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Radioactivity in the Risø District July-December 2013

Nielsen, Sven Poul; Andersson, Kasper Grann; Miller, Arne

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Radioactivity in the Risø District July-December 2013

A graphic consisting of a grid of squares in shades of blue and green, with a vertical red bar on the left containing the text 'DTU Nutech Report'.

DTU Nutech Report

Sven P. Nielsen, Kasper G. Andersson and Arne Miller
DTU-Nutech-R-0008(EN)
June 2014

DTU Nutech
Center for Nuclear Technologies



Author: Sven P. Nielsen, Kasper G. Andersson and Arne Miller
Title: Radioactivity in the Risø District July-December 2013
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DTU-Nutech-R-0008(EN)
June 2014

Abstract (max. 2000 char.): The environmental surveillance of the Risø environment was continued in July - December 2013. The mean concentrations in air were: $0.20 \pm 0.08 \mu\text{Bq m}^{-3}$ of ^{137}Cs , $2.23 \pm 0.64 \text{ mBq m}^{-3}$ of ^7Be and $0.16 \pm 0.08 \text{ mBq m}^{-3}$ of ^{210}Pb (± 1 S.D.; $N = 26$). The depositions by precipitation at Risø in the second half of 2012 were: 0.048 Bq m^{-2} of ^{137}Cs , 436 Bq m^{-2} of ^7Be , 31.3 Bq m^{-2} of ^{210}Pb and $< 0.7 \text{ kBq m}^{-2}$ of ^3H . The average background dose rate (TLD) at Risø (Zone I) was 44 nSv h^{-1} compared with $43 \pm 9 \text{ nSv h}^{-1}$ (± 1 S.D.; $N = 4$) in the four zones around Risø.

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Center for Nuclear Technologies
Technical University of Denmark
P.O.Box 49
DK-4000 Roskilde
Denmark
Telephone +45 46775300
www.dtu.dk

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Table 1. Radionuclides in ground level air collected at Risø (cf. Figs. 1, 1.1 and 1.2), July - December 2013. (Unit: $\mu\text{Bq m}^{-3}$)

| Date | ^7Be | ^{137}Cs | ^{210}Pb |
|-----------------------|---------------|-------------------|-------------------|
| 01-Jul-13 – 08-Jul-13 | 1852 | 0.144 | 100 |
| 08-Jul-13 – 15-Jul-13 | No data | No data | No data |
| 15-Jul-13 – 22-Jul-13 | 2663 | 0.380 | 167 |
| 22-Jul-13 – 29-Jul-13 | 3860 | 0.273 | 332 |
| 29-Jul-13 – 05-Aug-13 | 2418 | 0.098 | 142 |
| 05-Aug-13 – 12-Aug-13 | 2713 | 0.099 | 137 |
| 12-Aug-13 – 20-Aug-13 | 2468 | 0.074 | 124 |
| 20-Aug-13 – 26-Aug-13 | 3073 | 0.263 | 194 |
| 26-Aug-13 – 02-Aug-13 | 2402 | 0.211 | 173 |
| 02-Sep-13 – 09-Sep-13 | 1546 | 0.117 | 119 |
| 09-Sep-13 – 16-Sep-13 | 2056 | 0.146 | 168 |
| 16-Sep-13 – 23-Sep-13 | 1617 | 0.124 | 96 |
| 23-Sep-13 – 30-Sep-13 | 1357 | 0.202 | 150 |
| 30-Sep-13 – 07-Oct-13 | 2203 | 0.278 | 236 |
| 07-Oct-13 – 14-Oct-13 | 1866 | 0.197 | 239 |
| 14-Oct-13 – 21-Oct-13 | 2357 | 0.238 | 361 |
| 21-Oct-13 – 28-Oct-13 | 1831 | 0.084 | 56 |
| 28-Oct-13 – 04-Nov-13 | 2009 | 0.143 | 161 |
| 04-Nov-13 – 11-Nov-13 | 1987 | 0.153 | 17 |
| 11-Nov-13 – 18-Nov-13 | 2281 | 0.293 | 114 |
| 18-Nov-13 – 25-Nov-13 | 1564 | 0.280 | 169 |
| 25-Nov-13 – 02-Dec-13 | 1404 | 0.221 | 51 |
| 02-Dec-13 – 09-Dec-13 | 1719 | 0.220 | 77 |
| 09-Dec-13 – 16-Dec-13 | 2580 | 0.310 | 302 |
| 16-Dec-13 – 23-Dec-13 | 3797 | 0.276 | 249 |
| 23-Dec-13 – 30-Dec-13 | 2149 | 0.266 | 138 |
| Mean | 2231 | 0.204 | 163 |
| SD | 635 | 0.080 | 84 |

Table 2.1. Radionuclides in precipitation in the 10 m² rain collector at Risø (cf. Fig. 1), July - December 2013. (Unit: Bq m⁻³)

| Month | ⁷ Be | ¹³⁷ Cs | ²¹⁰ Pb |
|-----------|-----------------|-------------------|-------------------|
| July | 5572 | 0.671 | 447 |
| August | 2422 | 0.359 | 202 |
| September | 1666 | 0.147 | 142 |
| October | 1281 | 0.140 | 76 |
| November | 1375 | 0.090 | 121 |
| December | 1906 | 0.103 | 106 |

Table 2.2. Radionuclides in precipitation in the 10 m² rain collector at Risø (cf. Fig. 1), July - December 2013. (Unit: Bq m⁻²)

| Month | Precipitation (m) | ⁷ Be | ¹³⁷ Cs | ²¹⁰ Pb |
|-----------|-------------------|-----------------|-------------------|-------------------|
| July | 0.011 | 60 | 0.0072 | 5.1 |
| August | 0.018 | 44 | 0.0065 | 3.6 |
| September | 0.048 | 80 | 0.0071 | 6.8 |
| October | 0.081 | 104 | 0.0139 | 6.2 |
| November | 0.031 | 43 | 0.0073 | 3.8 |
| December | 0.055 | 105 | 0.0057 | 5.8 |
| Sum | 0.244 | 436 | 0.0477 | 31.3 |

Table 2.3. Tritium in precipitation collected at Risø (cf. Figs. 1, 2.3.1 and 2.3.2). July - December 2013. (Unit: kBq m⁻³)

| Month | 10 m ² rain collector* |
|-------------------------|-----------------------------------|
| July | 3.9 |
| August | 2.2 |
| September | < 2.5 |
| October | < 2.5 |
| November | < 2.5 |
| December | < 2.5 |
| Double determinations*. | |

Table 2.4. Tritium in precipitation collected at Risø (cf. Fig. 1). July - December 2013. (Unit: kBq m⁻²)

| Month | Precipitation (m) | 10 m ² rain collector |
|-----------|-------------------|----------------------------------|
| July | 0.011 | 0.043 |
| August | 0.018 | 0.040 |
| September | 0.048 | < 0.120 |
| October | 0.081 | < 0.203 |
| November | 0.031 | < 0.078 |
| December | 0.055 | < 0.138 |
| Sum | 0.244 | < 0.622 |

Table 3.1. Radionuclides in sediment samples collected at Bolund in Roskilde Fjord. (cf. Fig. 3.1) July - December 2013. (Unit: Bq kg⁻¹ dry)

| Date | ¹³⁷ Cs | K* |
|-------------------------------|-------------------|------|
| 27 July | 1.0 | 18.5 |
| *Unit: g kg ⁻¹ dry | | |

Table 4.1. Radionuclides in seawater collected in Roskilde Fjord (cf. Fig. 4.1) July - December 2013. (Unit: Bq m⁻³)

| Date | ¹³⁷ Cs |
|---------|-------------------|
| 27 July | 11.7 |

Table 4.2. Tritium in seawater collected in Roskilde Fjord (Risø pier) (cf. Fig. 4.2) July - December 2013.

| Month | kBq m ⁻³ |
|-------------------------|---------------------|
| September | < 2.5 * |
| December | < 2.5 * |
| * Double determinations | |

Table 5.1. Radionuclides in grass (* snow) collected at Risø (near the Waste Treatment Station (cf. Fig. 1)), July - December 2013. (**Measured on bulked ash samples)

| Week no. or month | Date | K (g kg ⁻¹ fresh) | ¹³⁷ Cs (Bq kg ⁻¹ fresh) | ¹³⁷ Cs (Bq m ⁻²) |
|----------------------|--------------|---------------------------------|--|--|
| 27 | 1 July | 5.7 | < 0.5 | |
| 29 | 15 July | 7.2 | < 0.7 | |
| 31 | 29 July | 10.6 | < 1.0 | |
| 33 | 12 August | 8.6 | < 0.9 | |
| 35 | 26 August | 8.5 | < 0.7 | |
| 37 | 09 September | 5.5 | < 0.4 | |
| 39 | 23 September | 4.1 | < 0.9 | |
| 41 | 7 October | 4.6 | < 1.0 | |
| 43 | 21 October | 3.6 | < 0.6 | |
| 45 | 4 November | 2.8 | < 0.5 | |
| 47 | 18 November | 2.8 | < 0.5 | |
| 49 | 2 December | 3.5 | < 0.8 | |
| 51 | 16 December | 1.5 | < 0.7 | |
| 53 | 30 December | 3.3 | < 0.8 | |
| **July | | 6.6 | 0.102 | 0.034 |
| **August | | 8.9 | 0.486 | 0.088 |
| **September | | 5.8 | 0.280 | 0.092 |
| **October | | 4.1 | 0.080 | 0.014 |
| **November | | 2.9 | 0.049 | 0.019 |
| **December | | 2.7 | 0.286 | 0.053 |

Table 5.2. Radionuclides in Fucus vesiculosus collected at Bolund in Roskilde Fjord. July - December 2013. (Unit: Bq kg⁻¹ dry)

| Date | ¹³⁷ Cs | K* | % dry matter |
|---------|-------------------|----|--------------|
| 24 July | 2.5 | 25 | 21 |

*Unit: g kg⁻¹ dry

Table 7.1. Waste water collected at Risø (cf. Fig. 1), July - December 2013.

| Week number | eqv. mg KCl l ⁻¹ | ¹³⁷ Cs (Bq m ⁻³) | ¹³¹ I (Bq m ⁻³) | ²²⁶ Ra (Bq m ⁻³) |
|-------------|--------------------------------|--|---|--|
| 27 | 140 | < 106 | < 110 | < 206 |
| 28 | 141 | < 108 | < 116 | < 207 |
| 29 | 146 | < 99 | < 105 | < 200 |
| 30 | 140 | < 97 | < 108 | < 204 |
| 31 | 138 | < 109 | < 114 | < 206 |
| 32 | 145 | < 112 | < 114 | < 234 |
| 33 | 182 | < 66 | < 68 | < 142 |
| 34 | 156 | < 106 | < 120 | < 207 |
| 35 | 174 | < 111 | < 117 | < 222 |
| 36 | 167 | < 110 | < 113 | < 210 |
| 37 | 124 | < 137 | < 145 | < 297 |
| 38 | 136 | < 67 | < 66 | < 155 |
| 39 | 130 | < 103 | < 112 | < 200 |
| 40 | 134 | < 99 | < 107 | < 203 |
| 41 | 146 | < 105 | < 112 | < 221 |
| 42 | 151 | < 101 | < 130 | < 204 |
| 43 | 162 | < 113 | < 123 | < 219 |
| 44 | 172 | < 63 | < 73 | < 124 |
| 45 | 165 | < 107 | < 114 | < 214 |
| 46 | 107 | < 106 | < 111 | < 205 |
| 47 | 121 | < 111 | < 119 | < 223 |
| 48 | 102 | < 101 | < 103 | < 204 |
| 49 | 114 | < 104 | < 108 | < 206 |
| 50 | 109 | < 114 | < 120 | < 221 |
| 51 | 85 | < 91 | < 49 | < 134 |
| 52 | 89 | < 128 | < 316 | < 272 |
| 53 | 77 | < 108 | < 201 | < 218 |
| Mean | 135.3 | | | |
| SD | 27.9 | | | |

Table 8.1. Background dose rates around the border of Risø (cf. Fig. 8.1) measured with thermoluminescence dosimeters (TLD) in the period May - October 2013. (Results are normalized to nSv h⁻¹)

| Location | nSv h ⁻¹ |
|----------|---------------------|
| 1 | 40 |
| 2 | 39 |
| 3 | 32 |
| 4 | 44 |
| 5 | 40 |
| 6 | 44 |
| Mean | 40 |

Table 8.2. Background dose rates around Risø (cf. Fig. 8.2 and Fig. 1) measured with thermoluminescence dosimeters (TLD) in the period May – October 2013. (Results are normalized to nSv h⁻¹)

| Risø zone | Location | nSv h ⁻¹ |
|-----------|----------|---------------------|
| I | 1 | 30 |
| I | 2 | 41 |
| I | 3 | 64 |
| I | 4 | 29 |
| I | 5 | 56 |
| Mean | | 44 |
| II | P1 | 34 |
| II | P2 | 54 |
| II | P3 | 47 |
| II | P4 | 48 |
| Mean | | 46 |
| III | P1 | 42 |
| III | P2 | 44 |
| III | P3 | 44 |
| Mean | | 43 |
| IV | P1 | 29 |
| IV | P2 | 27 |
| IV | P3 | 36 |
| IV | P4 | 34 |
| IV | P5 | 29 |
| IV | P6 | 33 |
| IV | P7 | - |
| Mean | | 31 |
| V | P1 | 38 |
| V | P2 | 44 |
| V | P3 | 139* |
| V | P4 | 28 |
| V | P5 | 52 |
| V | P6 | 47 |
| V | P7 | 47 |
| V | P8 | 45 |
| V | P9 | 39 |
| V | P10 | 43 |
| Mean | | 52 |

Note to Table 8.2. The standard deviation for the 4 pills in the dosimeter that measured 139 nSv/h at Ledhøje is ca. 10 %. It must therefore be concluded that the measurement is correct, but it is unknown what caused this deviating measurement result.

Table 8.3. Terrestrial dose rates at the Risø zones (cf. Fig. 8.2 and Fig. 1) July - December 2013. Measured with a NaI(Tl) detector. (Unit: nSv h⁻¹)

| Risø zone | Location | October |
|-----------|----------|---------|
| I | P1 | 41 |
| I | P2 | 55 |
| I | P3 | 328 |
| I | P4 | 50 |
| I | P5 | 83 |
| Mean | | 112 |
| II | P1 | 47 |
| II | P2 | 49 |
| II | P3 | 44 |
| II | P4 | 46 |
| Mean | | 46 |
| III | P1 | 50 |
| III | P2 | 53 |
| III | P3 | 49 |
| Mean | | 51 |
| IV | P1 | 47 |
| IV | P2 | 52 |
| IV | P3 | 48 |
| IV | P4 | 48 |
| IV | P5 | 36 |
| IV | P6 | 47 |
| IV | P7 | 47 |
| Mean | | 46 |
| V | P1 | 43 |
| V | P2 | 55 |
| V | P3 | 56 |
| V | P4 | 49 |
| V | P5 | 53 |
| V | P6 | 56 |
| V | P7 | 50 |
| V | P7a | 47 |
| V | P8 | 52 |
| V | P9 | 54 |
| V | P10 | 42 |
| Mean | | 51 |

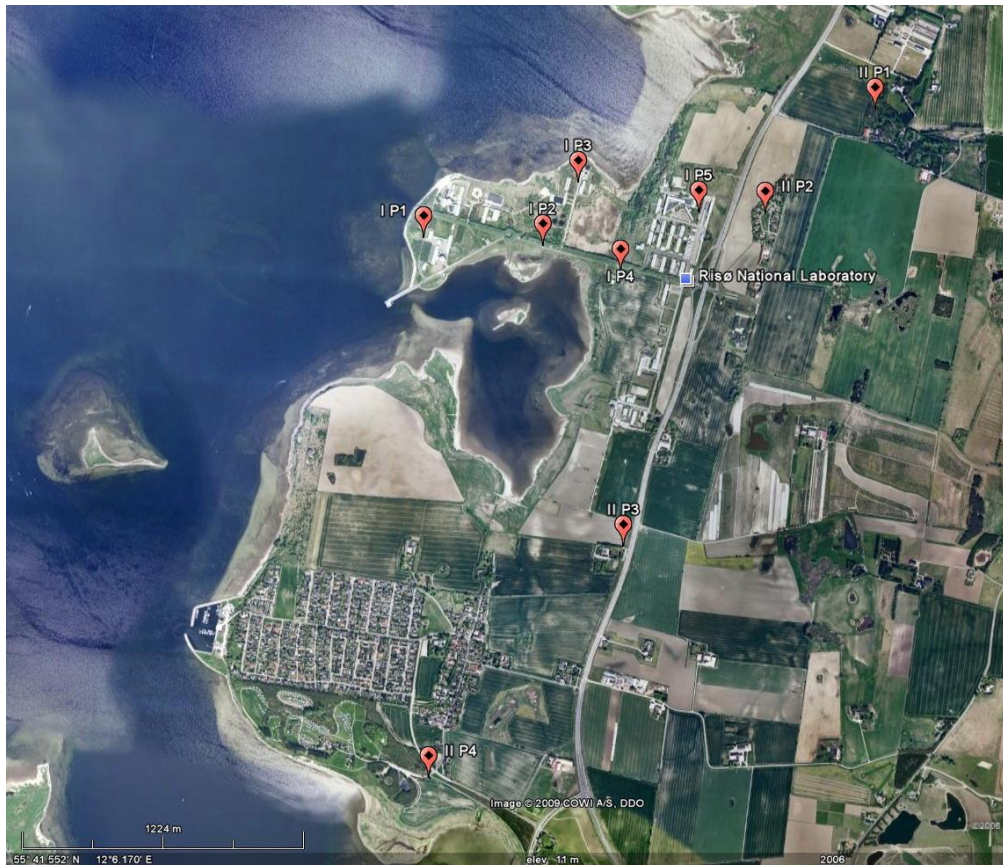


Fig. 1. Locations for measurements of gamma-background radiation Zone I and II (cf. Tables 8.2 and 8.3)

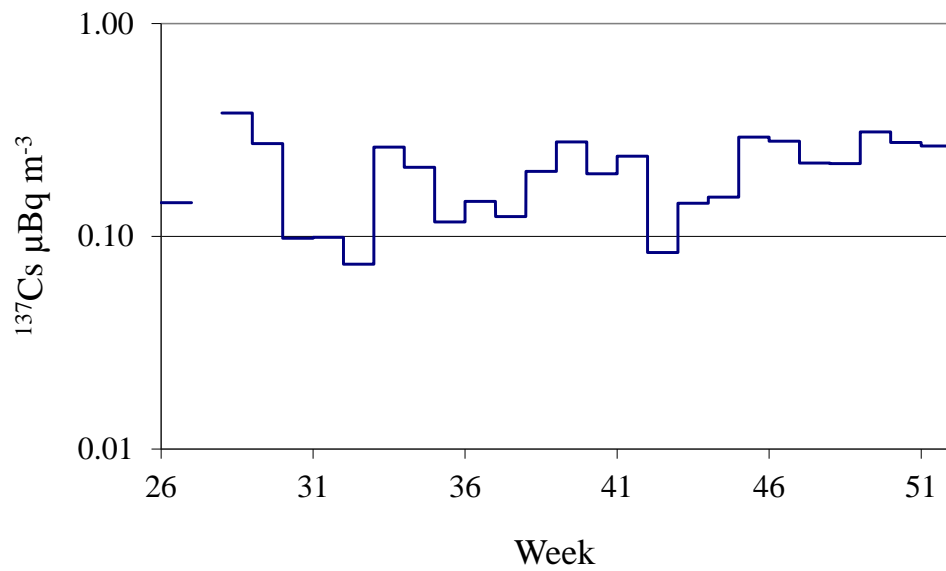


Fig. 1.1. Caesium-137 in ground level air collected at Risø in July-December 2013. (Unit: $\mu\text{Bq m}^{-3}$)

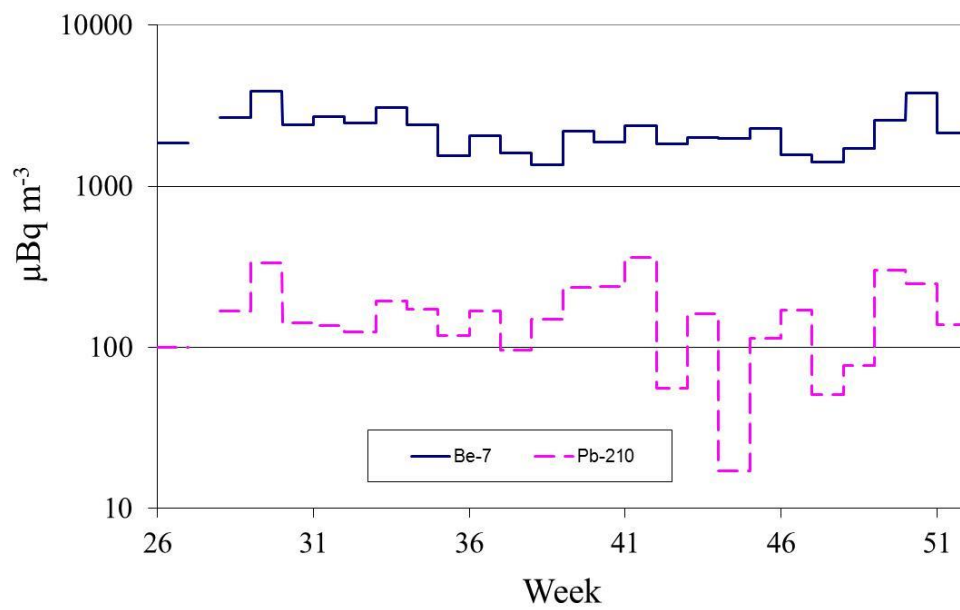


Fig. 1.2. Beryllium-7 and lead-210 in ground level air collected at Risø in July-December 2013. (Unit: $\mu\text{Bq m}^{-3}$)

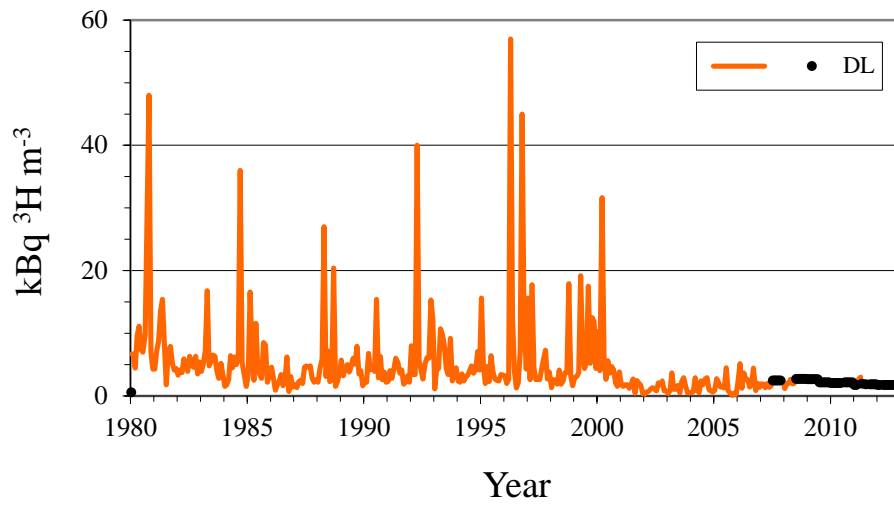


Fig. 2.3.1. Tritium in precipitation collected at Risø (1 m² rain collector) 1980 - 2012. (Unit: kBq m⁻³; DL = detection limit). This rain collector was taken out of operation in 2013.

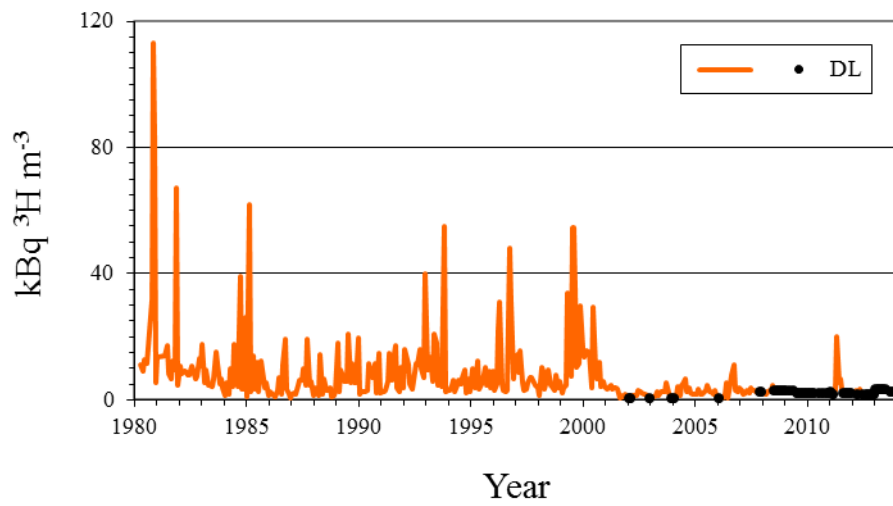


Fig. 2.3.2. Tritium in precipitation collected at Risø (10 m² rain collector) 1980 - 2013. (Unit: kBq m⁻³; DL = detection limit)

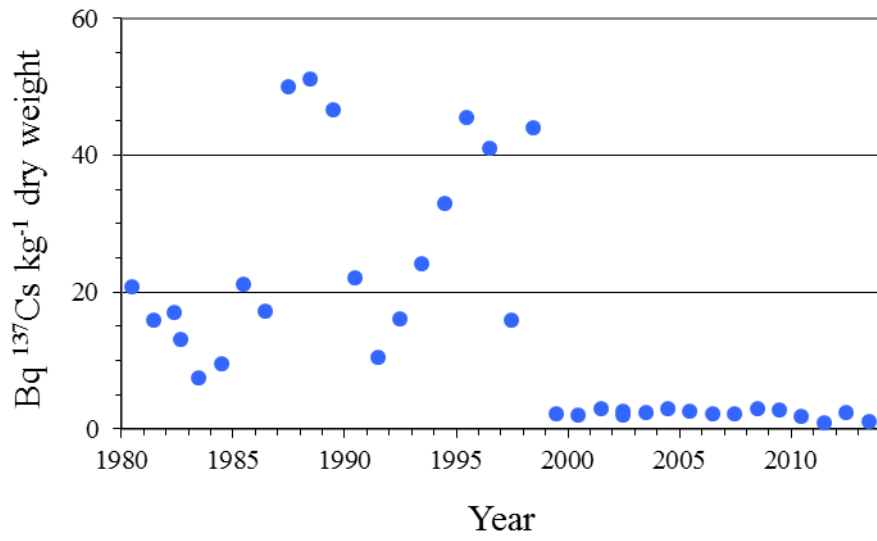


Fig. 3.1. Caesium-137 in sediment samples collected at Bolund in Roskilde Fjord. 1980 – 2013. (Unit: Bq kg⁻¹ dry matter)

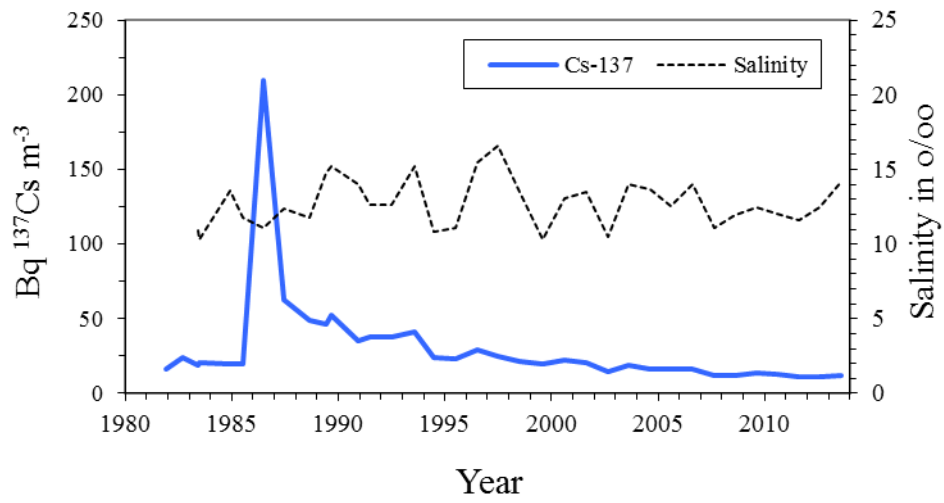


Fig. 4.1. Caesium-137 in seawater collected in Roskilde Fjord 1980 - 2013. (Unit: Bq m^{-3})

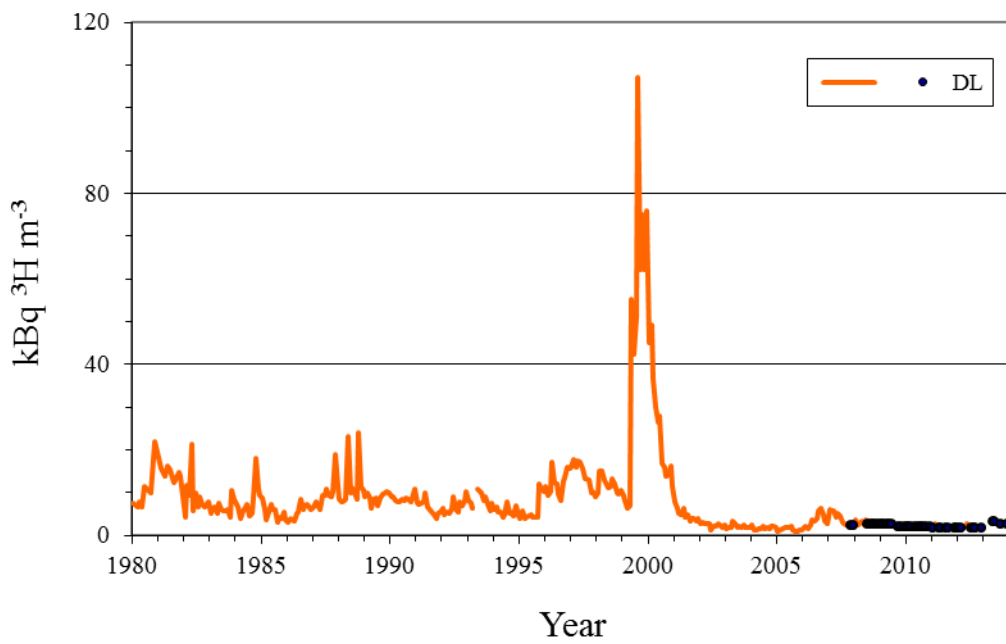
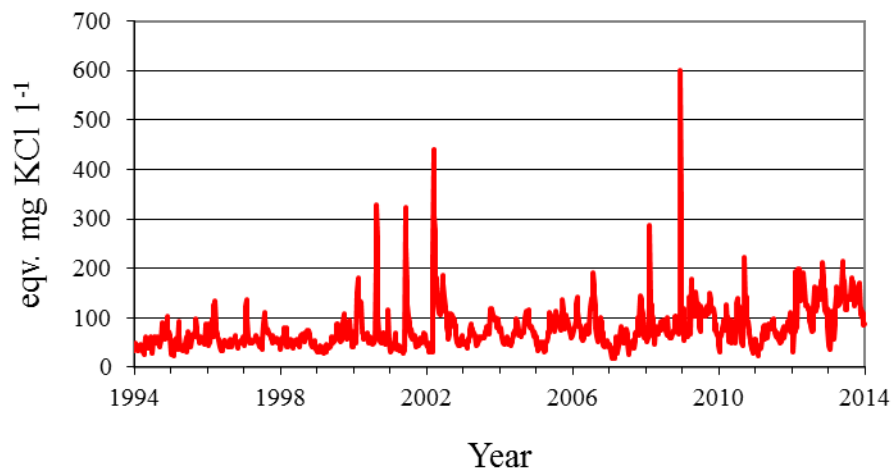


Fig. 4.2. Tritium in seawater collected in Roskilde Fjord 1980 - 2013. (Unit: kBq m^{-3} ; DL = detection limit)



*Fig. 7.1. Total-beta radioactivity in waste water collected at Risø 1994 - 2013.
(Unit: eqv. mg KCl l⁻¹)*

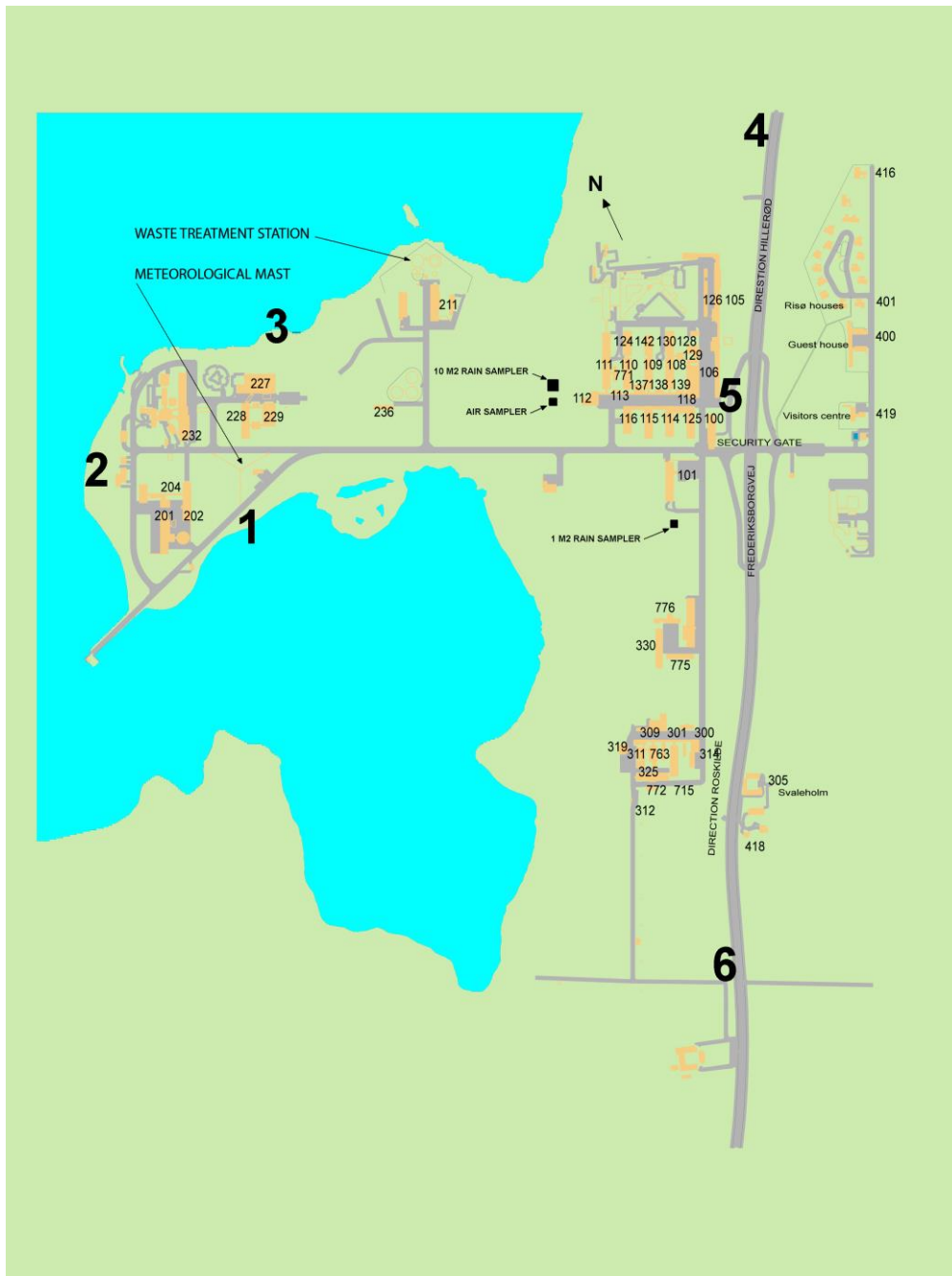


Fig. 8.1. Locations (1-6) for TLD measurements around the border of Risø (cf. Table 8.1).



Fig. 8.2. Locations for measurements of background radiation around Risø in Zones III, IV and V.

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DTU
Center for Nuclear Technologies
Technical University of Denmark

Frederiksborgvej 399
PO Box 49
DK-4000 Roskilde
Denmark
Phone +45 4677 4677
Fax +45 4677 5688

www.dtu.dk