SCK•CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ÉTUDE DE L'ÉNERGIE NUCLÉAIRE

RADIOLOGICAL SURVEILLANCE OF THE BELGIAN TERRITORY

1991 - 1992

Report on the Meuse,
the Scheldt Estuary and
the North Sea.

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CONTENTS

1. INTRODUCTION

The report presents the results of the surveillance programme of the Meuse, the Scheldt Estuary and the North Sea performed by the Radiation Protection Unit of the CEN.SCK with the financial support of the Federal Ministry of Public Health and Environment, the Service of Radiological Protection against Ionizing Radiations (SPRI.DBIS), during 1991-1992.

The Belgian surveillance programme, which started in 1965 (R.Kirchmann et al.,1968), around the French-Belgian PWR (290 MWe) located at Chooz, has since that time extended to the whole Belgian territory. An updated version of the organization is described in the annual report issued in 1984 by the Institute of Hygiene and Epidemiology (H.De Clercq-Versele et al.,1984).

The aim of the surveillance network is to determine the dispersion in the environment, of on the one hand the liquid radioactive effluents in the various compartments of the receiving water bodies (water,fauna,flora,sediments) and, on another hand, the gaseous/aerosols radioactive releases in the atmosphere and transfer e.g. in grass-cow-milk foodchain.

In general, the liquid radioactive effluents are released in an as big as possible volume of water, in order to assure a maximum dilution. Hence the direct measurement of the contamination level of the waters is difficult, due to the low levels of radioactivity and the diversity of the radionuclides to be measured. In consequence, it is interesting to use living organisms which accumulate specific radionuclides. However a high "concentration capacity" is not the only criterion for a good biological indicator. Other characteristics are a fast response to the contamination, the ease of collect, the abundance of the species and adequate distribution in the surveyed zone, the longevity and persistence of the localisation.

An analogous situation exists in the case of atmospheric releases. It is well known that lichens accumulate natural and man-made radionuclides and heavy metals. Their concentrations in the thalli of lichens exceed by far the content of the same substances in various organs of vascular plants (Biazrov,L.G.;1990). Furthermore these organisms are able to sustain high doses of ionizing radiations (Brodo,I.M.,1964).

2. RESULTS AND DISCUSSION

2.1. Meuse

In the framework of the present report, the surveillance programme focused on one hand on the river ecosystem itself, upstream and downstream of the nuclear sites of concern (Chooz-A and Tihange), and on another hand on the lichens epiphytic collected at various stations around the Chooz-A site only as no such possibility exists in the case of the site of Tihange.

For the interested readers,a general description of the Meuse ecosystem has been given recently (BLG 635, june 1992) including the location and the characteristics of the Nuclear Power Plants.

2.1.1 Bio-indicators of atmospheric releases

2.1.1.1 Lichens epiphytic

Results of radioactivity measurements of lichens collected during 1991 and 1992 are presented respectively in the tables 2.1.1.1(a) and 2.1.1.1(b). It is underlined that for routine surveillance purposes one collect per year is sufficient but as the Nuclear Power Plant (NPP) Chooz-A is under a decommissioning procedure since october 1991, it has been judged necessary to increase significantly the frequence of collect in order to follow more closely the response of the bio-indicator to these new exposure conditions. The station of reference for this aim is located along the road from Heer to Falmignoul, in the prevailing wind direction. The localisation of the sampling stations is shown in figure 1.

2.1.2 Bio-indicators of liquid radioactive releases

2.1.2.1 Bryophytes

For purposes of radiological surveillance, certain aquatic mosses (especially *Cinclidotus danubicus)* have proved to be very suitable indicators for the principal radionuclides discharged in effluents from nuclear power plants into a river ecosystem. Results of measurements of aquatic mosses collected in the upper part of the Meuse river, upstream and downstream of the NPP Chooz-A during 1991-1992, are given in table 2.1.2.1.(a). Results of aquatic mosses and algae *(Cladophora glomerata)* collected downstream of the NPP Tihange are shown in table 2.1.2.1.(b).

2.1.3 Discussion

2.1.3.Response to atmospheric release from Chooz-A NPP.

The tables 2.1.3.1.(a) and (b) provided by the operator of the Chooz-A NPP, indicates the radioactivity of aerosols released continously, during 1991-1992. The significant values are listed in table 2.1.3.1(c) together with the ratio of the relevant isotopes. The following observations can be made:

a) Three radionuclides,namely Co-60,Cs-134 and Cs-137 are present in the atmospheric releases as well as in the lichens collected. When Co-60, is present, it is only observed at the reference station (road Heer to Falmignoul) whereas Cs-137 is present almost everywhere;

b) The levels of Cs-137 in the lichens collected at the various stations are of the same order of magnitude which means that this radionuclide originates mainly from the global and Chernobyl fallout;

c) The high level Cs-134 content of sample UL7LO6, which has been confirmed,is rather surprising as this sample is a duplicate of sample UL6LO6 , in which the Cs-134 content seems normal. A possible explanation would be the presence of a high activity particle release in the Chernobyl accident. However the ratio Cs-137/Cs134 does not support this hypothesis neither does the release from the Chooz-A NPP.

d) If one compares the Cs-137 content of the three species of lichens collected around the Chooz-A NPP one can conclude that the efficiency of retention of the fallout is in increasing order: Ramahina <Evernia<~=Hypogymnia;

e) An interesting relation is the ratio between deposition and the concentration in lichens.If one uses the values measured after the Chernobyl accident, the observed ratios were respectively 0.8 m^2/kg and 0.7 m^2/kg for Hypogymnia and Evernia (Vangelder,E., et al.1988). These values are two to three times higher than those observed in Denmark and Austria after Chernobyl, in the case of Hypogymnia (W.Hofmann et al.,1993). It must be noted that the value of the deposition of the Chernobyl fallout, in the Chooz region, is based on the data provided by the Nuclear Power Plant operator (780 MBq /km^2).

2.1.3.2 Response to liquid radioactive effluents released from Chooz-A NPP

Table 2.1.3.2.(a) shows the radioactivity released in the liquid effluents in 1991 during the period January up to and including July. These figures are based on the data provided by the operator of the NPP. More detailed values about Co-58 and Co-60 released in the liquid effluents during 1991-1992, are given in the tables 2.1.3.2.(b) and (c).
The following observations can be made:

a) In aquatic mosses the contents of the activation products Mn-54 and Co-58 are below the detection limit whereas the Co-60 levels are generally above the detection limit in 1991 and below the detection limit in 1992. As the average ratio of Co-60/Co-58 in the effluents released is about 34, it is not surprising that no Co-58 could be measured in the samples collected. It is noticeable that Co-60 is also present in samples collected upstream of the NPP (Ham). The origin of this Co-60 is unknown but could be i.e. from an industrial source.

b) The radiocesiums which represent about the 77% of the released radioactivity (except H-3) in 1991 and 93% in 1992 are generally measurable in the samples of aquatic mosses collected downstream the NPP which is not the case for the samples collected upstream (Ham). This means that the Cs-137 originating from the global fallout and from the Chernobyl accident is no longer detectable in the samples surveyed.

2.1.3.3 Response to liquid radioactive effluents released from Tihange NPP.

Table 2.1.3.3.(a) shows the radioactivity released in 1991, according to data provided by the SPRI. More detailed values about the Co-58 and the Co-60 contents of the liquid effluents are given in table 2.1.3.3.(b).
The following observations can be made:

a) The activation products are clearly present in the aquatic mosses collected at the Ivoz station and also in the algae collected at Monsin.
The Co-60 contents are in general slightly below those of the Co-58, which is in agreement with the ratio observed in the effluents released. The values of this ratio vary from 0.44 to 0.93 depending on the nuclear power plant (Unit) considered. Similarly the activities of the radiocobalts released vary by a factor up to 6. It must be underlined that the activity of the radiocobalts represented 71% of the total bêta-gamma (excluded tritium) activity released in 1991 whereas in the case of Chooz-A,it represented only 17% in 1991.

b) If one considers the case of the radiocesiums,the situation is opposite. Their releases, in 1991, represented only 4.3% of the total activity in the case of the NPP Tihange but 76.7% for Chooz-A. In 1992 the latter value reached 93.1%. The reason for these differences in radiocobalts and radiocesiums contents in the effluents is due to the age of the nuclear reactors: 6-16 years on one hand and 25 years on another hand. The levels of radiocesiums in the aquatic mosses and algae collected at Ivoz and Monsin are below or near the thresholds of detection.

2.2. Scheldt Estuary

The Scheldt is a lowland river with a rather weak flow-rate (annual mean 88 m^3/s). It reaches the North Sea through an estuary which until the last century had two arms, a Western and an Eastern arm. Actually only the Western one receives the polluted water of the Scheldt. Two NPP sites, Doel and Borssele, are located on the western arm as well as two phosphate industrial plants.

In the framework of the present report, the surveillance programme which started in 1969, has been limited to the macrophytes and intertidal surface sediments. A detailed study on the behaviour of natural radionuclides released in effluents from the two important phosphates industries has been conducted in the 80's, (Kirchmann,R.,et al.,1985), (Bonnyns-Vangelder,E.,et al.,1986).

2.2.1 Bio-indicators of liquid radioactive releases

Results of radioactivity measurements of macrophytes (seaweeds) collected during 1991-1992 in the Western Scheldt estuary and in 1992 in the Eastern arm are presented in the tables 2.2.1.1. (a),(b) and (c) respectively. These seaweeds have proved to be most appropriate as bio-indicators for the principal radionuclides discharged by nuclear installations in coastal environments. They provide also a good response to the natural radionuclides from the U-238 series.

2.2.2 Discussion

2.2.2.1 Response to liquid radioactive releases from Nuclear Power Plants (Doel, Borssele)

The tables 2.2.2.1.(a) and (b) show the radioactivity released in 1991, respectively by the Borssele NPP (The Netherlands) and the Doel NPP (Belgium), in the Scheldt estuary. These figures are based on data provided by PARCOM (Oslo and Paris Commission). The location of the nuclear power plants and the sampling stations is shown in figure 2.
The following observations can be made:

a) No activation product released by these installations is present above the detection level in Fucus vesiculosus;

b) The radiocesiums are generally below the limit of detection. When the levels are around the limit of detection, one can observe the presence of Cs-137 both in the macrophytes collected in the Western and in Eastern arms of the Scheldt. The contribution of the global and Chernobyl fallout is still detectable in some samples. This observation is confirmed by the presence of Sr-90 from the global fallout from nuclear weapons tests.

2.2.2.2 Response to liquid radioactive effluents from the phosphate industry

The impact of these releases on the Ra-226 levels in the Scheldt water is well known (Kirchmann,R., et al, 1985). When one considers the levels of Ra-226 observed in the macrophytes collected, on one hand in the Western arm of the estuary and on another hand in the Eastern one, the impact is striking. The concentrations in the Western arm are increased by one order of magnitude. It is also interesting to mention the importance of the location of the sampling station. The Ra-226 levels in the Fucus collected at Hoofdplaat are about three times lower than in the case of the samples from Kloosterzande (located upstream). Various processes such as dilution, fixation by suspended matter, can explain this difference in the levels of contamination .

2.2.3 Water and intertidal surface sediments

2.2.3.1 Water of estuary

Table 2.2.3.1.(a) shows the radioactivity of the water samples collected at BEVEREN, in the surrounding of the place where the liquid effluents are released by the NPP Doel, during the year 1992.The samples were measired by means of gamma spectrometry. It is worthwhile to remark the presence, in some samples, of Co-60 which is also present in sediments (table 2.2.3.2). Unfortunately no bio-indicators are collected at this place of release.

Table 2.2.3.1.(b) refers to water samples collected in 1991 and 1992 at BEVEREN and measured by means of radiochemical analyses.Those dealing with the Ra-226 and Po-210 contents are of particular interest considering the releases from the phosphate industry.

Table 2.2.3.1.(c) refers to samples collected in 1991 and 1992 at ANTWERP. Only the Ra-226 concentration was determined.

2.2.3.2 Intertidal surface sediments

Table 2.2.3.2. shows the results of gamma spectrometry of the samples collected in 1992 at BEVEREN. The mean value of the ratio Cs-137/Cs-134 in the sediments is 9.16 which is about 8 times higher than the value of the ratio in the effluents released by NPP Doel. This result shows that the sediments collected were not recently contaminated by the releases or at least are a mixture of old and recent contaminated sediment.
If one considers the Kd calculated for Co-60, one observes a mean values of 6.4, which is about three orders of magnitude lower than the value given in Safety Series N°57 (IAEA, 1982) which is 10,000. This result shows either that a great dilution of the freshly "labelled" sediment due to the "tide effect" in the Estuary, or more likely that the level of Co-60 in Scheldt water is overestimated due to the fact that this sample is "raw" water.

In the case of Ra-226 the Kd value calculated is 2830, which is lying between freshwater and marine sediments Kd values.

2.3 North Sea

The North Sea constitutes the European continental shelf. In the middle the depth being about 100 meters increases to the North-East to 200 meters. In the coastal areas the depth reaches only 20 meters and in the South part of the sea the depth does not exceed 60 to 70 meters. The total volume of the North Sea is about 54,000 km^3. Each year 23,000 km^3 of seawater from the North Atlantic, thanks to the Gulf Stream, are introduced into the North Sea from the North and 1,800 km3 through the Channel. That means, in theory, that the waters of the North Sea could be renewed every two years. But, practically, this is not the case for every part of the sea i.e. the coastal areas, the estuaries and the bays, due to the decrease of the current. This happens also at the center of the sea where currents of opposite direction are mutually neutralized. These regions deserve particular attention in the framework of the surveillance programmes. The western part of the Belgian coast benefits from the clean Atlantic waters brought through the Channel. But the coastal area, beginning at Nieuwport, becomes increasingly wider and reaches 30 km at Zeebrugge; in this coastal zone the influence of the current from the Atlantic is diminished and will have little dilution effect on the polluted Scheldt waters so that the pollutants will settle on the sea bottom.

2.3.1 Bio-indicators of liquid radioactive releases

2.3.1.1 Fish

Radionuclide concentrations in marine fish caught in the North Sea during the years 1991-1992 are shown in table 2.3.1.1. The location of the sampling stations are shown in figure 3 for the North Sea and figure 4 for the Belgian coast.
The levels of radioactivity are low and among the radionuclides investigated only H-3 measurements are generally above the limit of detection. Some Cs-137 results are near the limit of detection. In these conditions it is difficult to conclude if there are differences between the species sampled and/or the various locations of catch. It must also be underlined that the concentration factor for radiocesium in marine fish is roughly two orders of magnitude lower than for freshwater fish (IAEA,1982).

2.3.1.2 Crustaceans (shrimps)

Radionuclide concentrations in brown shrimps caught in the North Sea during the years 1991-1992 are shown in table 2.3.1.2.
As in the case of fish the levels of activity are low. This observation is not surprising if one considers the fact that the concentration factor for radiocesium is lower in crustaceans than in fish (IAEA,1982). The values of organic bound tritium (OBT) are of the same order of magnitude as in fish but the range observed is broader. The highest value is observed in zone 2 (station 18) and the lowest along the Belgian coast and in the dump zone 1 (stations 4,5,38)(see figure 3).

2.3.1.3 Molluscs (mussels)

Only the contents in OBT are reported in table 2.3.1.3. They are of the same order of magnitude as for shrimps sampled along the Belgian coast.

2.3.2 Discussion

2.3.2.1 Source-terms to be considered

In the framework of the MARINA Project (1985-1989), a review of the disposal of liquid and solid radioactive waste in the Northern European marine waters, including the Irish Sea, the North Sea, the English Channel and the Baltic has been prepared by the Working Group 1 (McColl,N.P.et al.), and a synthesis has been presented during the Seminar on "The Radiological Exposure of the population of the European Community from Radioactivity in North European Marine Waters" held in Bruges 10-16 June 1989.

Discharges data from a total of 72 sites which discharge either directly or indirectly into northern European waters have been collected and collated. The period covered is from the start of discharges up to the end of 1984 for all sites and up to 1986 for reprocessing plants. The sites comprise:

57 nuclear power stations,
3 nuclear reprocessing plants,
2 fuel production plants,
2 uranium enrichment plants and
8 research establishments.

As far as the Belgian Surveillance Programme is concerned, two main sources of liquid radioactive releases have to be considered:

a) the NPP -Gravelines (6 Units PWR of 900 Mwe);
b) the Fuel Reprocessing Plant of La Hague.

The tables 2.3.2.1.(a) and (b) show respectively the radioactivity released, in 1991, in the liquid effluents of these nuclear installations (data supplied by PARCOM Secretariat).
The following observations can be made:

a) The tritium contents of the marine animals surveyed are generally above the limit of detection which is not surprising when considering the amount of tritium released by the FRP of La Hague. By comparison the release of tritium by the NPP Gravelines was in 1991 about 60 times lower.

b) Sr-90 and Ru-106 also represent an important part of the radioactivity released by the FRP. The levels measured in shrimps sampled in 1986 were above the detection limit. This was not the case in shrimps collected in 1991 for Ru-106. The Sr-90 content was not measured in 1991 as it is a labour consuming operation and there are no particular relevant bio-indicators in the marine ecosystem for this radionuclide (CF <=10)(IAEA,1982).

c) Co-60 is also a significant component of the liquid releases of these two nuclear facilities. As the CF are in the range of 100 for fish and 1000 for crustacean(shrimps) it is not surprising to observe samples were the levels are just above the detection limit.

d) Cs-137 is a more complicated case. Indeed, the Sellafield reprocessing plant released at least one order of magnitude more Cs-137 than La Hague and a part of it reaches the Southern region of the North Sea. Also some contribution of the Chernobyl fallout has still to be taken into account, but becomes difficult to detect in the marine environment (MAFF,1993).

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TABLE 2.1.1.1 (a)

LICHENS EPIPHYTIQUE
(Evernia prunastri except *Hypogymnia physodes,**Ramahina farinacea)
Collected in 1991 around the NPP of CHOOZ-A

Radioactivity Bq/kg dry matter

N°Sample	Date	Location	K-40	H-3	Mn-54	Co-60	Ru-106	Cs-134	Cs-137
UL1LO1	17.01	Heer	97			55		LD	LD
UL2LO1	17.01	Heer	LD			161		LD	69
18.712	20.11	Stat.I		<7±5	<15	<30	<150	<15	≈47
18.713*	20.11	Stat.I		6±2	<8	≈8	<70	<8	62
18.174	20.11	Stat.II		7±2	<8	<15	<80	≈5	≈27
18.175*	20.11	Stat.II		8±2	<5	≈4	<40	≈6	≈21
UL8L11	13.11	Heer	246			LD		LD	81
UL11L12	30.12	Heer	237			10		LD	62
UL12L12 **	30.12	Heer	LD			53		LD	52

Measurement techniques:

H-3 : liquid scintillation
K-40, Mn-54, Co-60, Ru-106, Cs-134, Cs-137 : gamma spectrometry

TABLE 2.1.1.1 (b)

LICHENS EPIPHYTIQUE
(Evernia prunastris except *Hypogymnia physodes,**Ramahina farinacea)
Collected in 1992 around the NPP of CHOOZ-A

Radioactivity Bq/kg dry matter

N°Sample	Date	Location	K-40	H-3	Mn-54	Co-60	Ru-106	Cs-134	Cs-137
UL1LO2	07.02	Heer	184			LD		LD	57
UL4LO5	02.05	Heer	LD			LD		23	46
UL5LO5**	02.05	Heer	74			LD		9	36
UL6LO6	01.06	Heer	208±28					57±14	26±3
UL7LO6	01.06	Heer	158±49					1798±36	31±5
UL8LO6**	01.06	Heer	226±74					95±8	25±7
UL11LO8	14.08	Heer	440±70						128±9
18.726	26.08	Heer		≤9	<30	<40	<300	<30	≈21
18.729*	24.09	Stat.I		12.8±3.9	<20	<30	<200	<18	≈46
18.730	24.09	Stat.I		6.5±2.0	<18	<30	<160	<20	≈49
18.731	24.09	Stat.II		10.0±2.2	<11	<16	<110	≈6	≈45
18.732	24.09	Stat.V		8.0±3.4	<30	<40	<300	<30	≈53
18.733	24.09	Stat.X		4.4±1.6	<30	<30	<200	<30	93
18.734	25.09	Heer		9.2±2.3	<18	<30	<150	<17	≈31
UL14L11	03.11	Heer	224±28						36±4
18.735	16.11	Heer		7.6±2.3	<8	<10	<80	<9	≈8
18.736**	16.11	Heer		6.5±2.3	<13	<17	<110	<15	≈41
18.739	03.12	Stat.III		12.9±2.8	<12	<17	<110	<15	≈25
18.740	03.12	Stat.IV		16.4±2.6	<9	<12	<80	<9	≈20
18.741	03.12	Stat.VIII		11.0±2.4	<11	<16	<100	<12	47
18.742	03.12	Stat.IX		10.2±2.5	<12	≈11	<120	<14	≈38
18.743	03.12	Stat.XI		18.3±2.7	<5	<6	<40	<5	49

Measurement techniques:
H-3 : liquid scintillation
K-40, Mn-54, Co-60, Ru-106, Cs-134, Cs-137 : gamma spectrometry

TABLE 2.1.2.1 (a)

AQUATIC MOSSES
(Cinclidotus sp.)
Collected in the upper part of the Meuse river, upstream[1] and downstream[2]
of the NPP CHOOZ-A

Radioactivity Bq/kg fresh matter
1991

N°Sample	Date	Location	K-40	Mn-54	Co-60	Cs-134	Cs-137
18.700	04.04	Hastière[2]		<6	≈5.8	<6	≈11
18.701	04.04	Ham[1]		<5	≈7.7	<5	<5
18.702	04.04	Givet[2]		<8	≈19	<8	≈11
UL4MO4	04.04	Givet[2]	68		5.3	LD	8.2
UL5MO4	04.04	Givet[2]	60			LD	LD
UL6MO4	04.04	Givet[2]	100		38.1	LD	LD
UL3MO7	03.07	Givet[2]	52		15.7	LD	2.3
18.710	20.10	Ham[1]		<8	≈5	<7	<9
UL7M11	13.11	Givet[2]	112		8.6	LD	6.8
18.711	20.11	Ham[1]		<5	≈4.7	<5	<6
UL9M12	30.12	Hastière[2]	77		1.3	LD	2.8
UL10M12	30.12	Givet[2]	42		3.5	LD	2.8

Measurement technique : gamma spectrometry

TABLE 2.1.2.1 (a) (continued)

AQUATIC MOSSES
(Cinclidotus sp.)
Collected in the upper part of the Meuse river, upstream[1] and downstream[2]
of the NPP CHOOZ-A

Radioactivity Bq/kg fresh matter (*: dry matter)
1992

N°Sample	Date	Location	K-40	H-3*	Mn-54	Co-58	Co-60	Cs-134	Cs-137
UL2MO2	21.02	Ham[1]	80±18				5.8±1.7	LD	LD
18.716	16.03	Ham[1]		16±6.9	<15		<20	<15	<15
18.719	04.06	Ham[1]			<4	<4	<6	<4	<4
18.720	idem	Hastière[2]			<4	<4	<5	≈5	≈5.3
UL9MO6	08.07	Ham[1]						8.3±1.2	LD
UL10MO6	idem	Givet[2]	51±16					12.2±1.4	LD
18.722	09.07	Ham[1]			<5	<6	<6	<5	<4
18.723	idem	Hastière[2]			<4	<5	<6	<5	≈12.3
UL12MO8	14.08	Givet[2]	82±2					16.2±1.2	34±2
UL13MO9	21.09	Givet[2]	107±2					12.6±1.9	11.4±2
18.727	21.09	Ham[1]			<3	<5	<5	<4	≈3.4
18.728	22.09	Hastière[2]			<4	<5	<5	<3	≈8.4
18.745	09.12	Hastière[2]			<4	<6	≈3.1	<4	≈11

Measurement techniques :

H-3 : liquid scintillation
K-40, Mn-54, Co-60, Ru-106, Cs-134, Cs-137 : gamma spectrometry

TABLE 2.1.2.1 (b)

AQUATIC MOSSES
(Cinclidotus sp.) and Algae*
Collected in the Meuse , downstream of NPP TIHANGE, during 1991-1992

Radioactivity Bq/kg fresh matter

N°Sample	Date	Location	Mn-54	Co-58	Co-60	Cs-134	Cs-137
	1991						
15.502	18.11	Ivoz	30	300	59	<4	≈3
15.503	04.04	Ivoz	≈16	49	50	<7	<7
15.504	15.11	Ivoz	22	190	40	≈4	≈9
15.505	26.12	Ivoz	≈904	49	≈13	≈2.3	<5
	1992						
15.506	04.05	Ivoz	≈10	24	≈16	<4	<4
15.507*	04.06	Monsin	≈6	≈12	≈9	≈6	<15
15.508*	13.08	Monsin	<3	≈3	≈4	<3	≈3
15.509*	01.09	Ivoz	≈3	≈7	≈10	<3	<3
15.510*	30.09	Monsin	<14	<12	≈25	≈9	≈14
15.511	06.11	Ivoz	<4	<6	≈8	<4	<5
15.512	30.12	Ivoz	≈3	<4	≈7	≈2	≈2
15.513	09.12	Monsin	<7	<10	≈11	<7	<7

Measurement technique:

Gamma spectrometry

TABLE 2.1.3.1 (a)

Radioactivity of aerosols released continuously - SENA (NPP Chooz A)
1991

Date	Type of release	β-total Bq/m³	Co-58 Bq/m³	Co-60 Bq/m³	Cs-134 Bq/m³	Cs-137 Bq/m³
01 au 07.01.91	Permanent	1.1e-4	<4.1e-3	<6.3e-3	<5.2e-3	<4.3e-3
08 au 14.01.91	Permanent	8.1e-5	<3.9e-3	<2.6e-3	<4.9e-3	<3.6e-3
15 au 22.01.91	Permanent	1.4e-4	<5.7e-3	<3.7e-3	<5.3e-3	<5.0e-3
22 au 31.01.91	Permanent	<1.9e-4	<1.2e-2	<8.1e-3	<1.3e-2	<9.6e-3
01 au 07.02.91	Permanent	1.1e-2	<1.2e-2	<9.1e-3	<1.1e-2	<9.6e-3
08 au 14.02.91	Permanent	3.9e-4	<5.2e-3	<3.8e-3	<5.9e-3	<5.0e-3
15 au 21.02.91	Permanent	2.2e-3	<1.5e-2	1.2e-2	<2.0e-2	3.8e-2
22 au 28.02.91	Permanent	8.1e-4	<5.4e-3	<7.7e-3	<7.0e-3	8.6e-3
01 au 07.03.91	Permanent	3.0e-4	<6.8e-3	<4.6e-3	<8.1e-3	<5.2e-3
08 au 14.03.91	Permanent	3.8e-4	<7.0e-3	<4.9e-3	<8.0e-3	<6.1e-3
15 au 21.03.91	Permanent	7.3e-5	<3.1e-3	1.0e-2	<3.7e-3	<3.4e-3
22 au 31.03.91	Permanent	<2.7e-4	<1.5e-2	<1.1e-2	<1.7e-2	<1.4e-2
01 au 07.04.91	Permanent	2.2e-4	<6.1e-3	<3.9e-3	<5.7e-3	<5.1e-3
08 au 14.04.91	Permanent	4.4e-4	<5.3e-3	6.3e-3	<5.0e-3	<4.2e-3
15 au 21.04.91	Permanent	1.7e-4	<5.5e-3	<6.5e-3	<5.8e-3	<9.1e-3
22 au 30.04.91	Permanent	3.0e-4	<4.0e-3	<3.0e-3	<4.4e-3	<3.3e-3
01 au 07.05.91	Permanent	1.8e-4	<4.7e-3	<5.5e-3	<5.5e-3	<4.9e-
08 au 14.05.91	Permanent	2.0e-4	<6.3e-3	<4.6e-3	<5.5e-3	<4.8e-3
15 au 21.05.91	Permanent	2.4e-4	<5.1e-3	<6.2e-3	<5.1e-3	<5.0e-3
22 au 31.05.91	Permanent	1.6e-3	<4.4e-2	<4.5e-2	<4.2e-2	<3.6e-2
01 au 07.06.91	Permanent	2.3e-4	<5.0e-3	<4.2e-3	<5.3e-3	<4.3e-3
08 au 14.06.91	Permanent	1.5e-4	<4.9e-3	<4.4e-3	<5.7e-3	<5.1e-3
15 au 21.06.91	Permanent	1.2e-4	<5.7e-3	<4.4e-3	<5.9e-3	<4.3e-3
22 au 30.06.91	Permanent	1.0e-4	<5.0e-3	<3.9e-3	<4.6e-3	<3.6e-3
01 au 07.07.91	Permanent	2.0e-4	<4.7e-3	<5.7e-3	<5.5e-3	<4.4e-3
08 au 14.07.91	Permanent	2.0e-4	<6.1e-3	<5.0e-3	<6.0e-3	<5.0e-3

TABLE 2.1.3.1 (a) (continued)

Date	Type of release	β-total Bq/m³	Co-58 Bq/m³	Co-60 Bq/m³	Cs-134 Bq/m³	Cs-137 Bq/m³
15 au 21.07.91	Permanent	1.6e-4	<5.4e-3	<4.3e-3	<5.6e-3	<4.8e-3
22 au 31.07.91	Permanent	3.2e-4	<1.3e-1	<1.2e-1	<1.3e-1	<1.0e-1
01 au 07.08.91	Permanent	2.1e-4	<6.5e-3	<3.7e-3	<5.5e-3	<5.8e-3
08 au 14.08.91	Permanent	1.6e-4	<5.8e-3	<3.6e-3	<6.5e-3	<4.4e-3
15 au 21.08.91	Permanent	2.3e-4	<5.8e-3	<4.5e-3	<6.1e-3	<5.4e-3
22 au 31.08.91	Permanent	2.8e-4	<3.8e-3	<3.1e-3	<3.4e-3	<3.6e-3
01 au 07.09.91	Permanent	2.4e-4	<5.0e-3	<5.2e-3	<5.3e-3	<5.1e-3
08 au 14.09.91	Permanent	2.2e-4	<5.0e-3	<5.4e-3	<5.9e-3	<5.0e-3
15 au 21.09.91	Permanent	3.4e-4	<5.1e-3	<4.9e-3	<5.3e-3	<4.2e-3
22 au 31.09.91	Permanent	2.4e-4	<3.9e-3	<6.4e-3	<4.0e-3	<5.7e-3
01 au 07.10.91	Permanent	<1.8e-4	<8.3e-3	<7.7e-3	<9.8e-3	<1.4e-2
08 au 14.10.91	Permanent	9.4e-5	<3.1e-3	<3.2e-3	<3.4e-3	<2.8e-3
15 au 21.10.91	Permanent	<1.1e-4	<4.6e-3	<4.1e-3	<4.9e-3	<4.0e-3
22 au 31.10.91	Permanent	6.4e-4	<3.8e-3	<3.7e-3	<3.9e-3	<3.1e-3
01 au 07.11.91	Permanent	1.6e-4	<4.1e-3	<4.4e-3	<5.4e-3	<4.4e-3
08 au 14.11.91	Permanent	1.3e-4	<4.8e-3	1.2e-2	<4.4e-3	<3.7e-3
15 au 21.11.91	Permanent	1.1e-4	<5.2e-3	<5.3e-3	<4.8e-3	<4.6e-3
22 au 30.11.91	Permanent	2.2e-4	<3.8e-3	<3.2e-3	<4.4e-3	<3.8e-3
01 au 07.12.91	Permanent	<1.4e-4	<6.5e-3	<4.9e-3	<7.0e-3	<6.9e-3
08 au 14.12.91	Permanent	<1.1e-4	<5.7e-3	<3.6e-3	<4.9e-3	<5.4e-3
15 au 21.12.91	Permanent	1.5e-4	<5.8e-3	<4.4e-3	<6.7e-3	<4.5e-3
22 au 31.12.91	Permanent	2.0e-4	<4.0e-3	<3.0e-3	<4.6e-3	<3.1e-3

TABLE 2.1.3.1 (b)

Radioactivity of aerosols released continuously - SENA (NPP Chooz A)
1992

Date	Type of release	β-total Bq/m³	Co-58 Bq/m³	Co-60 Bq/m³	Cs-134 Bq/m³	Cs-137 Bq/m³
01 au 07.01.92	Permanent	<1.1e-4	<2.8e-3	<8.0e-3	<3.0e-3	<4.0e-3
08 au 14.01.92	Permaent	<1.3e-4	<2.4e-3	<4.9e-3	<2.5e-3	<4.6e-3
15 au 21.01.92	Permanent	<6.3e-5	<8.0e-4	<3.3e-3	<1.3e-3	<3.2e-3
22 au 31.01.92	Permanent	<8.0e-5	<2.0e-3	<3.5e-3	<2.4e-3	<5.0e-3
01 au 07.02.92	Permanent	<1.0e-4	<2.5e-3	<4.3e-3	<2.3e-3	<5.8e-3
08 au 14.02.92	Permanent	<1.0e-4	<2.5e-3	<3.5e-3	<2.2e-3	<4.9e-3
15 au 21.02.92	Permanent	<9.5e-5	<2.1e-3	<4.1e-3	<1.9e-3	<4.1e-3
22 au 28.02.92	Permanent	<9.0e-5	<2.2e-3	2.0e-3	<2.1e-3	<1.9e-3
01 au 07.03.92	Permanent	<8.2e-5	<2.2e-3	<2.2e-3	<1.8e-3	<2.0e-3
08 au 14.03.92	Permanent	<8.1e-5	<1.8e-3	<2.1e-3	<1.9e-3	<1.8e-3
15 au 21.03.92	Permanent	<8.9e-5	<2.0e-3	<2.3e-3	<2.3e-3	<2.1e-3
22 au 31.03.92	Permanent	<6.7e-5	<2.6e-3	<1.8e-3	<2.3e-3	<1.5e-3
01 au 07.04.92	Permanent	<7.6e-5	<2.3e-3	<3.7e-3	<1.7e-3	<3.4e-3
08 au 14.04.92	Permanent	<8.0e-5	<1.9e-3	<3.9e-3	<1.8e-3	<5.0e-3
15 au 21.04.92	Permanent	<1.7e-4	<5.0e-3	<1.3e-2	<4.5e-3	<1.6e-2
22 au 30.04.92	Permanent	<7.8e-5	<2.3e-3	<3.7e-3	<2.2e-3	<4.0e-3
01 au 07.05.92	Permanent	<8.5e-5	<1.9e-3	<3.6e-3	<1.9e-3	<5.0e-3
08 au 14.05.92	Permanent	<8.3e-5	<2.4e-3	<4.2e-3	<2.4e-3	<3.6e-3
15 au 21.05.92	Permanent	<8.5e-5	<4.6e-3	<3.9e-3	<2.1e-3	<4.7e-3
22 au 31.05.92	Permanent	<6.4e-5	<9.0e-4	<2.7e-3	1.7e-3	<3.0e-3
01 au 07.06.92	Permanent	<8.6e-5	<1.8e-3	<4.0e-3	<2.3e-3	<5.0e-3
08 au 14.06.92	Permanent	<9.9e-5	<1.4e-3	<3.0e-3	<1.3e-3	<3.0e-3
15 au 21.06.92	Permanent	<8.0e-5	<1.6e-3	3.8e-3	<2.2e-3	<5.0e-3
22 au 30.06.92	Permanent	<1.5e-4	<1.6e-3	<4.8e-3	<1.5e-3	<2.9e-3
01 au 07.07.92	Permanent	<8.0e-5	<1.9e-3	<4.4e-3	<1.2e-3	<4.4e-3
08 au 14.07.92	Permanent	<8.4e-5	<1.6e-3	<4.7e-3	<1.1e-3	<4.2e-3

TABLE 2.1.3.1 (b) (continued)

Date	Type of release	β-total Bq/m³	Co-58 Bq/m³	Co-60 Bq/m³	Cs-134 Bq/m³	Cs-137 Bq/m³
15 au 21.07.92	Permanent	<8.1e-5	<2.0e-3	<5.0e-3	<1.9e-3	<4.3e-3
22 au 31.07.92	Permanent	<5.9e-5	<1.5e-3	<3.1e-3	<1.6e-3	<2.8e-3
01 au 07.08.92	Permanent	<8.4e-5	<2.0e-3	<4.5e-3	<2.0e-3	<4.5e-3
08 au 14.08.92	Permanent	<8.3e-5	<2.5e-3	<5.0e-3	<2.1e-3	<4.1e-3
15 au 21.08.92	Permanent	<8.5e-5	<2.2e-3	<3.6e-3	<2.2e-3	<6.5e-3
22 au 31.08.92	Permanent	<7.1e-5	<2.0e-3	<3.7e-3	<1.6e-3	<3.7e-3
01 au 07.09.92	Permanent	7.8e-3	<8.5e-4	<1.6e-3	1.9e-3	1.5e-2
08 au 14.09.92	Permanent	1.7e-2	<7.5e-4	<1.2e-3	3.8e-3	2.7e-2
15 au 21.09.92	Permanent	2.6e-3	<9.0e-4	<1.3e-3	1.0e-3	4.5e-3
22 au 30.09.92	Permanent	3.3e-4	<6.0e-4	<7.5e-4	6.5e-4	<1.1e-3
01 au 07.10.92	Permanent	<1.0e-4	<1.6e-3	<2.6e-3	<3.2e-3	<3.4e-3
08 au 14.10.92	Permanent	2.2e-4	<1.5e-3	<2.2e-3	3.3e-3	<2.7e-3
15 au 21.10.92	Permanent	3.0e-4	<1.5e-3	<2.2e-3	5.4e-3	<3.3e-3
22 au 31.10.92	Permanent	2.6e-4	<1.1e-3	<3.6e-3	4.4e-3	<1.9e-3

TABLE 2.1.3.1 (c)

Activity (mBq/m³) of aerosols released by NPP CHOOZ A
Significant values of tables 2.1.3.1 (a)(b)

Date	Co-58	Co-60	Co60 / Co-58	Cs-134	Cs-137	Cs-137 / Cs-134
15 au 21.02.91	<15	12	>0.8	<20	38	>1.9
22 au 28.02.91	<5.4	<7.7		<7	8.6	>1.2
15 au 21.03.91	<3.1	10	>3.2	<3.7	<3.4	
08 au 14.04.91	<5.3	6.3	>1.2	<5	<4.2	
22 au 31.07.91	<130	<120		<130	<100	
01 au 07.09.92	<0.8	<1.6		1.9	15	7.9
08 au 14.09.92	<0.7	<1.2		3.8	27	7.1
15 au 21.09.92	<0.9	<1.3		1.0	4.5	4.5
22 au 30.09.92	<0.6	<0.7		0.65	<1.1	<15
08 au 14.10.92	<1.5	<2.2		3.3	<2.7	<0.8
15 au 21.10.92	<1.5	<2.2		5.4	<3.3	<0.6
22 au 31.10.92	<1.1	<3.6		4.4	<1.9	<0.4

TABLE 2.1.3.2 (a)

Radioactivity released in the liquid effluents of NPP CHOOZ-A in 1991 during the period January up to and including July.

Radionuclides	Activity	% of total	Ratios
H-3	25900 GBq		
Mn-54	315 MBq	2.4	
Co-58	62 MBq	0.5	Co-60 / Co-58 = 34.2
Co-60	2120 MBq	16.6	
Cs-134	1380 MBq	10.8	Cs-137 / Cs-134 = 6.1
Cs-137	8460 MBq	65.9	

Total β - γ = 12800 MBq soit 96.7%
(except H-3)

Remark : Sb- 124 = 43.2 MBq (0.4%)
Ag-110m = 50.3 MBq (0.4%)

TABLE 2.1.3.2 (b)

Released (MBq) Co-58 and Co-60 in the liquid effluents of NPP CHOOZ-A
1991

Month	Co-58	Co-60	Co-60/Co-58
01	6.01	769	128
02	7.40	282	38.1
03	21.6	256	11.8
04	3.57	133	37.2
05	5.34	211	39.5
06	1.70	72.6	42.7
07	1.93	71.0	36.8
08	1.09	78.6	72.1
09	1.00	66.8	66.8
10	0.77	33.3	43.2
11	10.1	90.8	9.00
12	1.49	51.0	34.2
	Σ 62.0	2120	34.2

TABLE 2.1.3.2 (c)

Released (MBQ) Co-58 and Co-60 in the liquid effluents of NPP CHOOZ-A
1992

Month	Co-58	Co-60	Co-60/Co-58
01	1.11	27.3	24.6
02	1.40	54.1	38.6
03	2.88	146.0	50.7
04	1.33	37.1	27.9
05	1.52	68.5	45.0
06	1.25	36.5	29.2
07	0.55	7.5	13.6
08	1.47	95.5	65.0
09	0.52	8.8	16.9(triennal)
10	0.82	21.5	26.2
11	1.27	12.1	9.5
12	1.13	20.7	18.3
	Σ 15.2	536	35.2

TABLE 2.1.3.3 (a)

Radioactivity released in the liquid effluent of NPP-TIHANGE (2770 MWe) in 1991

Radionuclides	Activity		% of total (except H-3)	Ratios
H-3	36.5	TBq		
Mn-54	2215	MBq	4	
Co-58	22576	MBq	41	Co-60 / Co-58 = 0.73
Co-60	16514	MBq	30	
Cs-134	614	MBq	1.1	Cs-137 / Cs-134 = 2.9
Cs-137	1784	MBq	3.2	
			79.3	

Total β - γ (except H-3)
Unit 1 : 8216 MBq
Unit 2 : 32058 MBq
Unit 3 : 14783 MBq

Total site 55057 MBq

Remark : Sb-124 1096 MBq 2
Ag-110m 4399 MBq 8
Cr-51 3041 MBq 5.5

TABLE 2.1.3.3 (b)

Monthly releases (MBq) Co-58 and Co-60 of NPP TIHANGE in 1991

Month	Unit 1			Unit 2			Unit 3		
	Co-58	Co-60	Co-60 / Co-58	Co-58	Co-60	Co-60 / Co-58	Co-58	Co-60	Co-60 / Co-58
01	358	75	0.20	899	1440	1.60	56	66	1.18
02	6	38	6.33	3770	826	2.19	67	174	2.60
03	15	69	4.6	366	1270	3.47	1310	1420	1.08
04	102	131	1.28	138	494	3.58	299	583	1.95
05	17	34	2.00	84	214	2.55	192	318	1.66
06	75	108	1.44	2110	1140	0.54	95	207	2.18
07	70	66	0.94	2240	804	0.36	8	14	1.75
08	67	238	3.55	803	467	0.58	46	96	2.08
09	1080	283	0.26	404	471	1.16	357	184	0.51
10	1350	336	0.25	902	637	0.70	343	87	0.25
11	588	228	0.39	1527	927	0.61	488	331	0.68
12	157	123	0.78	1750	2090	1.19	3830	525	0.14
Σ	3885	1729	x=0.44	11600	10780	x=0.93	7091	4005	x=0.56

TABLE 2.2.1.1 (a)

MACROPHYTES (Fucus vesiculosus) collected in the Western Scheldt Estuary, at HOOFDPLAAT, in 1991 - 1992.

Radioactivity: Bq/kg fresh matter (* dry matter)

N°Sample	Date	Co-60	Sr-90 (*)	Ru-106	Cs-134	Cs-137	Ra-226 (emmanat) (*)	Th-232
17.247	05.03.91	<3	≤2	<25	<2.5	<2.0	21.6±0.4	≈8.1
17.248	17.04.91	<3	≤2	<25	<3	<2.5	18.1±0.4	<15
17.251	23.08.91	<3	≤2	<25	<3	<2.5	23.2±0.4	<15
17.253	19.12.92	<3	≤2	<15	<2.0	<2.0	80.0±0.7	≈12

Measurement techniques :

Co-60, Ru-106, Cs-134, Cs-137, Th-232 : gamma spectrometry
Sr-90 : chemical separation
Ra-226 : Lucas method

TABLE 2.2.1.1 (b)

MACROPHYTES (Fucus vesiculosus) collected in the Western Scheldt Estuary, at KLOOSTERZANDE, in 1991 - 1992.

Radioactivity: Bq/kg fresh matter (* dry matter)

N°Sample	Date	K-40	Mn-54	Co-60	Sr-90 (*)	Ru-106	Cs-134	Cs-137	Ra-226 (emmanat) (*)	Th-232
17.246	20.02.91			<3	≤2	<25	<2.5	<2.5	71±0.6	≈5.9
17.249	20.05.91			<3	≤2	<20	<2.5	<2.0	69.2±0.9	<7
17.250	23.08.91			<3	≤2	<25	<2.5	<2.5	65.0±0.6	≈11.9
17.252	26.09.91			<1.5	≤2	<15	<1.5	≈0.7	68.0±1.0	≈2.1
17.257	06.05.92			<0.8	1.95±1.36	<7	<0.8	<0.9	55.4±0.3	
17.258	25.09.92			<1.0	1.30±1.22	<6	<0.7	↾1.2	50.5±0.3	
17.259	17.10.92	192	<0.9	<1.0	≤1.3	<8	<0.9	<0.9	69.5±0.4	
17.260	01.12.92	2.4E2	<0.7	<1.0	≤1.3	<6	<0.8	9	61.5±0.3	

Measurement techniques :

K-40, Mn-54, Co-60, Ru-106, Cs-134, Cs-137, Th-232 : gamma spectrometry
Sr-90 : chemical separation
Ra-226 : Lucas method

TABLE 2.2.1.1 (c)

MACROPHYTES (Fucus vesiculosus) collected in the Eastern arm of the Scheldt Estuary, at YERSEKE in 1992.

Radioactivity: Bq/kg fresh matter (* dry matter)

N°Sample	Date	K-40	Mn-54	Co-60	Sr-90 (*)	Ru-106	Cs-134	Cs-137	Ra-226 (emmanat) (*)
17.255	08.07.92			<1.0	1.62±1.38	<7	<7	<7	6.7±0.3
17.256	01.09.92			<9	1.64±1.27	<5.0	<6	<8	5.9±0.3
17.261	09.11.92	2.6E2	<0.8	<1.1	≤1.3	<6	<0.7	≈0.8	9.9±0.1
17.262	14.12.92	2.3E2	<0.3	<0.4	2.7±1.4	<3	<0.4	↾0.3	8.3±0.1

Measurement techniques :

K-40, Mn-54, Co-60, Ru-106, Cs-134, Cs-137 : gamma spectrometry
Sr-90 : chemical separation
Ra-226: Lucas method

TABLE 2.2.2.1 (a)

Radioactivity released in the liquid effluents of NPP BORSSELE (485 MWe) in 1991.

Radionuclides	Activity		% of total	Ratios
H-3	2.9	TBq		
Mn-54	30	MBq	2.5	
Co-58	160	MBq	13.3	Co-60 = 5.25
Co-60	840	MBq	70.0	Co-58
Cs-137	40	MBq	3.3	
			89.1	
Total β - γ (except H-3)	1200	MBq		

Remark :

Sb-124	10	MBq	0.8
Cr-51	80	MBq	6.7
Cs-134	not mentioned		

TABLE 2.2.2.1 (b)

Radioactivity released in the liquid effluents of NPP-DOEL (2680 MWe) in 1991.

Radionuclides	Activity	% of total	Ratios
H-3	38.1 TBq		
Co-58	1.66 GBq	5.5	Co-60 / Co-58 = 1.02
Co-60	1.63 GBq	5.4	
Cs-134	8.49 GBq	28.3	Cs-137 / Cs-134 = 1.08
Cs-137	9.19 GBq	30.6	

		69.8	
Total β - γ (except H-3)	30 GBq		

Remark :

Te-123	479	MBq
I-131	461	MBq
Mn-54	0	Bq
Cr-51	0	Bq

TABLE 2.2.3.1 (a)

WATER samples collected in the Scheldt Estuary, at BEVEREN in 1992
Radioactivity : Bq/l

N° Sample	Date	Be-7	Co-60	I-131	Cs-134	Cs-137
1	07.01.92	<2		<0.5	<0.2	<0.3
2	14.01.92	<2		<0.3	<0.3	0.16
3	21.01.92	<1.5		<0.3	<0.2	<0.2
4	28.01.92	<2		<0.5	<0.3	<0.3
5	04.02.92	<2		<0.3	<0.2	<0.2
6	11.02.92	<2		<0.3	<0.2	<0.3
7	18.02.92	<2		<0.3	<0.2	<0.3
8	25.02.92	<1.5		<0.3	<0.2	<0.2
9	03.03.92	<1.5		<0.3	<0.2	<0.2
10	10.03.92	<1.5		<0.3	<0.2	<0.2
11	17.03.92	<2		<0.4	<0.3	<0.3
12	24.03.92	<2		<0.3	<0.2	<0.3
13	31.03.92	<2	1.86	<0.3	<0.3	<0.3
14	07.04.92	<0.7		<0.1	<0.08	<0.08
15	14.04.92	<2		<0.3	<0.3	0.15
16	21.04.92	<2		<0.3	<0.3	<0.2
17	28.04.92	<1.5		<0.2	<0.2	<0.2
18	05.05.92	<0.7		<0.2	<0.08	<0.09
19	12.05.92	<1.5		<0.2	<0.2	<0.2
20	19.05.92	<1.5		<0.3	<0.2	<0.2
21	26.05.92	<2		<0.4	<0.2	<0.2
22	02.06.92	<0.7		<0.15	<0.08	<0.09
23	09.06.92	<0.7		<0.15	<0.07	<0.08
24	16.06.92	<2		<0.3	<0.2	<0.3
25	23.06.92	<1.5		<0.3	<0.2	<0.2
26	30.06.92	<0.7		<0.1	<0.08	<0.08
27	07.07.92	<1.5		<0.3	<0.2	0.18

TABLE 2.2.3.1 (a) (continued)

N° Sample	Date	Be-7	Co-60	I-131	Cs-134	Cs-137
28	14.07.92	<0.9	1.1	<0.5	0.06	<0.07
29	21.07.92	<0.8		<0.3	<0.08	0.1
30	28.07.92	<2		<0.4	<0.2	<0.2
31	04.08.92	<2		<0.4	<0.2	<0.2
32	14.08.92	<1.8		<0.4	<0.2	<0.2
33	18.08.92	<2		<0.3	<0.2	<0.3
34	25.08.92	<1.5		<0.3	<0.2	<0.2
35	01.09.92	<1.7		<0.3	<0.19	<0.2
36	08.09.92	<2		<0.3	<0.2	<0.2
37	15.09.92	<1.4		<0.3	<0.2	<0.2
38	22.09.92	<2		<0.3	<0.2	<0.3
39	29.09.92	<0.7		<0.15	<0.08	<0.12
40	06.10.92	<0.7		<0.1	<0.08	<0.09
41	13.10.92	<0.7		<0.1	<0.09	0.09
42	20.10.92	<2		<0.3	<0.2	<0.2
43	27.10.92	<1.5		<0.3	<0.2	<0.2
44	03.11.92	<0.7		<0.09	<0.08	0.08
45	10.11.92	<0.7		<0.11	<0.08	<0.09
46	17.11.92	<4	0.46	<0.5	<0.4	<0.5
47	24.11.92	<1.5		<0.3	<0.18	<0.17
48	01.12.92	<0.7		<0.12	<0.09	<0.09
49	08.12.92	<1.9		<0.4	<0.2	<0.3
50	15.12.92	<1.5		<0.3	<0.19	<0.19
51	22.12.92	<1.8		<0.7	<0.18	<0.19
52	29.12.92	<0.7		<0.17	<0.08	<0.08

Measurement technique : gamma spectrometry

TABLE 2.2.3.1 (b)

WATER samples collected in the Scheldt Estuary, at BEVEREN, in 1991 - 1992
Radioactivity: mBq/l

N°Sample	Date	T-Alpha	T-Beta	H-3	Sr-90	Po-210	Ra-226	Am-241	T-Pu	T-U
1	14.01.91	110	690				14			
2	13.02.91	180	2300				23			
3	14.03.91	160	1600				28			
4	12.04.91	240	2900				22			
5	27.05.91	62	2800	15	≤40	20	33		2	34
6	11.06.91	200	3900	21	≤40	17	43		2	29
7	10.07.91	83	1600	11	≤40	22	40		2	32
8	09.08.91	170	3400	15	≤40	8	59		2	42
9	06.09.91	200	3300	16	≤40	8	56		2	33
10	07.10.91	120	3200	21	≤40	3	46		2	37
11	05.11.91	530	4400	19	≤40	6	34	≤3	≤2	8
12	06.12.91	230	2700		50	27	35		≤2	36
1	07.01.92			≤11±15.3						
2	14.01.92			≤11±1.6						
3	28.01.92			≤11±12.3						

TABLE 2.2.3.1 (b) continued

N°Sample	Date	T-Alpha	T-Beta	H-3	Sr-90	Po-210	Ra-226	Am-241	T-Pu	T-U
	07.01-28.01.92	118.50	2657		65	22.4	31.1	≤3	≤2	43
4	04.02.92			12.6±6.1						
5	18.02.92			≤11±7.5						
6	25.02.92			≤11±6.8						
	04.02-25.02.92	228.50	3080		40	18	31.6	≤3	≤3	32
7	03.03.92			≤12±10.1						
8	10.03.92			≤13±9.1						
9	17.03.92			≤12±12.2						
10	24.03.92			≤11						
11	31.03.92			≤12						
	03.03-31.03.92	233.60	2004		≤50	17	25.5	≤3	≤3	29
12	07.04.92			≤12						
13	14.04.92			19.5±6.7						
14	21.04.92			≤12						
15	28.04.92			≤12						
	07.04-28.04.92	131.20	2092		≤50	4	27.8	≤3	≤3	26
16	05.05.92			12.3±5.5						
17	12.05.92			≤11						
18	19.05.92			≤11						

TABLE 2.2.3.1 (b) continued

N°Sample	Date	T-Alpha	T-Beta	H-3	Sr-90	Po-210	Ra-226	Am-241	T-Pu	T-U
19	26.05.92			14.1±6.9						
	05.05-26.05.92	209.90	2720		≤40	22	39.3	≤3	≤3	34
20	02.06.92			13.8±6.5						
21	09.06.92			≤11.0						
22	16.06.92			≤11.0						
23	23.06.92			17.0±7.3						
24	30.06.92			≤14.0						
	02.06-30.06.92	124.40	1904		≤30	13	38.5	≤3	≤3	38
25	07.07.92			22.6±7.1						
26	14.07.92			18.7±7.0						
27	21.07.92			14.0±6.6						
28	28.07.92			17.9±6.9						
	07.07-28.07.92	101.50	3192		≤40	6	41.1	≤3	≤3	26
29	04.08.92			≤13.0						
30	11.08.92			≤12.0						
31	25.08.92			17.2						
	04.08-25.08.92	189.10	3572		≤20	10	47.4	≤3	≤3	29
32	01.09.92			≤12.0						
33	08.09.92			≤12.0						

TABLE 2.2.3.1 (b) continued

N°Sample	Date	T-Alpha	T-Beta	H-3	Sr-90	Po-210	Ra-226	Am-241	T-Pu	T-U
34	15.09.92			≤13.0						
35	22.09.92			≤12.0						
36	29.09.92			≤13.0						
	01.09-29.09.92	169.90	2167		21	6	43.8	≤3	≤3	22
37	06.10.92			15.4±6.7						
38	13.10.92			10.1±5.4						
39	20.10.92			12.3±5.7						
40	27.10.92			≤10.0						
	06.10-27.10.92	201.40	5630		36	5	53.9	≤3	≤3	27
41	03.11.92			≤9.0						
42	10.11.92			≤10.0						
43	17.11.92			≤10.0						
44	24.11.92			≤9.0						
	03.11-01.12.92	216.60	2676		≤20	6	33.4	≤3	≤3	29
45	01.12.92			≤11.0						
46	08.12.92			≤10.0						
47	15.12.92			≤10.0						
48	22.12.92			≤10.0						
49	29.12.92			≤10.0						

TABLE 2.2.3.1 (b) continued

N°Sample	Date	T-Alpha	T-Beta	H-3	Sr-90	Po-210	Ra-226	Am-241	T-Pu	T-U
	08.12-29.12.92	94.80	972		≤20	4	21.3	3	4	26

Measurement techniques :

H-3 : liquid scintillation

Sr-90 , T-Alpha, T-Beta, Po-210, Am-241, T-Pu, T-U: chemical separation

Ra-226 : Lucas method

TABLE 2.2.3.1 (c)

WATER samples collected in the Scheldt Estuary, at ANTWERP, in 1991-1992
Radioactivity : mBq/l

N° Sample	Date	Ra-226
1	14.01.91	11.10±2.00
2	13.02.91	11.10±1.00
3	14.03.91	18.00±2.80
4	12.04.91	18.00±2.60
5	27.05.91	13.00±2.20
6	11.06.91	9.20±2.40
7	10.07.91	15.00±2.20
8	09.08.91	33.00±4.00
9	06.09.91	31.00±1.60
10	07.10.91	22.00±1.40
11	05.11.91	15.00±1.20
12	21.12.91	34.5±0.9
1	20.01.92	21.1±0.6
2	17.02.92	26.6±0.8
3	25.03.92	19.7±0.6
4	16.04.92	26.9±0.7
5	14.05.92	27.0±0.8
6	15.06.92	31.7±0.8
7	13.07.92	27.6±0.8
8	11.08.92	41.9±1.1
9	25.09.92	41.2±1.0
10	26.10.92	35.3±0.8
11	24.11.92	15.1±0.6
12	23.12.92	19.3±0.7

Measurement technique : Lucas method

TABLE 2.2.3.2

SEDIMENTS samples collected in the Scheldt Estuary, at BEVEREN, in 1991 and 1992.
Radioactivity: Bq/kg dry matter

N°Sample	Date	Be-7	K-40	Co-60	Cs-134	Cs-137	Ra-226	Th-228	Th-232
1	10.12.91	34±16.3	660±2.7	8.2±6.6	2±15.6	26±3.2	165±2.5	57±3	51±9.3
1	07.01.92	28±3	590±60	5.8±0.6	1.1±0.2	23±2	110±11	43±4	48±5
2	04.02.92	15±2	500±50	4.5±0.5	1.8±0.2	21±2	57±5.7	39±4	39±4
3	03.03.92	20±3	550±60	5.0±0.5	0.84±0.2	21±2	66±7	41±4	41±4
4	07.04.92	29±3	580±60	5.4±0.5	2.2±0.2	21±2	64±6	44±4	46±5
5	05.05.92	35±4	1011±100	9.5±1	1.79±0.2	36±4	156±16	74±7	77±8
6	02.06.92	<20	59060±	5.2±0.5	3.7±0.4	21±2	115±12	48±5	46±5
7	14.07.92	25±3	620±60	5.4±0.5	3.4±0.3	21±2	119±12	49±5	46±5
8	04.08.92	18±22	570±60	4.8±0.5	3.3±3	17.9±2	87±9	39±4	39±4
9	01.09.92	19±3	620±60	4.9±0.5	3.5±0.4	20±2	86±9	45±4	46±5
10	13.10.92	24±2	630±60	5.7±0.6	1.50±1.5	24±2	125±12	50±5	44±4
11	17.11.92	34±3	620±60	5.4±0.5	2.3±0.2	23±2	144±15	50±5	46±5
12	01.12.92	45±5	660±70	6.7±0.7	4.5±4.5	26±3	101±10	50±5	50±5

Measurement techniques : gamma spectrometry

TABLE 2.3.1.1

FISH caught in the North Sea during the years 1991-1992
Radioactivity : Bq/kg fresh matter (*: dry matter)

N°Sample	Date	Location	Species	H-3*	Mn-54	Co-60	Ru-106	Cs-134	Cs-137	Th-232
1638	30.04.91	Belgian coast	Cod	≤5.0						
1639	30.04.91	English Channel	Dab	5.7±2.8						
1640	30.04.91	Belgian coast	Cod	≤6.0						
1641	30.04.91	English Channel	Pout	6.4±2.8						
1642	30.04.91	Stat.14KK	Dab	≤6.0						
1643	30.04.91	Stat.24BK	Dab	≤5.0						
1644	18.09.91	Stat.16-26BK	Dab	≤16.0						
1645	18.09.91	Stat.19BK	Dab	≤7.0						
1646	18.09.91	Stat.23BK	Dab	≤5.0						
1647	18.09.91	Stat.5BK	Dab	≤5.0						
1648	18.09.91	Stat.11BK	Dab	≤2.0						
1649	18.09.91	Stat.22BK	Dab	≤2.0						
1650	18.09.91	Stat.18BK	Dab	1.7±0.9						
1651	18.09.91	Stat.21BK	Dab	≤2.0						
1652	18.09.91	Stat.28BK	Dab	≤2.0						
1653	18.09.91	Stat.20BK	Dab	≤2.0						

TABLE 2.3.1.1 (continued)

N°Sample	Date	Location	Species	H-3*	Mn-54	Co-60	Ru-106	Cs-134	Cs-137	Th-232
1668	20.04.92	Stat.45	Cod	24.2±1.9	<4	<3	<30	<3	≈1.4	<15
1669	20.04.92	Stat.46	Cod	28.9±2.3	<2	<3	<17	<1.7	<1.7	<6
1670	20.04.92	Stat.47	Cod	11.5±2.7	<3	<3	<20	<2	<1.9	<8
1671	20.04.92	Stat.48	Cod	5.7±2.6	<2	<3	<17	<1.8	≈3	<9
1672	02.04.92	Ostend	Dab	9.2±2.6	<1.2	<1.2	<11	<1	<1	<4
1673	20.04.92	Ostend	Dab	≤5.0	<1.2	<1.2	<10	<1	≈0.8	<4
1674	02.04.92	Stat.49	Flounder	≤7.0	<1.3	<1.3	<11	<1	≈1.8	<4
1675	20.04.92	Stat.49	Flounder	≤5.0	<1.2	<1.2	<10	<1	≈0.9	<4
1676	20.04.92	Stat.50	Flounder	18.2±3.1	<3	<3	<20	<2	≈1.9	<9
1677	20.04.92	Stat.51	Flounder	≤5.0	<2	<3	<18	<1.8	<1.7	<7
1686	14.09.92	Stat.5	Dab	12.8±3.0	<12	<15	<100	<10	<9	<40
1687	14.09.92	Stat.6	Dab	13.4±3.0	<11	≈11	<90	<9	<8	<50
1688	14.09.92	Stat.11	Dab	13.3±2.9	<7	<7	<60	≈6.8	<8	<20
1689	14.09.92	Stat.12	Dab	6.3±2.8	<12	≈8	<100	<10	<9	<40
1690	14.09.92	Stat.19	Dab	7.0±2.6	<18	<30	<150	<15	<14	<70
1691	14.09.92	Stat.19	Dab	≤5	<7	<7	<60	<6	<6	<30
1692	14.09.92	Stat.21	Dab	9.5±2.7	<13	<12	<100	<10	<9	<40
1693	14.09.92	Stat22-24	Dab	≤4	<13	<13	<100	<11	<9	<40

TABLE 2.3.1.1 (continued)

N°Sample	Date	Location	Species	H-3*	Mn-54	Co-60	Ru-106	Cs-134	Cs-137	Th-232
1694	14.09.92	Stat.26	Dab	≤5	<16	<15	<130	<13	<11	<60
1695	14.09.92	Stat.35	Dab	≤4	<8	<7	<60	<7	<6	<30
1696	14.09.92	Stat37-38	Dab	7.4±2.4	<13	<13	<100	<11	<9	<40
1697	18.09.92	Vak 31F2	Dab		<11	≈11	<90	<9	<8	<40
1698	18.08.92	Vak 34F1	Dab		<16	<15	<130	<12	<11	<60
1699	18.08.92	Vak 35F2	Dab		<14	<13	<120	<11	<10	<50
1700	18.08.92	Vak 34F2	Dab		<13	<14	<100	<9	≈5.6	<40
1701	18.08.92	Vak 33F2	Dab		<9	<7	<70	<7	<6	<20
1702	18.08.92	Vak 32F2	Dab		<18	<30	<40	<15	<13	<70
1703	18.08.92	Vak 35F1	Dab		<13	<12	<110	<10	<9	<40
1704	18.08.92	Vak36F1	Dab		<16	<15	<140	<13	≈9	<70
1705	18.08.92	Vak37F1	Dab		<12	<14	<100	<9	≈12.9	<40
1706	18.08.92	Vak 36F0	Dab		<19	<30	<140	<15	<13	<13
1707	18.08.92	Vak 35F0	Dab	12.2±2.7	<13	<12	<110	<10	<9	<40
1708	18.08.92	Vak 32F2	Plaice	5.2±2.5	<7	<6	<60	<7	≈4.9	<19
1709	18.08.92	Vak 34F1	Plaice	9.8±2.6	<8	<6	<60	<6	≈4.9	<19
1710	18.08.92	Vak 34F2	Plaice	12.5±2.8	<18	<30	<140	<14	<13	<60
1711	18.08.92	Vak 33F2	Plaice	11.4±2.7	<18	<30	<150	<15	<13	<70

TABLE 2.3.1.1 (continued)

N°Sample	Date	Location	Species	H-3*	Mn-54	Co-60	Ru-106	Cs-134	Cs-137	Th-232
1712	18.08.92	Vak 32F1	Plaice	12.1±3.0	<19	<30	<150	<14	<13	<70
1713	18.08.92	Vak 35F1	Plaice	8.6±2.7	<13	<12	<100	<11	≈11	<40
1714	18.08.92	Vak 36F1	Plaice	9.9±2.7	<19	≈13	<140	<14	<13	<70
1715	18.08.92	Vak 37F1	Plaice	7.3±2.7	<11	<11	<90	<10	<9	<40
1716	18.08.92	Vak 36F0	Plaice	5.9±2.7	<18	<25	<140	<14	<12	<60

N.B.: BK = Belgian coast

Measurement techniques :

Mn-54, Co-60, Ru-106, Cs-134, Cs-137, Th-232 : gamma spectrometry
H-3 : liquid scintillation

TABLES 2.3.1.2

BROWN SHRIMPS caught in the North Sea during the years 1991-1992
Radioactivity: Bq/kg fresh matter (*dry matter)

N°Sample	Date	Location	H-3*	Co-60	Ru-106	Cs-134	Cs-137	Ra-226	Th-232
1633	30.04.91	Belgian coast	≤4.0±0.4						
1634	30.04.91	Belgian coast	≤4.0±0.4						
1635	30.04.91	Belgian coast	≤3.0±0.4						
1636	18.09.91	Belgian coast	≤4.0±0.4						
1637	18.09.91	Belgian coast	≤6.0±3.2						
1656	20.04.92	Stat.21	≤4	<4	<30	<3	<3	≈8.5	≈7
1657	20.04.92	Stat.22	36±5.3	<1.9	<15	<1.5	<1.4	<4	<5
1658	20.04.92	Stat.26	≤4	<1.8	<15	<1.4	<1.4	<4	<5
1659	20.04.92	Stat.16	30.4±3.2	<1.8	<16	<1.5	<1.5	<4	<6
1660	20.04.92	Stat.18	43.5±3.1	≈1.1	<15	<1.5	≈1.4	<4	<5
1661	20.04.92	Stat.24	12.1±2	<4	<30	<3	<3	<7	<10
1662	20.04.92	Stat.14	7.7±2.2	≈2.9	<40	<4	<3	<8	<15
1663	20.04.92	Stat.3	7.0±2.1	<4	<30	<3	<3	<6	<6
1664	20.04.92	Stat.38	≤4	<1.7	<15	<1.4	<1.4	<4	<5
1665	20.04.92	Stat.4+35	≤4	<4	<40	<4	<3	<8	≈12
1666	20.04.92	Stat.19	29.8±2.4	<4	<30	<3	≈3.6	<7	<14
1667	20.04.92	Stat.17	11.2±1.7	<2	<17	<1.4	<1.6	<4	<6

Measurement techniques : Co-60, Ru-106, Cs-134, Cs-137, Ra-226, Th-232 : gamma spectrometry
H-3 : liquid scintillation

TABLE 2.3.1.3

MUSSELS (soft parts) collected in the North Sea region, during the year 1991
Radioactivity: dry matter

N°Sample	Date	Locations	H-3
1622	08.11.91	Ostend	≤17.0±2.0
1623	08.11.91	Koksyde	≤9.0±1.1
1624	12.08.91	Ostend	4.9±2.5
1625	12.08.91	Koksyde	≤12.0±11.6
1626	30.09.91	Ostend	6.4±2.5

TABLE 2.3.2.1 (a)

Radioactivity released in the liquid effluents of NPP-GRAVELINES
(6 units PWR of 900 MWe), in 1991

Radionuclides	Activity	% of total (except H-3)	Ratios
H-3	80 TBq		
Mn-54	0.7 GBq	1	
Co-58	12.5 GBq	18.8	Co-60 / Co-58 = 0.96
Co-60	12.0 GBq	18.1	
Cs-134	2.2 GBq	3.3	Cs-137 / Cs-134 = 2.9
Cs-137	3.6 GBq	5.4	
Ag-110m	20.8 GBq	31.4	
Sb-124	14.2 GBq	21.4	
I-131	0.3 GBq	0.4	

Total of 8 radionuclides (except H-3)		66.3 GBq	

TABLE 2.3.2.1 (b)

Radioactivity released in the liquid effluents of fuel reprocessing Plant - LA HAGUE, in 1991

Radionuclides	Activity		Ratio
H-3	4710	TBq	
Co-60	2700	GBq	
Sr-90	29800	GBq	
(Zr + Nb)-95	< 1	GBq	
Tc-99	910	GBq	
I-129	455	GBq	
Ru-106	17800	GBq	
Cs-134	650	GBq	$\frac{\text{Cs-137}}{\text{Cs-134}} \simeq 8.6$
Cs-137	5600	GBq	
Ce-144	6	GBq	
Pu-241	2520	GBq	
Am-241	32	GBq	

Total = β emitters released (except H-3) 116 TBq

α emitters released (except H-3) 150 GBq

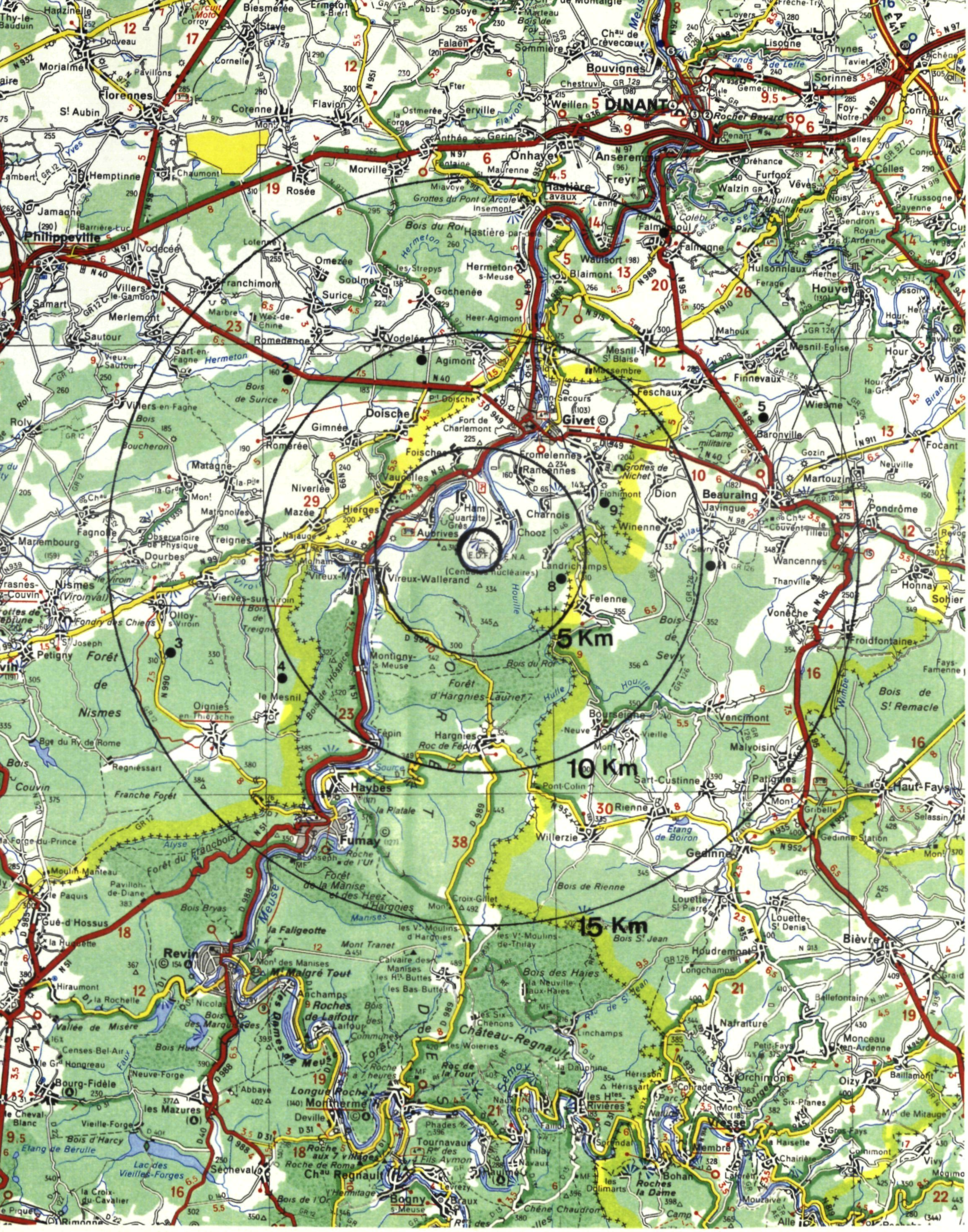

Figure 1. : Site of S.E.N.A. (NPP Chooz A)
Stations for sampling the Lichens Epiphytiques

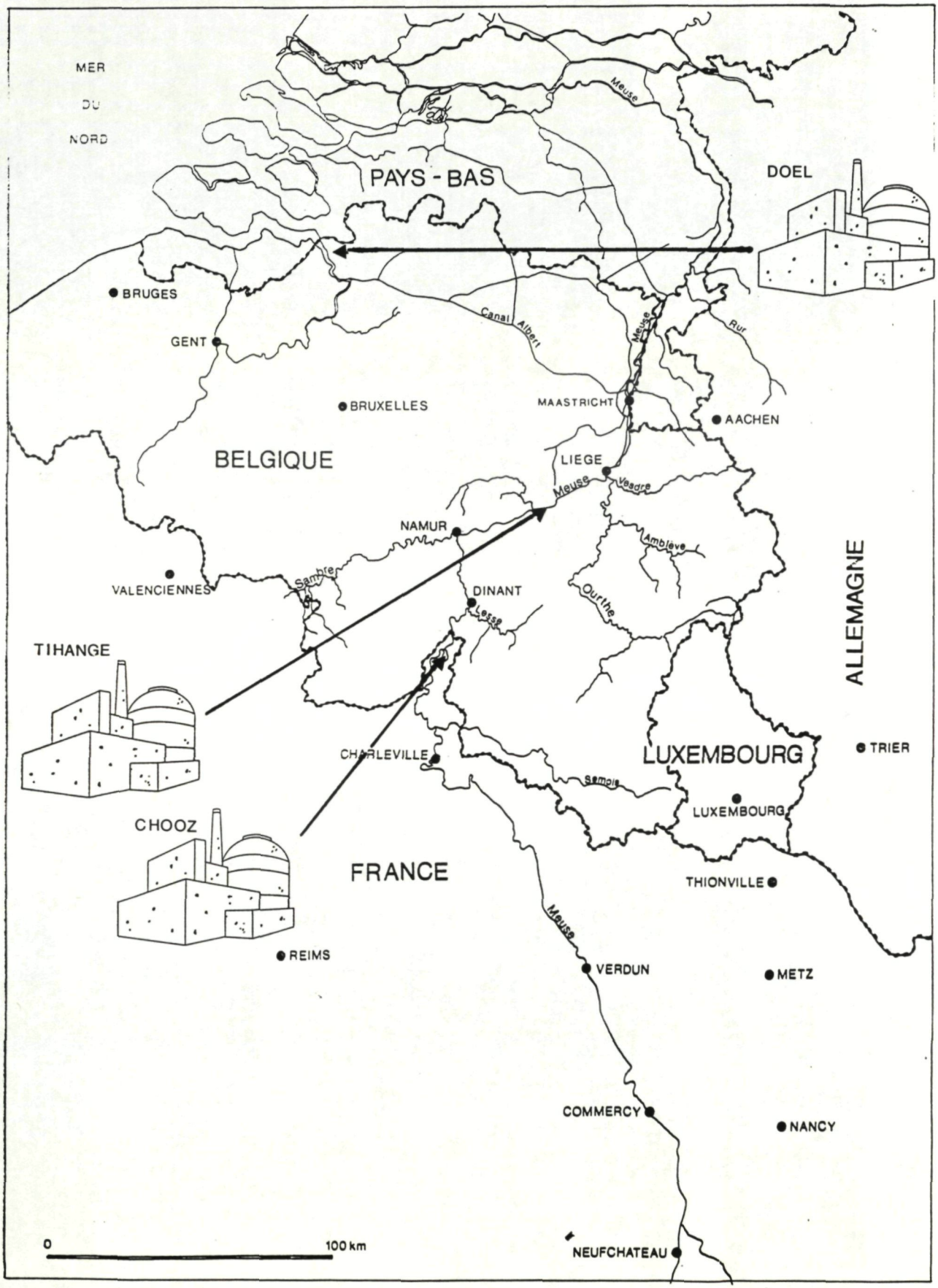

Figure 2 : Implantation of the Nuclear Power Plants.

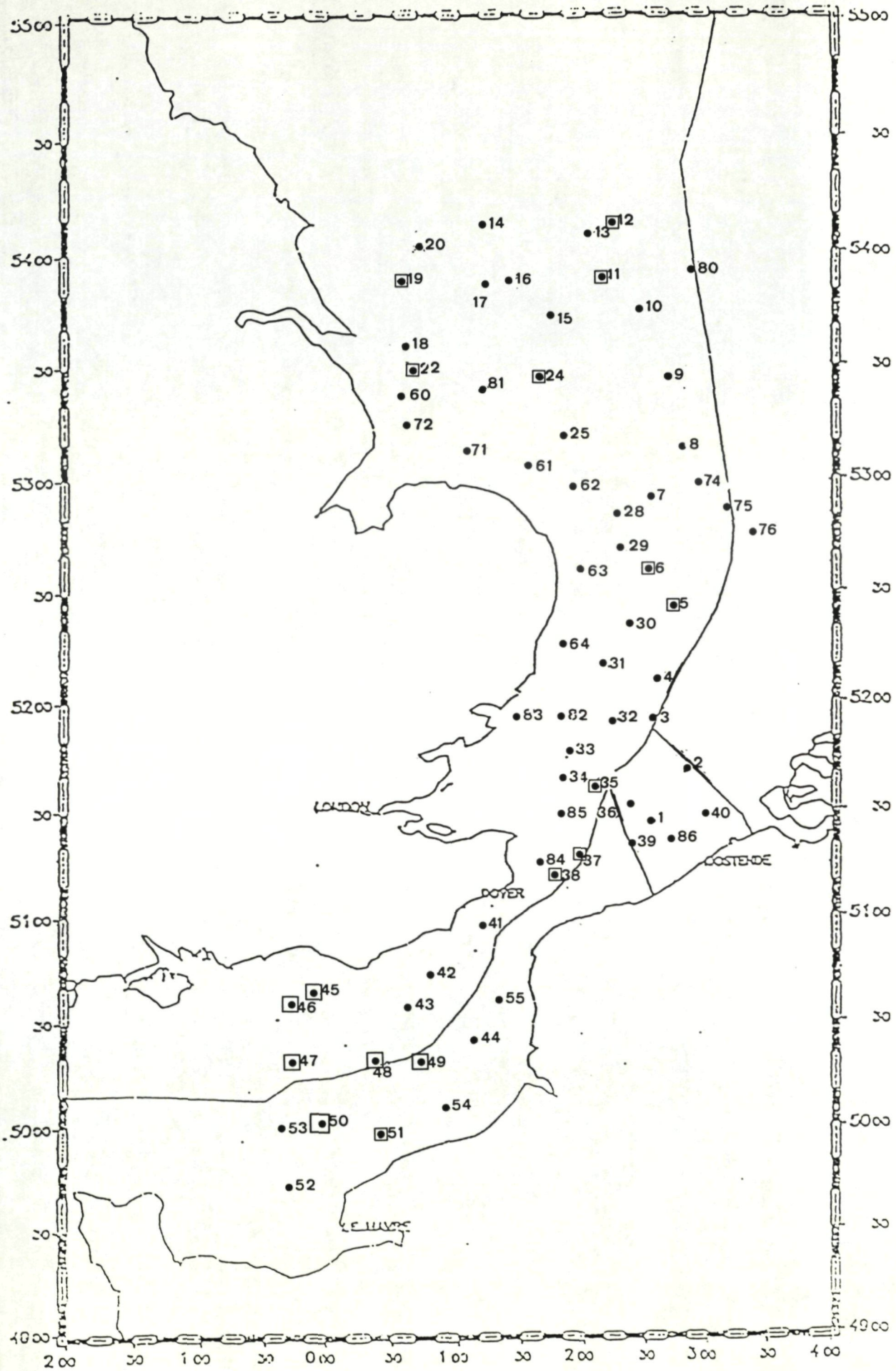

Figure 3 : Location of the intended sampling stations in the North Sea. The stations where a sample was taken are indicated with □

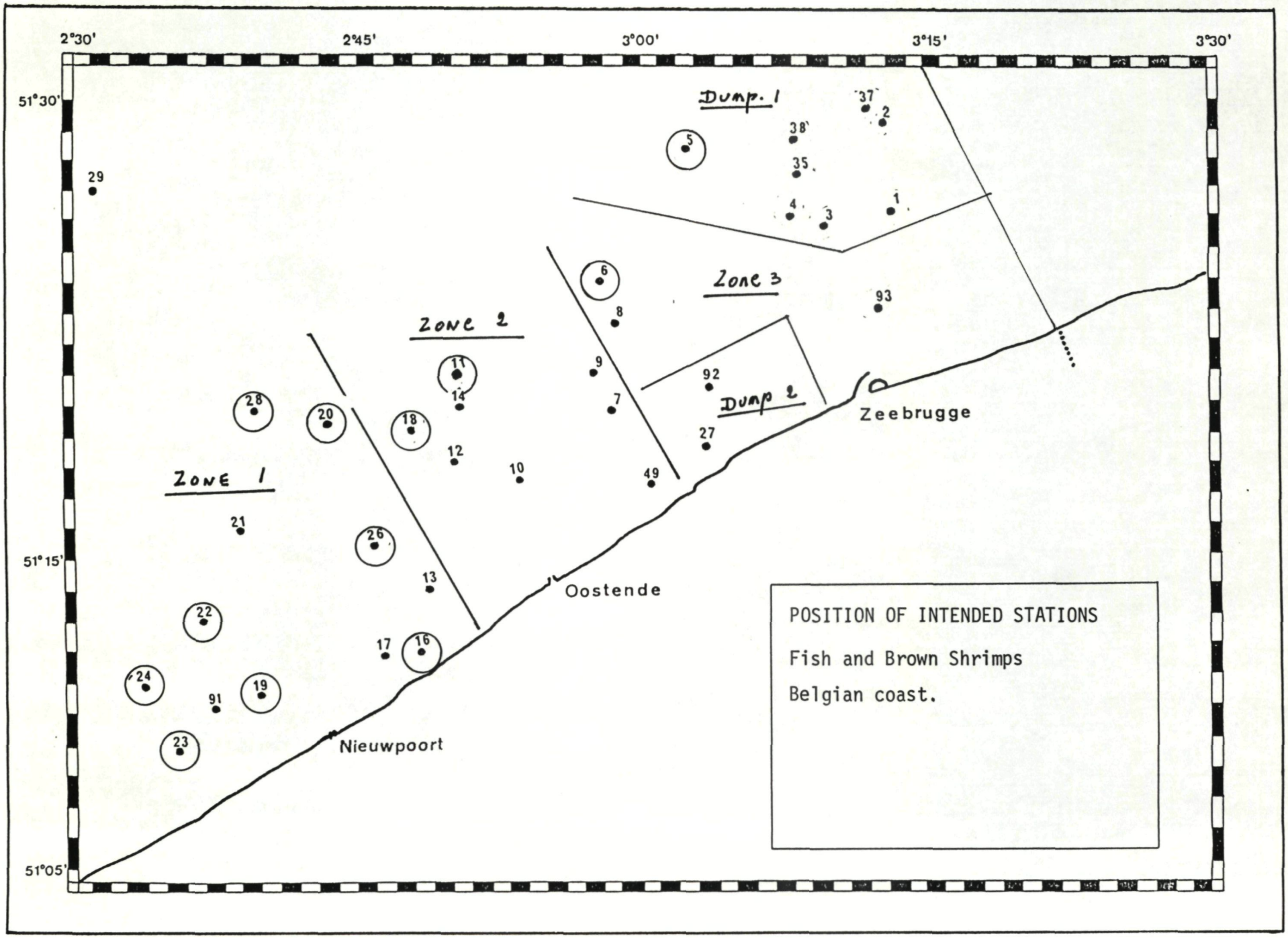

Figure 4 : Location of the intended sampling stations in the North Sea. The stations where a sample was taken are indicated with O