.30275	7.09655
Dollard	Heringsplaat Noord Oost	HERPNOT	53.29990	7.15735
Dollard	Oost Friesche Plaat Zuid West	OOSTFSPZWT	53.24815	7.17381
Brackish Unterems	Eems Pogum	EEMSPGM	53.32149	7.25400

Table 5. Dutch LMW stations for water level.

Area	Station name	Code	Lat.	Lon.
Outer estuary	Eemshaven	EMSH	53.44870	6.82839
Inner estuary	Delfzijl	DLFZ	53.32636	6.93312
Dollard	Nieuwe Statenzijl	NWST	53.23156	7.20742

Table 6. Dutch / German stow net stations for fish. Source: Jager et al. (2011).

Area	Station name	Lat.	Lon.
Outer estuary	Spijk/Krummhörn	53.46740	6.90900
Inner estuary	Oterdum	53.32584	7.00320
Brackish Unterems	Terborg	53.29373	7.39350

Table 7. Dutch and German stations for contaminants in biota. Sources: Marine Environmental Data Base (MUDAB) Germany, Rijkswaterstaat (2014b), TMAP.

Area	Station name	Code	Type	Lat.	Lon.
Outer estuary	Borkum, Inselwatt	Bork_Myt_1	DE, cont. mussel	53.58833	6.78000
Inner estuary	Bocht van Watum	BOCHTVWTM	NL, cont. mussel	53.41716	6.87622
Inner estuary	Paap Groote Gat Reiderplaat		NL, cont. Flounder	53.38330	6.90000
Inner estuary	Delfzijl zeehavenkanaal	DELFFZZHVKNL	NL, bird egg	53.32219	6.95382
Dollard	Dollart		DE, bird egg		

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