National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Monitoring of radioactivity in the Netherlands

Surface water and seawater – results 2019

RIVM letter report 2021-0081
C.P. Tanzi | G.J. Knetsch

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Rijkswaterstaat
Ministry of Infrastructure and Water Management

Rijkswaterstaat (RWS)
Data on seawater and surface water from the main inland water bodies.
C. Engeler
A. Baak

This investigation was performed by order, and for the account, of Authority for Nuclear Safety and Radiation Protection, within the framework of Project 390220: environmental monitoring of radioactivity and radiation.

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Synopsis

Monitoring of radioactivity in the Netherlands
Surface water and seawater– results 2019

In 2019, the Netherlands fulfilled its annual European obligation to measure how much radioactivity is present in the environment. Radioactivity levels in surface water and seawater were similar to previous years.

All countries of the European Union are required to perform these measurements each year under the terms of the Euratom Treaty of 1957. The Netherlands performs these measurements following the guidance issued in 2000. The measurements represent the background values for radioactivity that are present under normal circumstances. They can be used as reference values, for instance, during a nuclear emergency. The results on radioactivity in the environment are reported to the European Commission by the National Institute for Public Health and the Environment (RIVM) on behalf of the competent authority in the Netherlands.

Keywords: radioactivity, surface water, seawater

Publiekssamenvatting

Monitoring van radioactiviteit in Nederland
Oppervlaktewater en zeewater – resultaten 2019

In 2019 voldeed Nederland aan de Europese verplichting om elk jaar te meten hoeveel radioactiviteit in het milieu zit. De radioactiviteitsniveaus in oppervlaktewater en zeewater zijn vergelijkbaar met die van eerdere jaren.

Alle landen van de Europese Unie zijn volgens het Euratom-verdrag uit 1957 verplicht om deze metingen te doen. Nederland volgt daarbij de aanbevelingen uit 2000 op om de metingen op een bepaalde manier uit te voeren. De metingen leveren achtergrondwaarden op, ofwel radioactiviteitsniveaus die er onder normale omstandigheden zijn. Deze waarden kunnen bij bijvoorbeeld calamiteiten of rampen als referentie dienen. Het RIVM brengt namens Nederland verslag uit aan de Europese Unie over radioactiviteit in het milieu.

Kernwoorden: radioactiviteit, oppervlaktewater, zeewater

Contents

Summary — 9

1 Introduction — 11

2 Results — 15
2.1 Surface water, activity concentrations ($Bq \cdot L^{-1}$) — 16
2.2 Surface water, activity in suspended solids ($Bq \cdot kg^{-1}$) — 19
2.3 Seawater, activity concentrations ($Bq \cdot L^{-1}$) — 22
2.4 Sea water, activity in suspended solids ($Bq \cdot kg^{-1}$) — 25

Summary

Radioactivity levels in surface water and seawater were determined for gross α, residual β (gross β minus naturally occurring ^{40}K), ^{3}H and ^{90}Sr, and additionally for ^{226}Ra in surface water only. Radioactivity levels in suspended solids in surface water and seawater were determined for ^{137}Cs and ^{210}Pb, and additionally for ^{60}Co and ^{131}I in surface water only.
The yearly averaged radioactivity levels were within the range of those found in previous years.

1 Introduction

Rijkswaterstaat (RWS) regularly monitors the concentration of a large number of radionuclides in surface water and seawater. A representative part of the RWS's monitoring programme is presented here. The monitoring data are publicly available on the website of RWS, or can be requested for specific locations. A more detailed description of the monitoring programme and its underlying strategy are reported elsewhere [1, 2, 3, 4].

The general monitoring strategy used for surface water is to monitor the inland and transborder water bodies of the Netherlands. Therefore, the about 20 sampling locations shown in Figure 1 are used for monitoring, as they represent the major inland, incoming and outgoing waters of the Netherlands. The locations for seawater presented in this report have been chosen to represent the major areas of seawater. Radionuclides were measured in water and in suspended solids. The samples were collected at equidistant times with frequencies ranging from weekly to quarterly, depending on location and radionuclide. The sampling frequencies of the selected locations are presented in Table 1 to Table 4. Measurements in sediment and biota are also part of the RWS monitoring programme, but the results are not presented in this report. The radionuclides were measured according to standard procedures [3].

Table 1 Frequency of the monitoring programme for the determination of radionuclides in surface water in 2019

Location	Gross α	Residual β	^{3}H	^{90}Sr	^{226}Ra
IJsselmeer	13	13	6	-	-
North Sea Canal (Noordzeekanaal)	13	13	13	-	-
Nieuwe Waterweg	13	13	7	7	7
Rhine	13	13	14	7	7
Scheldt	12	12	5	-	5
Meuse	13	13	14	7	7
Ghent-Terneuzen Canal	13	13	7	-	-
Haringvliet	13	13	6	-	-

[1] E.J. de Jong and O.C. Swertz, 2000. Radioactieve stoffen in de zoute wateren. RIKZ, The Hague, Report no. RIKZ/2000.041
[2] L.J. Gilde, K.H. Prins, C.A.M. van Helmond, 1999. Monitoring zoete rijkswateren. RIZA Lelystad, Report no. 99.004.
[3] MWTL Meetplan 2016, Monitoring Waterstaatkundige Toestand des Lands, Milieumeetnet Rijkswateren chemie en biologie, 19 augustus 2015.
[4] Web page: https://waterinfo-extra.rws.nl/monitoring/chemie/ (March 2021).

Table 2 Frequency of the monitoring programme for the determination of radionuclides in suspended solids (Bq·kg^{-1}) in surface water in 2019

Location	^{60}Co	^{131}I	^{137}Cs	^{210}Pb
IJsselmeer	13	13	13	-
North Sea Canal (Noordzeekanaal)	7	7	7	-
Nieuwe Waterweg	13	13	13	7
Rhine	25	25	25	8
Scheldt	12	12	12	5
Meuse	53	53	53	7
Ghent-Terneuzen Canal	4	4	4	-
Haringvliet	4	4	4	-

Table 3 Frequency of the monitoring programme for the determination of radionuclides in seawater in 2019

Location	Gross α	Residual β	^{3}H	^{90}Sr
Coastal Area	4	4	4	-
Southern North Sea	4	4	4	4
Central North Sea	4	4	4	4
Delta Coastal Waters	12	12	12	12
Western Scheldt	13	13	13	13
Eems Dollard	4	4	4	-
Wadden Sea West	4	4	4	-
Wadden Sea East	4	4	4	-

Table 4 Frequency of the monitoring programme for the determination of radionuclides in suspended solids (Bq·kg^{-1}) in seawater in 2019

Location	^{137}Cs	^{210}Pb
Western Scheldt	4	4

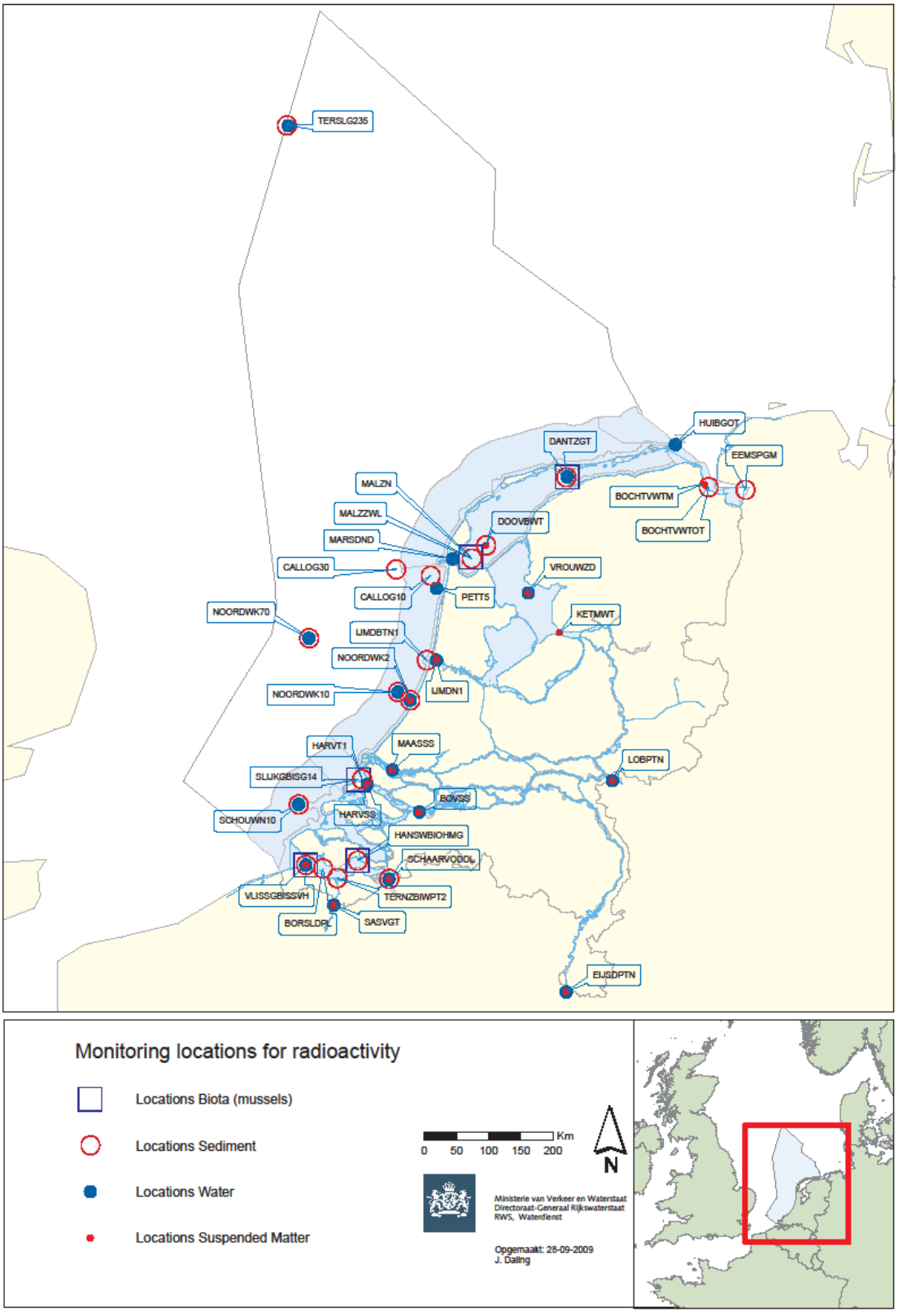

Figure 1 Overview of monitoring locations for the entire monitoring programme for surface water and seawater, as given by Rijkswaterstaat

2 Results

The yearly averages of the radioactivity measurements for the selected locations are presented in Table 5 to Table 8 and Figure 2 to Figure 17. The results of the complete monitoring programme conducted by RWS is presented elsewhere [5].

Table 5 Yearly averaged Gross α, residual β, ^{3}H, ^{90}Sr and ^{226}Ra activity concentrations ($mBq \cdot L^{-1}$) in surface water in 2019

Location	Gross α	Residual β	^{3}H	^{90}Sr	^{226}Ra
IJsselmeer	40	20	3,290	-	-
North Sea Canal (Noordzeekanaal)	214	31	3,280	-	-
Nieuwe Waterweg	234	53	4,640	< 1.0	5.3
Rhine	53	30	3,560	< 1.2	2.5
Scheldt	350	129	10,000	-	8.9
Meuse	27	15	14,200	< 1.1	2.5
Ghent-Terneuzen Canal	179	26	2,290	-	-
Haringvliet	29	18	3,500	-	-

Table 6 Yearly averaged ^{60}Co, ^{131}I, ^{137}Cs and ^{210}Pb activity concentrations in suspended solids ($Bq \cdot kg^{-1}$) in surface water in 2019

Location	^{60}Co	^{131}I	^{137}Cs	^{210}Pb
IJsselmeer	< 1	< 1	2.6	-
North Sea Canal (Noordzeekanaal)	< 1	23	3.8	-
Nieuwe Waterweg	< 1	< 1.2	6.8	97
Rhine	< 1	< 2.3	8.1	147
Scheldt	< 1	< 0.7	4.5	71
Meuse	9.3	< 7.2	8.8	157
Ghent-Terneuzen Canal	< 1	< 0.7	3.4	-
Haringvliet	< 1	< 1	10.5	

[5] Web page: https://www.rijkswaterstaat.nl/water/waterdata-en-waterberichtgeving/waterdata (March 2021).

Table 7 Gross α, residual β, ^{3}H and ^{90}Sr activity concentrations (mBq·L^{-1}) in seawater in 2019

Location	Gross α	Residual β	^{3}H	^{90}Sr
Coastal Area	650	33	4,800	-
Southern North Sea	440	33	4,600	1.8
Central North Sea	560	55	320	3.3
Delta Coastal Waters	480	71	4,800	4.5
Western Scheldt	520	104	5,100	1.8
Eems Dollard	530	41	3,700	-
Wadden Sea West	640	38	4,600	-
Wadden Sea East	460	138	3,800	-

Table 8 ^{137}Cs and ^{210}Pb activity concentrations in suspended solids (Bq·kg^{-1}) in seawater in 2019

Location	^{137}Cs	^{210}Pb
Western Scheldt	3.6	65

2.1 Surface water, activity concentrations (Bq·L^{-1})

Gross α and residual β are indicative parameters. In general, gross α and β analysis is used as a screening method to determine the total radioactivity present in the form of α and β radiation, without regard to the identity of specific radionuclides.

The yearly averages of gross α and residual β activity concentrations are presented in Table 5 and in Figure 2 and Figure 3. The yearly average activity concentrations of gross α in 2019 were within the range of those in previous years. Residual β in the North Sea Canal (Noordzeekanaal), Nieuwe Waterweg and Scheldt has shown a change in trend since 1994, caused by a change in the measuring technique applying only to salt and brackish water [6]. This change in trend was therefore not seen for residual β in the IJsselmeer, Rhine or Meuse. The yearly average activity concentrations of residual β in 2019 were within the range of those in previous years.

[6] E.J. de Jong and O.C. Swertz, 2000. Radioactieve stoffen in de zoute wateren. RIKZ, The Hague, Report no. RIKZ/2000.041

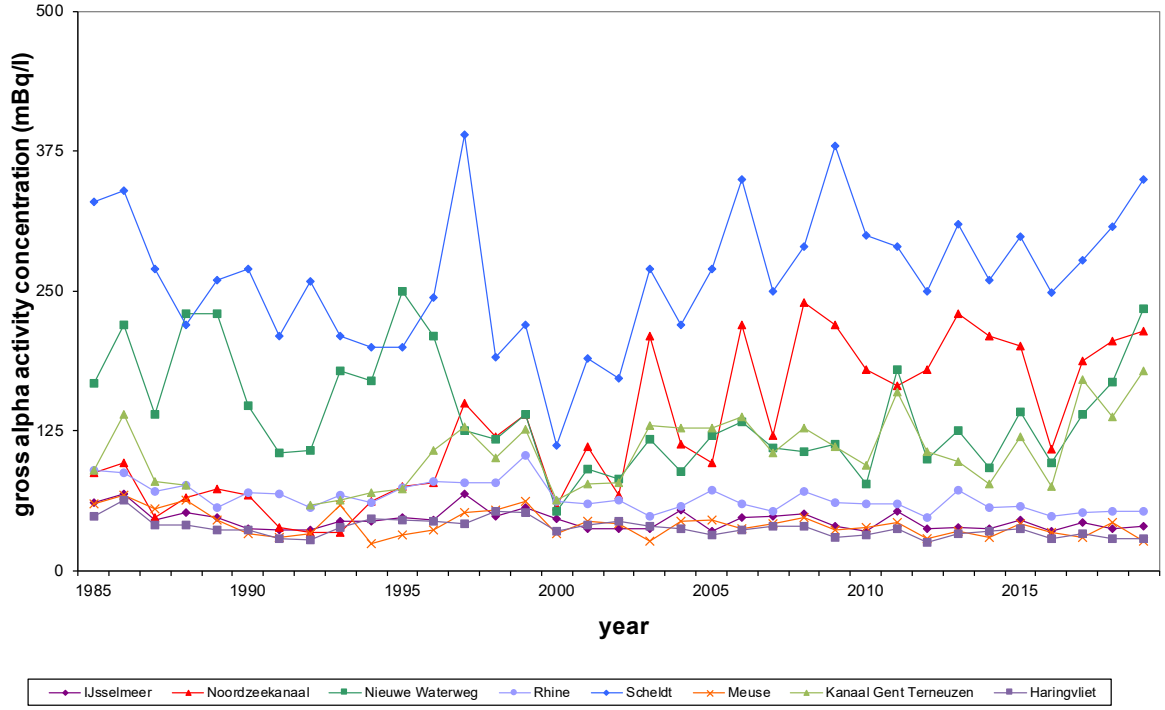

Figure 2 Yearly average gross α activity concentrations

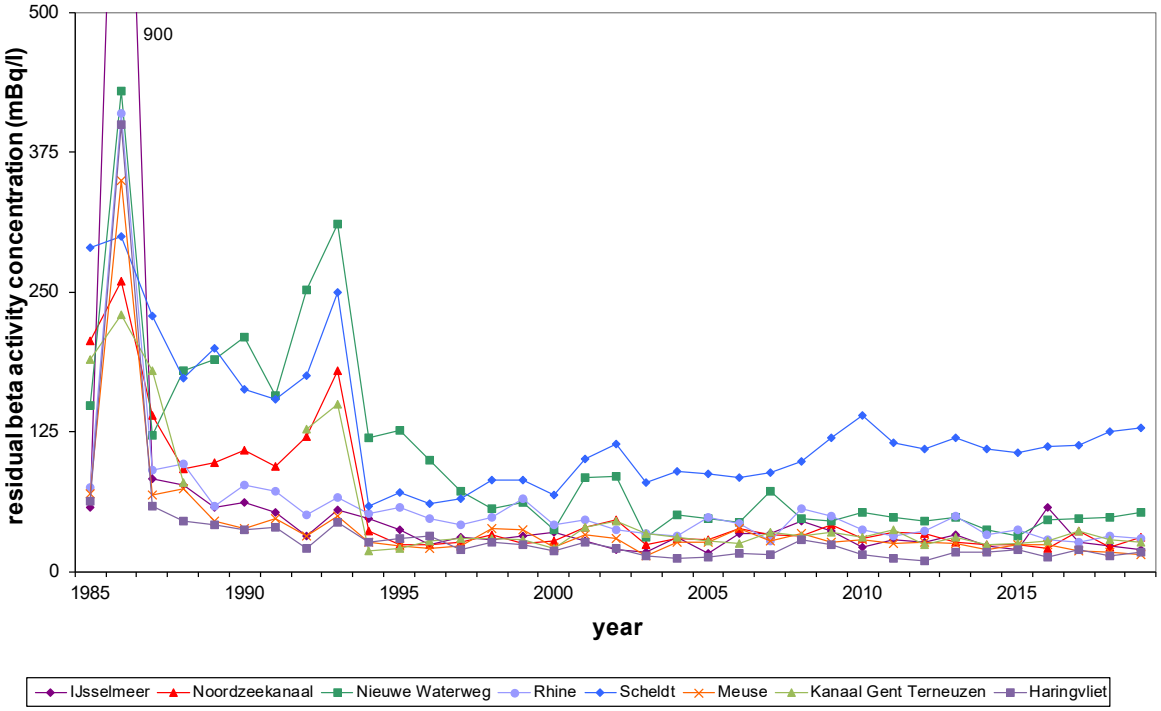

Figure 3 Yearly average residual β activity concentrations

The yearly averages of ^{3}H activity concentrations are presented in Table 5 and Figure 4 and were within the range of those in previous years. In general, elevated levels of ^{3}H in the Rhine may originate from several nuclear power plants or research reactors in Germany, France or

Switzerland. Elevated levels of ^{3}H in the Meuse could have originated from the nuclear power plants at Tihange (Belgium) or Chooz (France). Elevated levels of ^{3}H in the Scheldt could have originated from the nuclear power plant at Doel (Belgium).

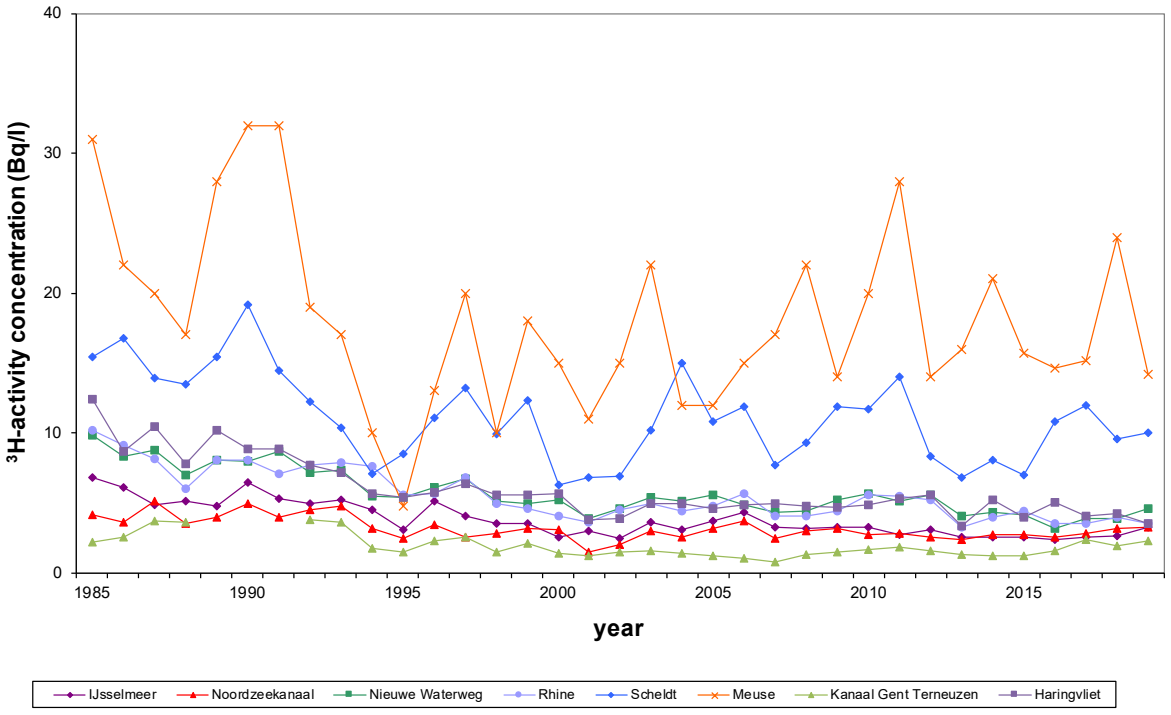

Figure 4 Yearly average ^{3}H activity concentrations

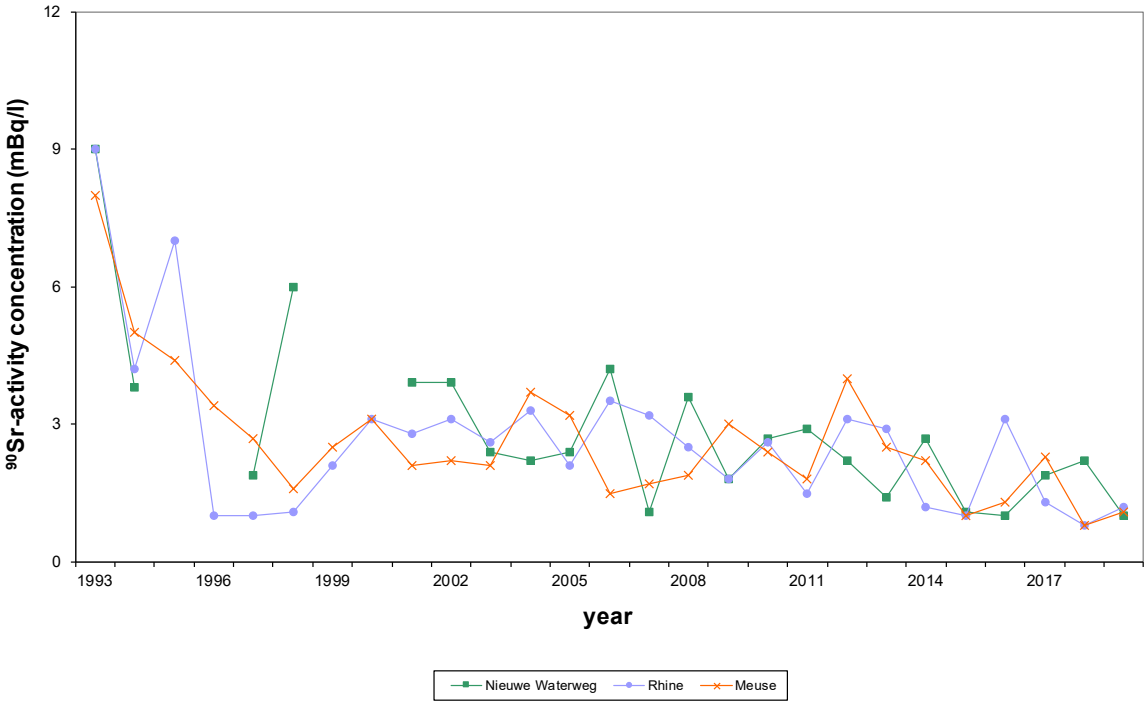

Figure 5 Yearly average ^{90}Sr activity concentrations. Data are not available for the Nieuwe Waterweg in 1995, 1996, 1999 and 2000

The radionuclide ^{90}Sr is released into the environment by nuclear power plants and nuclear reprocessing plants. The yearly averages of ^{90}Sr activity concentrations are presented in Table 5 and Figure 5 and were within the range of those in previous years.

The nuclide ^{226}Ra is released into the environment by the ore-processing industry and transhipment. ^{226}Ra in the Nieuwe Waterweg and Scheldt might originate from these industries in the port areas of Rotterdam-Rijnmond and Antwerp, respectively. The yearly averages of ^{226}Ra activity concentrations are presented in Table 5 and Figure 6 and were within the range of those in previous years.

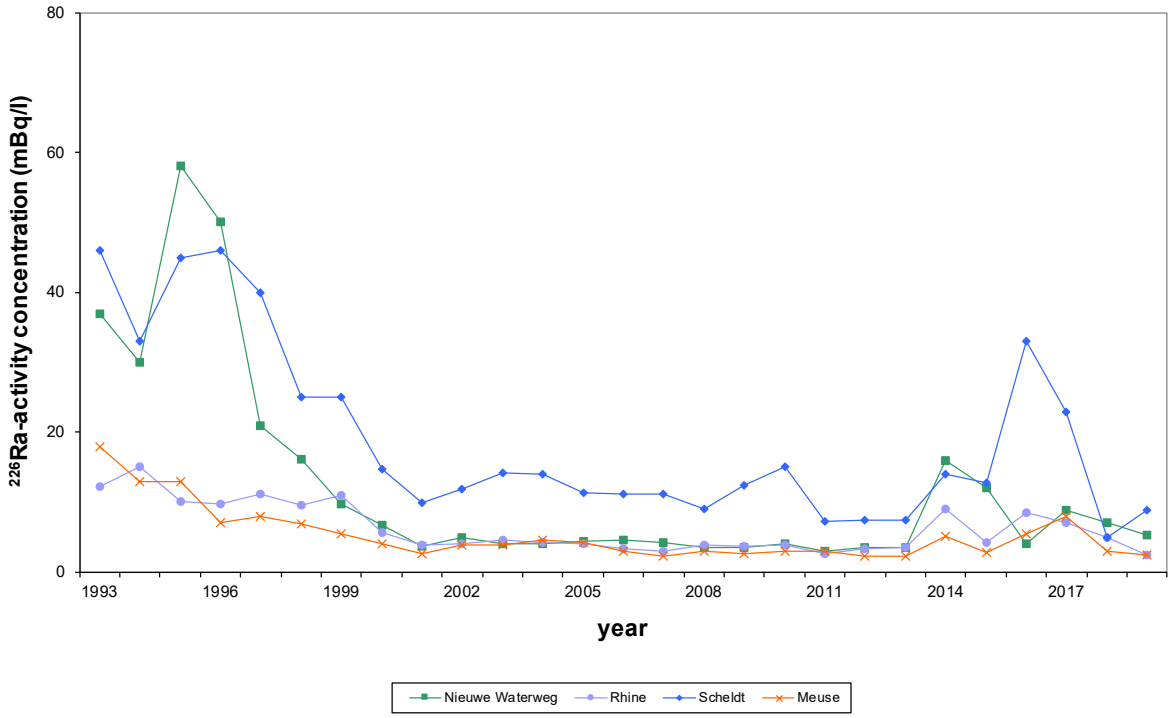

Figure 6 Yearly average ^{226}Ra activity concentrations

2.2 Surface water, activity in suspended solids (Bq·kg^{-1})

The radionuclides ^{60}Co and ^{137}Cs are released into the environment by nuclear power plants. The yearly averages of ^{60}Co and ^{137}Cs activity concentrations are presented in Table 6, Figure 7 and Figure 8 were within the range of those in previous years.

The radionuclide ^{131}I is released into the environment primarily by medical facilities. The yearly averages of ^{131}I activity concentrations are presented in Table 6 and Figure 9 and were within the range of those in previous years. ^{131}I activity concentrations are higher in the North Sea Canal (Noordzeekanaal, at location IJmuiden) and Meuse than elsewhere. ^{131}I in the Meuse might originate from medical facilities in Belgium, and ^{131}I in the North Sea Canal might originate from a sewage treatment plant in the port area of Westpoort. One of the contributions to the sewage waters is discharge from medical facilities. Without further investigation

we can't correlate changes of activity concentrations over the years, as may be observed in Figure 9, to changes in discharges over time.

The radionuclides ^{210}Po and ^{210}Pb originate from the uranium decay chain and are released by the ore-processing industry. Since ^{210}Po is usually in equilibrium with ^{210}Pb in suspended solids, RWS reports only ^{210}Pb. ^{210}Pb in the Nieuwe Waterweg and Scheldt might originate from these types of industries in the port areas of Rijnmond and Antwerp, respectively. The yearly averages of ^{210}Pb activity concentrations are presented in Table 6 and Figure 10 and were within the range of those in previous years with one exception. The yearly averages of ^{210}Pb activity concentrations were within the range of those in previous years.

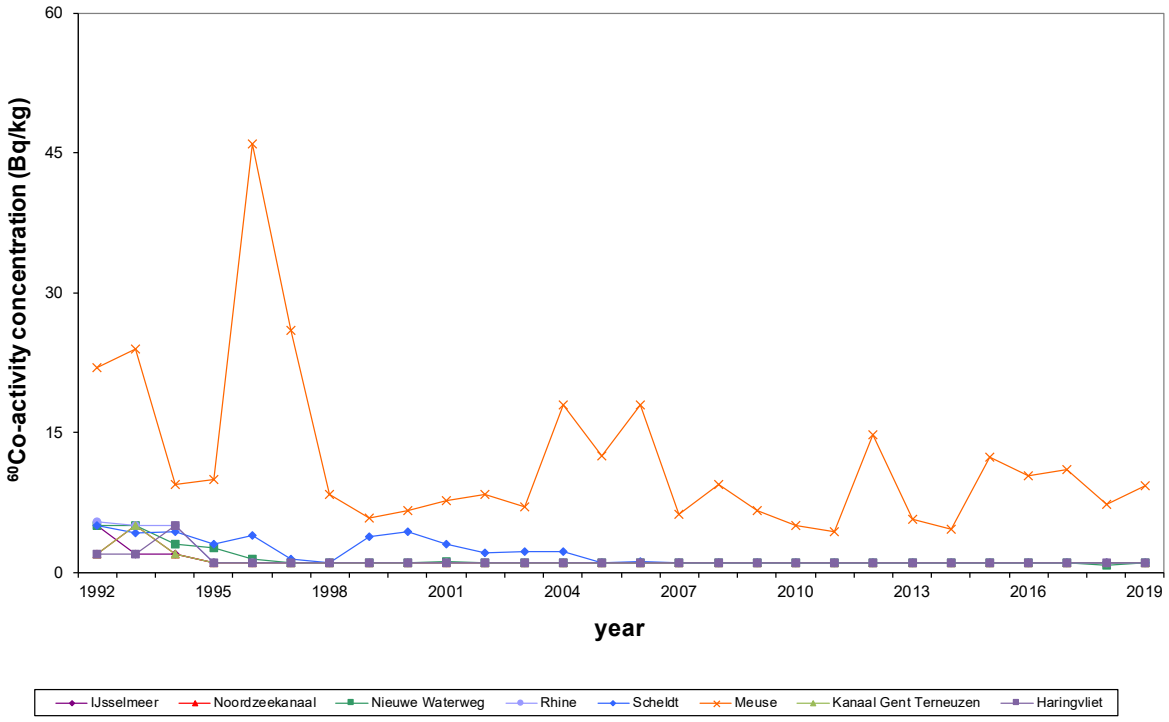

Figure 7 Yearly average ^{60}Co activity concentrations in suspended solids

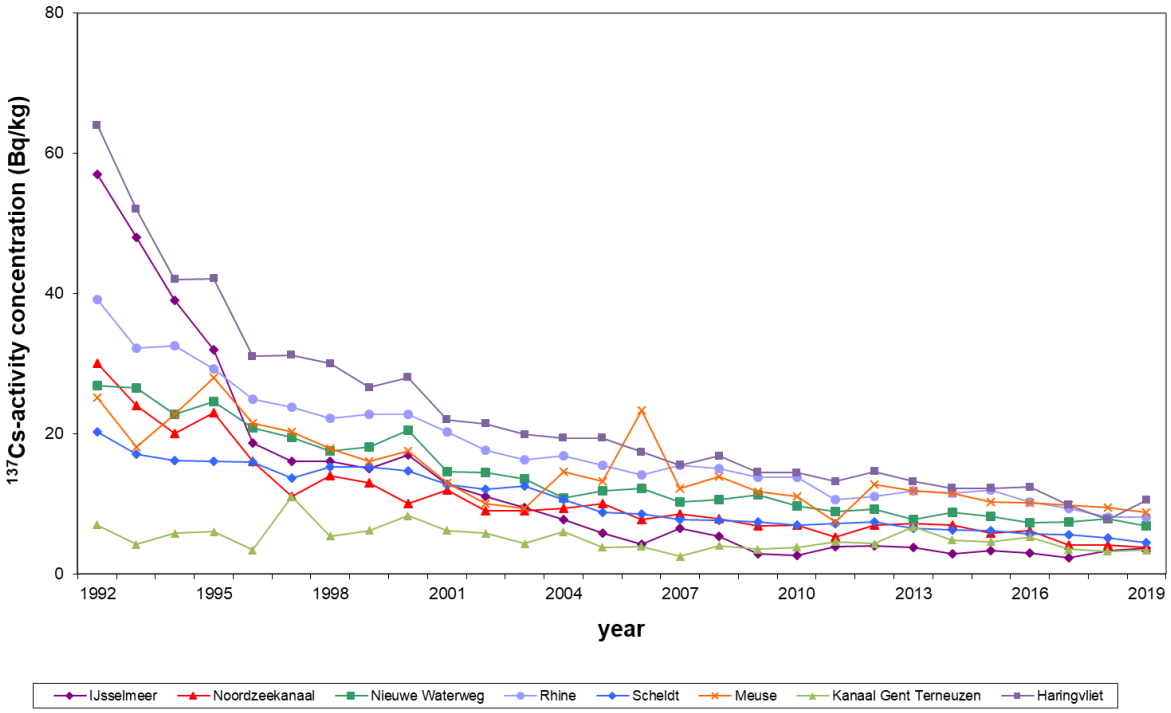

Figure 8 Yearly average ^{137}Cs activity concentrations in suspended solids

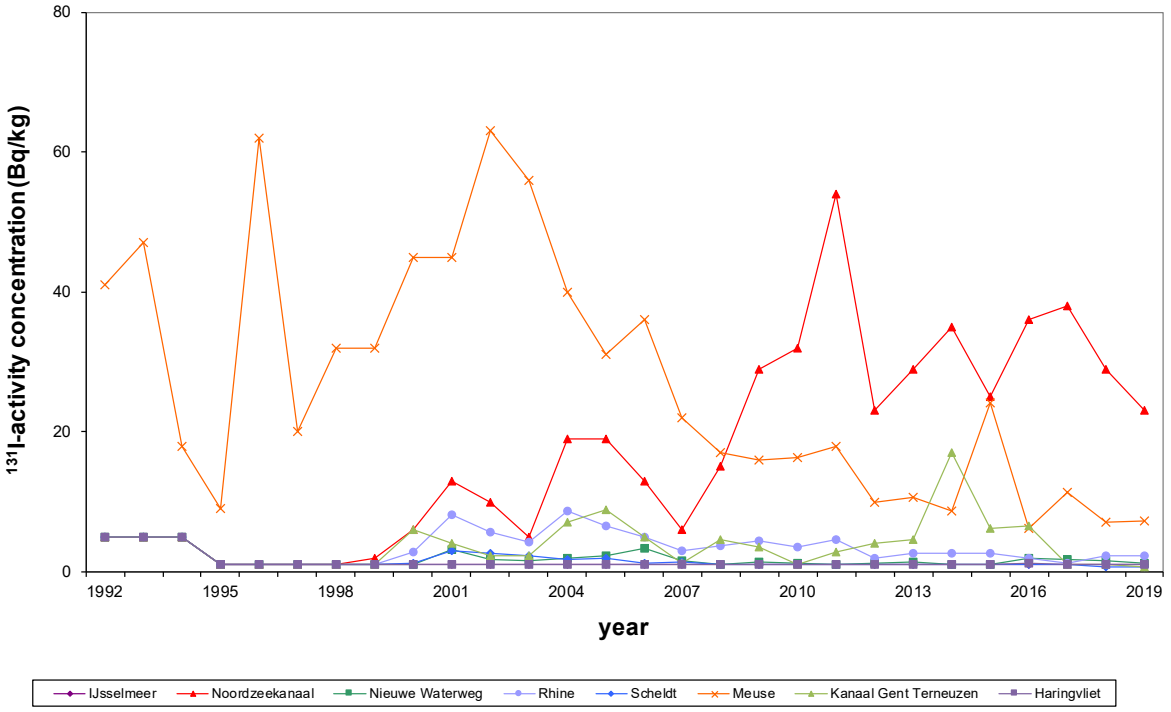

Figure 9 Yearly average ^{131}I activity concentrations in suspended solids

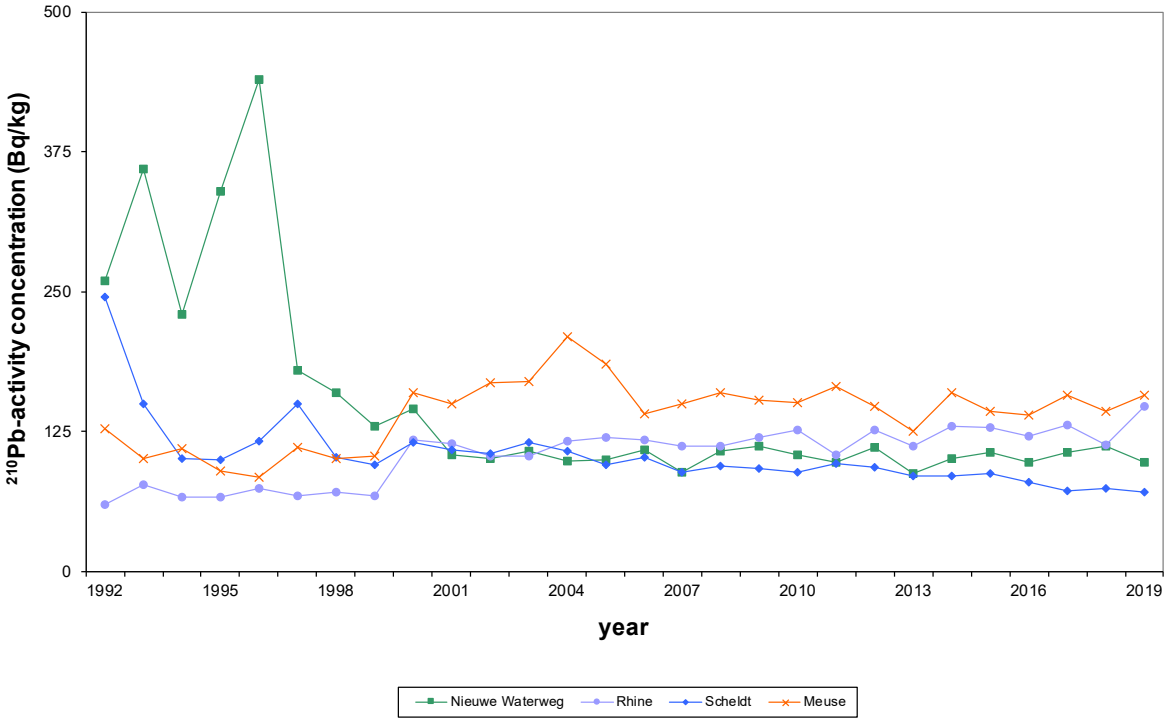

Figure 10 Yearly average ^{210}Pb activity concentrations in suspended solids

2.3 Seawater, activity concentrations (Bq·L^{-1})

Gross α and residual β are indicative parameters. The yearly averages of gross α and residual β are presented in Table 7, Figure 11 and Figure 12. The yearly average activity concentrations of gross α and residual β in 2019 were within the range of those in previous years. Residual β shows an apparent change in trend since 1994. This was caused by a change in measuring technique that applies to salt and brackish water [6].
Nuclear power plants discharge the radionuclides ^{3}H and ^{137}Cs, among others. Nuclear fuel reprocessing plants discharge the radionuclides ^{3}H and ^{90}Sr, among others. Discharges from the nuclear power plants at Doel (Belgium) and Borssele (Netherlands) are monitored in the Western Scheldt (WS) area. The impact of reprocessing plants at Sellafield (England) and Le Havre (France) is monitored in the Central North Sea (CN) and Southern North Sea (ZN) areas, respectively [6]. The impact of both sources (nuclear power and reprocessing plants) is monitored indirectly in the Delta Coastal Waters (VD) area.
The yearly averages of ^{3}H and ^{90}Sr activity concentrations are presented in Table 7, Figure 13 and Figure 14 and were within the range of those in previous years.

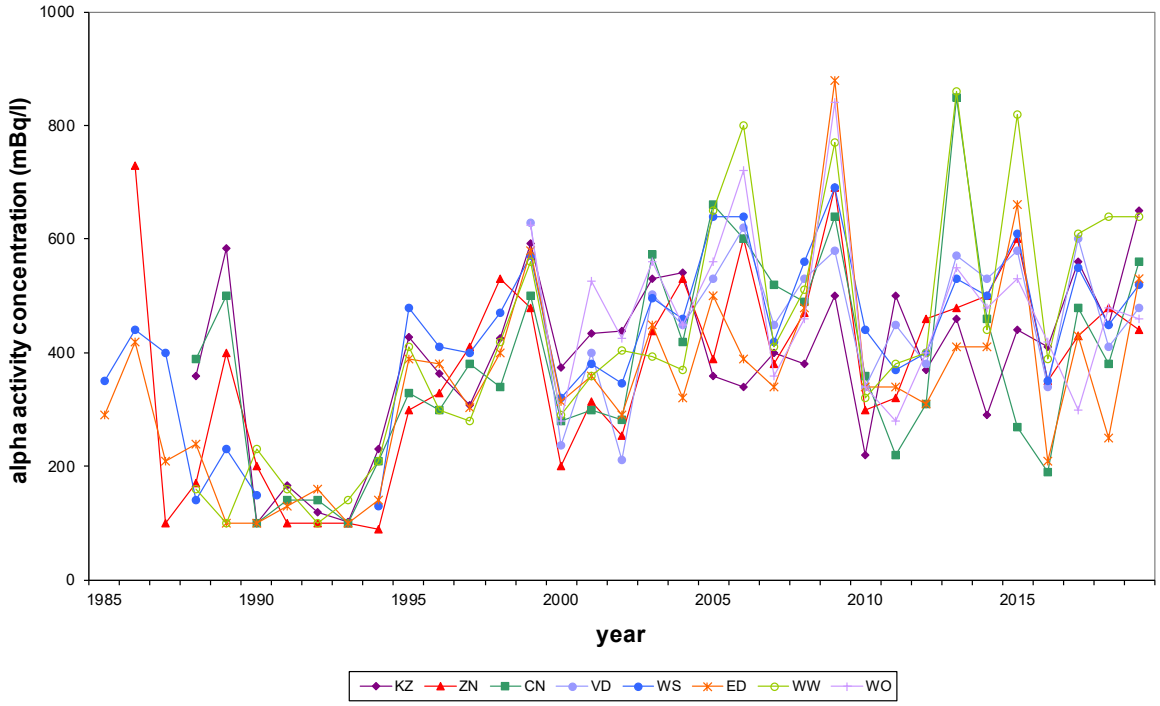

Figure 11 Yearly average gross α activity concentrations in seawater for the Coastal Area (KZ), Southern North Sea (ZN), Central North Sea (CN), Delta Coastal Waters (VD), Western Scheldt (WS), Eems-Dollard (ED), Wadden Sea West (WW) and Wadden Sea East (WO)

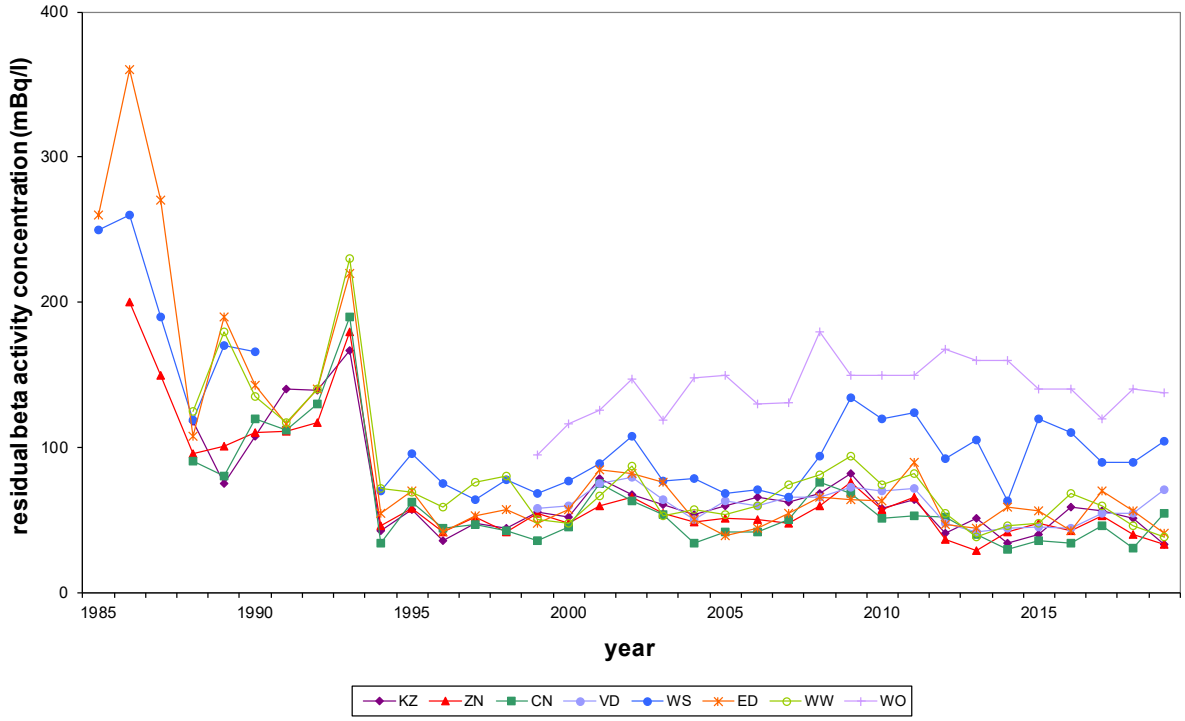

Figure 12 Yearly average residual β activity concentrations in seawater for the Coastal Area (KZ), Southern North Sea (ZN), Central North Sea (CN), Delta Coastal Waters (VD), Western Scheldt (WS), Eems-Dollard (ED), Wadden Sea West (WW) and Wadden Sea East (WO)

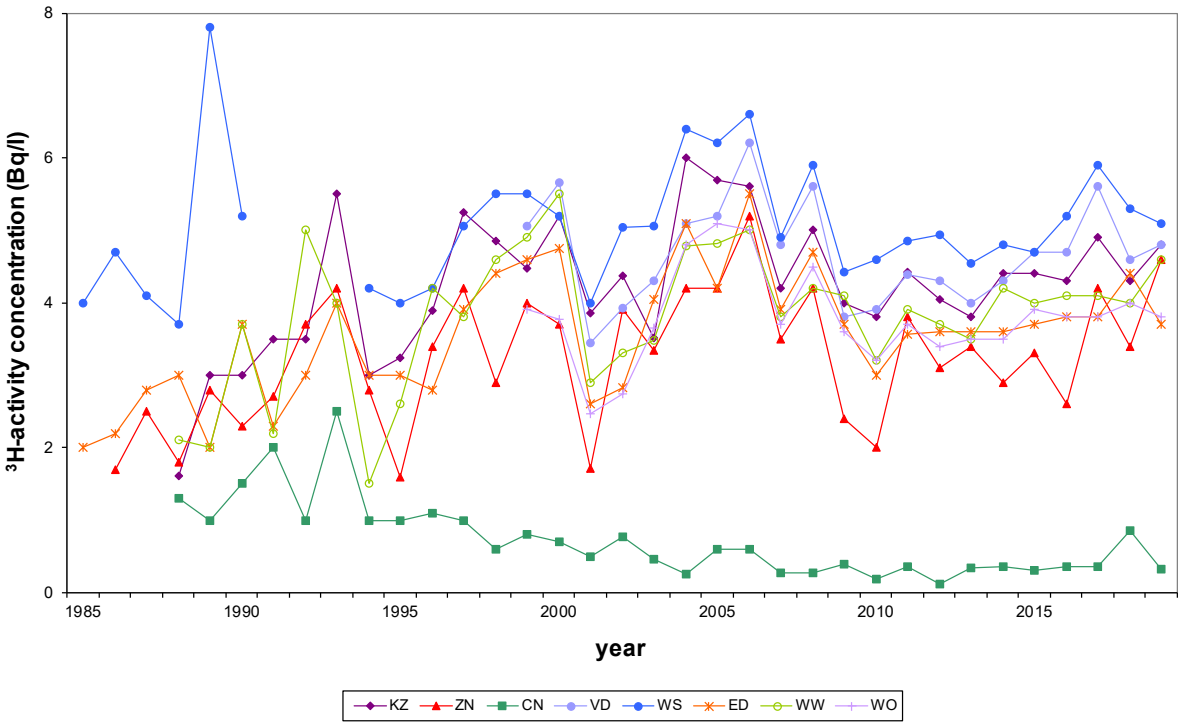

Figure 13 Yearly average ^{3}H activity concentrations in seawater for the Coastal Area (KZ), Southern North Sea (ZN), Central North Sea (CN), Delta Coastal Waters (VD), Western Scheldt (WS), Eems-Dollard (ED), Wadden Sea West (WW) and Wadden Sea East (WO)

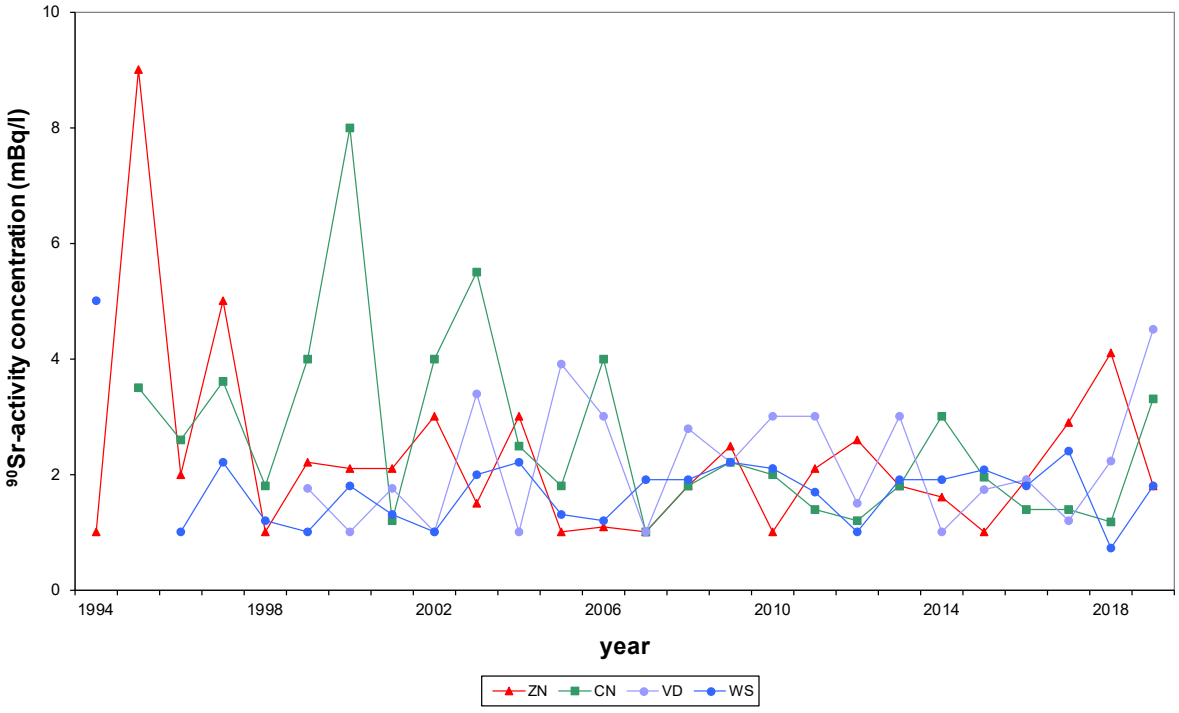

Figure 14 Yearly average ^{90}Sr activity concentrations in seawater for the Southern North Sea (ZN), Central North Sea (CN), Delta Coastal Waters (VD) and Western Scheldt (WS)

2.4 Sea water, activity in suspended solids (Bq·kg^{-1})

The radionuclides ^{210}Pb and ^{210}Po originate from the uranium decay chain and are released, for example, by the phosphate-processing industry and production platforms for oil and gas [6]. The phosphate-processing industry has not been operational in the Netherlands since 2012. Since ^{210}Po is usually in equilibrium with ^{210}Pb in suspended solids, RWS reports only on ^{210}Pb (as in surface water). In cases in which a strong increase in the gross α value is noticed, however, ^{210}Po is determined as well. Discharges via the main rivers are monitored in the Coastal Area (KZ). Discharges from the ore- and phosphate-processing industries in Belgium and the Netherlands are monitored in the Western Scheldt (WS) area. Discharges from Delfzijl, Eemshaven and plants in Germany are monitored in the Eems-Dollard (ED) area. The impact of these discharges, together with activity originating from the North Sea, is monitored indirectly in the Wadden Sea (WW and WO) area. Since 2009, Wadden Sea West has replaced Wadden Sea East as a monitoring location. Since 2014, the monitoring of suspended solids has been discontinued in the Coastal Area, Eems-Dollard and Wadden Sea West. The yearly averages of ^{137}Cs and ^{210}Pb activity concentrations are presented in Table 8, Figure 15 and Figure 16, and were within the range of those in previous years.

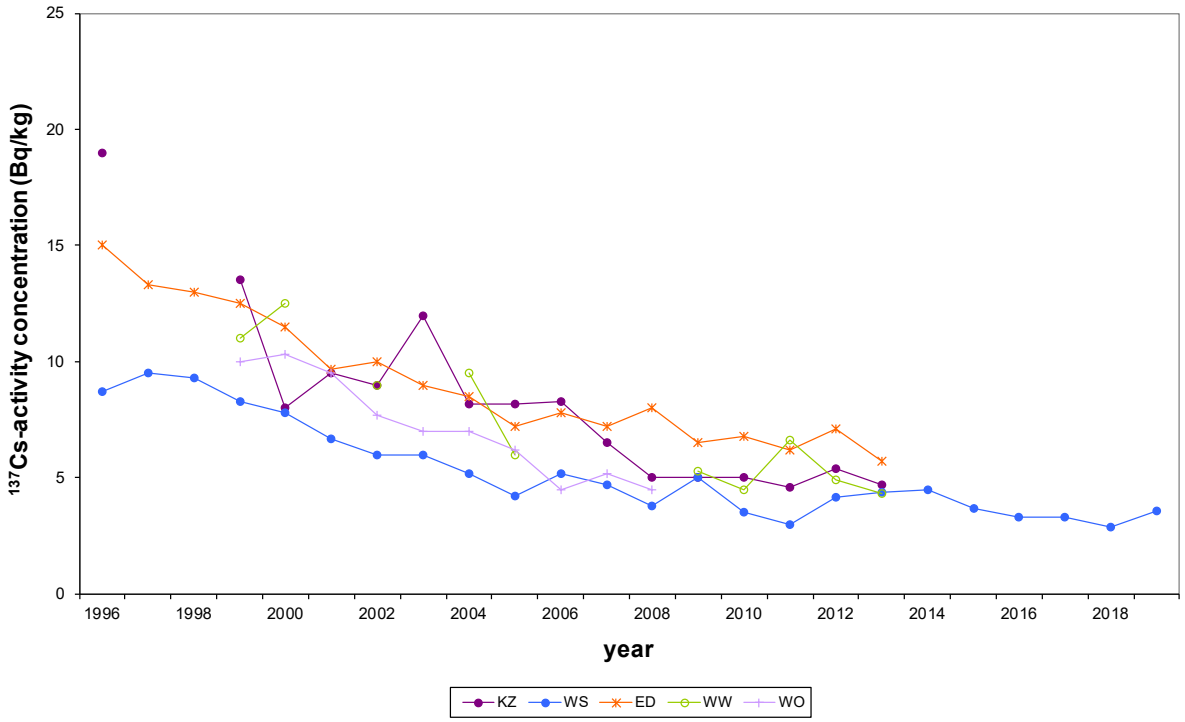

Figure 15 Yearly average ^{137}Cs activity concentrations in suspended solids. Since 2009, Wadden Sea West (WW) has replaced Wadden Sea East (WO) as a monitoring location. Since 2014, the monitoring of suspended solids has been discontinued in the Coastal Area (KZ), Eems-Dollard (ED) and Wadden Sea West (WW). The monitoring continues for the Western Scheldt (WS)

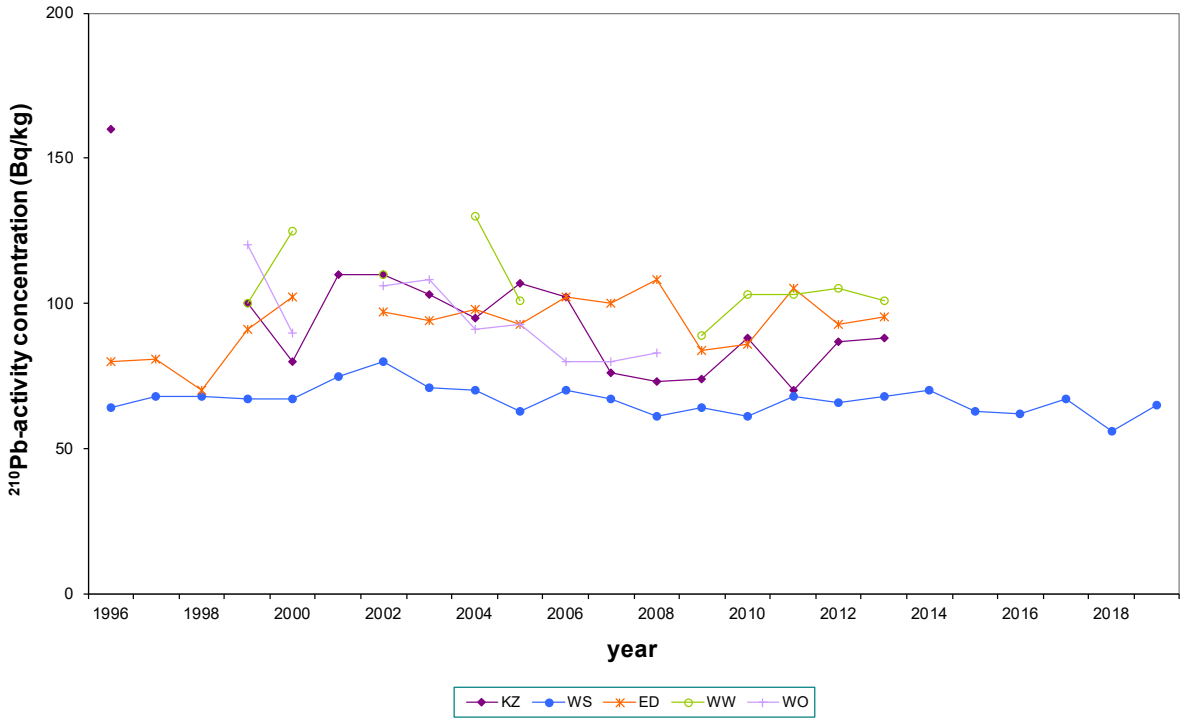

Figure 16 Yearly average ^{210}Pb activity concentrations in suspended solids. Since 2009, Wadden Sea West (WW) has replaced Wadden Sea East (WO) as a monitoring location. Since 2014, the monitoring of suspended solids has been discontinued in the Coastal Area (KZ), Eems-Dollard (ED) and Wadden Sea West (WW). The monitoring continues for the Western Scheldt (WS)

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