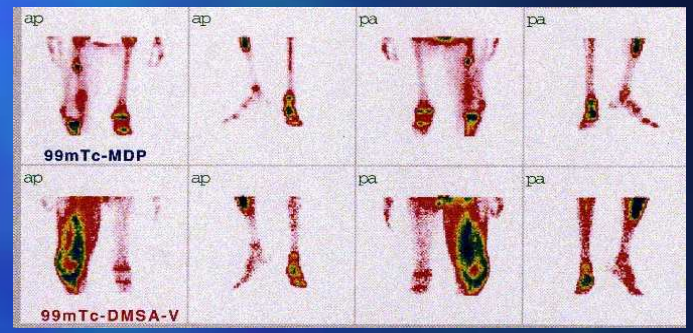
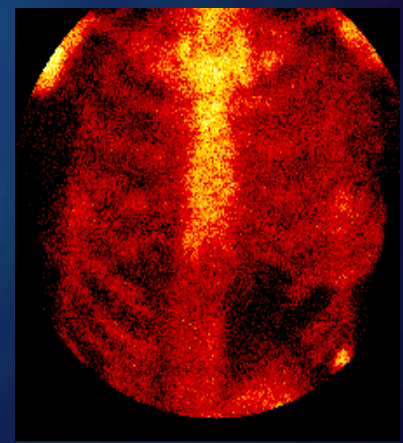
RADIOCHEMICAL LABORATORY FOR ENVIRONMENT, RADIOPHARMACY & COMBATING NUCLEAR TERRORISM

- RADIOECOLOGY
  - Radionuclides and Heavy metals
  - Marine ecosystems
  - Geological matrixes

- Production of Radiopharmaceuticals for Nuclear medicine diagnostics



- **Specialized Lab** for analysis of unknown samples for Combating the illicit trafficking of Nuclear and Radioactive materials



Laboratory For Radiochemistry and Radiopharmacy

Map of sampling locations along the Bulgarian Black Sea coast

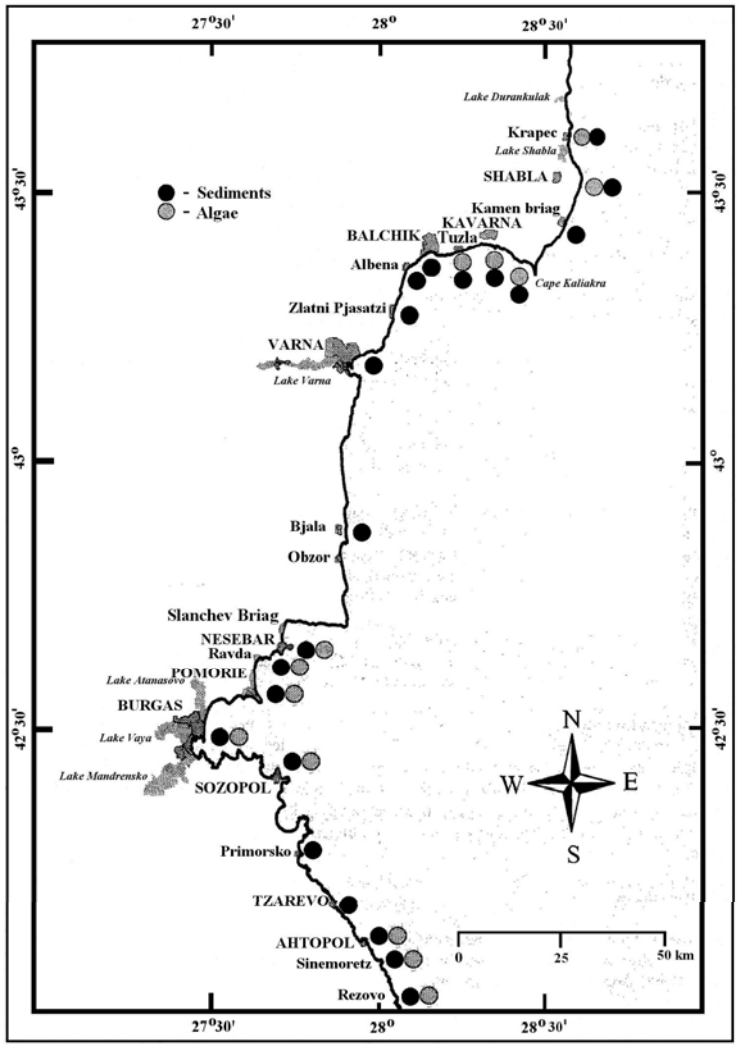
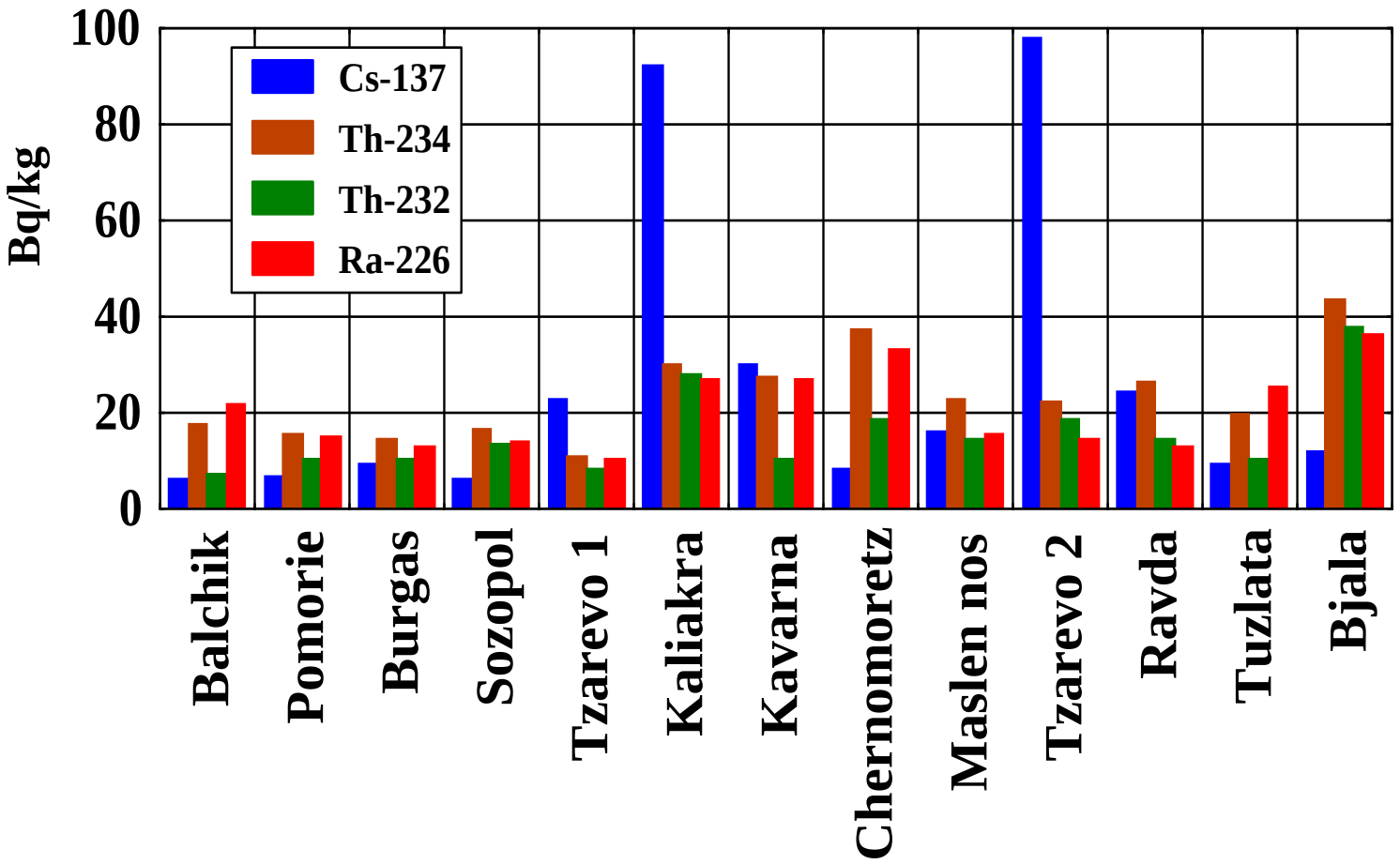


Fig. 1 Diagram of sampling locations at the Bulgarian Black Sea Coast

- *35 sampling locations- 210 samples from three seasons (spring, summer and autumn) in the period 1991-2003*
- *Four types of sediments - slime, silt, sandy and sand*
- *8 deep-sea (30, 150, 300, 2040 m depth) sediment samples*

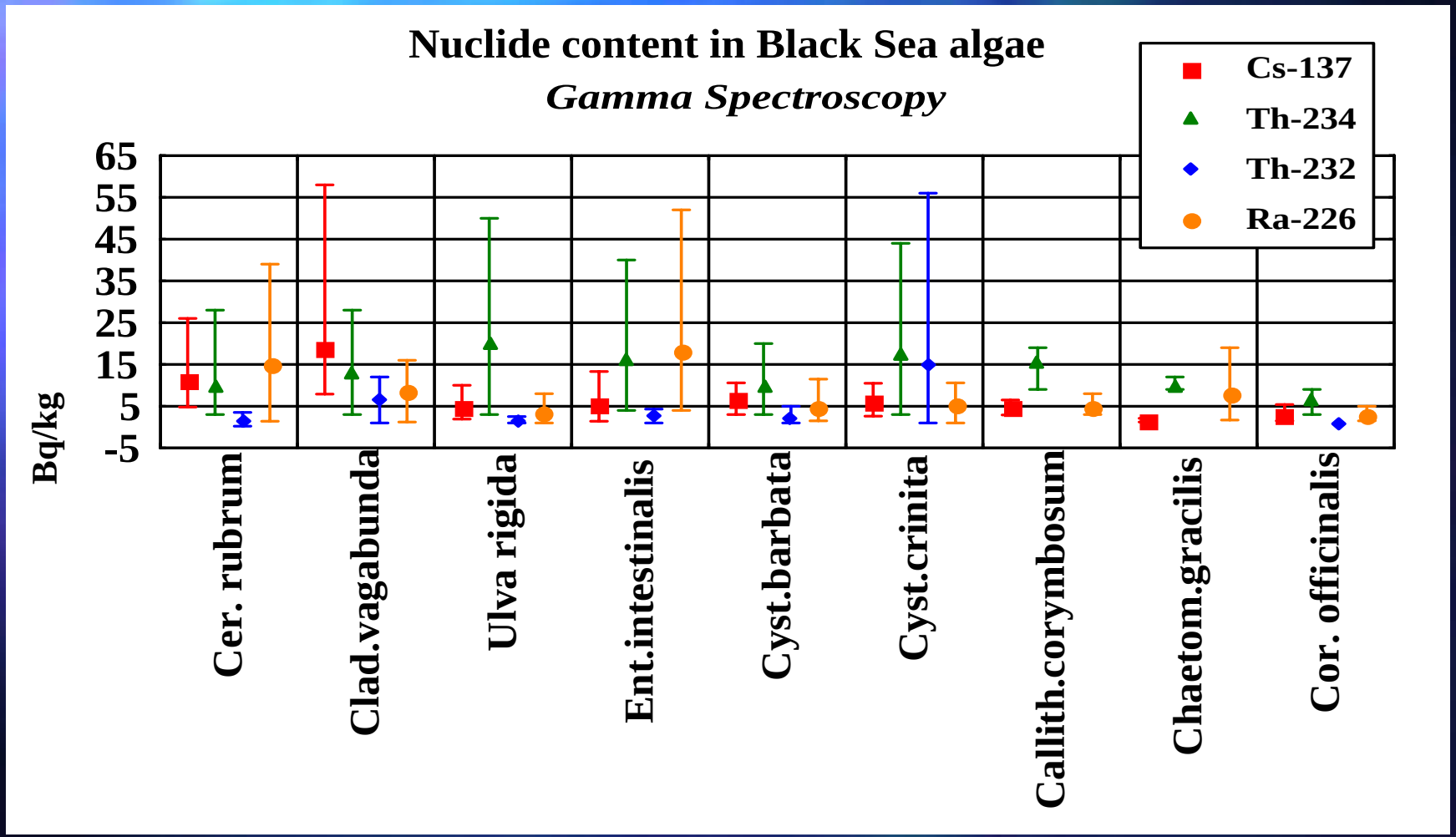
Radionuclide content in slime and silt sediments

Gamma Spectroscopy



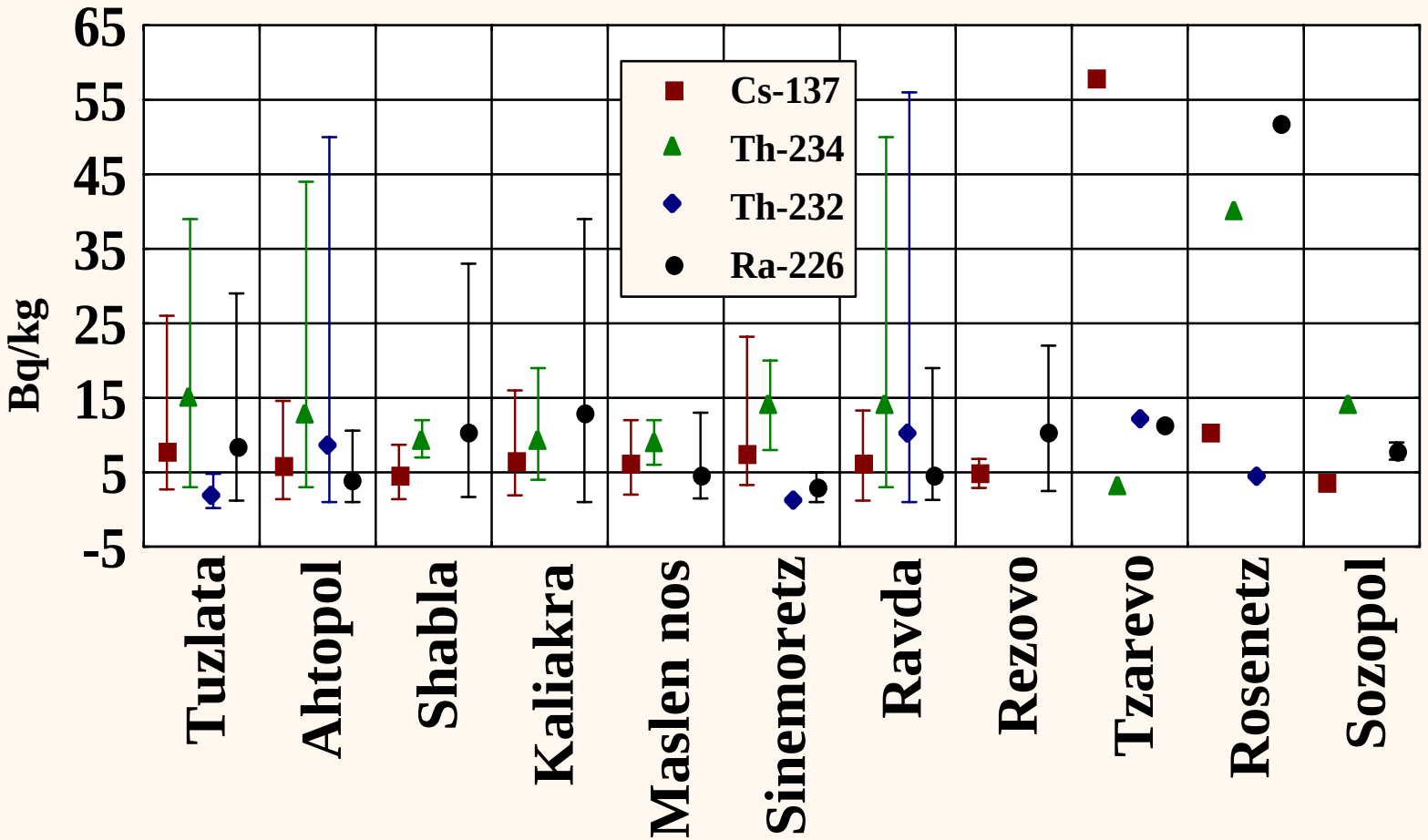
- Nuclide content has been determined in ten Black Sea macroalgae species:
  - Green - *Cladofora vagabunda, Ulva rigida, Enteromorpha intestinalis, Chaetomorpha gracilis, Bryopsis plumosa;*
  - Brown - *Cystoseira crinita, Cystoseira barbata;*
  - Red - *Ceramium rubrum, Callithanium corymbosum, Corallina officinalis*
- Average natural nuclides values:
  - ^{238}U - 34 Bq/kg;
  - ^{232}Th - 13 Bq/kg;
  - ^{226}Ra - 10 Bq/kg.
- ^{137}Cs - 1.7 - 26 Bq/kg

Radionuclide content in Black Sea algae

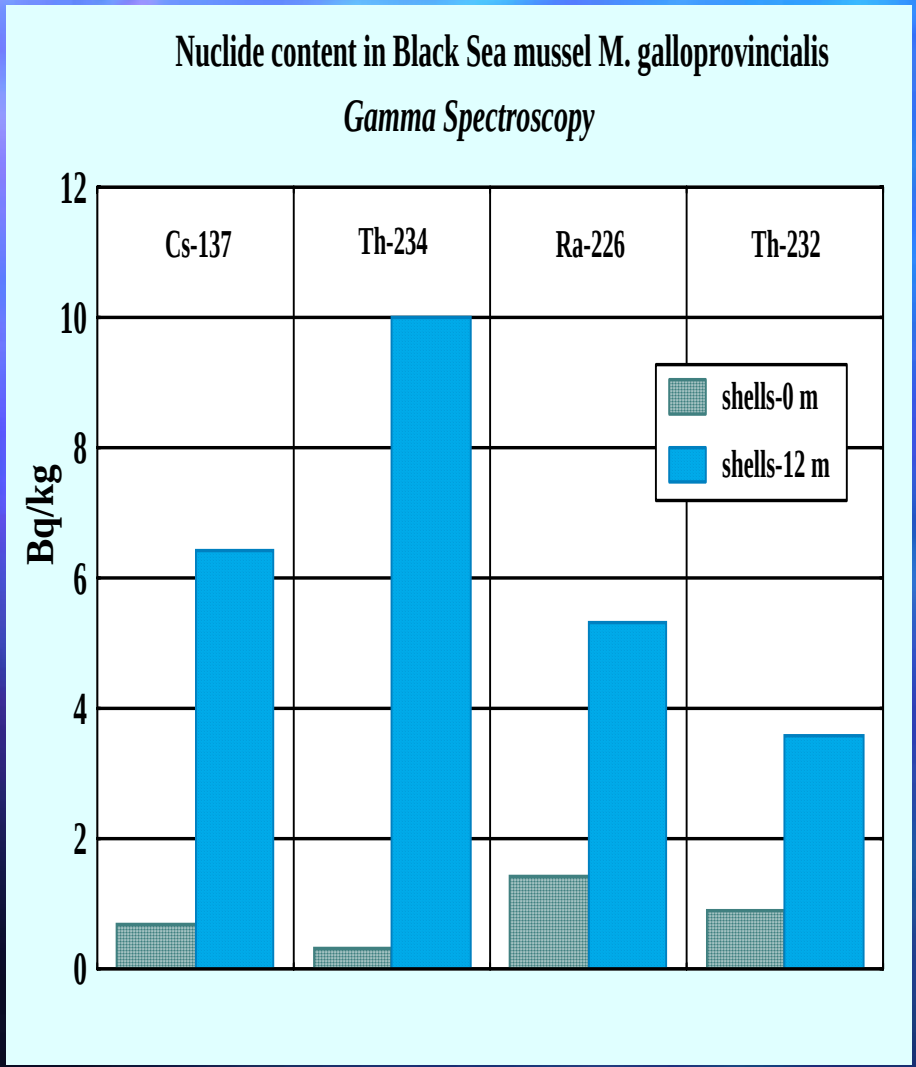


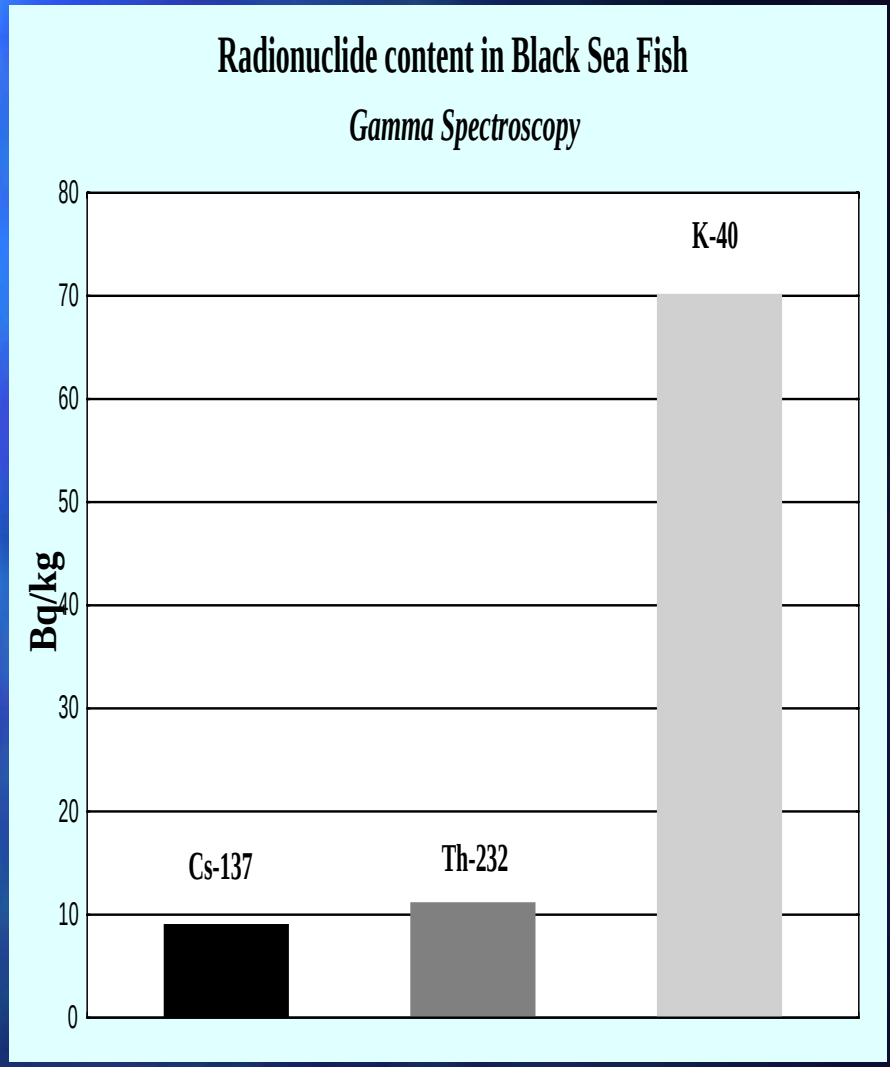
Nuclide content in algae from Black Sea coast locations

(Gamma Spectroscopy)



Radionuclides measured in Black Sea mussels and fish





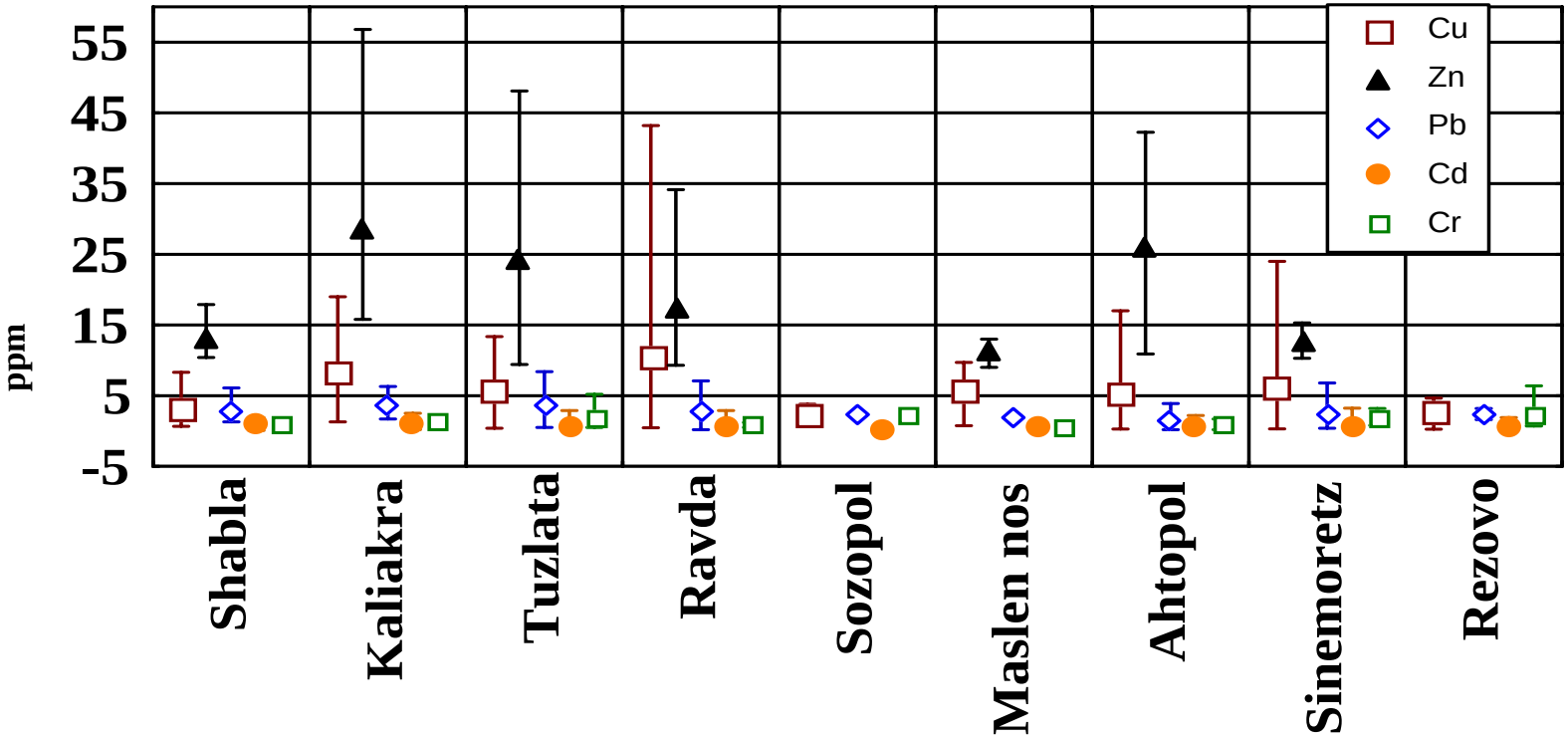
- Heavy metal content in sediments and macroalgae

METHODS:

- Atomic absorption (ETAAS) for Pb and Cd.
- Flame AAS for Fe, Mn and Cu.
- X- ray fluorescence (XRF) analysis for Zn, Cu, Pb, Cd, Ni and As
- ICP-AES

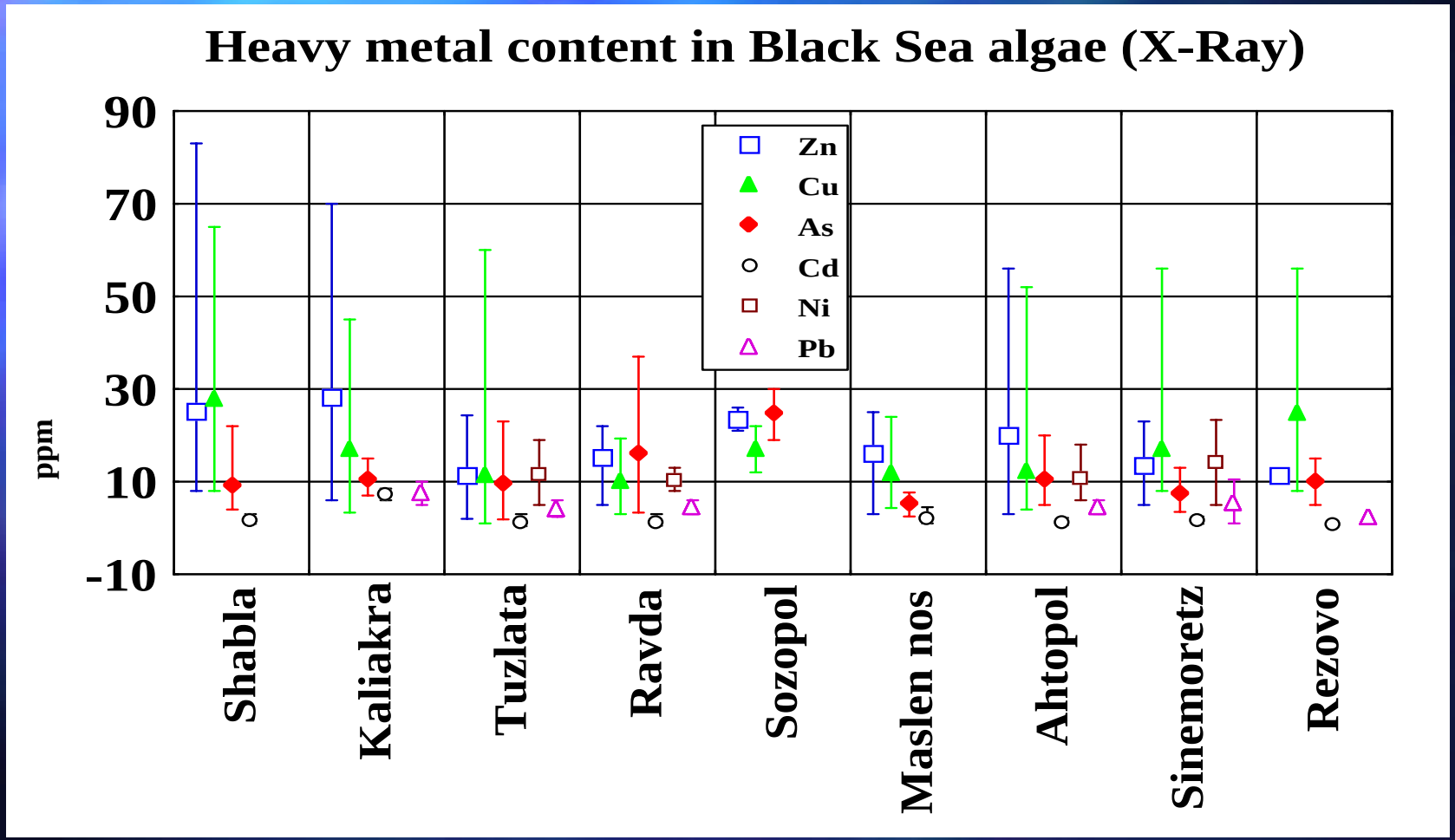
Heavy metal content in Black Sea Macroalgae depending on the location

Atomic Absorption Spectrometry

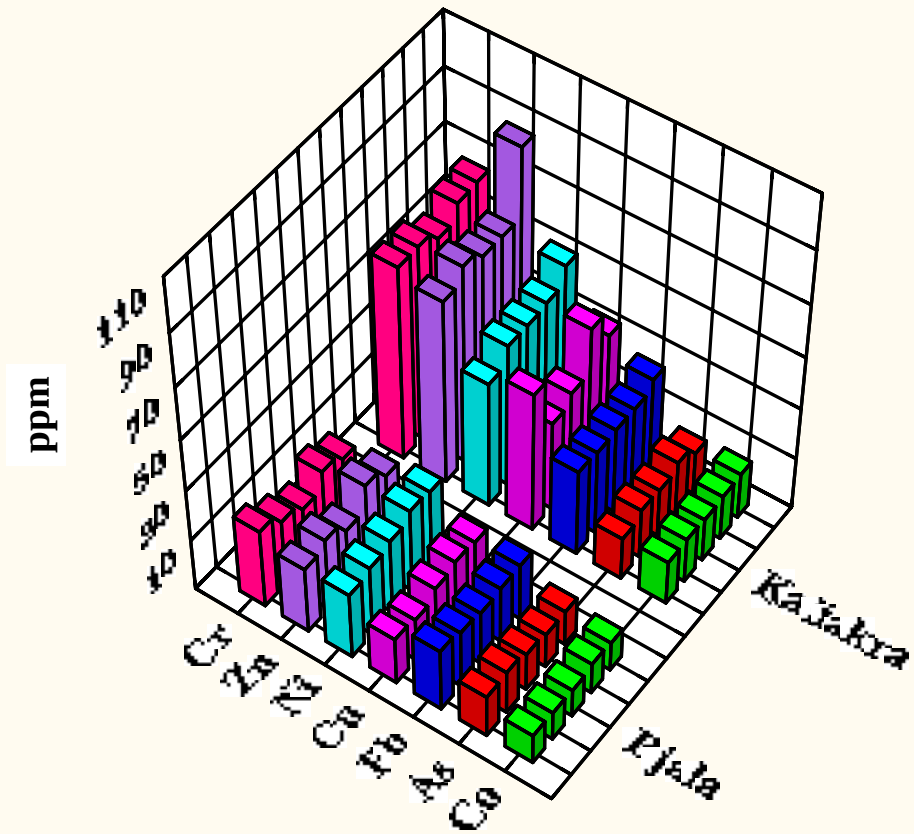


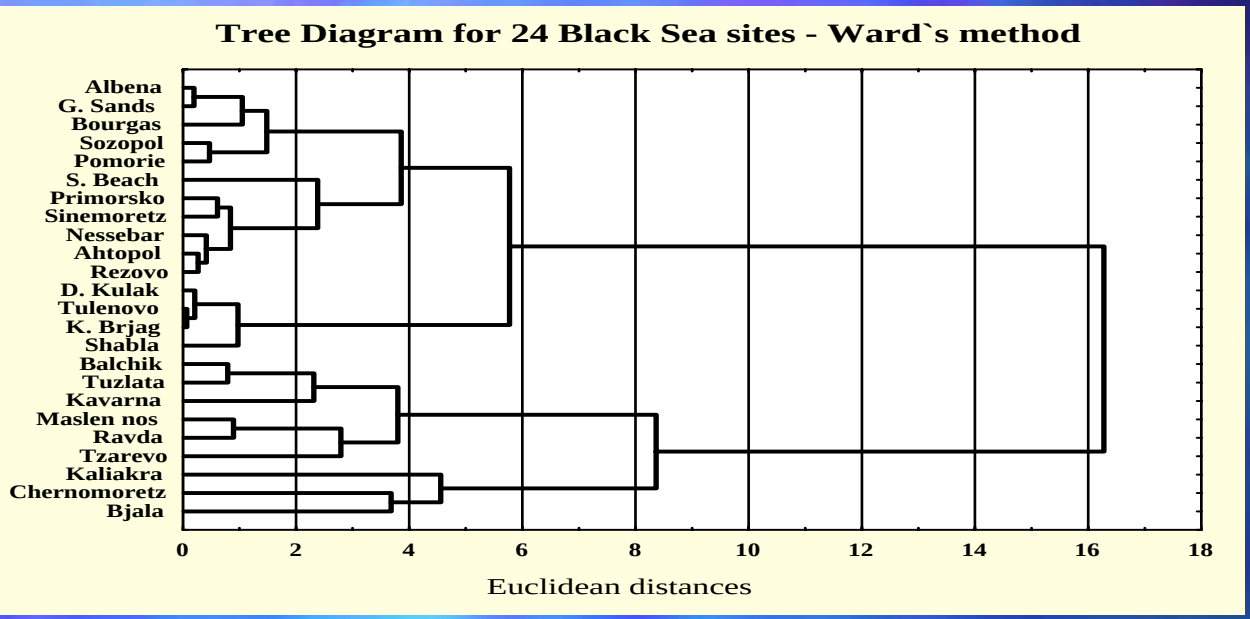
Heavy metal content in Black Sea Macroalgae depending on the location

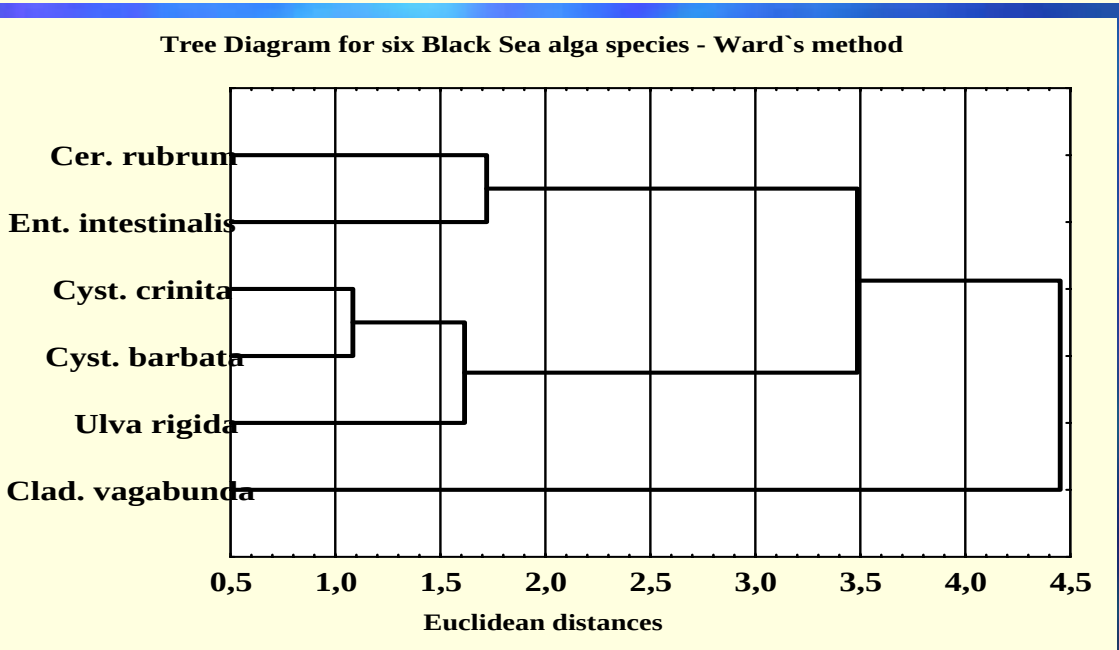
X - Ray Fluorescence Analysis



- Cr, Zn, Ni, Cu, Pb, As and Co content in Kaliakra and Bjala sediments from 1991-1993





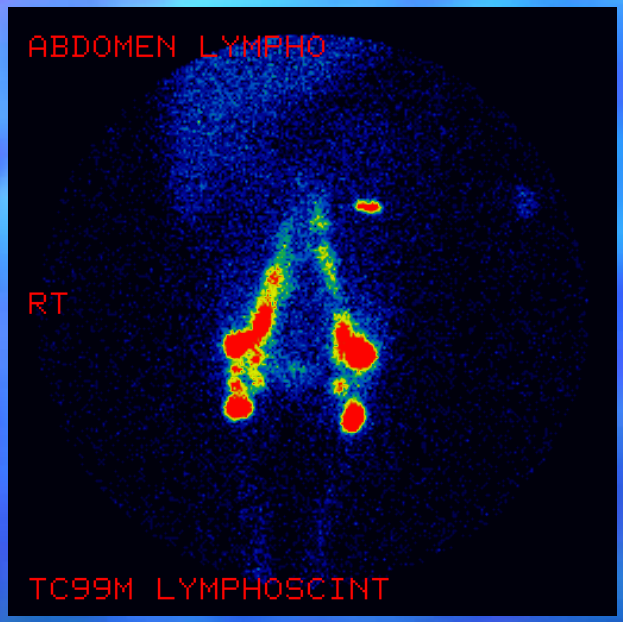


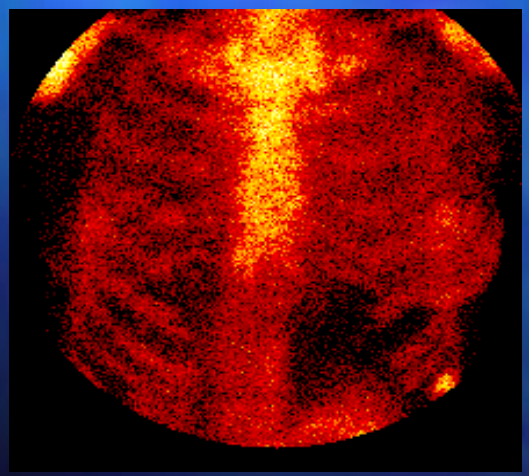
- Creation of a database for radionuclides and heavy metals in sediments
- Creation of a database for radionuclides and heavy metals in Green, Brown and Red macroalgae
- Statistical assessment of databases to predict contaminants' impact on Black Sea marine ecosystems

Radionuclide Diagnostics

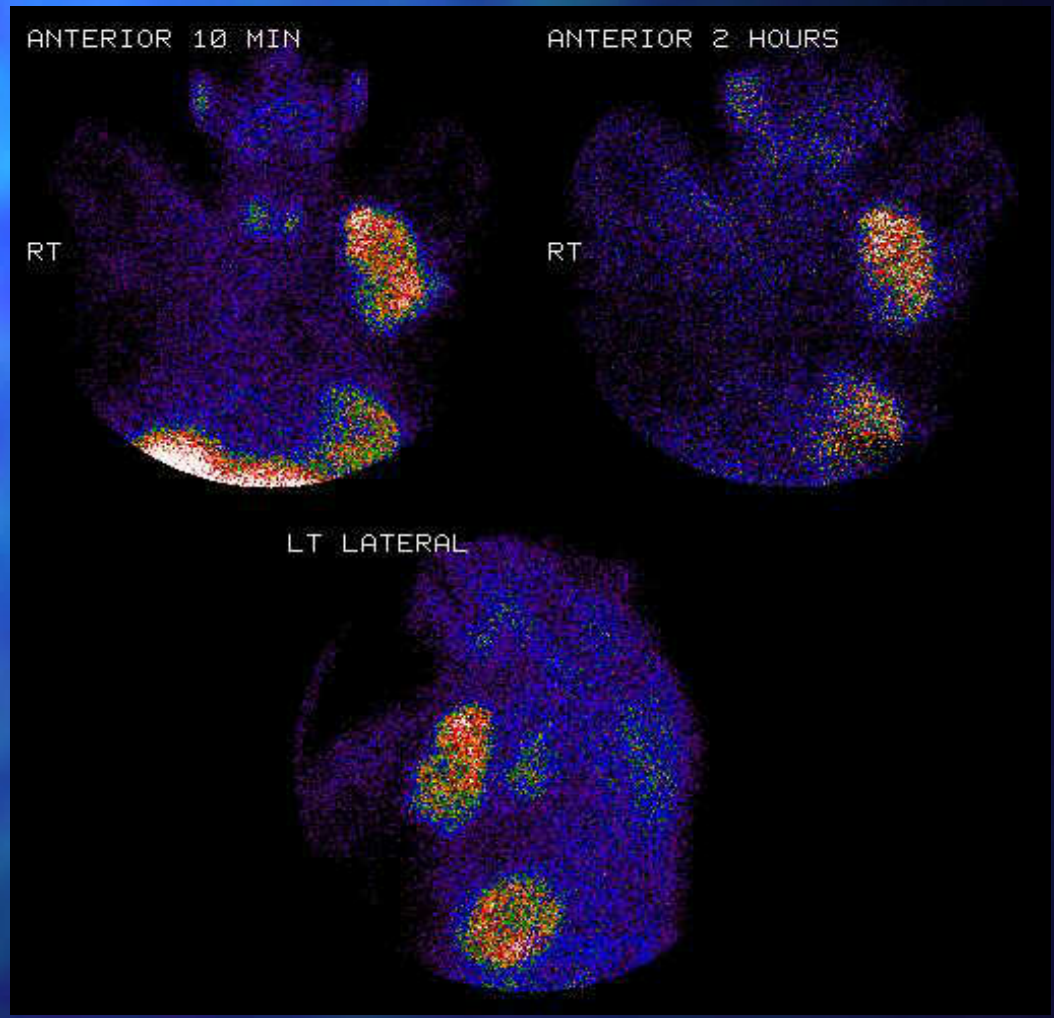
- **Basic Principles of Nuclear Medicine**
  - **Radionuclides are applied for investigation of human organs**
  - **Selective accumulation of labeled complexes in target organs**
  - **The degree and speed of accumulation and clearance is characteristic of the organ's functioning**
  - **The basic task is the study of functional and morphological condition of organs and systems in human organism by means of specific organotropic radiopharmaceuticals**

Lymphoscintigraphy of children lymphoedema





Mamscyntigraphy with Tc-99m MIBI

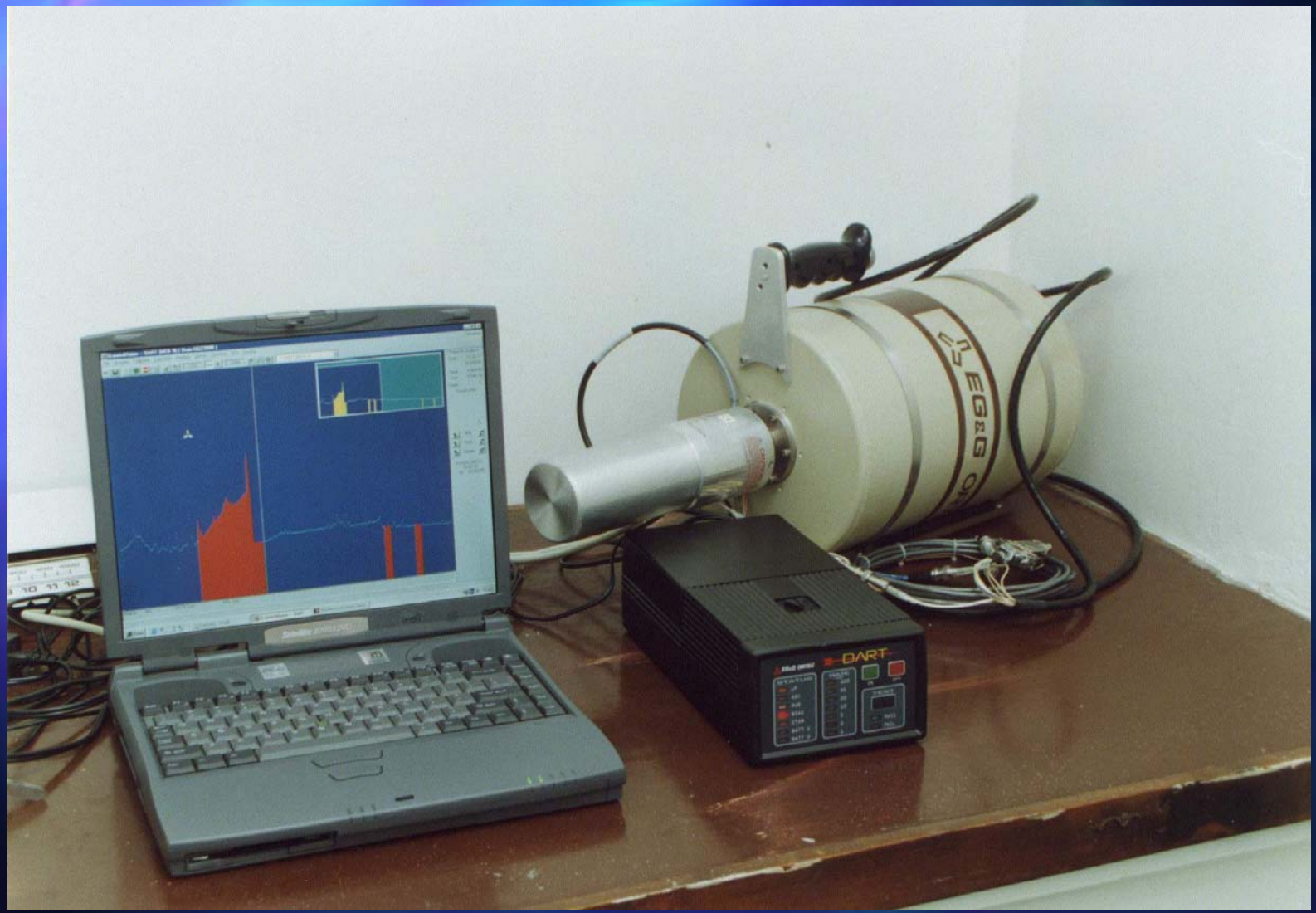


International collaboration

- **PHARE** project ***FONSAVE*** for improvement the capacities for analysis of seized nuclear materials containing Uranium and Plutonium – Prof. Lotar Koch, ITU/JRC 1998 - 2003
- Assistance was provided by EU experts (Institute for Transuranium Elements ITU, Karlsruhe Germany) to Purchase of equipment for identification, categorization and analysis of nuclear materials and by NDA measurements of seized vagabonding material
- PECO project Harmonization of Techniques and Methodologies for Measuring Radioactivity in the Environment – Prof. Maria Betty ITU/JRC 2003 - 2006
- CIESM Mediterranean Mussel Watch Program – Prof. Frederick Briand – Monaco, France 2003 - 2006

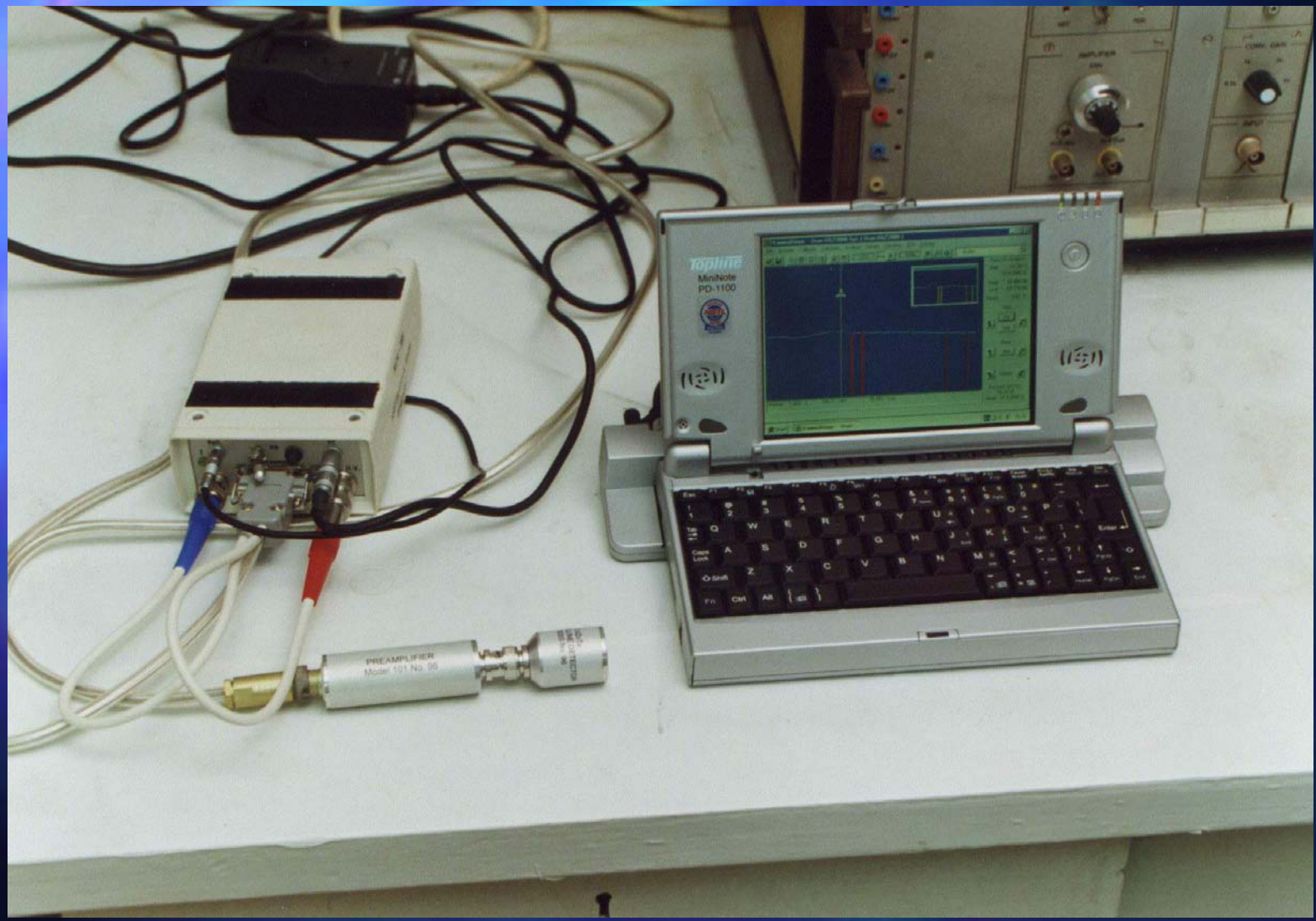
PORTABLE NDA EQUIPMENT

Planar HPGe Detector, DART Spectrometer, Laptop



PORTABLE NDA EQUIPMENT

CdZnTe Detector, MiniMCA Spectrometer, Notebook



Projects for Combating Illicit Traffic of Nuclear and Radioactive Materials

FONSAVE
PECO
GAMDETEC

Coordinator – ITU Karlsruhe, Germany
Beneficient – Nuclear Regulatory Agency
Recipient Institute – INRNE – BAS, Bulgaria

LAW ENFORCEMENT INSTITUTIONS IN BULGARIA

A. MINISTRY OF INTERNAL AFFAIRS

- National Security Service
- NSBOP (National Service for Combating Organized Crime)
- SOTI (Service for Acquiring Technical Information)
- Border Police
- Police

B. CUSTOMS

C. CIVIL DEFENCE

D. STATE AGENCY FOR NUCLEAR REGULATION

I. MODEL ACTION PLAN

First Step

- Preservation of evidence
- Health physics analysis
- Application of proper protocols, adopted by the law enforcement forces - police, customs etc.

Second Step

- NDA analysis to categorize the radioactive material
  - radioactive, non-fissile material
  - nuclear fuel (^{235}U content less 20 %)
  - Pu and/or enriched U (^{235}U content higher 20 %)
- Ge(Li) high Resolution Gamma Spectroscopy
- Passive Neutron interrogation for Pu
- Active neutron interrogation for ^{235}U

Third Step

- In-Depth Analysis by Specialized laboratory
  - traces (dust, pollens etc.) on packaging material
  - packing material
  - element composition of nuclear material including traces

External traffic

- The external traffic of illicit materials is the transfer of raw materials and expensive metals from the former Soviet Union towards Western Europe and the Middle East.
- Al, Os, Cs, Sc, Rare earth elements
- Nuclear Materials
  - Red Mercury
  - Pu
  - Enriched U

Internal traffic

- **Stolen radioactive sources imported from Soviet Union**
- **Diversion and transport materials from Uranium mining industry including different amounts of “yellow cake”**
- **Cases of illegal traffic with radioactive sources or isotopes of highly radioactive devices containing isotopes Cs-137, Co-60, Ir-192, Ra-226, Am-241 :**
  - **Level meters**
  - **Dense meters**
  - **Devices removing static electricity**
  - **Weighing devices**
  - **Parts of irradiation devices**
  - **Smoke detectors etc.**
  - **Natural or depleted Uranium containers or shielding**

- **FIRST INTERNATIONAL EXERCISE ON COMBATING ILLICIT TRAFFIC OF NUCLEAR MATERIALS**

PARTICIPATING COUNTRIES: TURKEY – BULGARIA

PLACE – BORDER CROSSING POINT KAPI KULE

TIME – 14 – 15 OCTOBER 2002

Acting Partners

Cekmece Nuclear Center - Istanbul

Institute For Nuclear Research & Nuclear Energy - Sofia

BULGARIA - TURKEY International Exercise at KAPI KULE Border Checkpoint October 2002

Discovery of "Illicit" Nuclear Material at Kapi Kule

Measurement of "Illicit" Nuclear Material at Kapi Kule

Analysis of "Illicit" Nuclear Material at Kapi Kule

Laboratory For Radiochemistry and Radiopharmacy

OBSERVERS TO THE JOINT EXERCISE

- 1. EU Representatives – experts from ITU, Karlsruhe, Germany
- 2. Experts from IAEA – Vienna, Austria
- 3. Interpol
- 4. Europol
- 5. USA embassy in Sofia

Happy end" of the Joint Exercise – Bulgarian - Turkish teams