FACHVERBAND FÜR STRAHLENSCHUTZ E.V.

Member of the International Radiation Protection Association (IRPA)

RADIOACTIVITY IN THE FEDERAL REPUBLIC OF GERMANY AND IN SWITZERLAND AFTER THE REACTOR ACCIDENT AT CHERNOBYL

Results of a survey of the Working Group on Environmental Monitoring

M. Winter[1), H. Völkle[2), J. Narrog[3), P. Meyer[1), K. Kirchhoff[4)

1) Hauptabteilung Sicherheit, Kernforschungszentrum Karlsruhe GmbH, Karlsruhe

2) Eidg. Kommission zur Überwachung der Radioaktivität, Fribourg

3) Ministerium für Ernährung, Landwirtschaft, Umwelt und Forsten, Stuttgart

4) Niedersächsisches Landesamt für Immissionsschutz, Hannover

FS - 86 - 39 - AKU / e

October 1986

(Translation, March 1987)

FOREWORD

In response to a request by the Directorate of the Fachverband für Strahlenschutz e. V. (German-Swiss Professional Association for Radiation Protection), the Arbeitskreis Umweltüberwachung (Working Group on Environmental Monitoring) has carried out a survey on the effects of the accident at Chernobyl on the various regions of the Federal Republic of Germany and Switzerland. The working group has already presented a selection of the results at the fourth European IRPA Congress which was held from September 15th - 19th, 1986 at Salzburg. The complete report with the results of the survey summarised to give an overview is now available.

I would like to take this opportunity to thank all colleagues who participated in the survey for their work. Thanks are due from the Fachverband für Strahlenschutz to all institutions whose measured results have contributed to this report. The names of these institutions are listed on the following two pages. Special thanks to Dipl.-Phys. Waltraut Winter without whose unstinting help in evaluating the extensive data material it would have been impossible to complete the report in time for the Congress at Salzburg.

The Secretary
of the Working Group on Environmental Monitoring

Karlsruhe, October 1986

The results of the survey of the Working Group on Environmental Monitoring include data from the institutions listed below.

FEDERAL REPUBLIC OF GERMANY

1 Bayerische Landesanstalt für Wasserforschung, München
2 Bayerisches Landesamt für Umweltschutz, München
3 Bundesanstalt für Gewässerkunde, Koblenz
4 Bundesanstalt für Zivilschutz, Institut für Atmosphärische Radioaktivität, Freiburg
5 Forschungszentrum Geesthacht GmbH, Geesthacht
6 Gemeinschaftskernkraftwerk Neckar GmbH, Neckarwestheim
7 Gesellschaft für Strahlen- und Umweltforschung mbH, Neuherberg
8 Hahn-Meitner-Institut für Kernforschung GmbH, Berlin
9 Hessische Landesanstalt für Umwelt, Kassel
10 Institut für Wasser-, Boden- und Lufthygiene des Bundesgesundheitsamtes, Berlin
11 Kernforschungsanlage Jülich GmbH, Jülich
12 Kernforschungszentrum Karlsruhe GmbH, Karlsruhe
13 Kernkraftwerk Krümmel GmbH, Geesthacht
14 Kraftwerk-Union AG, Erlangen
15 Landesamt für Umweltschutz und Gewerbeaufsicht, Mainz
16 Landesanstalt für Umweltschutz Baden-Württemberg, Karlsruhe
17 Ministerium für Ernährung, Landwirtschaft, Umwelt und Forsten Baden-Württemberg, Stuttgart
18 Niedersächsisches Landesamt für Immissionsschutz, Hannover
19 Physikalisch-Technische Bundesanstalt, Braunschweig
20 Preussen-Elektra AG, Hannover
21 Rheinisch-Westfälisches Elektrizitätswerk AG, Biblis
22 Technischer Überwachungs-Verein Norddeutschland, Hamburg
23 Universität des Saarlandes, Homburg
24 Zentralstelle für Sicherheitstechnik des Landes Nordrhein-Westfalen, Düsseldorf

SWITZERLAND

25 Nationale Alarmzentrale und Sektion Überwachungszentrale, Zürich
26 Einsatzgruppe Kommission AC-Schutz und "Gesamtleitung Tschernobyl", Bern
27 AC-Labor der Armee / A-Labor '86, Spiez
28 Eidg. Institut für Reaktorforschung und Hauptabteilung für die Sicherheit der Kernanlagen, Würenlingen
29 Kantonales Labor Basel-Stadt
30 Abt. Radioaktivität, Eidg. Anstalt für Wasserversorgung, Abwasserreinigung und Gewässerschutz, Dübendorf
31 Labor Freiburg der Eidg. Kommission zur Überwachung der Radioaktivität, Freiburg/CH
32 Institut de Radiophysique applique/Institut d'Electrochimie et de Radiochimie, EPF Lausanne
33 Kantonale Labors Graubünden und Tessin
34 Alle Kantonalen Laboratorien bzw. Lebensmittelinspektorate (Probenahmen)
35 Bundesämter für
-Gesundheitswesen (Strahlenschutz, Lebensmittelkontrolle), Bern
-Veterinärwesen, Bern
-Aussenwirtschaft, Bern
36 Eidg. Forschungsanstalten für
-Agrikulturchemie und Umwelthygiene, Liebefeld
-Obst-, Wein- und Gemüsebau, Wädenswil
-Milchwirtschaft, Bern
37 Schweizerischer Verband der Milchproduzenten, Bern
38 CERN, Genf

INDEX

1. INTRODUCTION

On June 19th and 20th 1986 the Arbeitskreis Umweltüberwachung, AKU (Working Group on Environmental Monitoring) of the Fachverband für Strahlenschutz e. V. (Professional Association for Radiation Protection) convened for a special meeting in Karlsruhe after the Chernobyl reactor accident. This special meeting was held to exchange experiences and results of measurements among AKU members. One week earlier the Directorate of the Fachverband für Strahlenschutz had decided to confer on AKU the task of drawing up a synopsis showing the impact of Chernobyl on the various regions of the Federal Republic of Germany and Switzerland as a topical contribution to the International Congress on Radiation Protection held at Salzburg from 15th to 19th September 1986.

AKU members were informed of these decisions made by the Directorate during the special meeting mentioned above. In view of the fact that the summer holidays were approaching and all the colleagues in the Working Group were already overloaded with work, it was doubted whether this assignment could be completed on time. The team of authors drawn from AKU members were later to feel how justified this scepticism had been. On top of this it was clear right from the start that AKU could not be expected to provide an overall report on the effects of Chernobyl which would really cover the whole area and be equally well supported statistically for all the regions. AKU decided to take up the challenge in spite of these misgivings because, faced with the confusing mass of individual measured results, AKU members, too, felt the need for an overview in the form of a radically summarising presentation.

At a special meeting at the end of June, AKU therefore decided to carry out a survey among its own members; this is a report on the structure and results of this survey.

Although the facts are by now widely known, the two following chapters briefly deal with the dates of arrival of the immissions and their nuclide compositions.

2. DATES OF ARRIVAL AND DEPOSITION OF THE RADIOACTIVITY

On April 26th 1986, at 1:23 a.m. local time a severe accident occurred in Unit 4 of the Chernobyl nuclear power plant which led to heavy releases of radioactivity into the atmosphere over several days; due to a strong thermal updraught this activity reached altitudes up to about 1500 - 2000 metres and was then carried over long distances by air currents.

The radioactivity from the first heavy release reached Scandinavia and that of the last release reached south-eastern Europe as well as Turkey, whereas Central Europe was exposed to emissions occurring in the time span in between. Since outside the Soviet sphere of influence it was Scandinavia which was affected first and it was from there that the world was informed of this unusual happening on the evening of 28th April, Central Europe was given a degree of early warning which the Environmental Monitoring Institutions were able to utilise to prepare for specific measurements. As early as on April 29th radioactivity from further releases at Chernobyl reached Berlin and eastern Bavaria. During the night and in the early hours of 30th April southern Bavaria, south-eastern Baden-Württemberg, the area around Lake Constance, eastern and northern Switzerland were exposed to relatively massive amounts of radioactivity, especially in places where precipitations washed out the radioactivity and deposited it on the ground. On the other hand, the precipitations meant that, on April 30th, radioactivity of only relatively low concentrations penetrated further west and it was only on May 1st that western Switzerland, the remainder of Baden-Württemberg, Hesse and Rhineland-Palatinate were exposed to higher activity concentrations from a new surge of radioactively contaminated air. Figure 2/1 shows the change in time of the activity concentration of iodine-131 in air typical for this region. This cloud subsequently drifted to the north and west passing across North Rhine-Westphalia, western Lower Saxony and France among others.

It is generally true to say that there is a distinct drop in radioactive contamination from south to north which is attributable on the one hand to the fact that the radioactive cloud which had arrived in southern Germany and Switzerland on April 30th and May 1st, had been carried there under favourable conditions (steady air currents of 30 - 50 km/h) and that, on the other hand, the precipitations in this area washed out much of the

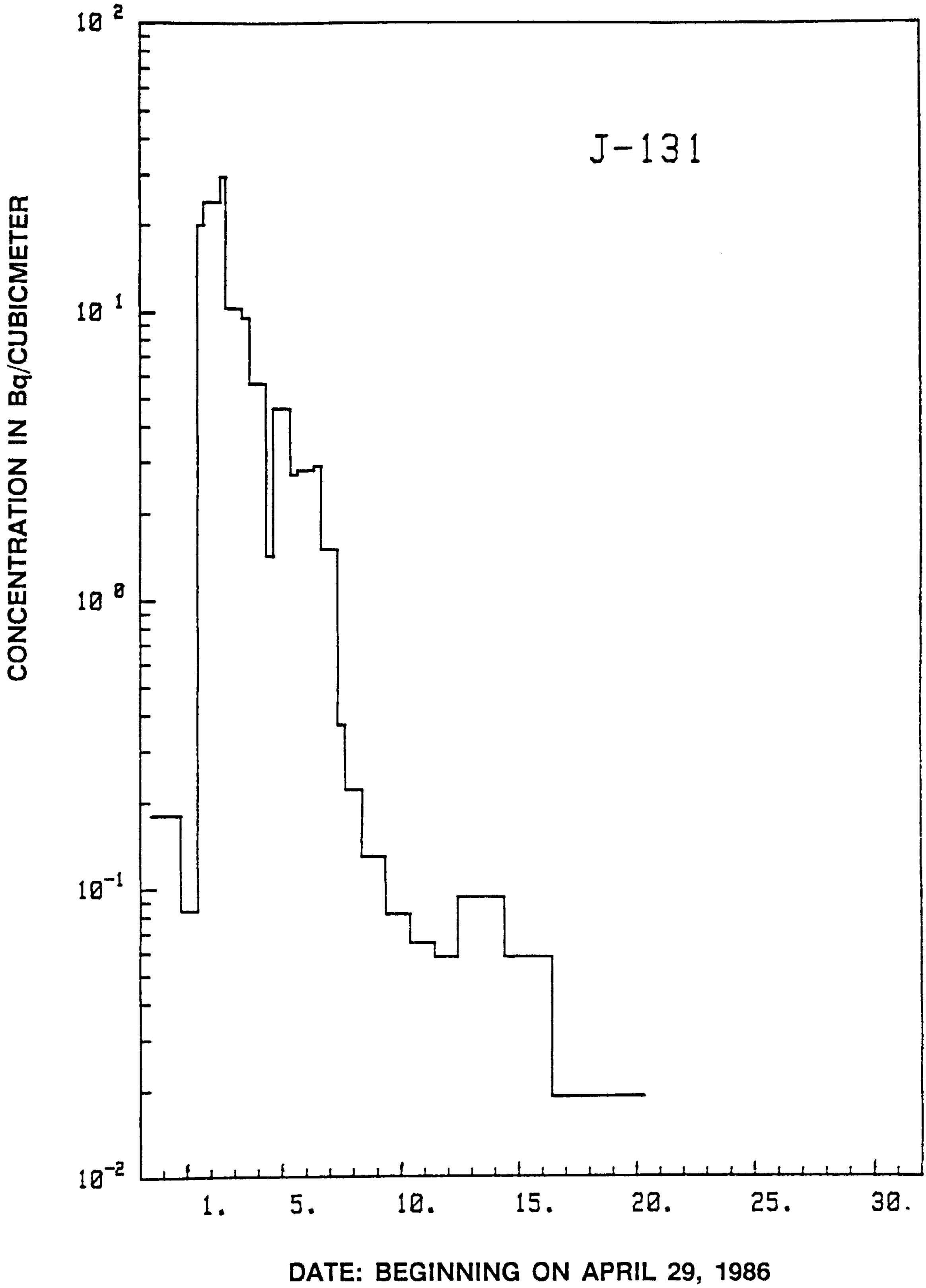


Fig. 2/1: Development of activity concentration in the nearground air measured in the vicinity of the Karlsruhe Nuclear Research Center during the first half of May 1986 (taken from KfK-Report 4115) radioactivity during the night to April 30th. Since the precipitations had transferred much more radioactivity to the soil and vegetation than resulted from dry deposition from the radioactive cloud, major regional differences can be observed which correspond to the intensity of the precipitations. During the first few days in May there was little precipitation and the increase happened only in the night to as well as during May 7th when airborne activity concentrations were again relatively low. However, rain did fall on May 1st in Ticino, southern Grison and in the Jura region of the Canton de Vaud which also led to an increase in the deposited activity in these areas. Although airborne radioactivity was roughly the same throughout Switzerland, these precipitations led to a noticeably stronger depostition of radioactivity above all in Ticino and in the southern valleys of Grison.

During the night to May 7th strong westerly currents and an extensive zone of rainfall reached Central Europe so that the atmosphere was largely purged of artificial radioactivity. After that there was no further inflow of radioactively contaminated air from Chernobyl. Only at the end of May/beginning of June were low airborne iodine-131 activities measured again in the region of a few mBq/m^3. Compared to the beginning of May the activity was a thousand times less and therefore of no significance in terms of radiation exposure; it was probably due to the radioactive cloud having completed its orbit around the earth and coming over for the second time.

During the first few days the precipitations contained relatively high radioactivity concentrations at times (up to max. 38,000 Bq iodine-131/litre); for short periods this led to clearly increased radioactivity contents in surface water - but not in ground water - which generally decayed very rapidly and have been carried away (with the exception of Cs contamination of biotopes in some lakes).

Initially the radioactive contamination of the vegetation and green vegetables grown out of doors was substantial in some places; due to radioactive decay, fast growth (dilution effect) and the rinsing action of rain, levels generally dropped considerably and very fast.

The greater part of the longer-lived radioactive substances lastly reached the ground, a small fraction being absorbed by plants via their roots.

Regrowing Vegetables therefore generally showed only low contents of artificial radionuclides whereas some types of fruit such as currants clearly showed more radioactivity, evidently also as a result of the contamination of flowers and leaves and the translocation of radioactive substances.

3. DETECTED RADIONUCLIDES AND THEIR PROPORTION IN THE TOTAL ACTIVITY

Apart from the short-lived radioactive inert gas xenon-133 which has a half life of 5.25 days and which has hardly any effect biologically, the main radionuclides which arrived were:

1. iodine-131
2. tellurium-132/iodine-132
3. barium-140/lanthanum-140, caesium-137, caesium-134, ruthenium-103 and low activities of other radionuclides.

The precise composition can be seen from figure 3/1 and table 9/1 (see appendix).

At the beginning of May the three groups of radionuclides mentioned were present in approximately the same amounts. Because of the rapid decay of the short-lived radioactive substances they can currently no longer be detected; now the radioactive caesium isotopes Cs-137 and Cs-134 (in the ratio 2:1) and ruthenium-103 predominate. The reference nuclide (i. e. predominant with respect to amount and biological effect) for short-lived radioactive substances (iodine-131, tellurium-132/iodine-132, barium-140/lanthanum-140) is iodine-131 (half-life: 8 d) and for longer-lived radionuclides it is caesium-137 (half-life: 30 a).

Airborne strontium-90 (half-life: 28,5 a) was found in southern Germany and Switzerland to amount to less than 1 % of the activity of caesium-137. Compared to caesium-137, 1 % of strontium-90 was found in vegetation and, at higher levels of contamination, between 0.3 and 2 % of strontium-90 were found in milk and various dairy products. Initially strontium-89 (half-life: 50 d) was found in approcimately ten times the concentration of strontium-90.

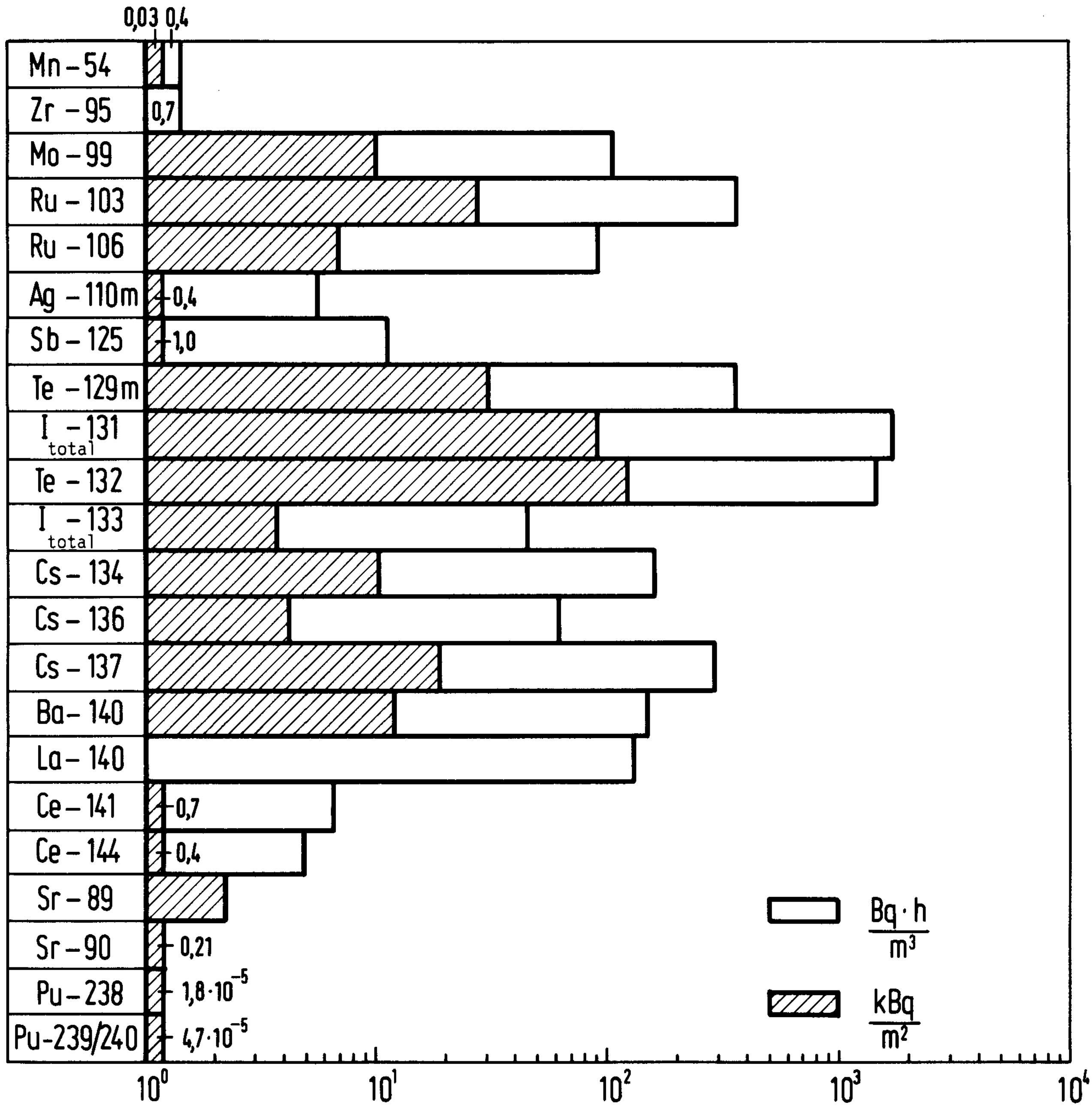


Fig. 3/1: **Time integrated nuclide spectra for near-ground air and precipitations from April 29 until May 9, 1986 (measured by GSF in Munich/Neuherberg)**

Sampling location	Sampling date	Activity concentration in Bq/l Sr-89	Sr-90	Cs-137	I-131
Ravensburg	May 13, 1986	2.6	0.3	72	138
Ravensburg	Febr. 5, 1986	-	0.09	< 0.04	< 0.02
Ravensburg	July 1963	8.0	3.3	8.6	-
Mosbach	May 13, 1986	0.06	0.07	0.5	1.9
Mosbach	Febr. 14, 1986	-	0.09	< 0.04	< 0.02
Öhringen	July 1963	4.2	1.2	4.6	-
Mannheim	May 15, 1986	0.4	0.08	9.3	27
Mannheim	Febr. 27, 1986	-	0.06	< 0.04	< 0.02
Karlsruhe	July 1963	5.2	1.2	4.8	-
Gemrigheim	May 16, 1986	0.06	0.05	1.8	7.5
Gemrigheim	Febr. 14, 1986	-	0.045	< 0.04	< 0.02
Ludwigsburg	July 1963	4.1	1.3	3.9	-

Table 3/1: Comparison of the activity concentrations of several radionuclides in milk as measured in 1986 before and after the Chernobyl accident and in July 1963 (measurements by Chemische Landesuntersuchungsanstalt Stuttgart).

In vegetation and milk samples with low contamination a Sr-90/Cs-137 ratio shifted towards strontium was found. As can be seen from table 3/1, the effect of Sr-90 from the fallout from nuclear weapons test explosions cannot be ignored. With low contamination the Sr-90 activity in milk in May was not or hardly higher than in February 1986.

The situation for plutonium is similar to that for strontium. Various measured results are available which show that the average soil activity of approximately 0.8 Bq/kg as a result of the fallout from nuclear weapons testing - which is of little significance in radiation protection terms - was not increased noticeably (see also table 9/1). This agrees with several measurements in air which showed no, or only very low values. The Karlsruhe Nuclear Research Centre for instance concluded indirectly via the detection of Cm-242 that the maximum Pu-239/240 concentration lies at $3 \cdot 10^{-5}$ Bq/m³. Now and again traces of the beta emitter Np-239 (half-life: 2.4 d) were measured which is transformed into Pu-239. In this, however, the activity decreases inversely proportional to the half-lives (approx. 1:3,600,000) so that it was generally no longer possible to detect Pu-239.

Considerable deviations from the ratios between the radionuclides described here occurred only now and again in so-called "hot particles".

It was also not possible to measure any increase in the C-14 content in air (the detection limit was 0.4 % of the previous artificial C-14 content of the atmosphere).

4. REQUIREMENTS AND OBJECTIVES OF THE SURVEY

The following reflects the main decisions and thought processes of the AKU related to the preparation of a summary ot the results of the immission measurements in the Federal Republic of Germany and Switzerland.

The AKU decided at its special meeting on June 19th, 1986 to carry out a survey among its members using suitable tables in order to ensure that all the data requested were supplied in a uniform manner.

The term used for the survey - Meßwerterhebung (Inquiry into Measured Values) - itself showed an important initial definition. Although numerous AKU members had already carried out initial doese estimates, the survey was to be limited to such variables which were directly amenable to measurement. Scanning and summarising the measured activity results obtained by many institutions carrying out measurements seemed already difficult enough. A survey using calculated dose values to estimate the radiation exposure of the public in different places or parts of the country, on the other hand, would certainly have led to dose values being supplied which could not be compared with each other at all. One only needs to think of the many possibilities of deciding on different dose variables, computer models, dose factors, eating habits, integration intervals studied etc. etc.

Everyone was agreed that it was a matter of reducing the huge number of individual measured values to mean values which should be as representative as possible and applied to relatively large regions or parts of federal states (laender) or even entire states. Following a controversial discussion the majority of AKU members decided in favour of forming arithmetic means stating the single standard deviation in %. Values below the detection limit were to be considered as zero values when averaging.

Averaging was to be carried out both in terms of space and time for given time intervals. The details of spatial averaging were left to the data suppliers. There was an express requirement for clear information regarding the place if measured results were valid only at certain points and for information giving the approximate area to which the mean value was to apply.

The overall report period for the survey was fixed as follows: approximately April 28th up to and including June 20th 1986.

The discussion on the question as to which measured variables should be collected for which of the monitored media led to the following results: apart from collecting measured values for determining external radiation exposure (local dose rate, local dose and background dose) results of nuclide-specific activity measurements should be collected for the media air, precipitation, grass, soil, cow's milk, green vegetables and other foodstuffs (e. g. meat and other foodstuffs of special regional importance).

The survey was to be restricted to what are called references nuclides, I-131 and Cs-137. In addition, typical gamma spectra for various media and, where possible, time-integrated nuclide spectra for air and precipitations were to be provided.

In spite of the very large number of available measured results, the gross beta activity deposited on the ground surface measured be contamination monitors was not to be enquired into. The same applies to measured results for surface, ground and drinking water since no significant concentrations of artificial radionuclides were found in any of these media except for the first days.

The forms for the tables to be used for data collection were designed at the AKU special meeting and sent to all AKU members on the 24th June. The 15th July, 1986 was fixed as the return date for the filled-in tables.

5. PROBLEMS ENCOUNTERED IN EVALUATING AND PRESENTING THE DATA

The objective of presenting the radioactive contaminations in the states and regions of the Federal Republic of Germany and Switzerland as a whole has been met only partly. Since, with few exceptions, it was only possible to carry out the survey among members of the Working Group on Environmental Monitoring, and in fact this had been the intention, no or only few measured results were available for a number of states, regions and time periods. This deficiency has partly been corrected by laborious evaluation of reports which had already been published by various institutions.

The fact that many of the data supplied were not intercomparable or seemed not reliable proved to be more serious. Reasons why measured data were not comparable and could therefore not be used for forming mean values were mainly differences in the measuring and sampling techniques employed and the lack of information about the exact origin of the samples, type of sampling as well as the sampling and measuring date. Thus a great number of iodine results, for instance, were useless because the time elapsed between sampling and measurement was eihter unknown or, where the correction to take into account decay had not been calculated, too long. The results of specific Cs-137 activity measurements in soil samples were not intercomparable in a particularly great number of cases because the sampling depth varied between 2 and 40 cm or was not known at all. For the reason given here as examples and for a great number of other reasons, many of the data supplied could not be used to form representative mean values.

Although stringent selection criteria were applied during the very careful checks of the data material to establish whether measured results could be used for the synopsis, altogether approximately 7,000 I-131 results and approximately 8,000 Cs-137 results went to make up the synoptical overviews and tables in this report. Table 5/1 gives details regarding the distribution of the number of individual results used with respect to the media monitored in the Federal Republic of Germany and Switzerland.

In view of the sometimes considerable scattter bands of the data to be expressed as mean values, the mean values were assigned to different level bands of the specific activity in order to achieve a synoptical representation in outline maps of the two countries. The level bands were

Media monitored	Number of measured results I-131	Cs-137
Federal Republic of Germany		
Air	463	438
Precipitations	-	16
Grass	1007	997
Soil	-	500
Cow's milk	2894	2074
Green vegetables	452	452
Other foodstuffs	-	804
Subtotal	4816	5281
Switzerland		
Air	73	73
Precipitation	7	7
Grass	461	424
Soil	-	54
Cow's milk	628	628
Green vegetables	745	833
Other foodstuffs	188	632
Subtotal	2102	2651
Total	6918	7932

Table 5/1: Number of measured results included in this report

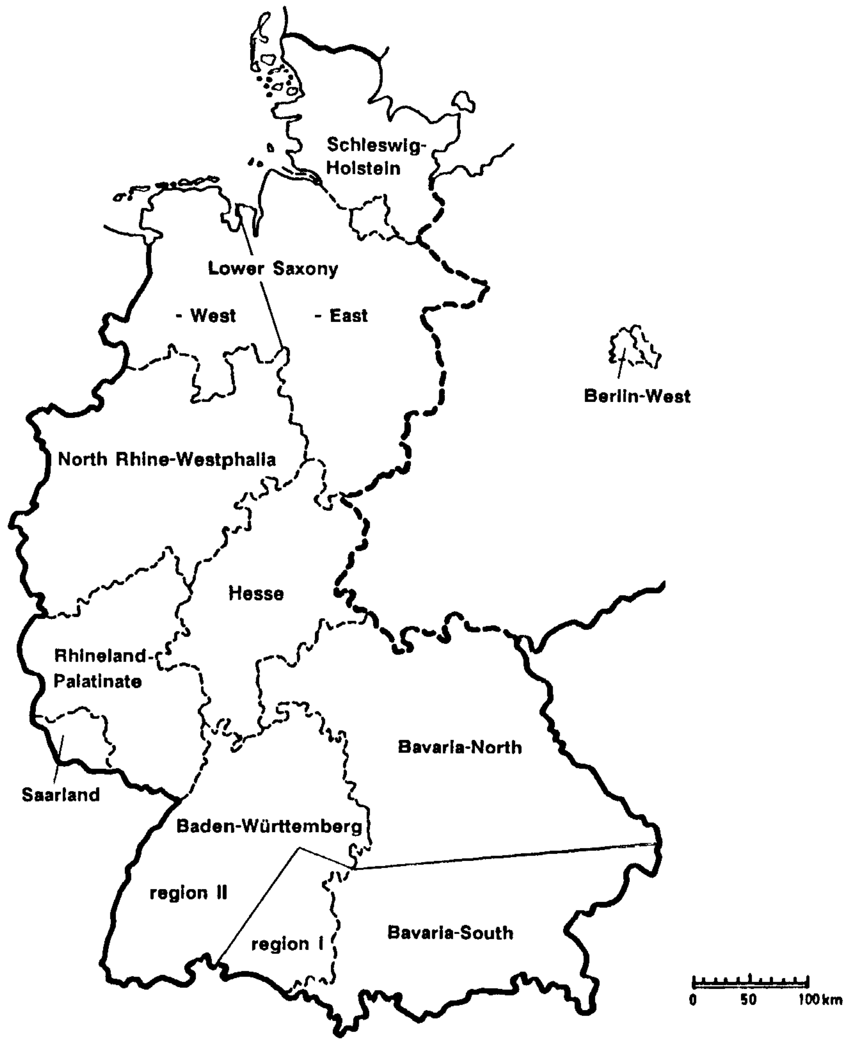


Fig. 5/1: Map of the Federal Republic of Germany
Federal States and regions

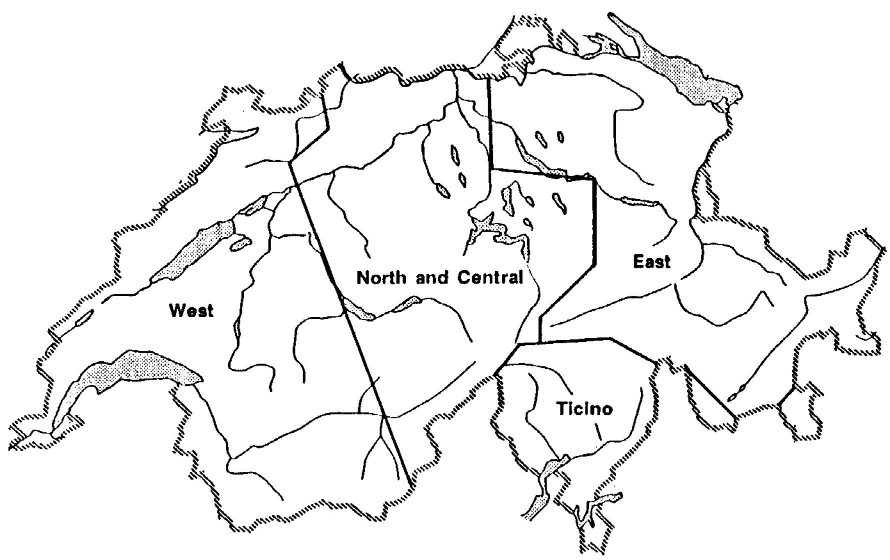


Fig. 5/2: Map of Switzerland, used regions

chosen as follows: 0-5, >5-10, >10-20, >20-50, >50-100 etc.

For the graphic representations Switzerland was subdivided into 4 regions (see figure 5/2) to correspond to the radiation exposure in the different parts of the country.

To present the results for the Federal Republic of Germany, the federal states (leander) were used as a basis (see figure 5/1). However, the federal states of Bavaria, Baden-Württemberg and Lower Saxony were subdivided into two regions each. The "border" between southern and northern Bavaria runs approximately along a line connecting Ulm and Passau. The south eastern part of Baden-Württemberg, which was subjected to clearly higher contamination from Chernobyl, was designated as region I and the other, much larger part of this federal state as region II. The "border" between eastern and western Lower Saxony runs roughly along the river Weser.

The mean values used as a basis for the synoptical representations in chapter 6, their percentage standard deviations and the number of samples used are given in the appendix in the form of tabular computer printouts.

6. SURVEY RESULTS FOR THE FEDERAL REPUBLIC OF GERMANY

6.1 LOCAL DOSE

One aim of the survey was to determine the additional external radiation exposure for the population in the Federal Republik of Germany as a result of the Chernobyl accident. The variable in question was the time integral of the gross local dose rate for the period from April 28th up to and including June 20th, 1986. The local background dose which can be determined from the mean local dose rate measured prior to the accident at Chernobyl was to be given for the same period of 54 days. The net local dose which is obtained by subtraction gives the increase in local dose due to the effect of Chernobyl.

As a rule the original variable measured by stationary and portable measuring systems is the exposure rate in air which is measured in µR/h. In accordance with German regulations 1 µR/h corresponds to 0.01 µSv/h. The mean values of the net local doses (see table 9/2, appendix) calculated for the federal states or certain regions of the states from the individual values were assigned to different level bands for the photon dose equivalent between 10 and 500 µSv. The result is shown in figure 6/1.

For the graphic representation of the level bands in figure 6/1 mean values were formed from numerous individual measured values originating from different locations which exhibited considerable scatter bands even within small areas. The reason for this are the locally very different precipitation intensities. The roughness of the ground surface at the measuring location is also of great importance. After the first heavy activity depositions by precipitation, subsequent precipitation rinsed off a considerable proportion of the deposited activity from smooth ground such as asphalt roads, whereas much less was removed from meadows and fields. This is why the local dose rate of near-ground air over meadows was initially often more than twice that in town areas close to. Later, however, the reverse was observed on a smaller scale because by then the activity deposited on meadows and fields had penetrated the soil, thus partially absorbing the radiation from it. The remaining activity which could not be rinsed off asphalt or concrete was fixed on porous surfaces.

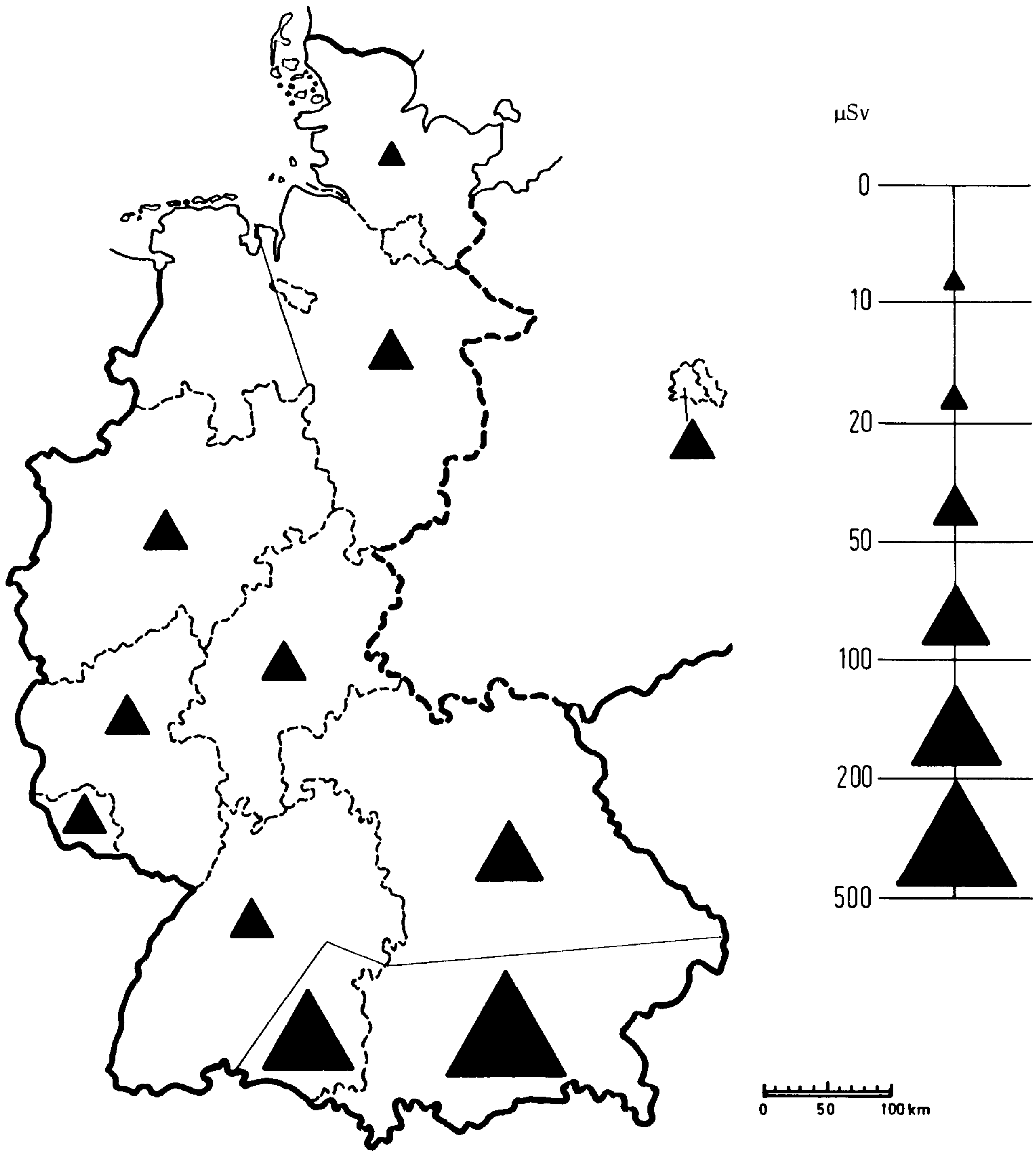


Fig. 6/1: Net local dose $\Delta D = D - D_0$
for the period April 28 until June 20, 1986
D = time integral of the measured local dose rate
D_0 = time integral of the background local dose rate
determined from $\bar{D}_0$ before the Chernobyl accident

The distribution of the radiation level bands for net local doses shown in figure 6/1 clearly identifies southern Bavaria and south-eastern Baden-Württemberg as the areas of the German Federal Republic with the highest exposure. The net local doses for the region north of the line Ulm - Passau are lower by a factor of 2 than for the southern Bavarian region. The lowest values were measured in Schleswig-Holstein. The mean net local doses for all other federal states including West Berlin fall into the same band of 20 - 50 µSv; for the period of 54 days up to the 20th June 1986 this corresponds to a fluctuation range of the mean additional local dose rate between 16 nSv/h and 40 nSv/h.

Although only single measured values were available for southern Bavaria and North Rhine-Westphalia, measured results which were made known later gave no reason for making any changes in the classification used for figure 6/1.

With the exception of southern Bavaria and south-eastern Baden-Württemberg, which was clearly higher contaminated and where even after the 20th June, 1986 the local dose rate had not quite returned to the old background value, all other areas of the Federal Republic no longer showed any significant increases in local dose rate towards the end of the period used for this survey.

Finally it should also be stated that the actual external radiation exposure of the public would correspond to the values shown here for the additional local dose only if they had been out of doors for 24 hours every day during the time period of 54 days looked at here.

6.2 AIR

Monitoring the radioactivity concentration of the primary medium air is important in order to be able to estimate the activity incorporation by inhalation. Since the product of activity concentration and exposure duration is a critical factor in calculating the radiation exposure, the requirements for the survey were that the time integrals of the activity concentration in air was to be given for the nuclides I-131 and Cs-137 for the period from approximately April 28th up to and including May 8th, 1986. The justification for limiting the integration interval to the 8th May was

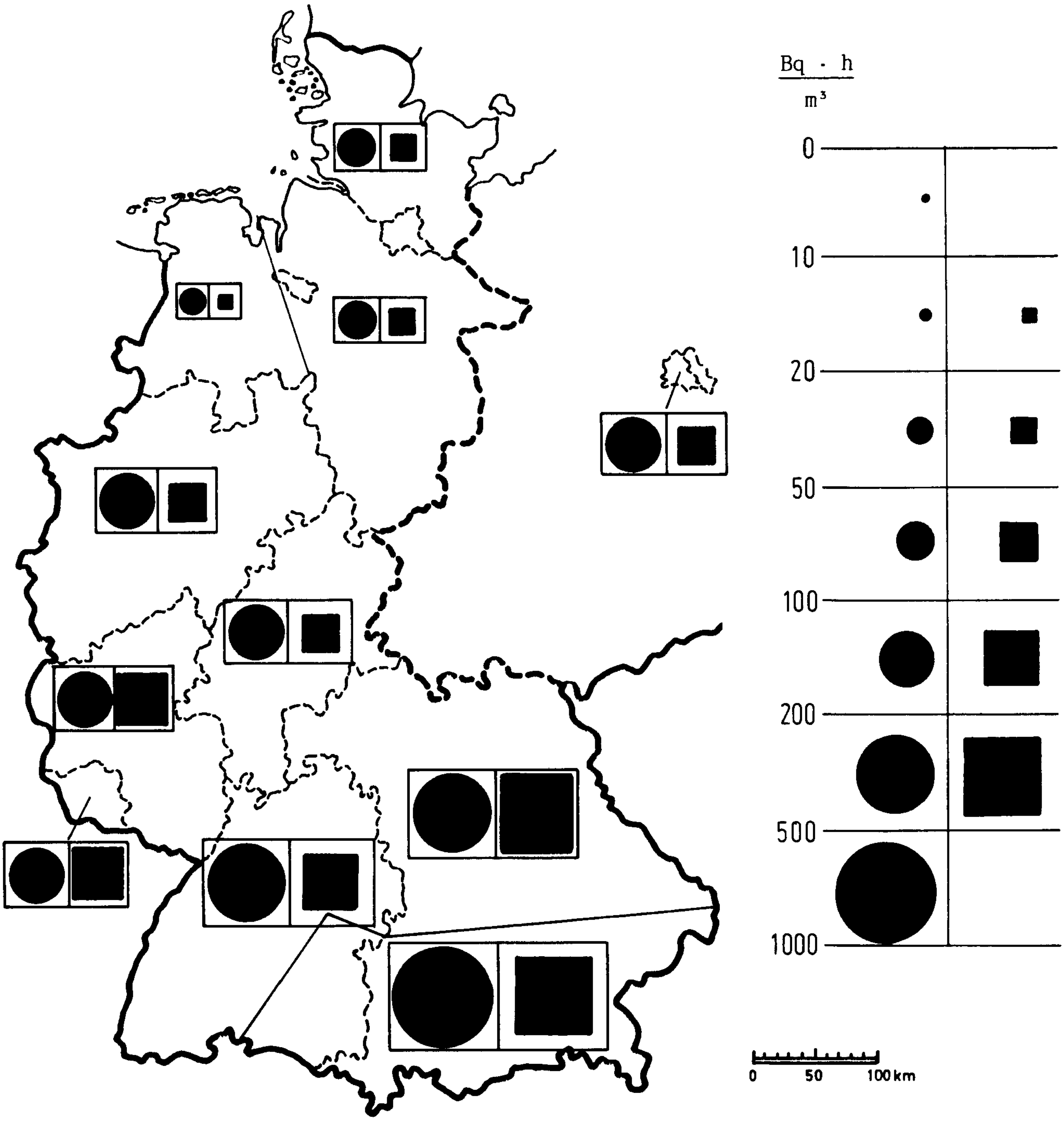


Fig. 6/2: Time integrated activity concentration in the air for the period from April 28 until May 8, 1986

● aerosol bound I-131 ■ Cs-137

that, because of the wash-out of the atmosphere by precipitation, nowhere in the Federal Republic were significant I-131 and Cs-137 concentrations in air detectable after that (see also fig. 2/1).

Although the time integrals both for total iodine as well as aerosol-bound iodine were to be entered in the tables for the survey, approximately 80 % of data suppliers were only able to provide values for aerosol-bound I-131. Both variables were determined at relatively few locations and a very small proportion of data suppliers gave only the value for total iodine. This is why the results in figure 6/2 are shown for aerosol-bound I-131 only. Where the time integral was given for total iodine, the aerosol proportion required to be able to give a uniform picture was arrived at by way of calculation. For this a mean ratio of aerosol-bound iodine to total iodine of 1:3 was used. In fact the ratio was not constant over time. Where pairs of values are available, however, the ratio 1:3 is a sufficiently well supported mean value for the time interval up to May 8th. The time integrals for total iodine I-131 not shown here can therefore be estimated by multiplying the mean values given in table 9/3 in the appendix by the factor 3.

Figure 6/2 shows the distribution of the different level bands for the time integrals for the activity concentration in air for the nuclides I-131 and Cs-137 in $Bq \cdot h/m^3$. Different geometric shapes were used to represent the two radionuclides. The overall picture shows a virtually steady drop from south both for I-131 and for Cs-137.

The band symbols for 500 - 1000 $Bq \cdot h/m^3$ for aerosol-bound I-131 and for 200 - 500 $Bq \cdot h/m^3$ for Cs-137 entered into the outline map in figure 6/2 for southern Bavaria apply similarly for the south-eastern part of Baden-Württemberg designated region I. The band symbols entered for western Lower Saxony are not representative for this region since they are only based on measured results obtained for Norderney.

6.3 PRECIPITATIONS

When monitoring the radioactivity in the environment, precipitations are a primary medium which is especially worth monitoring since the product of

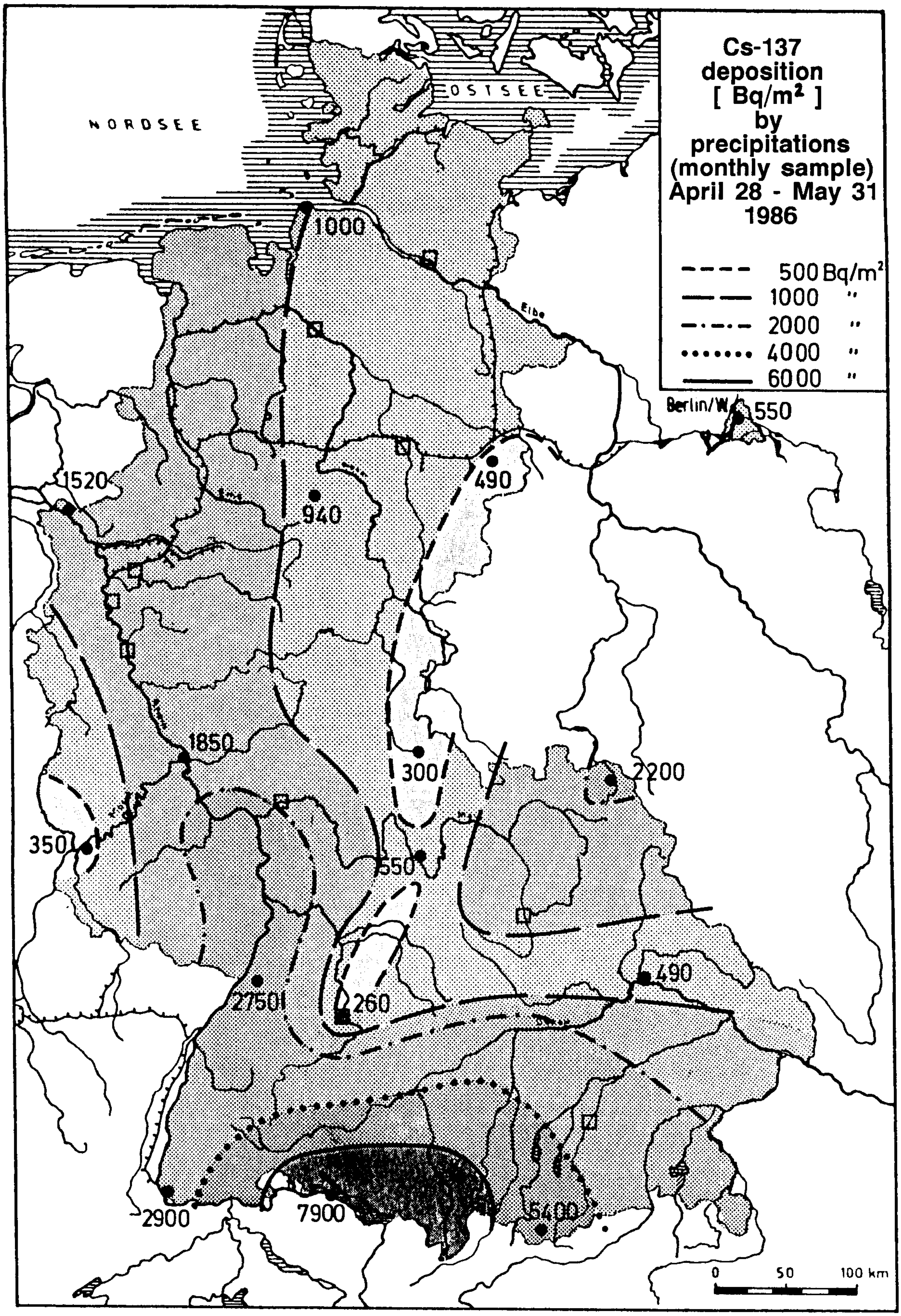


Fig. 6/3: Cs-137 activity deposition by precipitations

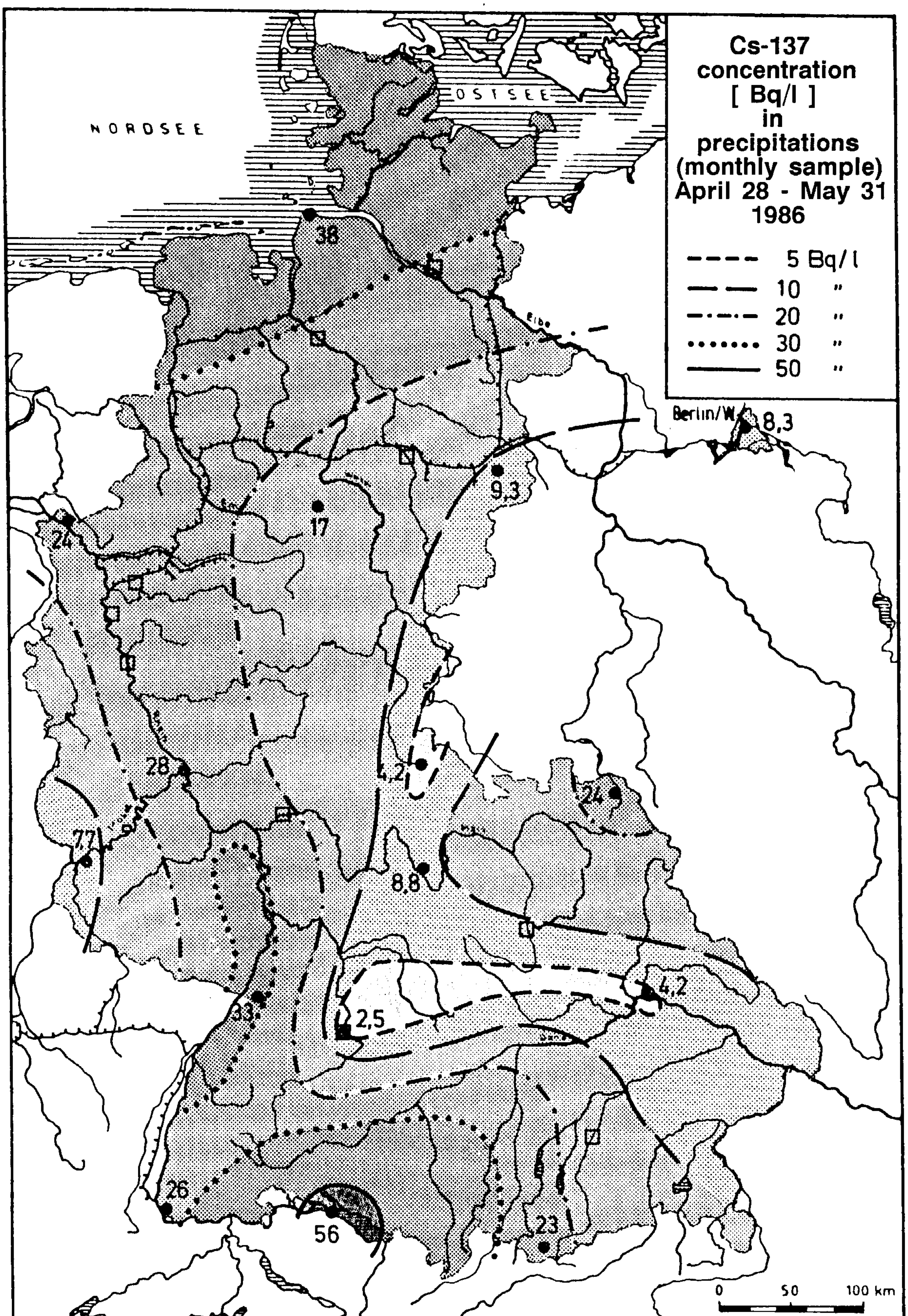


Fig. 6/4: Cs-137 concentration in precipitations

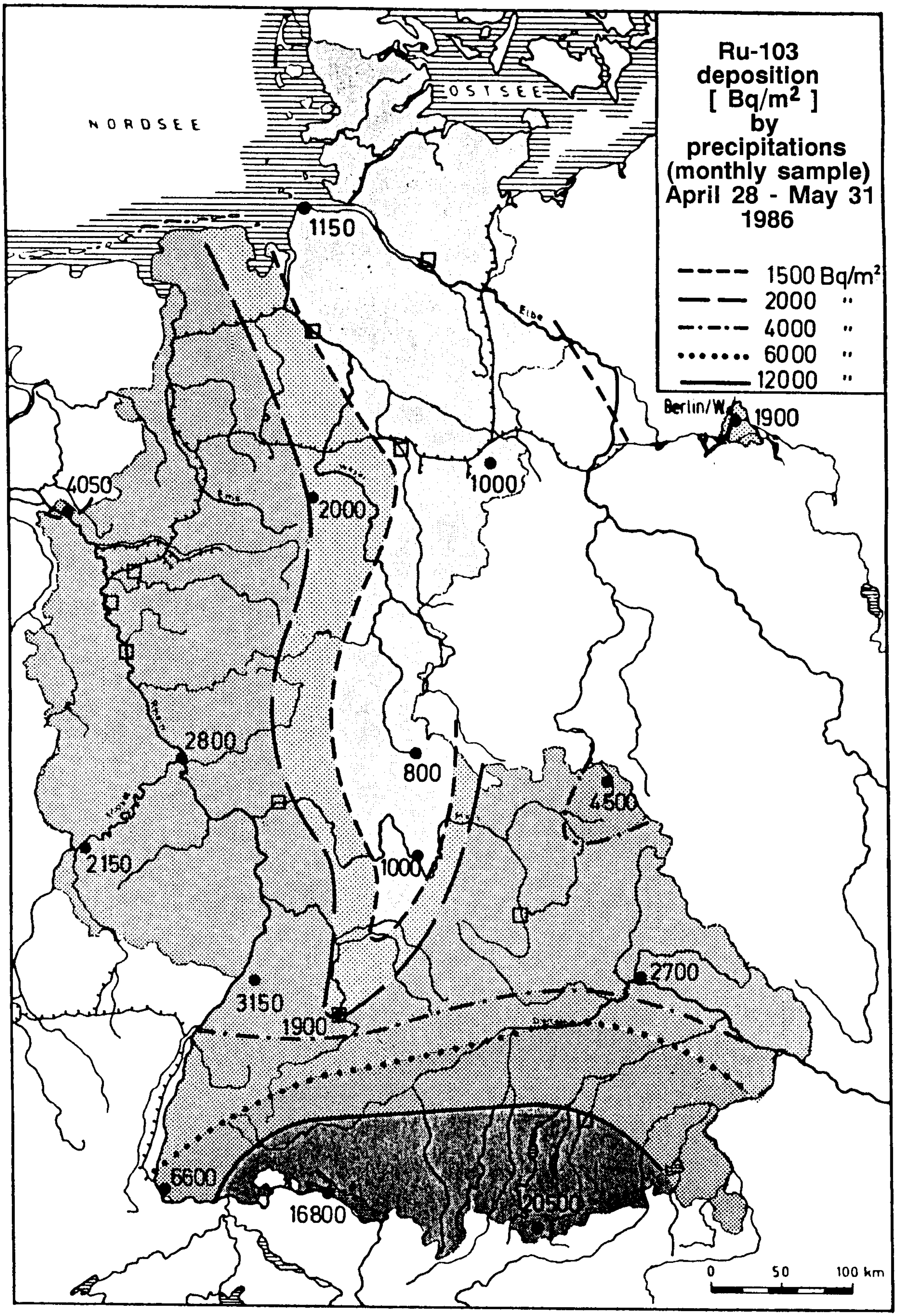


Fig. 6/5: Ru-103 activity deposition by precipitations

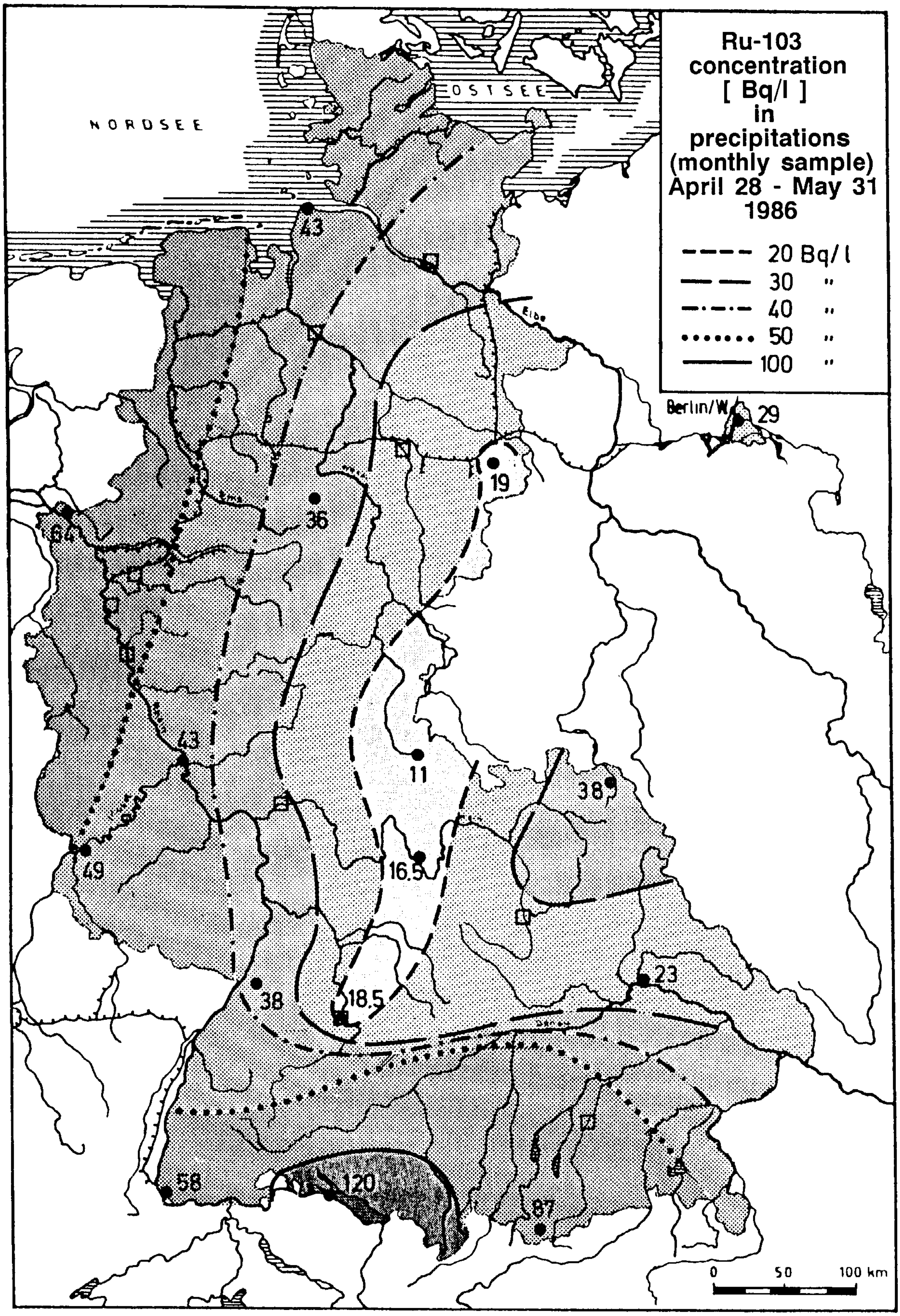


Fig. 6/6: Ru-103 concentration in precipitations activity concentration of the precipitation and its intensity describes the activity quantity supplied to the unit of ground surface by washing out the atmosphere. In spite of this, overall there are relatively few measured results related to precipitation for the Federal Republic of Germany and still fewer were available to AKU for evaluation. This is primarily due to the fact that the "Guideline for Emission and Immission Monitoring of Nuclear Installations" does not require any routine monitoring of precipitations either by operators or so-called independent measuring authorities or agencies. This means that most of the agencies dealing with environmental monitoring of nuclear installations cannot supply such data.

While activity concentration measurements on precipitations were carried out in a number of federal states during the first few weeks after the reactor accident at Chernobyl, the precipitation quantities were frequently not determined, however, so that it was not possible to calculate the more relevant variable of the activity deposited per unit area.

Figures 6/3 to 6/6 were made available to AKU by the Federal Institute for Hydrology at Coblenz. They show isoline diagrams for the radionuclides Cs-137 and Ru-103 both for activity deposition via precipitations in Bq/m^2 and for the activity concentrations in Bq/l. The diagrams cover the period from April 28th to May 31st, 1986 and are based on the evaluation of monthly samples; in this the proportions of precipitations in April from individual stations in southern Germany affected by the reactor accident were taken into account.

In the figures the sixteen precipitation collection stations are marked by dots. The figures by the dots show the measured values in the unit given in the legend. Along the borders of the Federal Republic of Germany the isoline position is understandably particularly unreliable. It is also possible that locally higher or lower activity values may have been measured at different places and by different measuring agencies so that possibly they do not fit into the distribution shown here. This is particularly true for the area around Munich for instance. During the period between April 29th and May 9th, 86 alone, considerably higher values were measured here than the peak values suggested by figures 6/3 and 6/5. The Cs-137 deposition for instance amounted to 19,000 Bq/m^2 here and the Ru-103 deposition to 27,000 Bq/m^2 (see also appendix, table 9/1). It can therefore safely be said that the isoline representation for southern Bavaria requires correction. The value of 2,900 Bq/m² for the Cs-137 deposition in the south-western corner of Baden-Württemberg (see figure 6/3), on the other hand, connects well with the value of 3,300 Bq/m² which was found in northern Switzerland near the border between the two countries (see figure 7/4).

However unreliable the isoline representation presented for Cs-137 and Ru-103 for the Federal Republic may be, they nevertheless show the enormous differences in the activity depositions on the ground surface. For the long-lived nuclide Cs-137 the measured values cover a range from 0.3 kBq/m² to approximately 20 kBq/m².

6.4 GRASS

Particular importance was attached to monitoring the radioactive content of grass since it is used as fodder for all grazing animals. The specific activity of grass is the reference variable for estimating the activity content to be expected in such important foodstuffs as milk, dairy products and meat. This is why a particularly large number of grass samples was measured throughout the Ferderal Republic.

In spite of many individual measured results being available, evaluating and summarising them in mean values was not without problems. At the beginning of May the measured results showed a wide scatter band because of the widely differing activity depositions due to dry fallout and precipitations. Even later the measured values showed a considerable scatter band since, depending on local precipitation intensity, the deposited activity was washed off to differing degrees. During the evaluation it was also found that the time intervals chosen for collecting the data (see figure 6/7) had not been chosen in the best possible way. The first time interval (April 28th to May 15th, 86) was found to be too long, since the effective half-life of the specific Cs-activity of the grass during this time interval, this being a period of rapid growth, was only one week. The measured results therefore depended heavily on the sampling date and this applied in particular to I-131.

In a great many cases the I-131 values showed a distortion of the overall

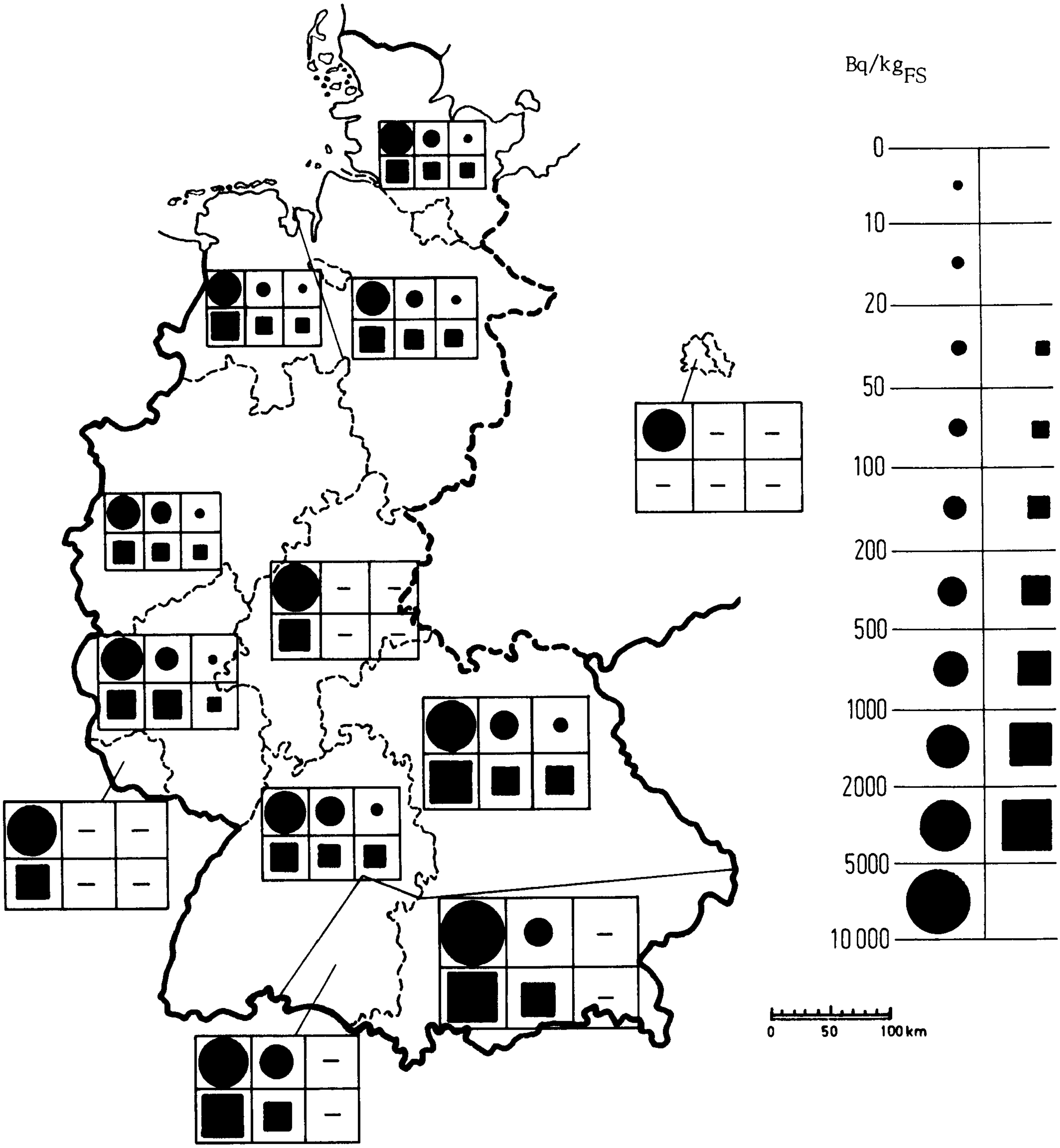


Fig. 6/7: Specific activity in grass

● I-131 ■ Cs-137

Apr. 28 - May 15	May 16 - June 4	June 5 - June 20

1986

picture since the time between sampling and measurement was too long and a decay correction had not been calculated due to lack of time. A further reason why the measured results were limited in their comparability was that the activity measurements were almost without exception carried out on the fresh grass substance; this is also why all the results are available only in the unit Bq/kg_{FS}. The time-consuming process of determining a well-defined area for grass sampling which, together with determining the weight, allows information to be given as to the vegetation densitiy, was omitted. Moreover, there was frequently no information as to whether the grass samples had been dried before the measurement or not and whether, in the case of dried samples, the measured result had again been corrected for fresh substance by way of calculation.

Although many measured results for reasons mentioned here had to be considered as possibly distorted or at least not comparable in fact and therefore rejected, the summarising representation nevertheless includes the I-131 and Cs-137 results of approximately 1,000 grass samples. Only for the state of North Rhine-Westphalia were very few results made available for the evaluation. For North Rhine-Westphalia only the results of the Nuclear Research Centre Jülich were included in the representation.

Specific activity bands were assigned to the mean values (see appendix, tables 9/4 and 9/5) for the three time intervals. Different geometric symbols were used for I-131 and Cs-137. Figure 6/7 shows the overall picture. For grass also there is a typical drop from south to north which extends in the first time interval for I-131 from the band 5 - 10 kBq/kg in southern Bavaria to the band 0.5 kBq/kg to 1 kB/kg in northern Germany. Overall it can be said that, by mid June, 1986, the specific activity values for grass dropped to 1 % and below in the case of I-131 and in the case of Cs-137 to approximately 15 % of the original values during the first half of May.

6.5 SOIL

The survey for soil samples only dealt with the specific Cs-137 activity. The subdivision into time intervals was found not to make much sense and in fact, because of the long half-life of Cs-137 and the fact that the radioactivity slowly penetrates into the top soil layers, it was in fact not necessary. This is why all the measured results for the month of May and June, 1986 were taken together when forming the mean values.

Evaluating and summarising the measured results was found to be particularly problematical in the case of the soil samples. In many cases even the data suppliers themselves did not have available to them exact data regarding location or information as to the type of sample. So it often remained unknown whether the soil sample had been taken from a ploughed field or unploughed natural soil. At the end it was not known for all the samples whether the turf had been removed or been measured together with the soil sample proper. The greatest obstacle to the data being comparable and thus allowing them to be averaged lay in the fact that sampling depths varied between 2 and 40 cm and in some cases were missing altogether. Mean values (see appendix, table 9/6) were therefore formed exclusively from measured results obtained from soil samples for which a sampling depth of 0 - 5 cm had been quoted. In spite of this stringent selection criterion this evaluation nevertheless includes measured results from 500 soil samples.

Unfortunately, no values were available for Hesse, Saarland and West Berlin. For Rhineland-Palatinate a mean value was formed from only 12 measured results and for North Rhine-Westphalia only the measured results form the Nuclear Research Centre Jülich were used. Figure 6/8 shows a grahic representation of the mean values which are again assigned to different level bands of the specific Cs-137 activity. The missing values for Hesse and Saarland and the obviously not representative and probably excessively low values for Rhineland-Palatinate and North Rhine-Westphalia mar the visual impression of the virtually steady drop from south to north which was also expected for soil.

The difficulties in the evaluation and summarising representation of the measured results on soil samples show particularly clearly how necessary it is to standardise the measuring procedures and in particular sampling methods. This is particularly true for exceptional situations such as in this case after the reactor accident at Chernobyl where lay persons or inadequately trained auxiliary personnel has to be used for sampling.

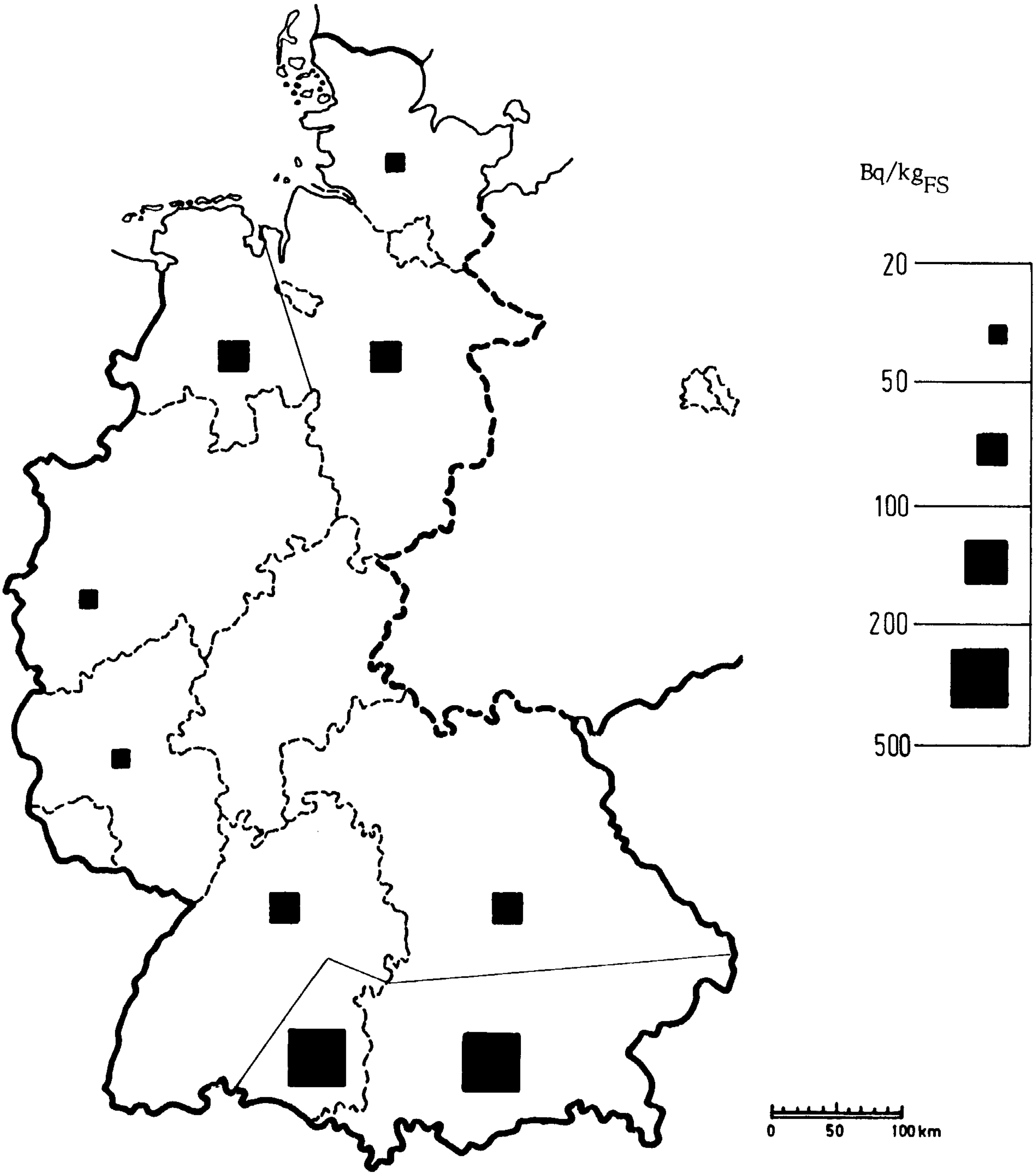


Fig. 6/8: Specific activity of Cs-137 in the soil (layer depth: 0-5 cm) Sampling period: May and June 1986

6.6 MILK

Since cow's milk and products derived from it are among the most important foodstuffs in Central Europe and it has also been known for a long time that radioactive (and other) environmental contamination have a particularly strong effect in milk because of enrichment effects, the activity concentration in cow's milk was monitored intensively in all federal states. Dairy milk was subject to particularly stringent checks in order to keep the precautions intervention level for I-131 of 500 Bq/l recommended by the German Advisory Committee on Radiation Protection (SSK) to be met.

When evaluating the data supplied as part of the survey, it was mainly dairy milk that was taken into account. The I-131 and Cs-137 means (see tables 9/7 and 9/8, appendix) established for the three time intervals set between April 28th and June 20th, 1986 were assigned to seven concentration categories between 0 and 500 Bq/l. Figure 6/9 shows the graphic representation of these concentration categories for both radionuclides and for three time intervals for the Federal Republic of Germany. For the states of Bavaria, Saarland, Hesse and Lower Saxony measured data were not available for all three time intervals and not always for both radionuclides. Altogether, however, this evaluation is based on just under 3,000 individual measured results for I-131 and approximately 2,000 individual measured results for Cs-137.

The maximum I-131 concentrations in dairy milk were reached as early as after approximately five days. However, even in the southern region of the Federal Republic, which had been most heavily affected, these peaks lay clearly below the value of 500 Bq/l recommended by the SSK. While the recommendation issued on May 2nd, 1986 not to drive the cows to pasture and not to feed them green fodder was not followed by all farmers and had to be discontinued in some places after a few days because of lack of winter fodder, it nevertheless had the effect of reducing the concentration peak in the dairy milk which is made up of many individual deliveries, and it also had a favourable effect on the further developments in the contamination of milk.

Figure 6/9 very clearly shows the general drop from south to north both for the I-131 and the Cs-137 concentration in cow's milk.

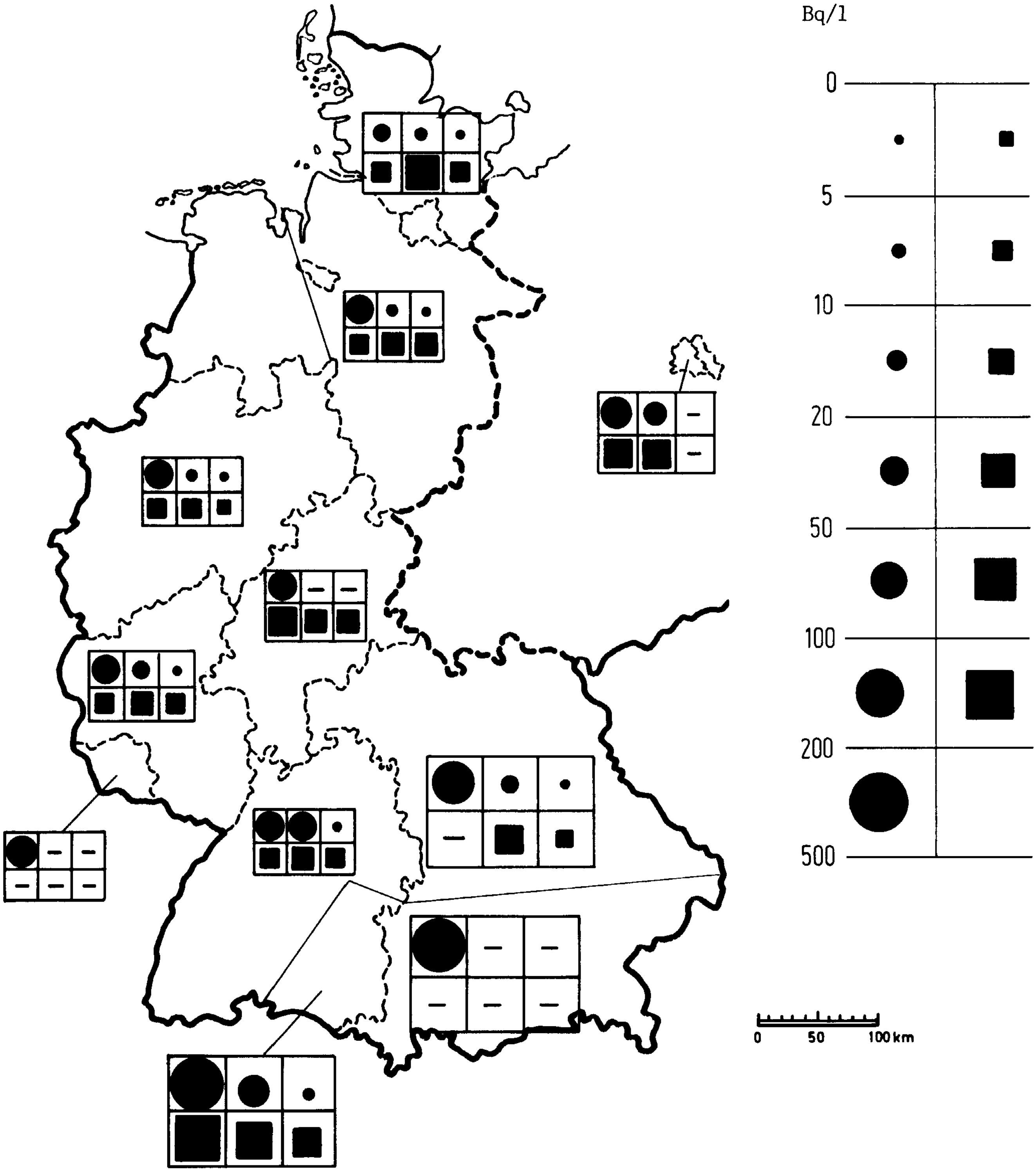


Fig. 6/9: Activity concentration in cow milk (mainly samples collected from dairies)

● I-131 ■ Cs-137

Apr. 28 - May 15	May 16 - June 4	June 5 - June 20	1986

As far as the I-131 concentration in cow's milk is concerned, there were some fluctuations in May and then it dropped relatively quickly to below 2 Bq/l (see figure 6/9) between the middle and end of June depending on the level of the initial values.

In contrast to I-131 the Cs-137 contamination of milk took longer to build up and to reduce. The peak was generally not found until the second half of May (see figure 6/9, second time interval). According to figure 6/9 this statement does not seem to apply to the south eastern region of Baden-Württemberg; for this it is to be borne in mind that the figures for the first and second time interval differ hardly at all (see table 9/8, in the appendix) and that the majority of the 40 samples for the first time interval were taken between the 10th and the 15th May. This is why the Cs-137 mean is a little higher and the I-131 mean a little lower than was to be expected if sampling had been evenly distributed over the time interval.

During June the Cs-137 concentration in cow's milk dropped sharply and during July and August it dropped to values below 20 Bq/l even in the regions which had been most heavily affected. By way of comparison it is worth mentioning that the natural K-40 concentration in milk is approximately 40 Bq/l.

The milk from goats and grazing sheep, which is of minor importance for nutrition in the Federal Republic of Germany, showed higher activity concentrations than cow's milk.

In human breast milk samples the I-131 and Cs-137 contents were extraordinarily low. The concentrations were generally around a few Bq/l.

6.7 GREEN VEGETABLES

For the federal states of Bavaria, Saarland, Hesse, Lower Saxony and Schleswig-Holstein as well as for West Berlin either no or so few measured values were supplied for green vegetables as part of the AKU survey that there was no point in trying to produce representative regional mean values. Even for the two regions of Baden-Württemberg (see figure 5/1), for

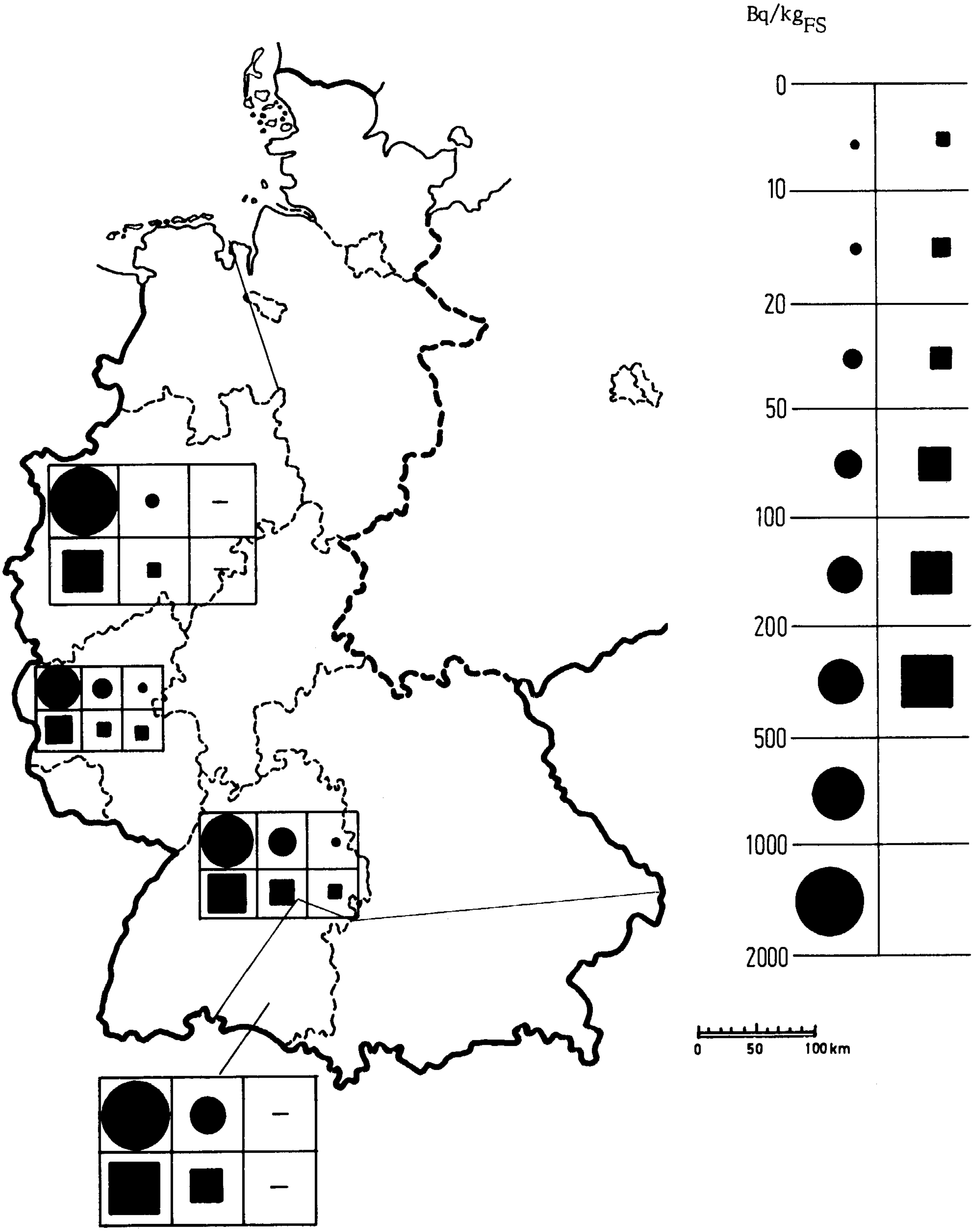


Fig. 6/10: **Specific activity in green vegetable (mainly outdoor lettuce, ready for consumption)**

● I-131 ■ Cs-137

Apr. 28 - May 15	May 16 - June 4	June 5 - June 20

1986

Rhineland-Palatinate andNorth Rhine-Westphalia producing mean values for the specific I-131 and Cs-137 activity in green vegetable samples proved highly problematical. Of the measured values for green vegetables available to AKU for North Rhine-Westphalia, only the data supplied by the Nuclear Research Centre Jülich proved suitable for evaluation. Some of the measured values within one federal state were scattered over two to three orders of magnitude. Even within small areas there were large differences in the contamination due to different precipitation intensities and plant growth states. The term green vegetable covered measured results from such different plants as lettuce, cauliflower, savoy cabbage and parsley.

For any summarising presentation it therefore only made sense to use subsets of data which referred to the same type of green vegetable. The values represented in this report are therefore mainly mean values of specific activity values for outdoor lettuce ready for consumption. Even the term "ready for consumption" proved to be woolly. Apart from the washing process in some cases the outer lettuce leaves were removed before the measurement, sometimes not. Furthermore it is not impossible that measured values for lettuce grown under plastic were included in the valuation because accurate sample marking to this effect was often missing during the hectic first few days.

Because of these problems in evaluating the extremely heterogeneous data, the mean values given for I-131 and Cs-137 in tables 9/9 and 9/10, in the appendix and the level bands for the specific activities in Bq per kg of fresh substance shown graphically in figure 6/10 can only be taken as very rough guide values.

6.8 OTHER FOODSTUFFS

Milk and green vegetables are the only foodstuffs of major importance which were directly affected by the radioactive contamination from Chernobyl. This is why they were dealt with separately in the preceding chapters. Other foodstuffs which were also affected directly but which are of less importance for human nutrition in Central Europe are freshwater fish and game. They will therefore be dealt with in this chapter. The radioactive contamination of honey also seemed of particular interest; very many measurements - in particular in Baden-Württemberg - were therefore carried out on it. Strawberries and currants, being typical representatives for fruit which is contaminated very slightly and more highly, respectively, are also dealt with briefly.

Since the survey for "other foodstuffs" was not carried out systematically, values from several states are missing in each case. This is why the results are given in tables only. Nevertheless this offers a sufficient overview for each of the foodstuffs listed.

For "other foodstuffs" the time limit of June 20th, 1986 was not used since, on the one hand, large numbers of samples were not measured until after this date and, on the other hand, the further development, e. g. with game and fish, seemed of particular interest. The representation was restricted to Cs-137 since the contamination with radioactive iodine of these foodstuffs is of minor importance for human nutrition (honey, strawberries, currants and fish initially showed low to moderate, deer sometimes a high radioactive iodine contamination but mainly before the hunting season started and concentrated in the animals' thyroid glands).

Edible fungi were not included in the survey. Contamination values for these were very widely scattered. At the beginning of September for instance xerocomus badius were found in region I of Baden-Württemberg with Cs-137 activities of 250 Bq/kg but also with 19,400 (peak value). Generally these fungi showed the highest values followed by other members of the boletus family, whereas ceps (boletus edulis) showed relatively low and field mushrooms (agaricus campestris) very low Cs-137 activities.

Table 6/1 gives the specific Cs-137 activity in venison of roe deer. Roe deer is generally among the most heavily contaminated types of game and was also available in large numbers. It was not possible to observe any significant difference between that and the few red and fallow deer samples; but it did show itself in comparison to hares, wild boars and feathered game which showed considerably lower contamination. Grazing sheep initially showed contamination values near those of the roe deer but they dropped more quickly with time, which is probably due to the different fodder available. Domestic animals such as pigs and cattle always showed a relatively low radioactive contamination of the meat because in central Europe pigs are

Federal state or region	Sampling period in 1986	Number of samples taken	Cs-137 in Bq/kg_{FS}	s in %
Baden-Württemberg (region I)	May 15-June 13	28	1,220	58
	July 7-Aug. 15	23	500	94
	Sept. 5-Sept. 23	22	950	110
Baden-Württemberg (region II)	May 20-June 13	52	250	60
	June 30-Aug. 15	73	180	144
	Sept. 5-Sept. 25	23	220	140
Bavaria-North	May 15-June 25	17	1,560	70
North Rhine-Westphalia	May 5-May 16	13	260	70
	May 17-June 30	28	200	66
Rhineland-Palatinate	May 16-June 20	42	390	-

Table 6/1: Specific Cs-137 activity in vension of roe deer
FS = Fresh substance, s = Standard deviation

kept indoors almost without exception and beef cattle are kept indoors during the last few weeks for fattening before being killed.

As can be seen from table 6/1, the radioactive contamination of roe deer is virtually the same in region II of Baden-Württemberg, North Rhine-Westphalia and Rhineland-Palatinate whereas it is noticeably higher in northern Bavaria and region I of Baden-Württemberg.

As can be seen for the values for region I of Baden-Württemberg which are subdivided in time, the Cs-137 contamination dropped initially; this is a development which no doubt also applies to the other more heavily affected regions. In fact in these areas the percentage drop in time was more than in the less heavily affected regions such as Baden-Württemberg II or North Rhine-Westphalia; this is due to the fact that the low radioactivity deposits together with subsequent precipitation had a greater effect in terms of percentages in the less contaminated areas than in the more contaminated ones. After the measured results available for up to mid September the trend to reducing values was obviously not continued in late summer and autumn, in fact in Baden-Württemberg an increase in Cs-137 activity was found which is mainly due to the different type of food available for roe deer (e. g. fungi). The contamination values for roe deer generally show a considerable scatter around the mean value. Roe deer is known to keep faithfully to certain locations which explains why there are clear differences within small areas, i. e. over distances of a few kilometres.

At the beginning of May the iodine-131 contamination of roe deer meat was roughly of the same order as the Cs-137 contamination. However, the iodine-131 contamination in the meat dropped very quickly and, from mid June onwards, it was mostly below the detection limit. However, a few peak values still reached levels of between 100 and 150 Bq/kg.

Table 6/2 gives the specific Cs-137 activity in fish. The Cs-137 contamination in fish is largely dependent on their biotope. Having many individual values available, it was found that fish from fish farms generally showed very low contamination, fish from running waters low and fish from lakes higher contaminations. The highest values were found in fish from lakes with little or virtually no outflow. So far the Cs-137

Federal state or region	Sampling period in 1986	Number of samples taken	Cs-137 in Bq/kg_{FS}	s in %	Remarks
Baden-Württemberg (region I)	June 10-Aug. 22	97	285	70	Various species of fish from lakes (e. g. Lake of Constance), ponds and pools
Baden-Württemberg (region II)	July 7-Aug. 22	15	13	185	Mainly breeding trouts and breeding carps
Bavaria-South	May 5-June 18	43	300	85	Lake white fish (plankton eaters)
	May 9-June 10	55	20	120	Trouts, carps, breams
North Rhine-Westphalia	June 25-July 3	9	10	120	Various fish species
Rhineland-Palatinate	June 5-June 20	3	8	-	

Table 6/2: Specific Cs-137 activity in fish
FS = Fresh substance, s = Standard deviation

Federal state or region	Sampling period in 1986	Number of samples taken	Cs-137 in Bq/kg_{FS}	s in %
Baden-Württemberg (region I)	May 17-June 4	36	92	100
Baden-Württemberg (region II)	May 17-June 4 June 5-Aug. 6	48 147	51 37	100 110
Bavaria-North	May 13-June 24	8	157	160
North Rhine-Westphalia	May 28-July 1	16	32	77
Rhineland-Palatinate	May 16-June 4	6	70	-

Table 6/3: Specific Cs-137 activity in honey
FS = Fresh substance, s = Standard deviation

Federal state or region	Sampling period in 1986	Number of samples taken	Cs-137 in Bq/kg_{FS}	s in %
Baden-Württemberg (region I)	June 18	6	10	58
Baden-Württemberg (region II)	May 25-June 25	34	10	78
Rhineland-Palatinate	May 16-June 20	18	5	-

Table 6/4: Specific Cs-137 activity in strawberries
FS = Fresh substance, s = Standard deviation

Federal state or region	Sampling period in 1986	Number of samples taken	Cs-137 in Bq/kg_{FS}	s in %
Baden-Württemberg (region I)	June 24-July 16	17	93	29
Baden-Württemberg (region II)	June 18-July 28	38	50	50
Lower Saxony (region East)	June 30-July 7	4	73	32

Table 6/5: Specific Cs-137 activity in currants
FS = Fresh substance, s = Standard deviation

contamination of fish from inland lakes still shows no drop, if anything an increase.

Table 6/3 shows the specific Cs-137 activity in honey. Here again the usual regional differences are visible; however, the contamination of honey overall remained relatively low. The individual values do not show such a wide scatter around the mean value as is the case with game and fish.

Table 6/4 gives the specific Cs-137 activity in strawberries. Even in the more heavily exposed areas strawberries shows only littel contamination.

Table 6/5 represents the specific Cs-137 activity in currants. The Cs-137 contamination of currants was a multiple of that for strawberries, in fact it nearly exceeded it by one order of magnitude. However, currants also show a comparably high natural K-40 activity which as a rule lies between 40 and 80 Bq/kg. Other summer fruits such as cherries, gooseberries and raspberries show specific activity values between those for strawberries and currants whereas autumn fruits such as apples, pears, plums and grapes generally showed very low contamination even below the values for strawberries.

7. SURVEY RESULTS FOR SWITZERLAND

The following is an overview of the radioactivity measurements carried out in Switzerland after the accident at Chernobyl. The summary is limited to the two major nuclides Cs-137 and I-131. For the various media which were examined, mean values are given for three time periods: April 28th to May 15th; May 16th to June 4th; June 5th to June 20th. Switzerland was subdivided into four regions to correspond to the radioactive contamination in the different parts of the country:

region I	=	Ticino and southern valleys of the Grison
region II	=	East Switzerland
region III	=	Central and North Switzerland
region IV	=	West Switzerland (i. e. to the west of Berne)

This way of summarising simplifies matters rather and does not do justice to all the details. However, it is sufficient for the overview intended here since all further details are given in detailed reports.

7.1 AIR (see figs. 7/1 and 7/2)

The air is monitored at 13 stations by aerosol filters which are normally changed and analysed by gamma spectroscopy weekly but at the beginning of May daily. Only the aerosol form of Iodine is deposited quantitatively on the filters. The total iodine should therefore be 3 - 5 times the values given for aerosol-bound iodine.

As early as on the 1st May the radioactivity in air reached its peak and then dropped rapidly. Since the cloud swept over all of Switzerland, the concentrations at the individual stations showed no significant differences. On the 1st May the station at Fribourg quoted among others: I-131: 4.2; I-132: 3.4; Te-132: 6.7; Cs-134: 0.5; Cs-137: 1,0; Ru-103: 1.6; Ba-140: 0.46; Mo-99: 0.65 Bq/m^3.

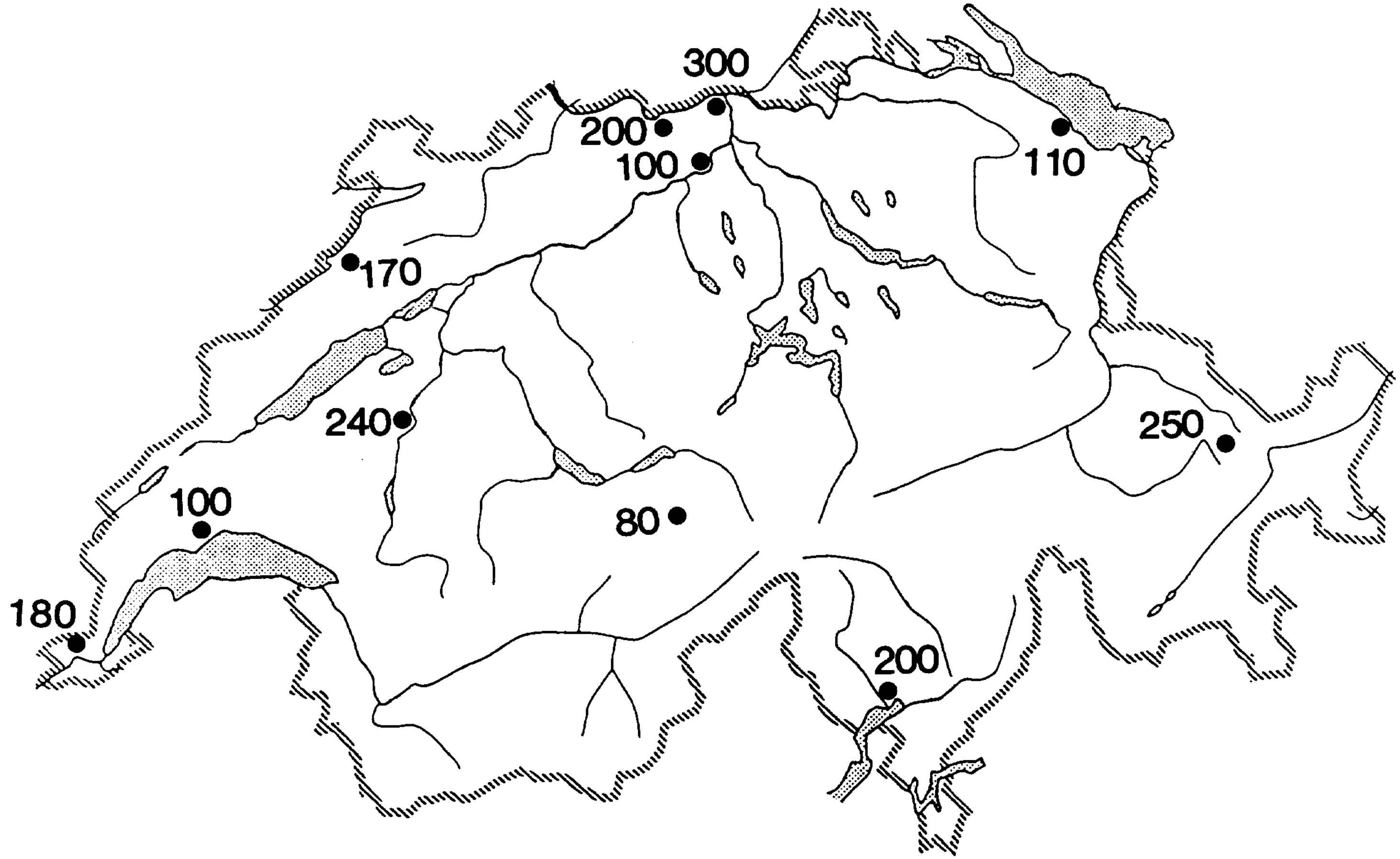


Fig. 7/1: I-131 (only aerosols) in the air in Bq·h/m^3 (April 28 to May 5)

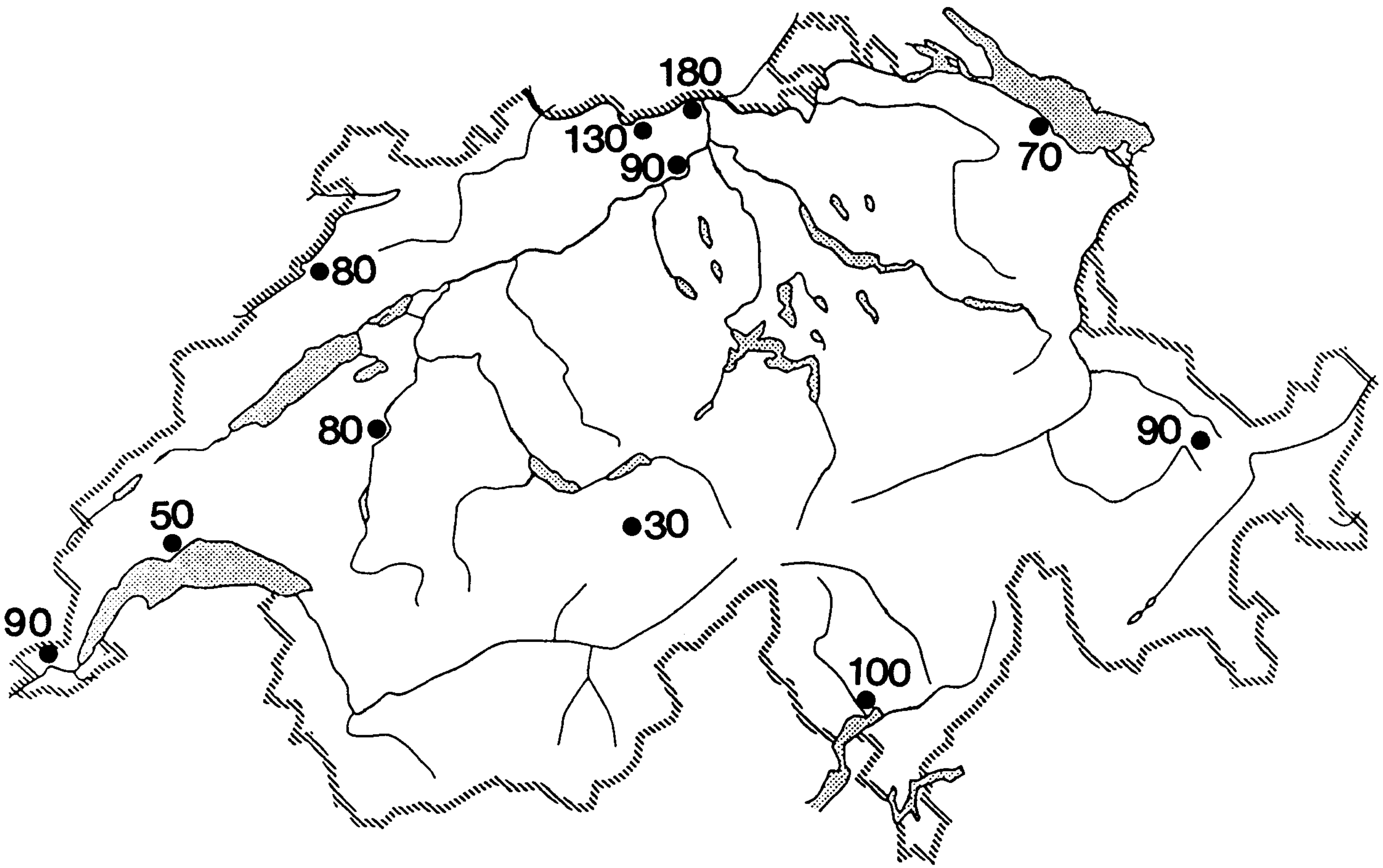


Fig. 7/2: Cs-137 in the air in Bq·h/m^3 (April 28 to May 5)

7.2 PRECIPITATIONS (see figs. 7/3 and 7/4)

The radioactivity of precipitations shows clearly that the deposit were highest in Ticino and lowest in west Switzerland. This state of affairs is reflected even more clearly for Cs-137 than for I-131. Most of activity was deposited in the first half of May; after that the activity in precipitations dropped markedly. Since iodine is in part also deposited dry, precipitation measurements do not cover all the iodine deposits.

7.3 LOCAL DOSE (see fig. 7/5)

The external radiation exposure was detected using different methods: automatic stations with GM counter tube, TL dosimeter, ionisation chamber, measuring trips using portable plastic scintillators etc. From these data radioactive contamination maps were established daily for the entire country. The dose integrals for the period from April 28th to June 20th compiled here were estimated from the available data. Since the external exposure was largely caused by radionuclides deposited with precipitations, the same pattern is present as with the precipitations: the highest values were measured in Ticino at the beginning of May: 0.6 - 1.5 µSv/h. In east Switzerland (region around Lake Constance) peak values were 1 µSv/h, in the rest of east Switzerland they were 0.3 - 0.8 µSv/h, in the Jura region of the Canton de Vaud 0.4 µSv/h and in the rest of Switzerland 0.2 - 0.3 µSv/h (gross values i. e. including natural background radiation). Towards the end of May exposure values had dropped to below 0.2 µSv/h (including background). Ticino was an exception to this; here the values were still between 0.2 and 0.4 µSv/h.

7.4 MILK (see fig. 7/6)

Being an important staple food, milk was at the fore of the monitoring operation right from the start since it has the highest consumption rate and the radiologically important nuclide I-131 is concentrated in it selectively. On the one hand individual milk samples (cow's milk) from selected farms were monitored continuously (initially daily) and on the other hand collective samples (from dairies and large distributors) were

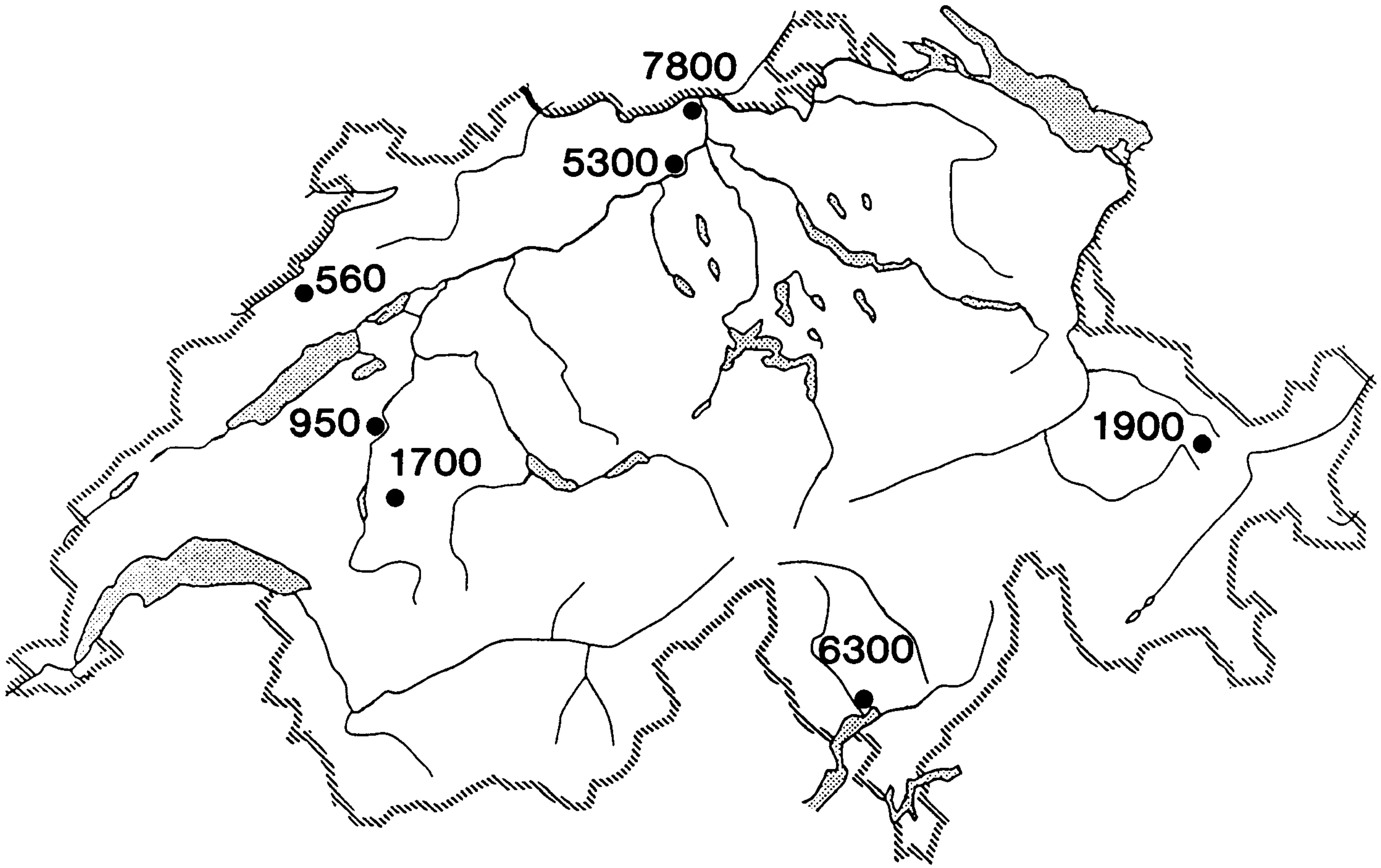


Fig. 7/3: I-131 deposition via precipitations in Bq/m^2 (April 25 to May 30)

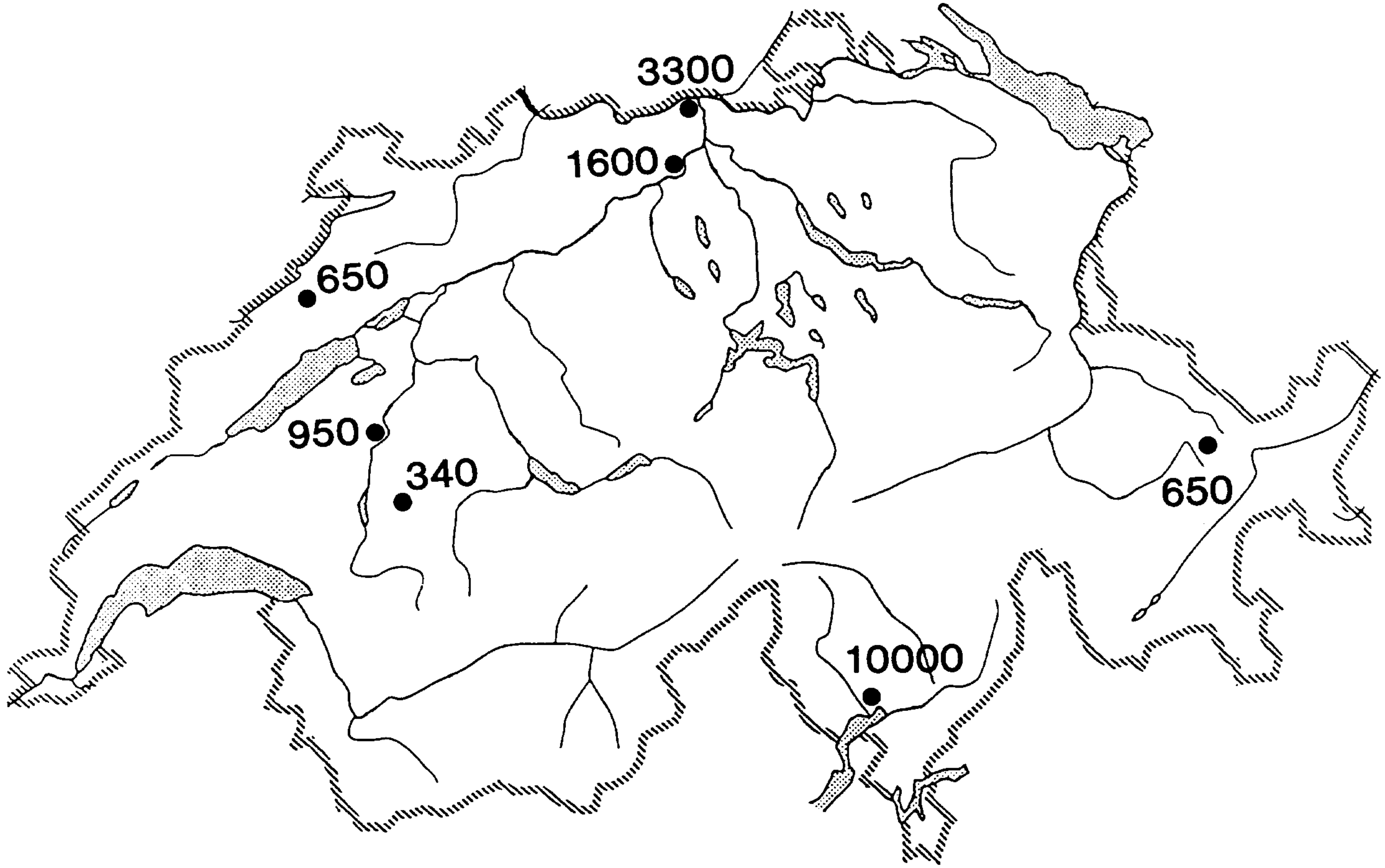


Fig. 7/4: Cs-137 deposition via precipitations in Bq/m^2 (April 25 to May 30)

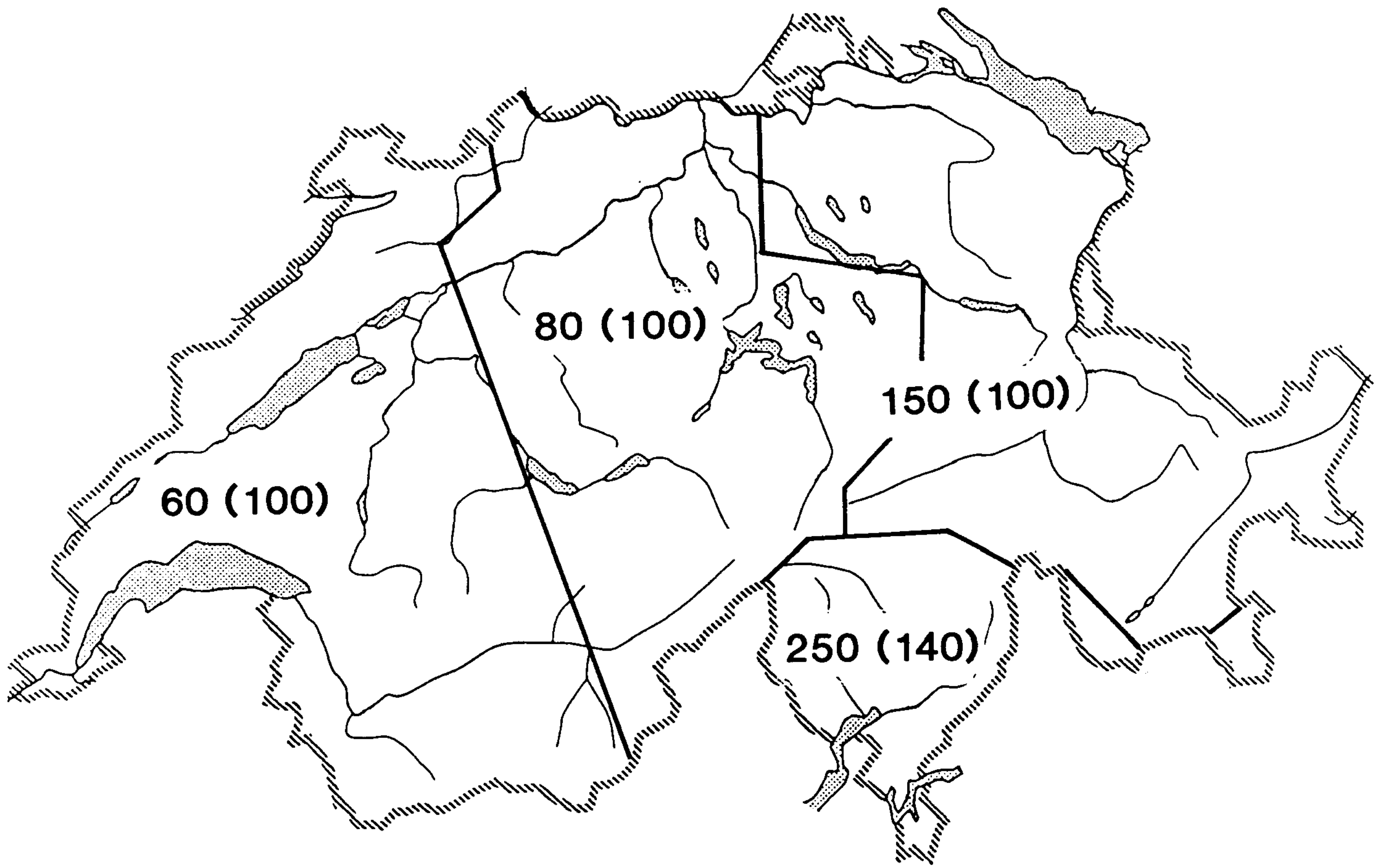
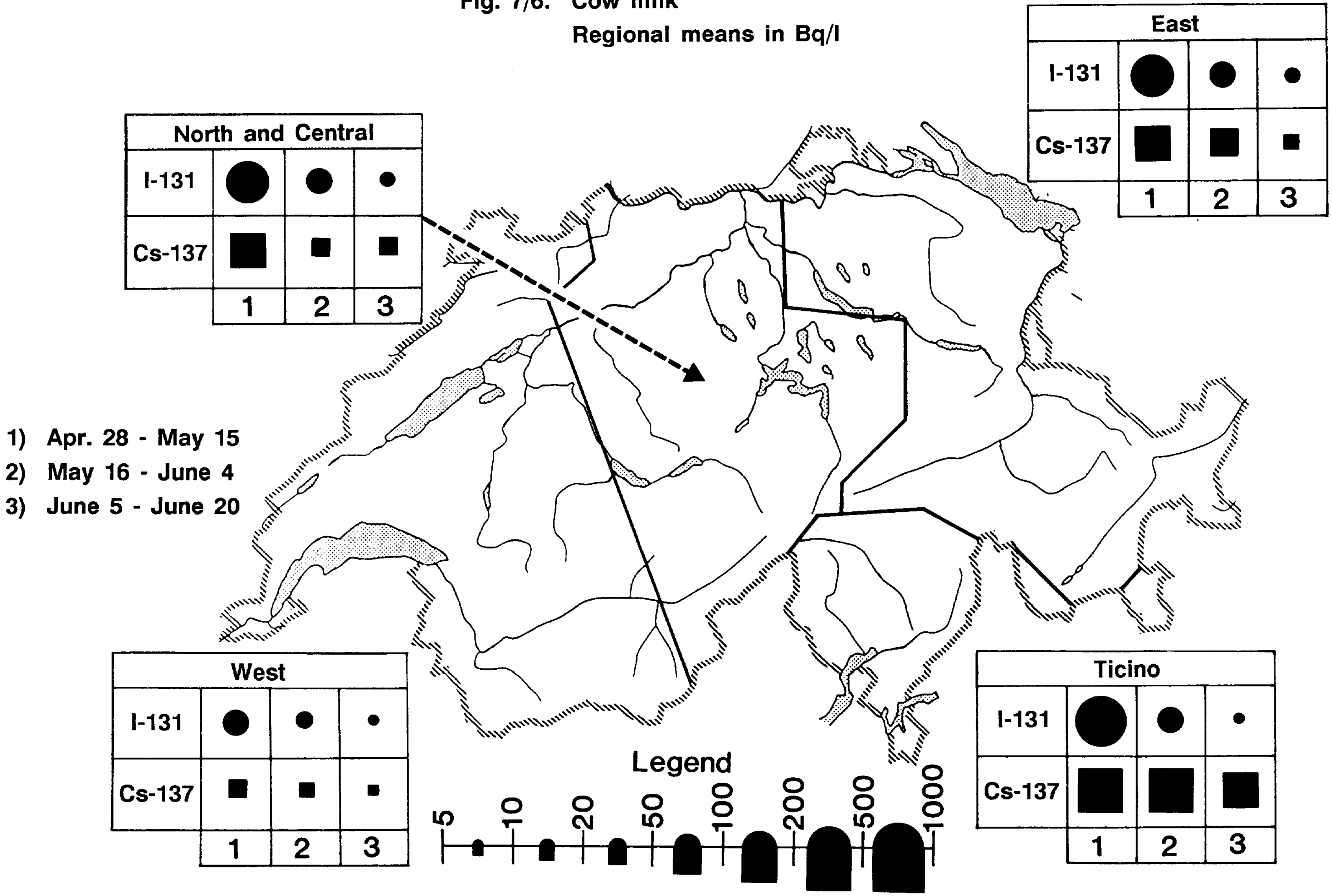


Fig. 7/5: **Integral local dose (net values)**
April 28 to June 20
Regional means in µSv (background in parentheses)

Fig. 7/6: Cow milk
Regional means in Bq/l



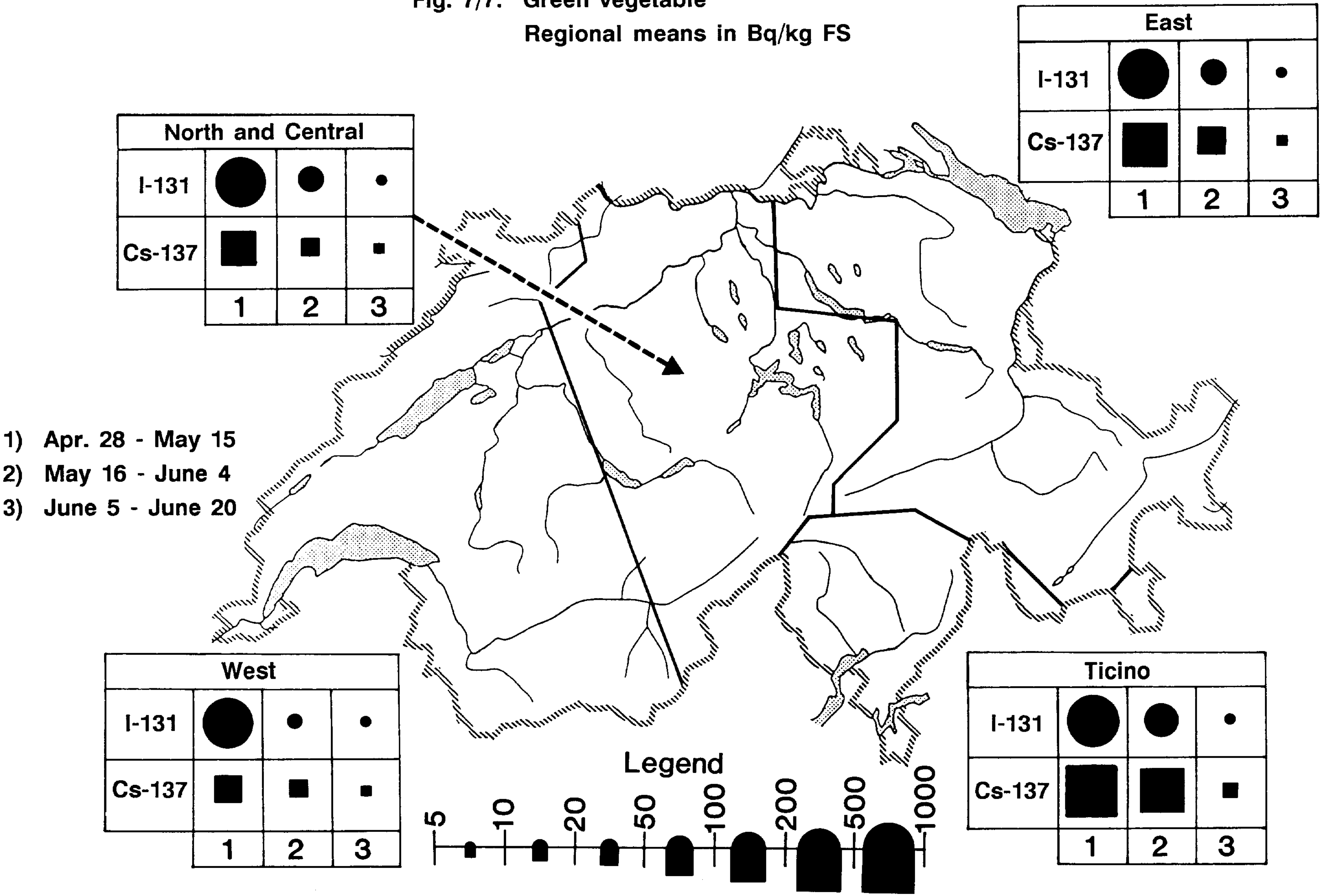
also examined. Goat's and sheep's milk as well as the soft fresh cheeses produced from it were also specially monitored since iodine is concentrated even more in the milk from these animals than in cow's milk. There were special sampling programmes dealing with milk products and the transfer of iodine and caesium into these foods (e. g. cheese, butter, etc.).

For I-131 the activity in milk shows a peak after a few days and then drops with an effective half-life of 4 -5 days. With Cs-137 the rise happens more slowly, the (flatter) peak is reached after approximately ten days and the activity drops subsequently with an effective half-life of 10 - 15 days. With milk, too, it is shown clearly that the canton of Ticino had the highest values and in fact more pronounced for Cs-137 than for iodine-131. In Ticino I-131 and Cs-137 reached maximum values of approximately 2,000 and 600 Bq/litre respectively, in north and east Switzerland 1,300 and 260 Bq/litre respectively and in the rest of Switzerland approximately 500 and 200 Bq/litre respectively. At the beginning of May the activity values for both nuclides in collective milk samples were below 350 Bq/litre in Ticino and 260 Bq/litre in the rest of Switzerland. In the first half of May sheep's milk produced a mean value for I-131 of 3,500 Bq/litre reaching a peak of 18,000 Bq/litre. For goat's milk the values are somewhat lower.

7.5 GREEN VEGETABLES (see fig. 7/7)

The contamination of green vegetables happened almost exclusively via deposition from the air. This is why large-leafed vegetables such as lettuce, spinach and cos were most heavily contaminated. However, this only applies to outdoor vegetables; plants raised under plastic cover showed lower activity values as a rule. Here again the most heavily affected regions were Ticino, north and east Switzerland, the Cs-137 activity in Ticino being almost as high as that of iodine-131, whereas in the rest of Switzerland it amounted to 25 - 50 % of the iodine activity. The change in time is characterised by the fact that the values of vegetables harvested in the second half of the month were clearly lower; this is, on the one hand, because the second harvest was no longer being contaminated by radioactive precipitations and, on the other, because the soil is turned over which means that subsequent vegetables no longer come into contact with the contaminated soil.

Fig. 7/7: Green vegetable
Regional means in Bq/kg FS



Peak values in green vegetables for I-131 and Cs-137 in the first half of May were 4,500 Bq/kg fresh weight (washed) for each nuclide in Ticino, 13,000 and 4,500 Bq/kg respectively in north and east Switzerland and 4,500 and 750 Bq/kg respectively in west Switzerland.

7.6 GRASS AND SOIL (see figs. 7/8 and 7/9)

As the first link of the exposure pathway grass-cow-milk-man contaminated directly by radioactive precipitation, grass was examined right from the start. Individual samples showed very wide differences depending on the age of the grass and vegetation density. It was also found that grass from the second cut was less contaminated. The maximum values for fresh grass were 9,000 Bq/kg fresh weight for both I-131 and for Cs-137.

Soil samples in Ticino yielded maximum values of 3,300 Bq/kg for Cs-137. Further studies to determine penetration depth and speed for the individual radionuclides into the soil are being carried out; the same applies to studying the connection between activity content of the soil and external radiation exposure.

7.7 MEAT (see figs. 7/10 and 7/11)

When cattle is fed on radioactively contaminated fodder (grass, hay, water, milk (sucking calves)), then the meat provided by these animals is also contaminated. The two most important nuclides were Cs-134 and Cs-137. Their physical half-lives are 2 and 30 years respectively; they are deposited primarily in muscular tissue and are excreted by the living animal through metabolism with a half-life of a few weeks or months.

In beef and veal the maximum Cs-137 concentrations measured were 2,600 (Ticino), 100 (west Switzerland) and 370 Bq/kg (rest of Switzerland). It can be seen that the longer term trend is for these values to drop.

Sheep, goats, rabbits and game, particularly those from Ticino, showed higher values. North of the Alps the Cs-137 values for these samples were below 1,500 Bq/kg, the regional average being below 370 Bq/kg. In Ticino the

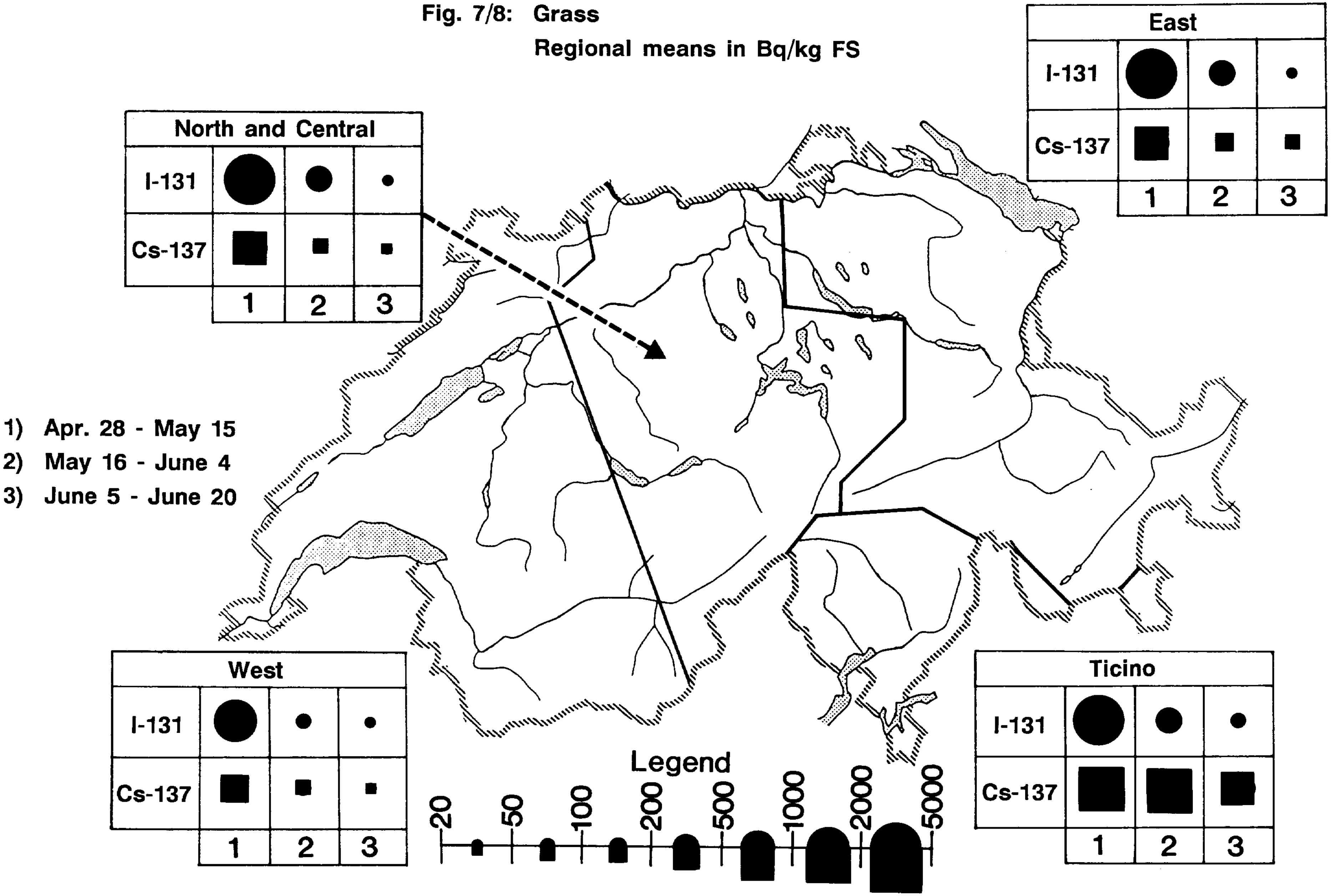


Fig. 7/8: Grass
Regional means in Bq/kg FS

Fig. 7/9: Soil
Regional means in Bq/kg FS

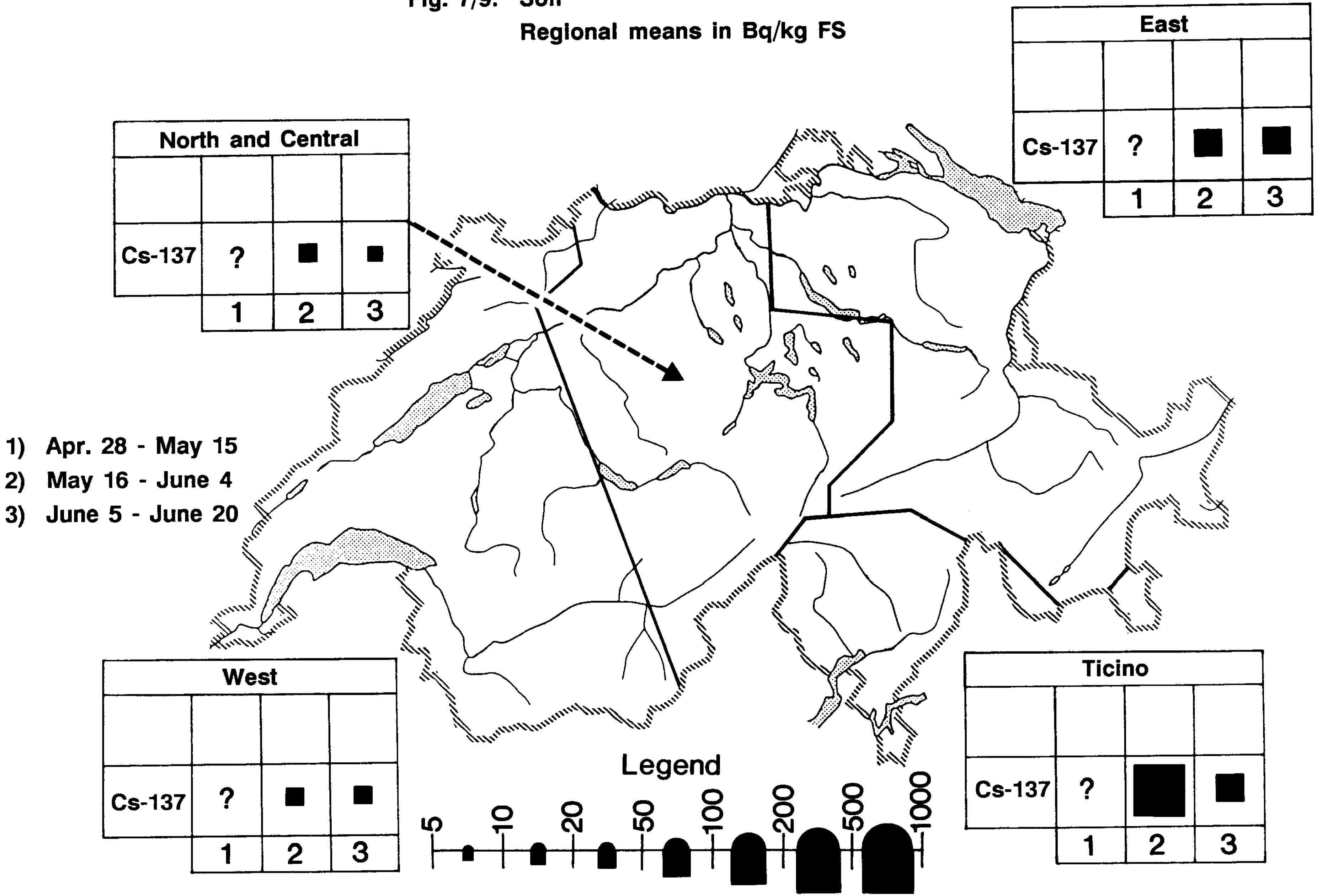


Fig. 7/10: Beef and veal
Regional means in Bq/kg

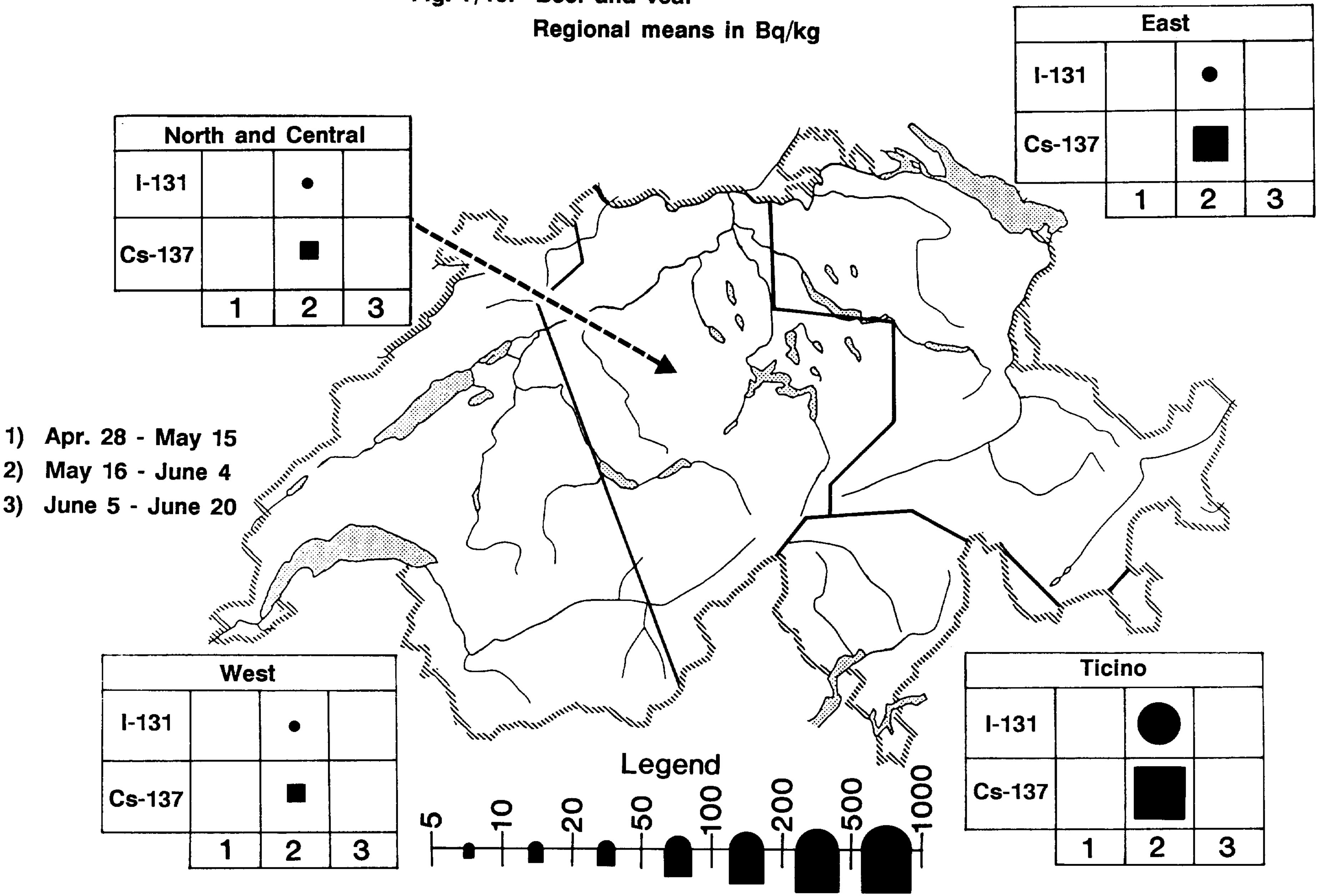
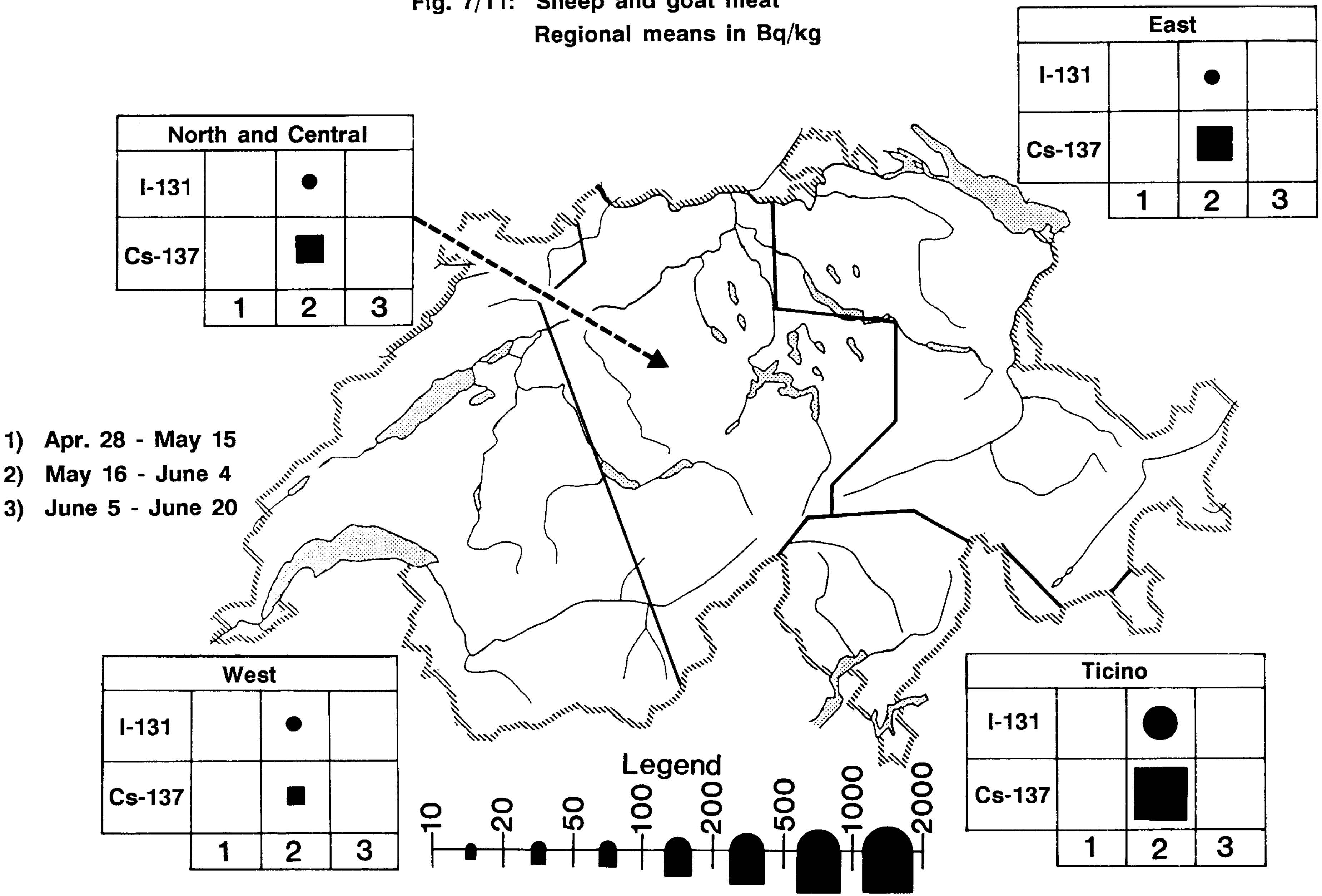


Fig. 7/11: Sheep and goat meat
Regional means in Bq/kg



Cs-137 values for the first half of May were on average 1,900 Bq/kg with a peak at 4,500 Bq/kg. Here again the trend for values to drop to about half within one month is found so that at the time of the large sheep auctions in September concentrations in Cs-137 in lamb and mutton will have dropped to values which should give no cause for concern.

The same also applies to game where the Cs-137 content also reduces to about half within one month so that the hunting season in autumn can be opened without restrictions.

7.8 OTHER FOODSTUFFS

Spring and ground water did not show any increased activity. In the case of rain water collected in tanks which is used as drinking water in the Jura region in some places, all values for iodine-131 were below 370 Bq/l most of them below 4 Bq/l.

In the period from May to July fish from rivers and lakes was found to have Cs-137 concentrations of up to 500 Bq/kg north of the Alps, averages of 190 Bq/kg (Ticino) and 110 Bq/kg (rest of Switzerland), whereas Lake Constance also had values up to 500 Bq/kg. In the months of August and September lakes in Ticino (Lake Lugano) showed increased values of up to 2,800 Bq/kg (average approximately 1,400 Bq/kg) which prompted the Executive Federal Council to prohibit fishing in this lake. Further studies are being carried out because there is not yet any clear tendency for these values to drop.

Samples of fungi, honey, fruit, berries etc. as well as numerous imported finished products and raw materials were examined. With the exception of edible fungi they showed only slightly increased activity concentrations which were considered safe for consumption (see table 7/1).

Type of samples	Origin of samples	Number of samples	Cs-137 in Bq/kg	s in %
Honey	Northern slope of the Alps	16	22	65
Honey	Ticino	27	63	67
Fruit	Northern slope of the Alps	22	5	60
Berries	Northern slope of the Alps	28	19	120
Currant	Northern slope of the Alps	6	63	35
Potatoes	Switzerland, total	8	~ 2	100
Carrots	Switzerland, total	13	< 4	-
Onions	Switzerland, total	5	< 10	-
Tomatoes	Switzerland, total	7	< 3	-
Mushrooms	Northern slope of the Alps	106	300	70 % of values below 200 Bq/kg
Mushrooms	Ticino	72	450	55 % of values below 200 Bq/kg
Cereals	Northern slope of the Alps	13	15	210
Cereals	Ticino	21	160	33

Table 7/1: Specific Cs-137 activity in various food items
Sampling period: June - September 1986

8. DOSE ESTIMATES

Dose estimates for the Federal Republic of Germany are contained in the report by the Institute for Radiation Protection "Environmental Radioactivity and Radiation Exposure in Southern Bavaria Due to the Accident at Chernobyl", GSF report 16/86 and for Switzerland in the paper "Situation of the Radioactive Contamination in Switzerland After the Accident at Chernobyl", Federal Health Office, Berne, September 1986. A summary of the results of the dose estimates is shown in table 8/1.

Radiation exposure	Effective dose equivalent in mSv			
	Children (up to 10 years age)		Adults	
	Munich[1]	Ticino[2]	Munich[1]	Ticino[2]
External gamma radiation	0.3-0.6	0.4	0.1-0.3	0.4
Inhalation and ingestion	0.4-1.0	1.0	0.4-0.8	1.1
Total	0.7-1.6	1.4	0.5-1.1	1.5

Table 8/1: Effective dose equivalents to be expected in the most heavily affected areas of the Federal Republic and Switzerland

[1]) calculated for the period May 1986 - April 1987

[2]) calculated for the period May 1986 - end of 1986

The dose values given in table 8/1 for children up to ten years old and for adults apply to the most heavily affected areas of the Federal Republic and Switzerland. The dose values are the effective dose equivalents to be expected which were calculated making conservative assumptions (e. g. unchanged consumption patterns in the population and all foodstuffs of local origin).

The ranges of variation given in table 8/1 under Munich for the dose values apply on average for southern Bavaria and south eastern Baden-Württemberg. The dose values given under Ticino are estimates for the most heavily affected areas in Switzerland which include mainly Ticino, the southern valleys of the Grison and parts of east Switzerland. The mean values for the population of the entire country are estimated to be about 10 times lower than the values for the Ticino. The dose estimates for the Ticino region have been confirmed as most conservative by body counter measurements of farmers from this region.

When comparing the dose values for the Munich area and Ticino it should be noted that the calculations for Munich were made to cover the first year following the accident, i. e. up until the end of April, 1987 whereas for Ticino they only went up to the end of the year 1986. Since the estimates for Switzerland do not take into account the first four months of the year 1987, the values for Ticino should be increased by approximately 10 % in order to have a direct comparison with the values for Munich.

Except for regional differences, the Federal Republic of Germany shows a general drop in radiation exposure from south to north. In the GSF report mentioned above, the following statement is made with regard to this: "measurements available from other regions in the Federal Republic of Germany point to the fact that there is a range of variation in radiation exposure due to this accident which it is assumed lies between 0.1 times and twice the value for the Munich area".

Measured results available now indicate that the mean value of the effective dose equivalent which can be calculated for the population of the Federal Republic of Germany should lie below the lower dose value given for the Munich area in table 8/1. When calculations of the effective dose equivalent are based on incorporation measurements, then one obtains results for the actual radiation exposure of the population which are even lower still by a noticeable degree.

9. APPENDIX

Figure 9/1 contains the accurate figures on which the graphic representation of the nuclide spectra for air and precipitation in figure 3/1 is based.

The computer printouts following this (tables 9/2 - 9/10) contain the mean values which are the basis for the synoptical representations in chapters 6 and 7, their percentage standard deviations (s) and the number of samples used in each case. In line with the graphic representation, all data have been listet separately for the federal states and regions and also for the different time intervals.

The data supplier code numbers given in the last column refer to the institutions which are listed on pages II and III after the foreword.

Nuclide	Time integrated activity concentration in air close to the ground between 11:30 a.m. on April 29 and 8:10 a.m. on May 8, 1986 Bq h/m³	Cumulated radionuclide deposition on the ground by precipitation between 9:00 a.m. on April 29 and 8:30 a.m. on May 9, 1986 Bq/m²
Mn-54	0.4	30
Sr-89	-	2,200 *
Sr-90	-	210 *
Zr-95	0.7	-
Mo-99	108	9,600
Ru-103	364	27,000
Ru-106	90	6,900
Ag-110^{m}	5.6	400
Sb-125	10.6	1,000
Te-129^{m}	362	30,000
I-131 (total)	1,730	92,000
Te-132	1,440	123,000
I-133 (total)	46	3,700
Cs-134	160	10,400
Cs-136	62	4,200
Cs-137	296	19,000
Ba-140	152	12,000
La-140	134	-
Ce-141	6.5	700
Ce-144	4.9	400
Pu-238	-	18×10^{-3}
Pu-239/240	-	47×10^{-3}

* April 29 - May 2, 1986

Table 9/1: Nuclide spectra measured by Gesellschaft für Strahlen- und Umweltforschung mbH, Munich/Neuherberg

Federal state or region	Mean value in µSv	Number of measuring locations	Data supplier code numbers
Bavaria-South	306	1	7
Bavaria-North	51	13	14
Baden-Württemberg I	170	30	17
Baden-Württemberg II	40	90	17
Saarland	28	1	15
Rhineland-Palatinate	21	4	15
Hesse	22	1	21
North Rhine-Westphalia	24	2	11, 20
Lower Saxony-East	40	6	18, 19, 20
Lower Saxony-West	-	-	-
Schleswig-Holstein	11	4	5, 13, 20
Berlin-West	33	1	8
Ticino	250	stationary TLD- measuring locations and cross-country measurement trips	25, 27, 28, 31, 32, 35, 38
Switzerland-East	150		
Switzerland-North and Central	80		
Switzerland-West	60		

Table 9/2: Net local doses for the period April 28 until June 20, 1986

Federal state or region	I-131 (Aerosol)			Cs-137			Data supplier code numbers
	Mean value in Bq·h/m³	Number of locations	Number of samples	Mean value in Bq·h/m³	Number of locations	Number of samples	
Bavaria-South	700	3	33	390	3	33	4
Bavaria-North	480	4	30	230	4	30	4, 14
Baden-Württemberg I	650	1	8	230	1	8	16
Baden-Württemberg II	350	11	137	140	11	137	4, 6, 12, 16
Saarland	150	2	34	120	2	34	15
Rhineland-Palatinate	180	5	33	110	5	33	4, 15
Hesse	150	2	15	70	2	15	4
North Rhine-Westphalia	140	4	30	70	3	29	4, 11, 20
Lower Saxony-East	70	5	26	21	3	24	4, 19, 20
Lower Saxony-West	40	1	7	20	1	7	4
Schleswig-Holstein	80	8	76	24	4	54	4, 5, 13, 20, 22
Berlin-West	200	2	34	70	2	34	4, 8
Ticino	200	1	8	100	1	8	31
Switzerland-East	180	2	15	80	2	15	31
Switzerland-North and Central	170	4	23	110	4	23	31
Switzerland-West	170	3	27	70	3	27	31, 38

Table 9/3: Time integrated activity concentration in the air for the peroid from April 28 until May 8, 1986

Federal state or region	April 28 - May 15, 1986			May 16 - June 4, 1986			June 5 - June 20, 1986			Data supplier code numbers
	Mean value in Bq/kg	s in %	Number of samples	Mean value in Bq/kg	s in %	Number of samples	Mean value in Bq/kg	s in %	Number of samples	
Bavaria-South	6300	80	15	450	80	7	-	-	-	7
Bavaria-North	2740	100	39	280	120	32	35	300	17	14
Baden-Württemberg I	4700	70	23	640	65	8	-	-	-	16
Baden-Württemberg II	1900	100	101	290	70	38	20	20	7	6, 12, 16
Saarland	2100	90	16	-	-	-	-	-	-	15
Rhineland-Palatinate	1220	110	69	200	60	13	0	-	1	15
Hesse	2700	80	316	-	-	-	-	-	-	9
North Rhine-Westphalia	670	55	10	140	65	12	3	200	5	11
Lower Saxony-East	970	60	57	90	60	56	4	30	10	18, 19, 20
Lower Saxony-West	510	30	8	50	30	18	3	30	6	18
Schleswig-Holstein	570	100	66	90	60	42	5	80	3	5, 13, 20
Berlin-West	1990	90	12	-	-	-	-	-	-	10
Ticino	2600	77	31	440	92	75	≤74	-	38	27, 28, 29, 30, 31 32, 33, 34, 36, 38
Switzerland-East	2400	86	52	200	113	32	≤37	-	6	
Switzerland-North and Central	2700	76	71	440	117	38	≤37	-	32	
Switzerland-West	1700	85	56	85	118	18	≤37	-	12	

Table 9/4: Specific I-131 activity in grass

Federal state or region	April 28 - May 15, 1986 Mean value in Bq/kg	s in %	Number of samples	May 16 - June 4, 1986 Mean value in Bq/kg	s in %	Number of samples	June 5 - June 20, 1986 Mean value in Bq/kg	s in %	Number of samples	Data supplier code numbers
Bavaria-South	2400	40	15	670	35	7	-	-	-	7
Bavaria-North	1070	90	39	310	120	32	220	250	17	14
Baden-Württemberg I	1800	80	23	430	90	8	-	-	-	16
Baden-Württemberg II	450	100	101	150	80	38	110	50	7	6, 12, 16
Saarland	600	70	16	-	-	-	-	-	-	15
Rhineland-Palatinate	430	60	69	230	40	13	30	-	1	15
Hesse	700	70	291	-	-	-	-	-	-	9
North Rhine-Westphalia	150	27	10	80	50	12	20	90	5	11
Lower Saxony-East	370	60	57	180	60	56	60	20	10	18, 19, 20
Lower Saxony-West	300	20	8	100	20	18	26	20	6	18
Schleswig-Holstein	190	80	66	70	70	42	26	40	3	5, 13, 20
Berlin-West	-	-	-	-	-	-	-	-	-	-
Ticino	1900	59	25	1200	91	85	590	113	38	
Switzerland-East	930	100	44	110	113	41	70	120	6	27, 28, 29, 30, 31
Switzerland-North and Central	850	87	56	180	78	41	36	85	32	32, 33, 34, 36, 38
Switzerland-West	370	79	43	67	89	21	37	90	12	

Table 9/5: Specific Cs-137 activity in grass

Federal state or region	Mean value Bq/kg (FS)	s in %	Number of samples	Data supplier code numbers
Bavaria-South	320	100	43	2, 14
Bavaria-North	80	100	46	2, 14
Baden-Württemberg I	210	80	33	16
Baden-Württemberg II	60	55	137	6, 12, 16
Saarland	-	-	-	-
Rhineland-Palatinate	40	50	12	15
Hesse	-	-	-	-
North Rhine-Westphalia	30	60	28	11
Lower Saxony-East	60	50	99	18, 19, 20
Lower Saxony-West	80	50	36	18
Schleswig-Holstein	21	40	66	5, 13, 20
Berlin-West	-	-	-	-
Ticino	300	100	17	31
Switzerland-East	70	90	16	31
Switzerland-North and Central	20	90	12	31
Switzerland-West	30	100	9	31, 38

Table 9/6: Specific Cs-137 activity in the soil
layer depth: 0 - 5 cm, sampling period: May and June, 1986

Federal state or region	April 28 - May 15, 1986			May 16 - June 4, 1986			June 5 - June 20, 1986			Data supplier code numbers
	Mean value in Bq/l	s in %	Number of samples	Mean value in Bq/l	s in %	Number of samples	Mean value in Bq/l	s in %	Number of samples	
Bavaria-South	280	65	89	-	-	-	-	-	-	2
Bavaria-North	160	110	49	19	60	8	3	-	1	2, 14
Baden-Württemberg I	205	50	40	50	40	34	6	40	20	17
Baden-Württemberg II	40	50	130	24	60	124	2	60	43	6, 12, 17
Saarland	45	150	58	-	-	-	-	-	-	23
Rhineland-Palatinate	30	55	138	14	35	129	0	-	19	15
Hesse	30	40	664	-	-	-	-	-	-	9
North Rhine-Westphalia	25	130	631	8	160	279	0	-	19	11, 20, 24
Lower Saxony-East	21	90	24	6	85	17	2	-	1	13, 20
Lower Saxony-West	-	-	-	-	-	-	-	-	-	-
Schleswig-Holstein	12	120	169	9	80	162	0	-	3	5, 13, 20, 22
Berlin-West	75	55	23	24	45	20	-	-	-	10
Ticino	640	56	52	89	92	67	10	100	40	
Switzerland-East	460	44	112	63	35	24	$\leq$14	-	16	27, 28, 29, 30, 31,
Switzerland-North and Central	390	75	115	67	111	33	$\leq$14	-	20	32, 33, 34, 36, 37, 38
Switzerland-West	120	50	59	24	154	72	1	50	18	

Table 9/7: I-131 activity concentration in cow milk

Federal state or region	April 28 - May 15, 1986			May 16 - June 4, 1986			June 5 - June 20, 1986			Data supplier code numbers
	Mean value in Bq/l	s in %	Number of samples	Mean value in Bq/l	s in %	Number of samples	Mean value in Bq/l	s in %	Number of samples	
Bavaria-South	-	-	-	-	-	-	-	-	-	-
Bavaria-North	-	-	-	32	60	8	8	-	1	14
Baden-Württemberg I	105	50	40	80	40	34	38	40	20	17
Baden-Württemberg II	6	40	128	15	50	119	8	80	43	6, 12, 17
Saarland	-	-	-	-	-	-	-	-	-	-
Rhineland-Palatinate	8	80	138	13	50	129	9	15	19	15
Hesse	32	40	11	18	30	20	11	20	3	9
North Rhine-Westphalia	6	210	631	8	170	279	5	100	38	11, 20, 24
Lower Saxony-East	10	80	24	19	40	17	18	-	1	13, 20
Lower Saxony-West	-	-	-	-	-	-	-	-	-	-
Schleswig-Holstein	6	110	169	26	60	162	8	40	3	5, 13, 20, 22
Berlin-West	32	40	17	32	25	20	-	-	-	10
Ticino	450	34	52	330	33	67	170	55	40	27, 28, 29, 30, 31, 32, 33, 34, 36, 37, 38
Switzerland-East	130	40	112	74	50	24	19	60	16	
Switzerland-North and Central	110	43	115	48	62	33	19	60	20	
Switzerland-West	30	25	59	17	43	72	6	59	18	

Table 9/8: Cs-137 activity concentration in cow milk

Federal state or region	April 28 - May 15, 1986			May 16 - June 4, 1986			June 5 - June 20, 1986			Data supplier code numbers
	Mean value in Bq/kg	s in %	Number of samples	Mean value in Bq/kg	s in %	Number of samples	Mean value in Bq/kg	s in %	Number of samples	
Bavaria-South	-	-	-	-	-	-	-	-	-	-
Bavaria-North	-	-	-	-	-	-	-	-	-	-
Baden-Württemberg I	1850	50	48	150	80	20	-	-	-	17
Baden-Württemberg II	870	50	136	100	50	79	4	80	10	17
Saarland	-	-	-	-	-	-	-	-	-	-
Rhineland-Palatinate	430	90	97	35	100	13	0	-	10	15
Hesse	-	-	-	-	-	-	-	-	-	-
North Rhine-Westphalia	1120	76	37	11	100	2	-	-	-	11
Lower Saxony-East	-	-	-	-	-	-	-	-	-	-
Lower Saxony-West	-	-	-	-	-	-	-	-	-	-
Schleswig-Holstein	-	-	-	-	-	-	-	-	-	-
Berlin-West	-	-	-	-	-	-	-	-	-	-
Ticino	930	112	125	170	124	20	-	-	-	
Switzerland-East	1000	184	289	85	294	92	-	-	-	27, 28, 29, 30,
Switzerland-North and Central	520	130	135	70	168	29	-	-	-	31, 32, 33, 34, 36
Switzerland-West	630	140	34	15	153	21	-	-	-	

Table 9/9: Specific I-131 activity in green vegetable

Federal state or region	April 28 - May 15, 1986 Mean value in Bq/kg	s in %	Number of samples	May 16 - June 4, 1986 Mean value in Bq/kg	s in %	Number of samples	June 5 - June 20, 1986 Mean value in Bq/kg	s in %	Number of samples	Data supplier code numbers
Bavaria-South	-	-	-	-	-	-	-	-	-	-
Bavaria-North	-	-	-	-	-	-	-	-	-	-
Baden-Württemberg I	420	60	48	60	60	20	-	-	-	17
Baden-Württemberg II	200	50	136	40	50	79	6	80	10	17
Saarland	-	-	-	-	-	-	-	-	-	-
Rhineland-Palatinate	80	100	97	6	110	13	0	-	10	15
Hesse	-	-	-	-	-	-	-	-	-	-
North Rhine-Westphalia	140	80	37	10	100	2	-	-	-	11
Lower Saxony-East	-	-	-	-	-	-	-	-	-	-
Lower Saxony-West	-	-	-	-	-	-	-	-	-	-
Schleswig-Holstein	-	-	-	-	-	-	-	-	-	-
Berlin-West	-	-	-	-	-	-	-	-	-	-
Ticino	810	164	117	250	146	20	11	100	26	27, 28, 29, 30, 31, 32, 33, 34, 36
Switzerland-East	220	210	267	81	397	98	10	285	64	
Switzerland-North and Central	130	156	129	41	183	26	9	236	18	
Switzerland-West	81	164	35	10	146	21	5	69	12	

Table 9/10: Specific Cs-137 activity in green vegetable