Norwegian Experience after Chernobyl and our Focus on Radioactivity in the Environment

Malgorzata K. Sneve
Director, Regulatory Cooperation Programme
Norwegian Radiation Protection Authority

4rd International Symposium Decontamination of Radioactive Materials
10 July 2015 Edogawa Ward, Tokyo

Statens strålevern
Norwegian Radiation Protection Authority

www.nrpa.no

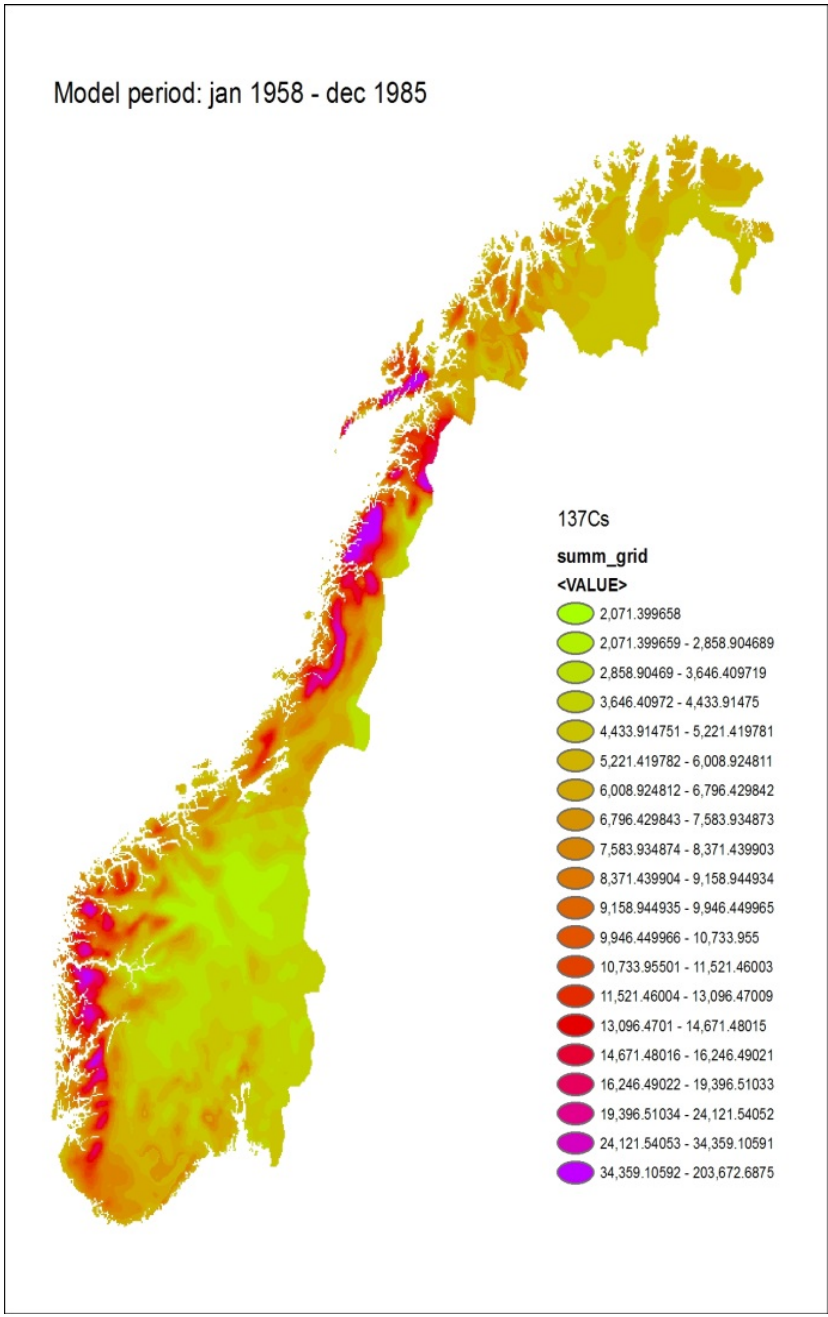
Prior to 1986

Before Chernobyl Accident, main source of radioactive contamination was global fallout due to atmospheric testing

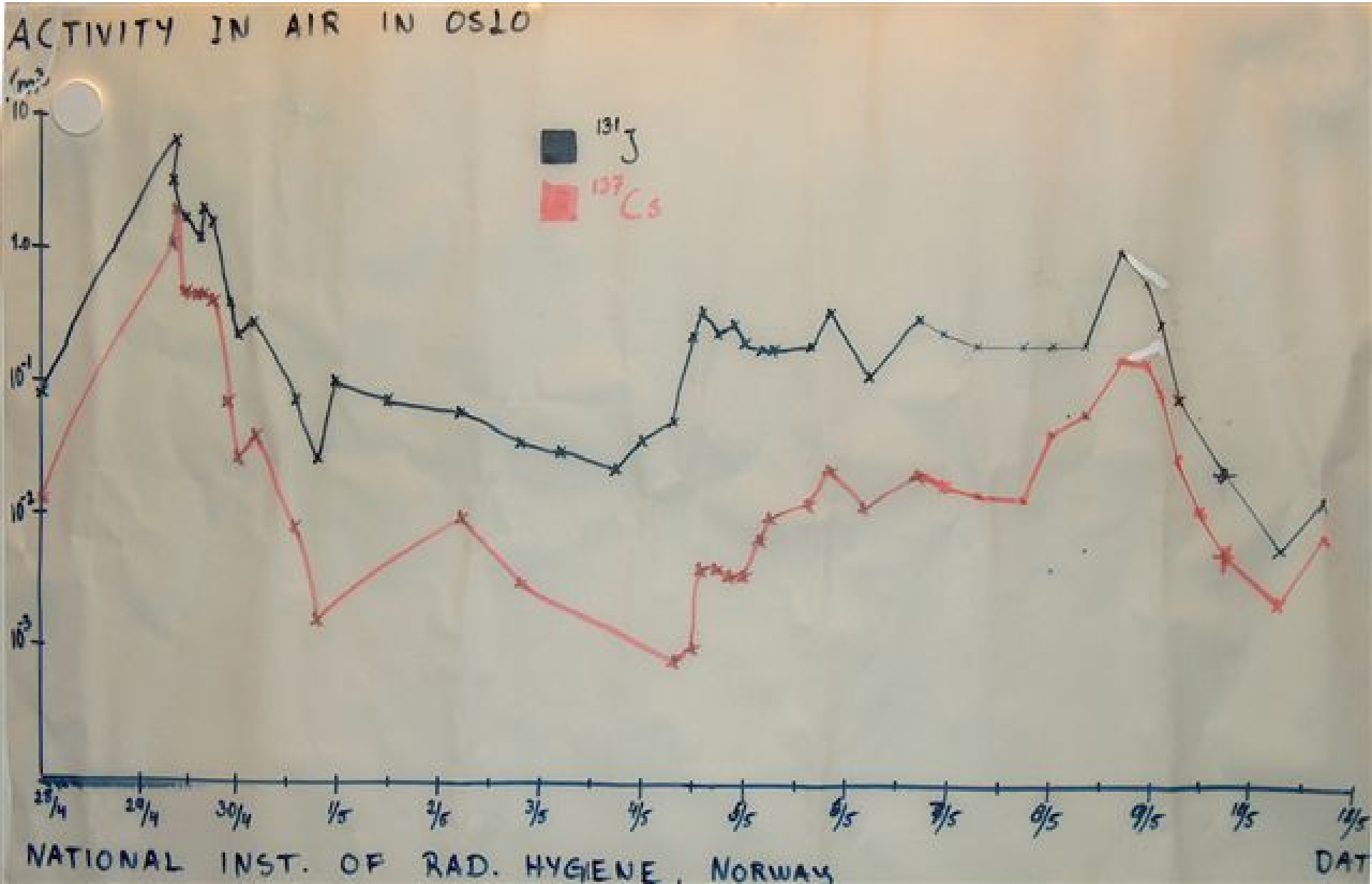
Areas of contamination were at coastal locations with precipitation patterns leading to elevated deposition of fallout.

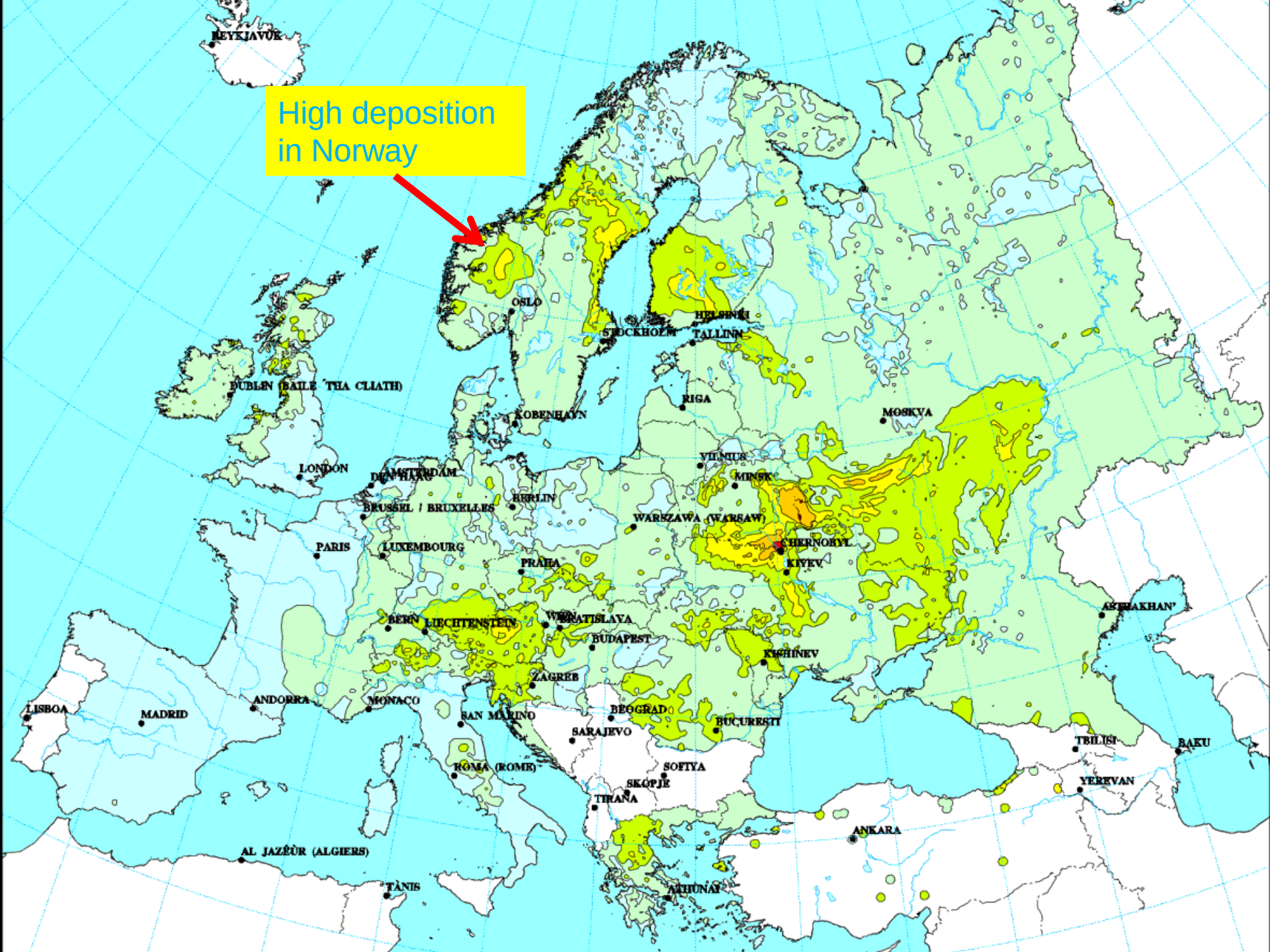
Before Chernobyl, Norway possessed only small scale network for measurement of deposited radioactivity

Emergency preparedness system was based upon ”cold war” understanding of radioactive contamination.



First indication: original graph from 1986!




High deposition
in Norway
REYKJAVÚK
OSLO
STOCKHOLM
HELSINKI
TALLINN
RIGA
MOSKVA
DUBLIN (BAILE ÁTHA CLIATH)
KOBENHAVN
LONDON
AMSTERDAM
BRUSSEL / BRUXELLES
BERLIN
VILNIUS
MINSK
WARSZAWA (WARSAW)
PARIS
LUXEMBOURG
PRAHA
CHERNOBYL
KIYEV
BERN
LIECHTENSTEIN
BRATISLAVA
BUDAPEST
KISHINEV
ZAGREB
LISBOA
MADRID
ANDORRA
MONACO
SAN MARINO
BEOGRAD
BUCURESTI
SARAJEVO
TBILISI
BAKU
ROMA (ROMR)
SOFIYA
SKOPJE
YEREVAN
TIRANA
ANKARA
AL JAZÊUR (ALGIERS)
TÀNIS
ATHINAI

Early phase

Immediately after the accident was a serous lack of information.

Information from the Soviet Union was not forthcoming and the relatively poor coverage of the radioactivity monitoring network hampered efforts.

Much confusion and uncertainty for the public, media generated significant concern as to levels of contamination and potential effects on the population.

Levels of deposition

A picture of contamination for Norway available by June 1986

Some ‘prefectures’ contamination up to 160 kBq/m^2 with hotspots of up to 500 kBq/m^2.

These areas experienced precipitation events in the days the contaminant cloud passed over Norway.

1986 Intervention levels

Established to ensure compliance with ICRP guidelines, and to maintain customers' confidence in the foods produced and released to the market

- Mid-May 1986: 1000 Bq/kg of ^{131}I, 300 Bq/kg ^{137}Cs
- **Revised mid-June** 1986: 370 Bq/kg (^{134}Cs + ^{137}Cs) in milk and baby-food, 600 Bq/kg for all other foodstuffs (in accordance with the EC)

Condemned meat in 1986:

- Mutton: 2,300 tons of mutton worth NOK 90-100 million (EUR 11-13 million)
- Reindeer: 545 tons of reindeer meat worth NOK 20 million (EUR ~2.5 million)
- Beef: ~20 tons

Maximum concentrations observed in 1986

- Sheep/lamb: 40,000 Bq/kg
- Reindeer: 150,000 Bq/kg
- Forest mushrooms: 1-2 MBq/kg
- Cow’s milk: 650 Bq/kg
- Goat’s milk: 2,900 Bq/kg

Early measures taken in 1986

Trade bans on:

- lettuce and parsley grown outdoors in central Norway in May and June (crops were ploughed in)
- milk from some farms producing animal feed
- wild freshwater fish from 33 municipalities

- In autumn: condemnation of lamb >2000 Bq/kg (3 %), clean feeding of sheep <2000 Bq/kg (27 %)
- In autumn: trade ban on reindeer from central and southern Norway
- No restrictions on forest and mountain grazing of sheep

Early conclusions

- Negligble ^{131}I problem as fallout arrived before the grazing season
- Negligble problems for products of ploughed land
- Significant problems regarding rough grazing
- Experience from the 1960’s showed that reindeer and the reindeer industry were very vulnerable to fallout
- Therefore expected continuing problems with reindeer prodcuts

The principal policy adopted was that producers should be economically unaffected for measures implemented by the authorities.

Specific problems

Some Norwegian agricultural practices led to high transfer of deposited radiocesium to animals:

- Traditional grazing of free-ranging cattle, sheep and goats on forest and mountain pastures during summer
- These unimproved pastures have high uptake of trace nutrients
- Mushrooms in autumn
- Reindeer: high intake and slow excretion on lichen diet

Decisions on longer term countermeasures

Additional measures to reduce contamination in milk of dairy animals, while avoiding long periods of clean feeding (labour intensive; problem of housing animals)

Countermeasures and methods developed with involvement of local authorities, farmer's and reindeer herder's unions, food industries etc. Direct contact between different people, from national scientists and experts to local people, was crucial for success of strategies

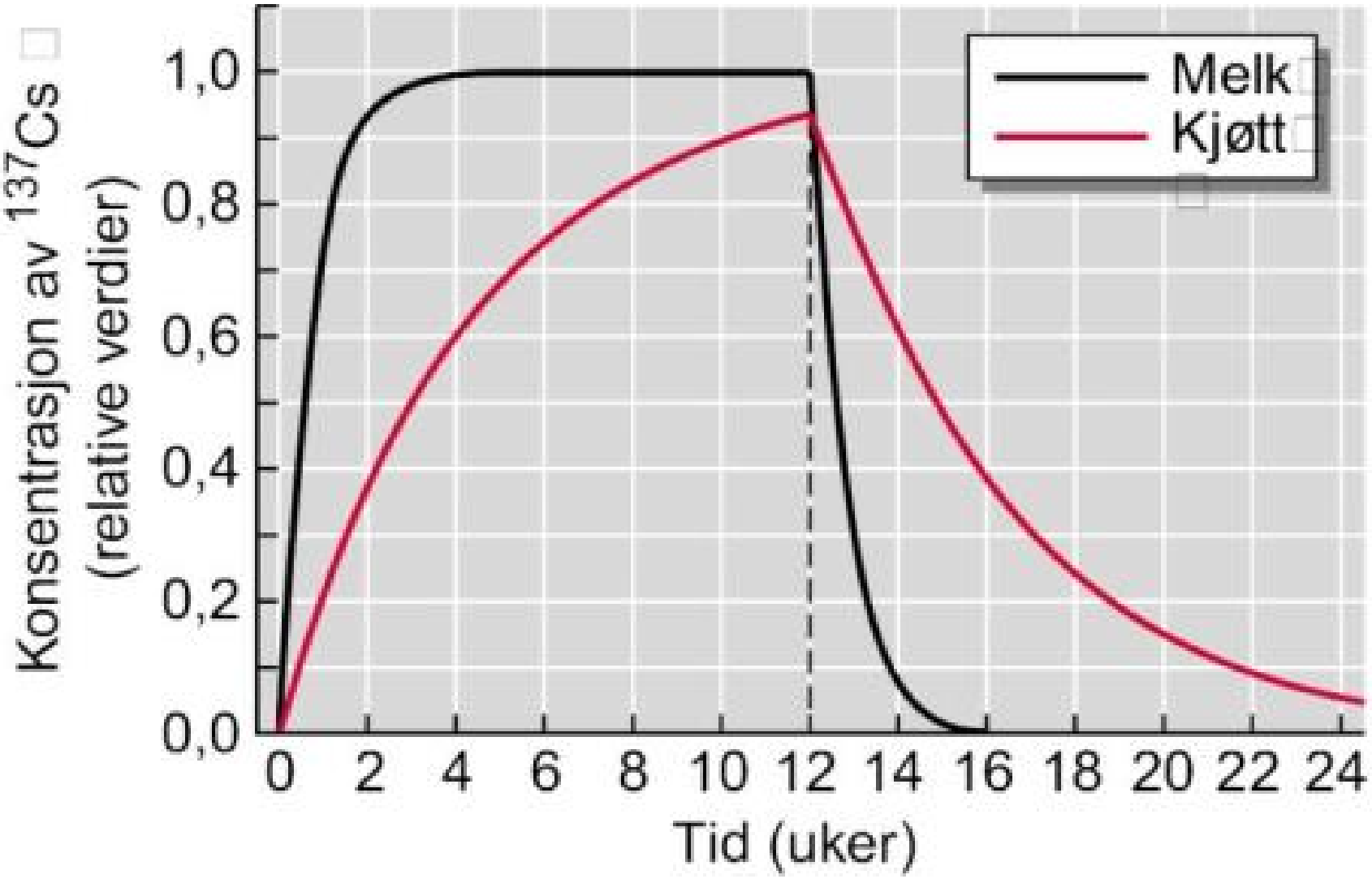
Cost/benefit analyses used to identify effective measures. Measures recommended if cost in person-Sv avoided is lower than the monetary value of a person-Sv.

Large scale condemnation of food, as made in 1986, not justified!

Countermeasures maintained in most affected areas

- Clean feeding procedure continued
- Caesium binders (at no cost for producers in contaminated areas):
  - Bentonite in concentrates (initially)
  - Giese salt (Prussian blue; in concentrates, salt-licks, rumen boli)
- Changing time of slaughter or changing grazing area

Effectiveness of clean feeding



Cost of countermeasures

During 1986 – 1995:

- Total costs approx. NOK 500 million (EUR 63 million) for sheep, reindeer and a smaller number of cattle and goats, incl. instruments and R&D
- Value of meat saved NOK 1,860 million (EUR 233 million)

Continued live animal monitoring

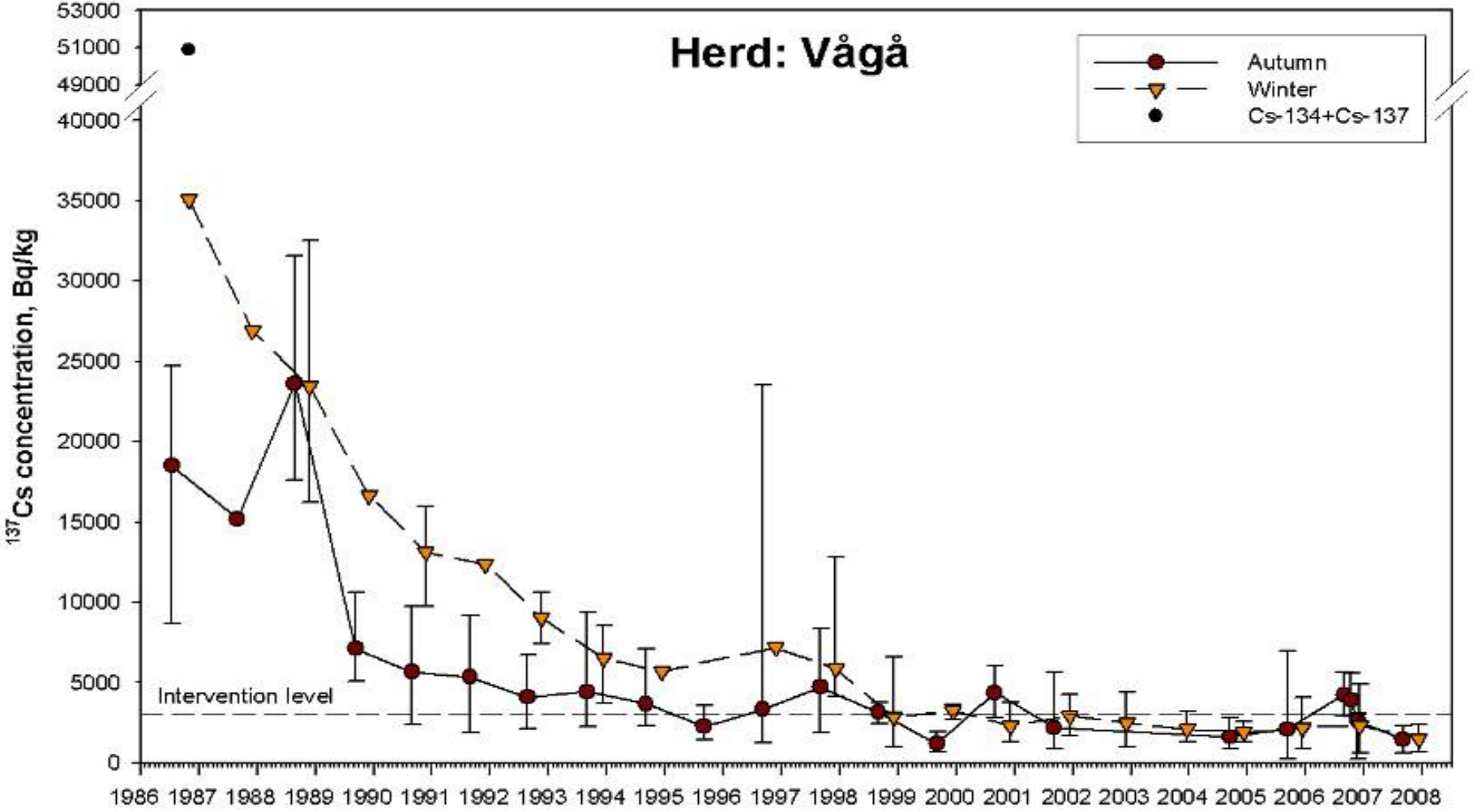
- Monitoring started on pasture (May or June) and continued until August or September
- Sampling and analyses performed by local food control stations
- High amounts of mushrooms on pastures were quickly reflected in the milk measurements

Objective: to give early warning about levels of radioactivity before the slaughter season in September

Cs-137 levels in meat in 2003

Meat 2003	Average Bq/kg	Maximum Bq/kg	Number of samples
Mutton			
intervention zones	246	1600	169
other zones	144	2450	1259
Beef			
intervention zones	27	288	171
other zones	21	613	314
Reindeer			
intervention zones	2120	3686	26
other zones	630	1992	92

^{137}Cs Concentrations in reindeer: Vågå district



Internal and external doses

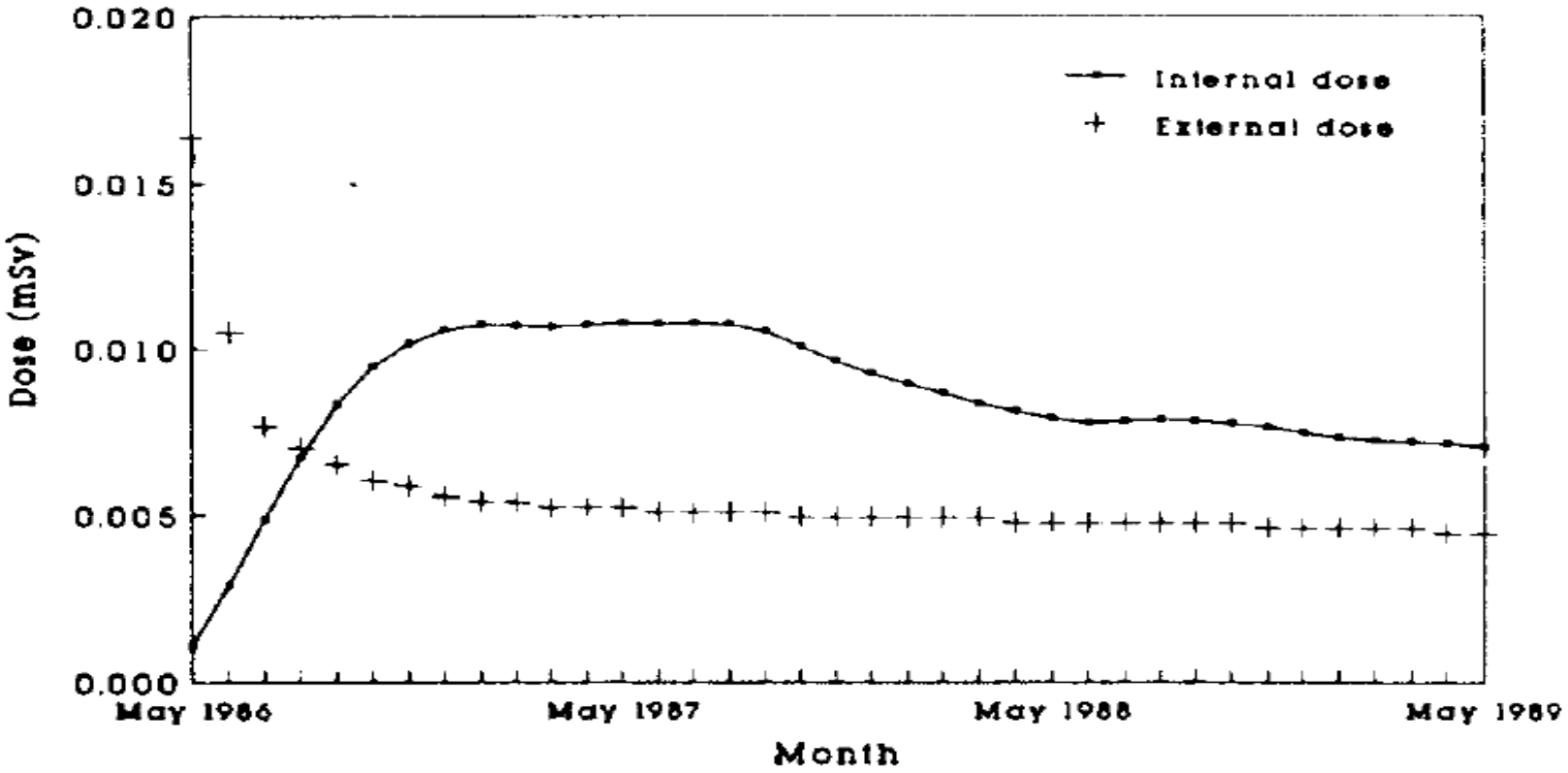
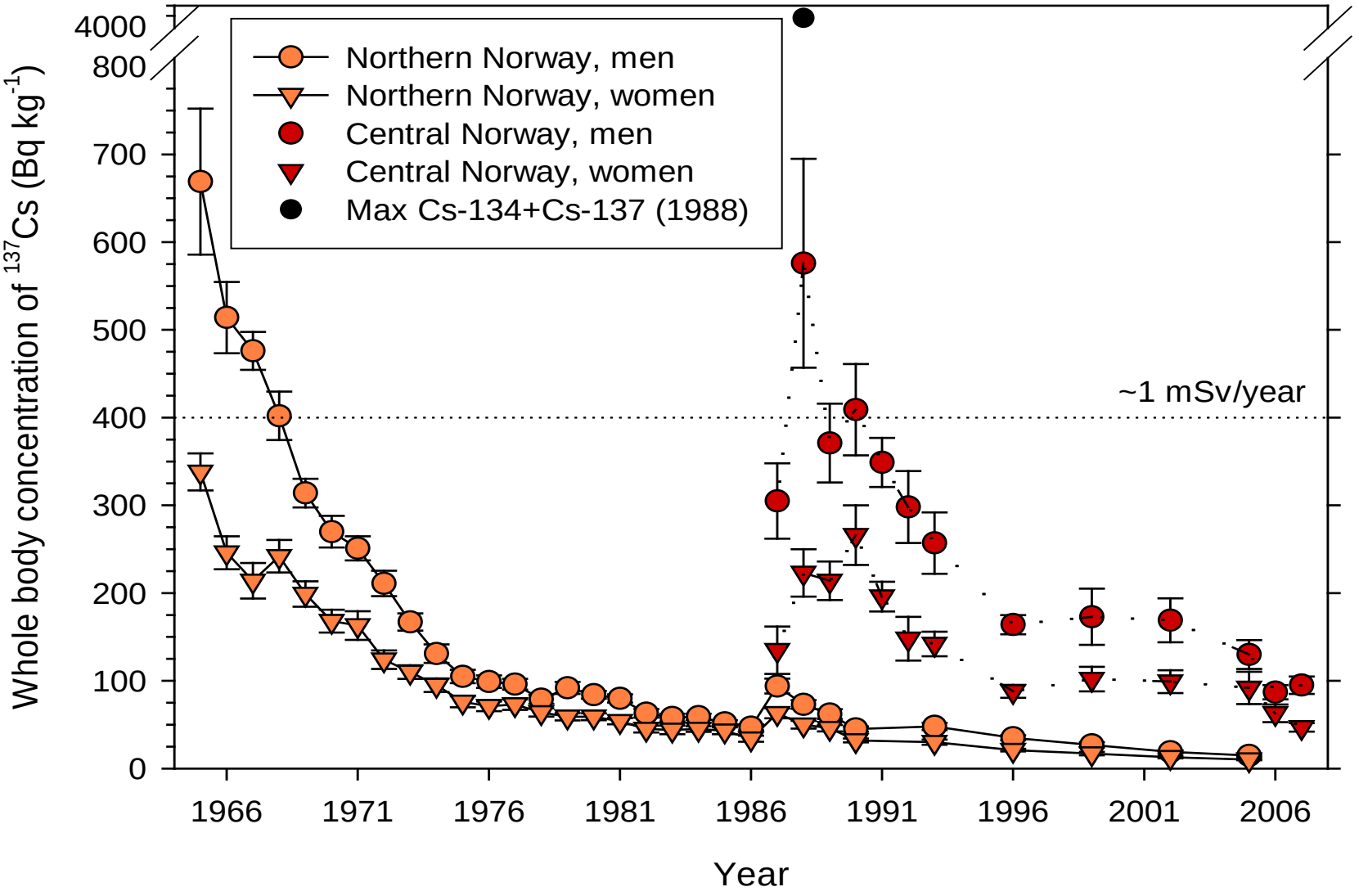


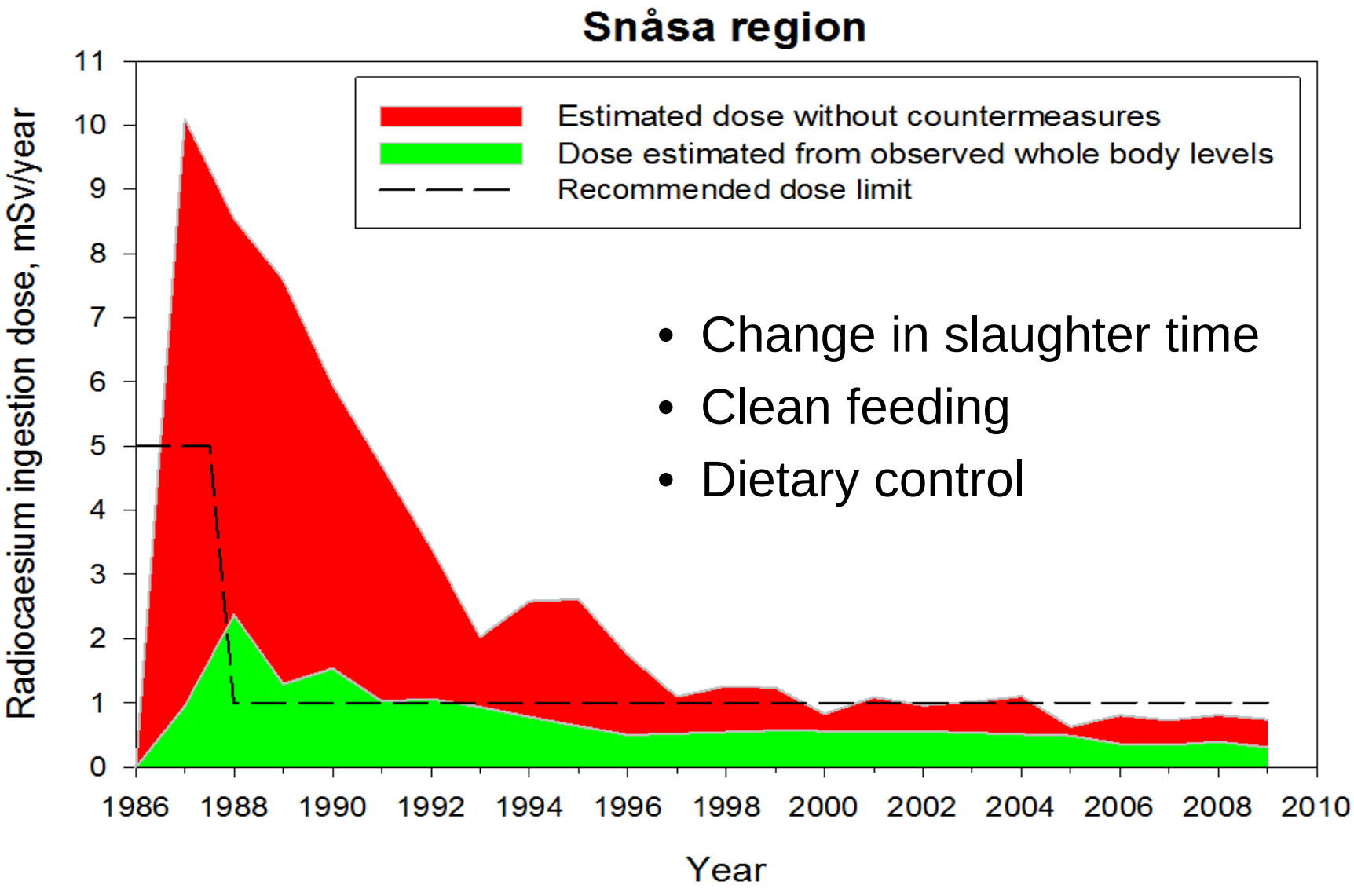
Fig. 4. Monthly internal doses calculated from food consumption and monthly external doses due to exposure to fallout the first 3 y following the Chernobyl accident.

From: Strand et al., 1992, Area and Time Distribution of External and Internal Doses From Chernobyl Fallout:The Lack of Correlation in Norway, Health Phys. 1992 Jun;62(6):512-8

Wholebody measurements of Cs-137 (Bq/kg)



Averted doses due to countermeasures



- Change in slaughter time
- Clean feeding
- Dietary control

Radiation health aspects in Norway

- Health consequences were derived from estimated radiation doses based on measured food activities and whole body measurements.
- Based on the assessed collective doses in Norway, it was estimated that 100 – 500 people might die of cancer as a result of the Chernobyl accident.
- With approximately 10,000 fatal cancers in Norway per year, the Chernobyl consequences would be much less than 1% of the total number and, using currently available methods, will probably remain undetectable. (c.f. UNSCEAR Report 2013)

Other effects in 1986

1000 people were asked about stress reactions and psychological problems as a result of the accident in 1986.

- 25% of children kept indoors more than usual
- 6% changed their diets
- 20% experienced unpleasant stress
- 1-2% had nightmares
- 2% trusted the information they had been given
- 22% had little or no faith in the information they had been given

Additional social actions: communication

Leaflet with dietary advice for consumers:

- How long will the contamination last?
- How can I reduce the uptake in agricultural products?
- How can I reduce my intake?
- What are the health consequences for me and my children in the long run?

Ny giv. Hele sauenæringa i Gudbrandsdalen gleder seg over at nesten alle områder slipper nedfôring. Her fra sauesanking på fjellet i Ringebu. Foto: Ole Martin Nybakken

Rekordlite radioaktiv sau i Norge

LARS KRISTIAN STEEN

redaksjonen@nationen.no |

PUBLISERT: 22.09.13 2

- Den første høsten etter Tsjernobyl-ulykken måtte 320.000 sauer i 117 kommuner nedfôres før slakting. I 2012 var det nedfôring av sauer i kun 18 kommuner, sier overingeniør Gunnar Kinn i Statens strålevern.

Additional actions for specific groups

Additionally for reindeer herders:

- Provision of reindeer meat from less contaminated areas
- Compensation for clean feeding of animals for own consumption
- Compensation for purchase of alternative foodstuffs
- Whole body monitoring, both for dose surveillance and understanding of personal countermeasure efforts

During whole body monitoring, staff were available to explain process and wider issues

Long-term migration of Cs-137 from soil

Most natural soils in Norway are podzols

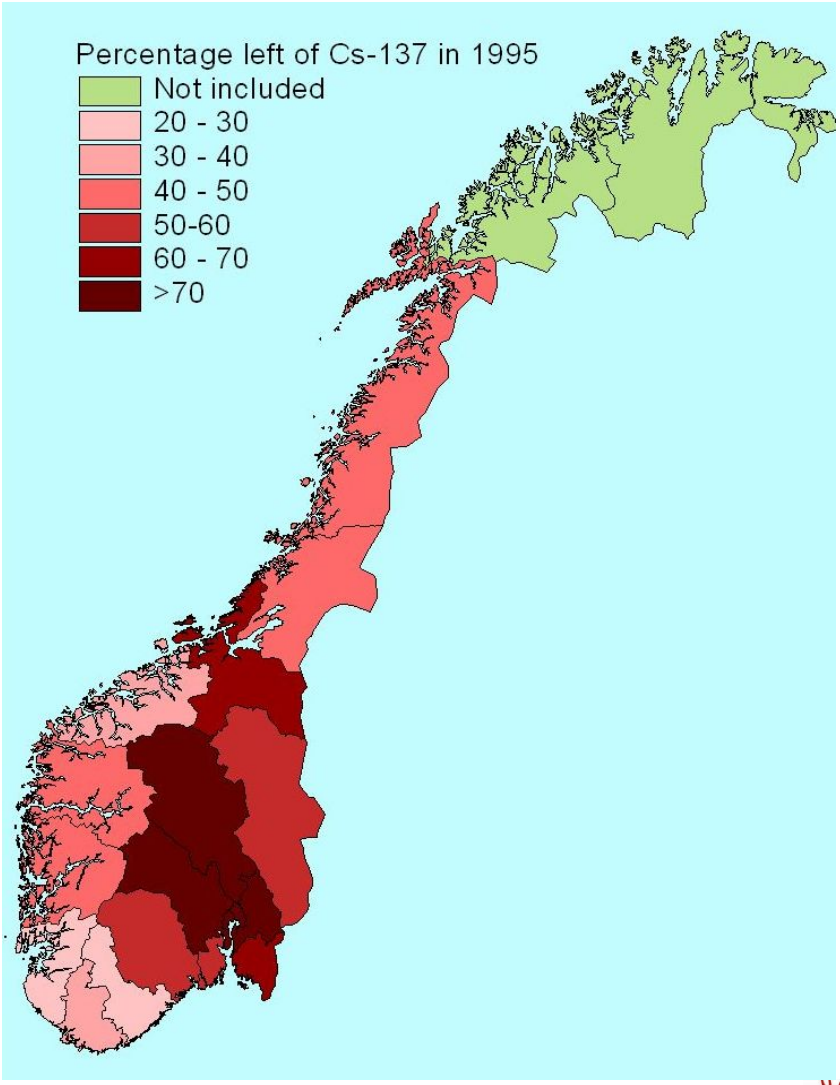
Long-term migration of Cs-137 from soil

By 1995:

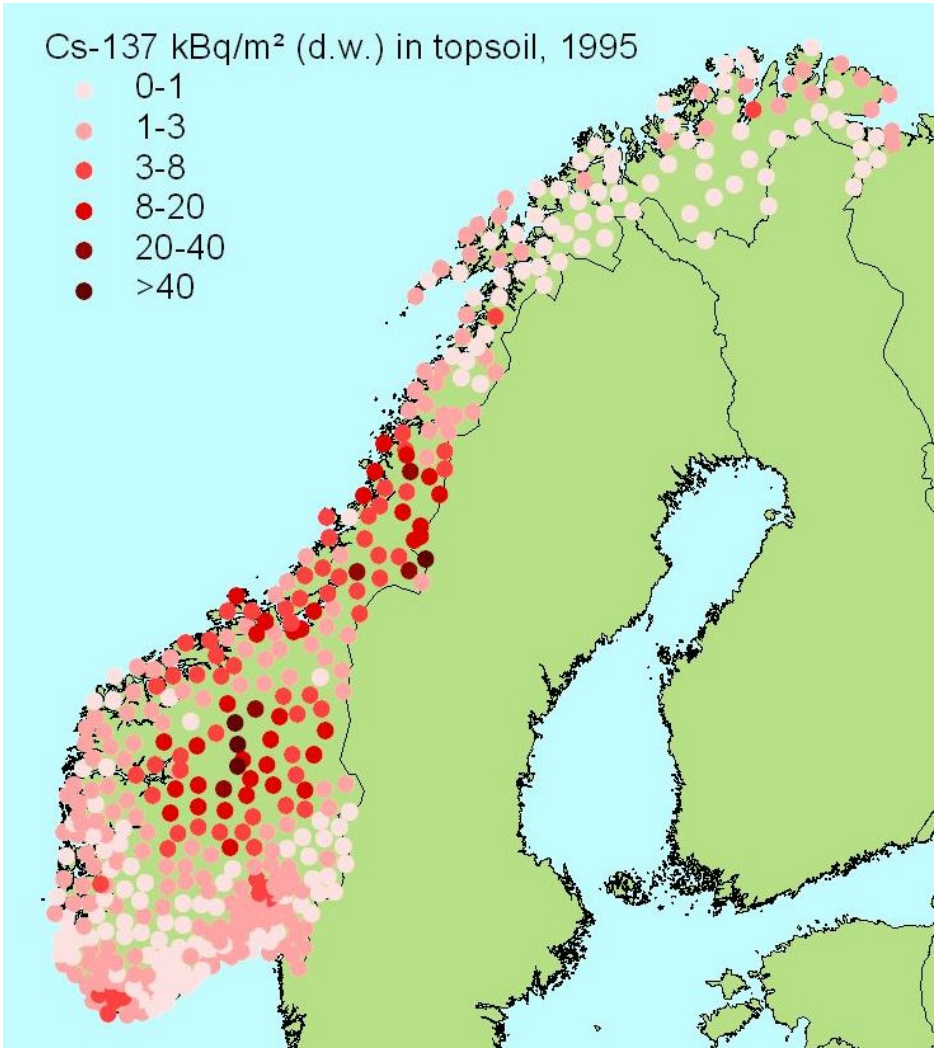
- Coastal areas lost > 50%
- Inland areas <30%

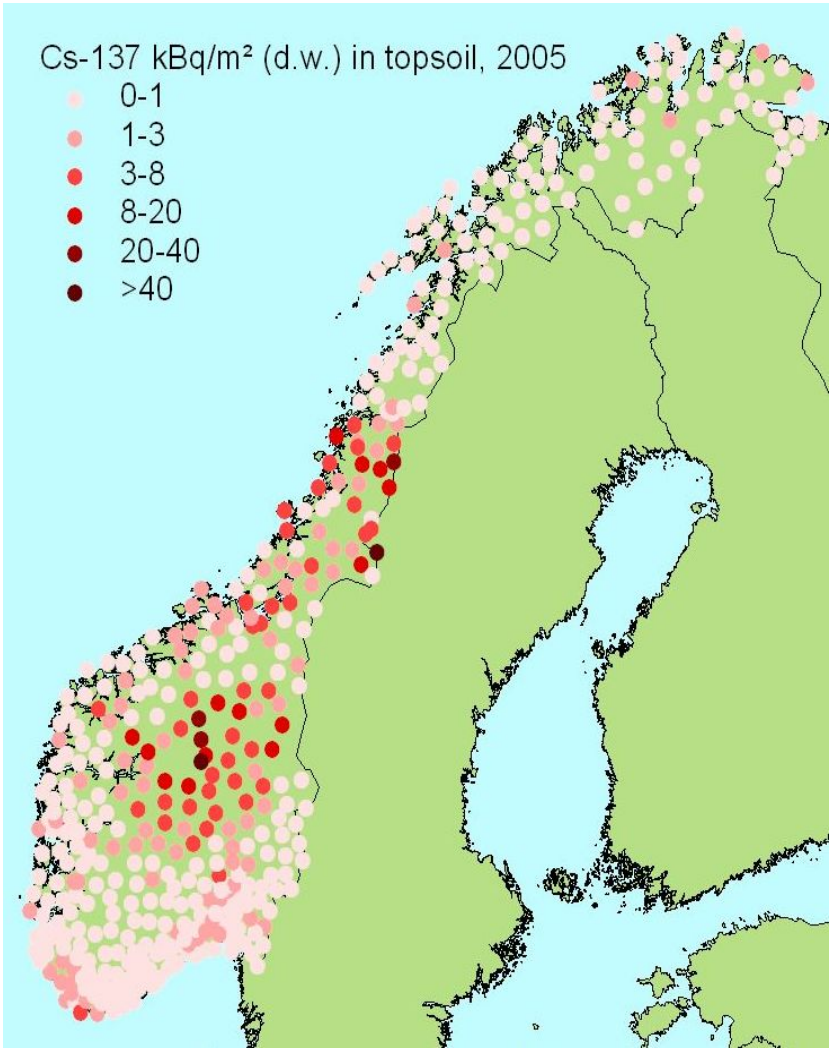
Hypothesis

- Marine cations (Na, Mg) in precipitation enhance leaching of Cs by cation exchange
- Further enhanced by cations from atmospheric deposition of pollutants

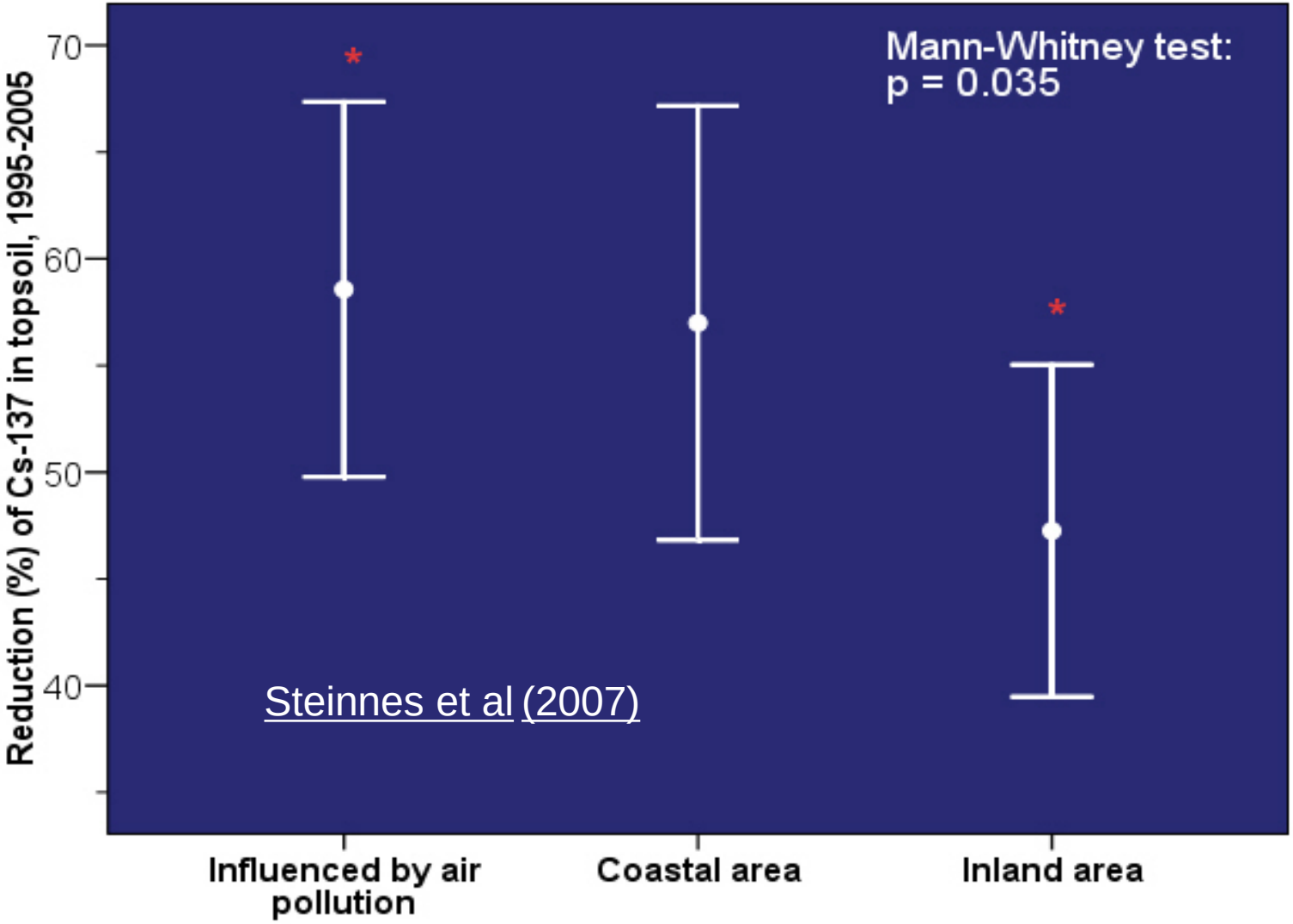


137Cs in natural soil (0-3 cm) in Norway 1995 and 2005 (kBq/m^2)





% Cs-137 reduction 1995-2005 in 0-3 cm soil in areas with different precipitation chemistry



Current perceptions in Norway

Media

- Articles locally every year, in national newspapers occasionally
- Descriptive, no exaggerated fear, but concern about long term effect

Consumers

- Rarely questions about radioactivity in foodstuffs from shops (must trust the authorities?)
- Concern in affected areas about radioactivity in self-gathered foodstuffs (mushroom, game, reindeer) – some measure their food before consumption at local food control stations

Farmer/manufacturers

- Procedures become part of their daily life
- Generally comply with instructions
- Discussions on amount of compensation from time to time

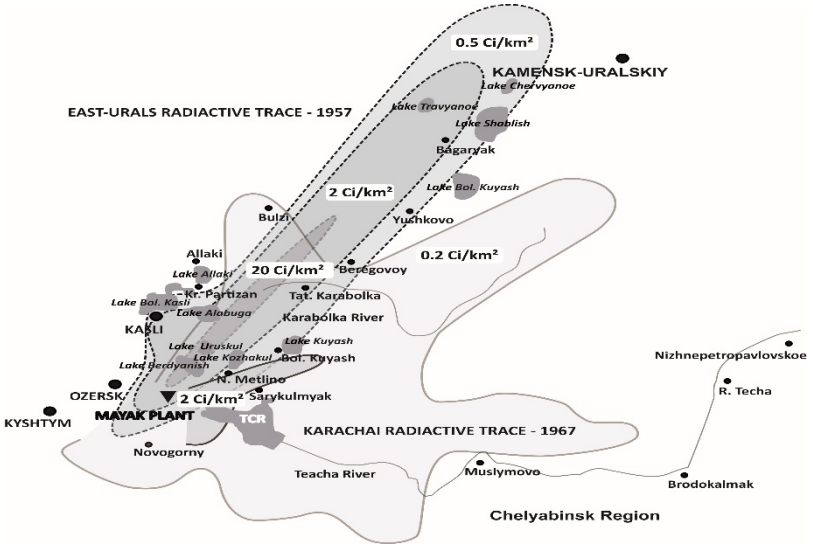
Reindeer herders

- Less content due to close cultural link with nature and animals
- Their most important food is the most contaminated foodstuff in Norway – concern about health and the long term effects
- Some choose not to comply with the dietary advice

Wider lessons: experience from other sites

NRPA bi-lateral research and regulatory cooperation projects in Russia presented last year. Much information and experience concerning:

- Behavioural properties of low level radioactive contaminants in the environment;
- Practical and scientific approaches to low level radioactive waste management;



What to do with dangerous waste which is also slightly radioactive?

Regulatory document for **Safe management of industrial waste containing toxic substances and low level man-made radionuclides,** from past activities and generated during remediation:

- Established the system of criteria, rules and restrictions ensuring safety and protection of workers and the public
- Establishes requirements for arrangement, maintenance and operation of the landfill for disposal of this waste, including its decommissioning
- Establishes requirements for contents of toxic and radioactive substances in waste conveyed to the landfill for disposal

One document addresses both radiation and other toxicity hazards for disposal of, in IAEA terms, Very Low Radioactive Waste (VLLW)

How to optimize allocation of resources?

Necessary to take into account the site conditions and waste characteristics, and also the existing regulatory framework, for radioactive and other waste.

So: what are the relevant regulatory requirements for legacy remediation wastes?

In Russian case it was decided to apply normal situation requirements, even though it was existing situation.

- we understand it is what stakeholders prefer
- there was no equivalent of existing situation to address the non-radioactive hazards

ICRP Committee 4 Task Groups

Objectives:

To describe and clarify the application of the Commission's Recommendations on radiological protection of workers, the public, and environment to exposures resulting from sites contaminated due to past activities (TG98) and to nuclear or radiological accidents (TG93)

Either we have to explain why an existing situation has to be controlled differently for past activities (TG98) and for accidents (TG93), or we have to develop guidance which applies to all existing situations, irrespective of the cause.

Other developments since last year

ICRER workshop: ***"Radioecology and Assessment Research in Support of Regulatory Supervision of Protection of the Environment and Human Health at Legacy Sites"*** September 2014

- Presentations very relevant to management of contaminated sites, both from accidents and planned releases.

- Papers and presentation available on request, including from Japan

Another development since last year

NRPA hosted international workshop on: *"**Comparison of Safety and Environmental Impact Assessments for Disposal of Radioactive Waste and Hazardous Waste**" Norway, Asker, February 2015*

- Measures of safety are very different for radionuclides and other pollutants
- Methods of safety assessment are very different and time-frame for assessment is very much longer for radioactive waste
- LLW and VLLW management needs to consider other hazardous chemicals, not just radiation
- International guidance giving joint consideration to the different hazards could be improved

Invitation

On behalf of all Norwegian colleagues, I would like to extend an offer to share scientific and regulatory experience with colleagues in Japan to all our mutual benefit.

Many thanks for your attention!