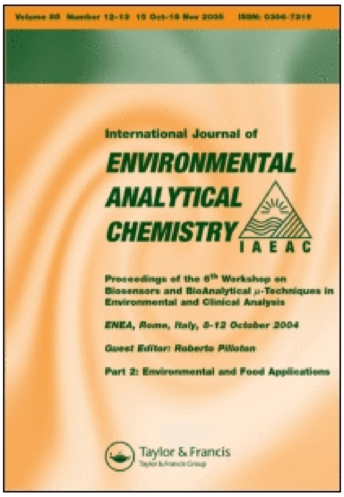


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# Radioecological Research on the Marine Environment Facing the Italian Base in Antarctica (1989-91)

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# RADIOECOLOGICAL RESEARCH ON THE MARINE ENVIRONMENT FACING THE ITALIAN BASE IN ANTARCTICA (1989–91)

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The results of the analysis of both natural (Th-232, U-238 and K-40) and artificial (Cs-137) radioactivity contained in samples collected during the 1989–90 and 1990–91 PNRA Scientific Campaigns in the Terra Nova Bay (Ross Sea) marine ecosystem, are presented in this paper. The data refers to samples of sea water, pack water, sediments and organisms belonging to demersal ichthyofauna (*Pagothenia bernacchii, Chionodraco hamatus*) and soft bottom macrofauna (*Adamussium colbecki*) collected in different coastal and off shore stations of the area investigated. Some sea water samples collected on the way to subAntarctic areas were also considered. The radiocontamination detected in sediments was correlated to the quantities of organic matter, organic carbon and nitrogen contained in the samples. Additionally, Cs-137 concentration factors were calculated for the different biological specimens and their anatomical components. Data values, with special consideration for anthropogenic Cs-137, are compared to results obtained from similar matrixes collected in the Northern Hemisphere in temperate waters before and after the accident at the Chernobyl nuclear plant.

**KEY WORDS**: Antarctica, Ross Sea, artificial radioisotopes, natural radioisotopes, radioecology,



## INTRODUCTION

In the past, research concerning radioactivity in Antarctica was mostly related to monitoring programmes necessary for the determination of the presence of fallout radionuclides in the South Pole atmosphere and ice cap[1,2,3,4]. The lack of data concerning radioecological studies on different environmental specimens, both biotic and abiotic, still represents an obscure point in the assessment of radioisotope circulation and transfer mechanisms throughout the compartments of the antarctic ecosystem, in an area where the particular oceanographic conditions strongly influence the chemistry of the Southern Ocean.

For this reason, the Operative Unit "Environment and Radioactivity" of the University of Parma participates in the framework of the Italian National Programme for Antarctic Research / Environmental Impact Sector, towards the characterization of the most important environmental marine specimens in order to assess the presence and distribution of important chemical and radioactive pollutants.

**Table 1** Sampling data concerning the 3rd Scientific Campaign (1989–90).

| *Specimen* | *Sample* | *Date* | *Sampling depth* | *Coordinates* | | *Sampling area* |
|---|---|---|---|---|---|---|
| | | | | *Lat (S)* | *Long (E)* | |
| Sea water | SW08 | 25.11.89 | 20 m | 61°49′05″ | 172°27′81″ | From convergence |
| | SW14 | 21.12.89 | 20 m | 70°11′79″ | 176°12′57″ | to the Bay |
| | SW24 | 31.12.89 | 20 m | 74°00′05″ | 179°57′02″ | " |
| | SW31 | 07.01.90 | 20 m | 75°00′71″ | 164°59′89″ | " |
| | SW33 | 20.01.90 | 0.5m | 74°46′57″ | 164°05 | Coast Base Ita |
| Coastal Sediment | SM24 | 08.01.90 | 368 m | 74°40′66″ | 164°09′76″ | Coast Base Ita |
| | SM33 | 27.01.90 | 105 m | 74°30′07″ | 164°10′70″ | " |
| | SM34 | 27.01.90 | 194 m | 74°38′55″ | 164°10′52″ | " |
| | SM35 | 27.01.90 | 300 m | 74°39′68″ | 164°09′93″ | " |
| | SM44 | 01.02.90 | 348 m | 74°43′38″ | 164°14′06″ | " |
| *Adamussium colbecki* | AC01 | 18.01.90 | 50m | 74°42′43″ | 164°06′58″ | Coast C. Icaro |
| | AC03 | 22.01.90 | 50m | 74°41′ | 164°08′ | Tehtys Bay |
| *Pagothenia bernacchii* | PB03 | 22.01.90 | 50 m | 74°41′ | 164°08′ | Tehtys Bay |
| *Chionodraco hamatus* | CH03 | 22.01.90 | 50 m | 74°41′ | 164°08′ | Tethys Bay |

Beginning with the 1st Scientific Expedition (1987–88) samples were collected in different coastal and off shore stations (Tables 1 and 2) to carry out radioecological research in the Terra Nova Bay (Ross Sea) area (Figure 1). Analyses were conducted on samples of sea water, pack water, sediments and organisms belonging to demersal ichthyofauna and

**Table 2** Sampling data concerning the 4th Scientific Campaign (1990–91).

| *Specimen* | *Sample* | *Date* | *Sampling depth* | *Coordinates* | | *Sampling area* |
|---|---|---|---|---|---|---|
| | | | | *Lat (S)* | *Long (E)* | |
| Sea water | SW02 | 04.01.91 | 0.5 m | 74°42′43″ | 164°06′58″ | Coast C. Icaro |
| | SWF | 02.02.91 | 0.5 m | 74°43′ | 164°07′ | Adelie Cove |
| | PW06 | 26.12.90 | 0.5 m | 74°40′07″ | 164°07′15″ | Gerlache Inlet |
| Coastal Sediment | SMB7 | 07.01.91 | 265 m | 74°40′07″ | 164°07′15″ | Gerlache Inlet |
| Off shore Sediment | SM03 | 12.12.90 | 3361 m | 70°39′83″ | 178°20′97″ | Ext. to the Bay |
| | SM06 | 14.12.90 | 2324 m | 71°06′60″ | 172°42′50″ | " |
| | SM12 | 22.12.90 | 568 m | 73°40′13″ | 171°11′88″ | " |
| | SM19 | 27.12.90 | 558 m | 74°25′90″ | 173°47′98″ | " |
| | SM22 | 29.12.90 | 528 m | 73°59′69″ | 169°11′70″ | " |
| | SM23 | 29.12.90 | 678 m | 74°25′68″ | 169°35′28″ | " |
| | SM29 | 04.01.91 | 1224 m | 75°11′01″ | 164°22′04″ | Drygalski Basin |
| | SM30 | 04.01.91 | 1113 m | 74°56′97″ | 165°47′34″ | " |
| | SM36 | 06.01.91 | 890 m | 74°58′30″ | 164°11′80″ | " |
| | SM38 | 07.01.91 | 924 m | 74°57′57″ | 164°48′80″ | " |
| *Adamussium colbecki* | Cost Base | 28.12.90 | 50 m | 74°42′ | 164°07′ | Coast Base Ita |
| *Pagothenia bernacchii* | Cost Base | 28.12.90 | 50 m | 74°42′ | 164°07′ | Coast Base Ita |

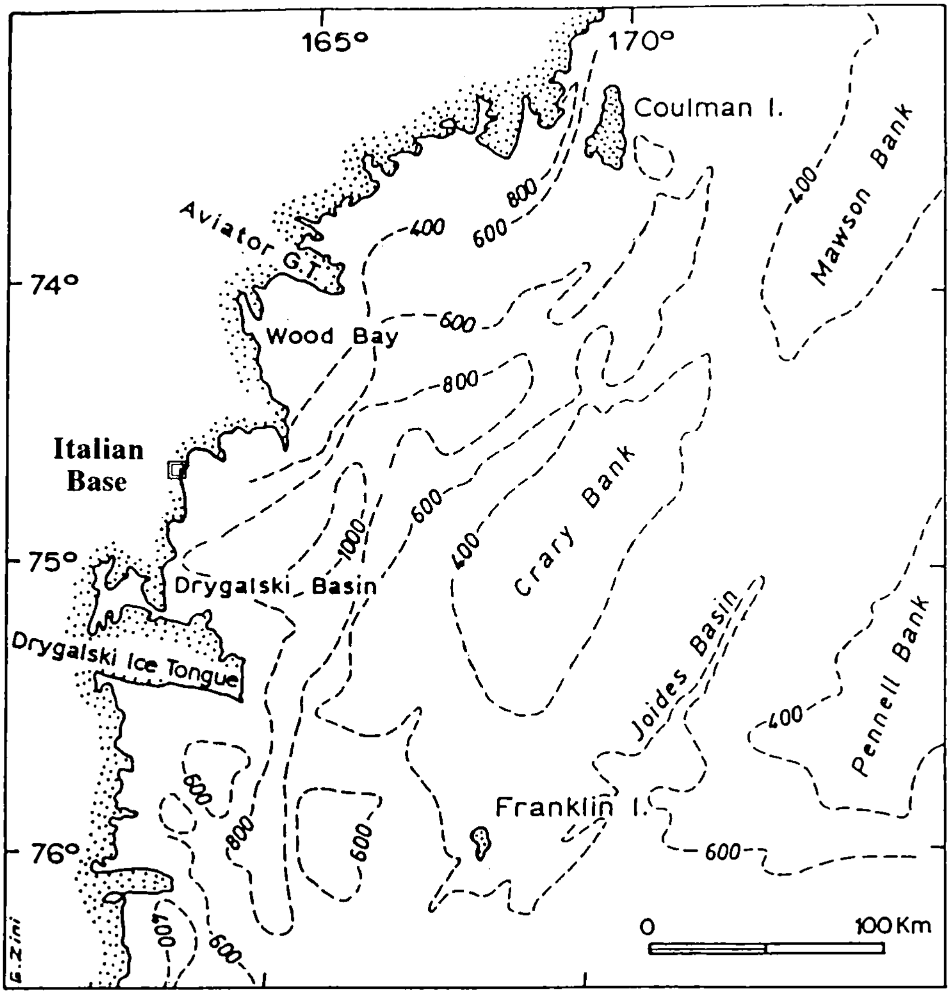


**Figure 1** Sampling area of marine specimens in the area facing the Italian Base at Terra Nove Bay (Ross Sea).

soft bottom macrofauna which represents the most significant species of the Antarctic coast. Additionally, sea water samples collected on the way to subAntarctic areas were also considered.

Gamma spectrometry measurements were performed to detect the anthropogenic isotope Cs-137 and the primordial nuclides K-40, Th-232 and U-238. In addition, Cs-137 concentration factors were calculated for all biologic samples and their principal anatomical components. Correlations were also made between the concentrations of Cs-137 and the presence of organic matter, organic carbon and nitrogen in samples of both coastal and off shore sediments.

All data from 1987 to 1989 have already been published in previous papers[5,6,7,8,9] whereas the results from the 3rd (1989–90) and 4th (1990–91) Scientific Campaigns are unpublished data and presented in this paper.

## MATERIALS AND METHODS

Unfiltered sea water samples collected during the 3rd Scientific Expedition, with volumes ranging between 150 and 200 liters were treated by the AMP—Cs extraction method to isolate the Cs-137 isotope. Each sample was acidified with HCl to pH 1, 60 mg of Cs carrier and 10 Bq of Cs-134 spike were added to evaluate the internal radiochemical separation yield. After a 15–20 minute stirring to reach an isotopic equilibrium, 60 g of AMP—$(NH_4)_3PO_4.12MoO_3.3H_2O$—powder were introduced into the solution to obtain caesium isolation. After a 3 hour slow stirring and a 48 hour settling the clarified surnatant liquid was extracted and eliminated. The AMP fraction was then centrifuged and the solid residue obtained was oven-dried at 105°C and stored in standard plexiglas containers to be counted for gamma spectrometry in definite geometry. The obtained separation yields ranged between 83% and 88% (Table 3). Beginning with the 4th Campaign (1990–91), the caesium extraction from one sample of sea water and one sample of pack water was executed during the scientific expedition by means of an automatic apparatus (RADECO—Milan) that passes the liquid through a NCFC—Ammonium hexacyanocobalt (II) ferrate (II)—bed ($10cm^3$) with an optimized flux of 5 l/h. The tested separation yield of caesium on the column was around 95%. Thanks to the high separation yield it was possible to evaluate very low activities, and therefore this technique will probably replace the previously used AMP extraction method in the future research concerning all water samples.

Specimens of soft bottom macrofauna and demersal ichthyofauna were collected by dredge and "Barracuda" net in coastal stations of Terra Nova Bay. Following biometric analyses and sex recognition, the Antarctic scallop *Adamussium colbecki* (Mollusca Bivalvia), the Notothenidae fish *Pagothenia bernacchii* (Osteichtyes Perciformes) and the Channichthydae "icefish" *Chionodraco hamatus* (Osteichtyes Perciformes) were dissected into their principal anatomic components: principally soft part and shells for the scallops, muscular, visceral and skeletal component for the fish. All samples were oven-dried to constant weight (110°C), and then minced and introduced into suitable containers for gamma spectrometry measures. All dry/humid ratios and percentages of anatomical components on total weight are reported in Tables 9 and 10.

**Table 3** Concentrations of Cs-137 in sea water samples collected during the 3rd Scientific Expedition (1989–90).

| *Sample* | *Method* | *Volume litres* | *Separation yield* | *Cs-137 Bq/m3* |
|---|---|---|---|---|
| SW08 | AMP | 200 | 83.43% | 0.61±0.18 |
| SW14 | AMP | 200 | 85.94% | 0.65±0.20 |
| SW24 | AMP | 200 | 87.82% | 0.24±0.15 |
| SW31 | AMP | 200 | 87.83% | 0.35±0.10 |
| SW33 | AMP | 150 | 87.47% | 0.31±0.13 |

During the 3rd Campaign, five samples of superficial sediments of different granulometric composition were collected by grab in coastal stations of Terra Nova Bay. Off shore sediment samples were also collected by box corer during the 4th Campaign, and most of them were studied at two different levels, mostly 0–15 cm and lower strata, to determine the radioactivity flow along the sedimentary compartment. All samples were oven-dried to constant weight and stored into standard containers as has already been explained in the case of the organisms.

The analytical samples, introduced into suitable source containers of different volumes and definite geometry, were measured by means of two Ge-Li gamma lines (Ortec and Silena). Instrument calibration and efficiency values were previously calculated using a standard reference source, an Amersham (U.K.) QCY-44 solution of known absolute emissions[10].

Standard measurement time was approximately 22 hours, although for environmental samples having very low activities, the measurement time was raised to 50 ÷100 hours to reach good counting statistics. By using a more efficient intrinsic Germanium detector and by raising counting times, complex radiochemical separations were avoided. The data, decay corrected to sampling date, were processed with an IBM AT Personal Computer equipped with an EG&G quantitative analysis software program for gamma spectrometry. Errors considered as standard deviation (1 sigma) refer only to the counting statistics, and it should also be noted that because of low signals, they resulted large and ranged between 30 and 60%.

All samples were kept sealed in the containers for one month before measurements to attain secular equilibrium among parents and granddaughters of the natural radioactive series. Thus, by considering the T1-208 and Bi-212 as well as Bi-214 and Pb-214 isotopes in equilibrium with Th-232 and U-238 respectively, the following conversion factors were used to calculate concentrations of the corresponding elements from radioactivity values:

$$4.1\ \text{Bq/kg (T1-208)} = 1\ \mu\text{g/g of Th}$$
$$12.4\ \text{Bq/kg (Bi-214)} = 1\ \mu\text{g/g of U}$$
$$307\ \text{Bq/kg (K-40)} = 1\%\ \text{of K}$$

Determination of organic matter in the sediments was obtained from the difference between dry (110°C) and ash weights (550°C), whereas organic carbon concentrations were determined through the COD method and nitrogen contents with a CHN-600 LECO instrument.

## RESULTS AND DISCUSSION

The concentrations of the anthropogenic Cs-137 detected in five sea water samples collected on the way from subAntarctic areas to the Italian Base at Terra Nova Bay are reported in Table 3. An increasing radiocontamination was noticed going from Antarctica (SW24, 31 and 33) towards lower latitudes, with higher values observed in samples SW08 and SW14 collected further north (60÷70° S latitude). No remarkable difference was demonstrated

**Table 4** Concentrations of Cs-137 in sea water samples collected during the 4th Scientific Expedition (1990–91).

| *Sample* | *Method* | *Volume litres* | *Separation yield* | *Cs-137 Bq/m3* |
|---|---|---|---|---|
| SW02 | NCFC | 300 | 95% | 0.17±0.06 |
| PW06 | NCFC | 400 | 95% | 0.22±0.06 |

**Table 5** Concentrations of Cs-137 and K-40 in superficial sediment samples collected during the 3rd Scientific Expedition (1989–90).

| *Sample* | *Specific Weight* | *Dry/Humid Percentage* | *Cs-137 Bq/kg dry* | *K-40 Bq/kg dry* | *K %* |
|---|---|---|---|---|---|
| SM24 | 1.40 | 84.35% | 0.10±0.05 | 997.76±8.62 | 3.25 |
| SM33 | 1.50 | 92.30% | 0.12±0.07 | 1783.1±14.6 | 5.81 |
| SM34 | 1.30 | 69.05% | 0.12±0.08 | 630.25±6.65 | 2.05 |
| SM35 | 0.95 | 65.32% | 0.21±0.10 | 645.86±7.32 | 2.10 |
| SM44 | 0.79 | 55.50% | 0.75±0.18 | 536.45±7.72 | 1.75 |



between sea water (0.17±0.06 Bq/m$^3$) and the Gerlache Inlet pack water (0.22±0.06 Bq/m$^3$) (Table 4) as had already been reported in the past[7].

Results concerning Cs-137 concentrations in surface-grabbed coastal sediments of the 1989–90 Expedition are shown in Table 5. An appreciable value of 0.75±0.18 Bq/kg dry weight was detected in the SM44 sample. It must be said that this sample contained high quantities of sponge spicules and consequently a high content of organic matter (11.8% dw, average value of the other samples equal to 1.7% dw), organic carbon (12.8mg/g vs average value of 7.9mg/g) and nitrogen (1.9mg/g vs 0.78mg/g). Significant positive correlations were observed between the Cs-137 concentrations of all coastal samples and the contents of organic matter (correlation index r=0.99), organic carbon (r=0.94) and nitrogen (r=0.97). No particular differences in Th-232 and U-238 concentrations between sampling stations were observed (Table 6), this in good agreement with previously published data[6,7,8].

Data concerning Cs-137 concentrations in off shore samples collected during the 1990–91 Expedition are reported in Table 7. Values were lower than those detected the previous year in the coastal area of the Bay, with the surface strata slightly more contaminated than the lower ones. A value of 0.19±0.11 Bq/kg dry weight was observed in station SM19 in

**Table 6** Concentrations of Th-232 and U-238 in superficial sediment samples collected during the 3rd Scientific Expedition (1989–90).

| *Sample* | *Specific Weight* | *Dry/Humid Percentage* | *Th-232 (Tl-208)* | | *U-238 (Bi-214)* | |
|---|---|---|---|---|---|---|
| | | | *Bq/kg dry* | *μg/g* | *Bq/kg dry* | *μg/g* |
| SM24 | 1.40 | 84.35% | 21.43±1.28 | 5.23 | 20.46±0.31 | 1.65 |
| SM33 | 1.50 | 92.30% | 32.62±1.14 | 7.96 | 12.69±0.24 | 1.02 |
| SM34 | 1.30 | 69.05% | 46.08±1.56 | 11.2 | 37.72±0.79 | 3.04 |
| SM35 | 0.95 | 65.32% | 38.86±1.12 | 9.48 | 39.40±0.61 | 3.18 |
| SM44 | 0.79 | 55.50% | 19.33±1.50 | 4.71 | 28.16±0.66 | 2.27 |

**Table 7** Concentrations of Cs-137 and K-40 in sediment samples of different strata collected during the 4th Scientific Expedition (1990–91).

| *Sample* | | *Specific Weight* | *Dry/Humid Percentage* | *Cs-137 Bq/kg dry* | *K-40 Bq/kg dry* | *K %* |
|---|---|---|---|---|---|---|
| Coastal area | | | | | | |
| SMB7 | | 0.94 | 53.62% | 0.11±0.08 | 821.55±7.02 | 2.68 |
| Off-shore area | | | | | | |
| SM03 | 0–30 cm | 0.85 | 49.04% | 0.16±0.08 | 814.82±7.62 | 2.65 |
| SM06 | 0–26 cm | 0.96 | 63.15% | 0.14±0.09 | 740.07±7.06 | 2.41 |
| SM12 | 0–12 cm | 0.96 | 73.79% | 0.14±0.09 | 679.78±6.95 | 2.21 |
| | 12–25 cm | 0.98 | 76.05% | 0.11±0.07 | 683.73±6.30 | 2.23 |
| SM19 | 0–36 cm | 0.70 | 40.10% | 0.19±0.11 | 576.17±7.58 | 1.88 |
| SM22 | 0–16 cm | 0.70 | 43.54% | 0.16±0.09 | 823.41±8.00 | 2.68 |
| | 16–32 cm | 0.80 | 58.00% | 0.14±0.09 | 786.55±7.63 | 2.56 |
| SM23 | 0–10 cm | 0.90 | 62.12% | <0.08 | 610.14±4.97 | 1.99 |
| | 10–24 cm | 1.01 | 68.21% | <0.08 | 675.99±5.75 | 2.20 |
| SM29 | 0–15 cm | 0.70 | 47.31% | 0.14±0.09 | 588.25±6.10 | 1.92 |
| | 15–33 cm | 0.77 | 55.46% | 0.13±0.09 | 630.96±6.70 | 2.06 |
| SM30 | 0–15 cm | 0.72 | 53.46% | 0.10±0.08 | 541.19±5.12 | 1.76 |
| | 15–34 cm | 0.89 | 44.84% | 0.11±0.08 | 743.25±6.59 | 2.42 |
| SM36 | 0–05 cm | 1.17 | 77.21% | 0.15±0.11 | 828.19±7.50 | 2.70 |
| SM38 | 0–15 cm | 0.95 | 69.63% | 0.10±0.08 | 763.42±6.76 | 2.49 |
| | 15–34 cm | 0.90 | 76.29% | <0.07 | 900.71±6.67 | 2.93 |

connection with a high content of organic matter (8% dw) and organic carbon (7.9mg/g). In spite of this, no significant correlations were drawn between the Cs-137 concentrations and the presence of organic matter (r=0.60) and organic carbon (r=0.48), thus demonstrating different trends between the contents of these compounds and the radionuclide concentrations in the off shore area.

As concerns natural radioactivity, high concentrations of U-238 were observed at station SM03, characterized by very deep bathymetry (3361 m) and located far from the Bay (Table 8). The quantities of potassium (1.75÷5.81% dw) present in both coastal and offshore sediments, obtained by radiometric analysis were in good agreement with the values reported by other authors for other sampling stations in the study area[11,12].

With regard to samples of icthyofauna and macrobenthos, the results obtained by considering total specimens, without anatomical dissection, showed Cs-137 concentrations higher in the bivalve *Adamassium colbecki* than in samples of *Pagothenia bernacchii* and *Chionodraco hamatus* (Tables 9 and 10). This may be related to the different ecological characteristics of the organisms, namely the filter feeding habit of *Adamussium* which lives on particle-rich substrates in comparison to the predatory behaviour of the other two fish. Tables 9 and 10 also report the Cs-137 and K-40 concentrations detected in the different anatomical components of the teleosts of the 3$^{rd}$ and 4$^{th}$ Campaign together with the corresponding dry weight/fresh weight percentages and the percentage of the anatomical component on the total sample. Interesting to observe, on the other hand was the higher contamination of the visceral component of *Pagothenia* in both years, despite the higher Cs-137 concentrations expected in the muscular component as observed in *Chionodraco*[9]

**Table 8** Concentrations of Th-232 and U-238 in sediment samples of different strata collected during the 4th Scientific Expedition (1990–91).

| *Sample* | | *Specific Weight* | *Dry/Humid Percentage* | *Th-232 (Tl-208)* | | *U-238 (Bi-214)* | |
|---|---|---|---|---|---|---|---|
| | | | | *Bq/kg dry* | *μg/g* | *Bq/kg dry* | *μg/g* |
| Coastal area | | | | | | | |
| SMB7 | | 0.94 | 53.62% | 26.55±0.86 | 6.47 | 23.98±0.47 | 1.93 |
| Off-shore area | | | | | | | |
| SM03 | 0–30 cm | 0.85 | 49.04% | 37.55±1.20 | 9.16 | 84.25±1.28 | 6.79 |
| SM06 | 0–26 cm | 0.96 | 63.15% | 32.95±1.57 | 8.04 | 40.25±0.96 | 3.24 |
| SM12 | 0–12 cm | 0.96 | 73.79% | 27.60±1.05 | 6.73 | 28.68±0.56 | 2.31 |
| | 12–25 cm | 0.98 | 76.05% | 26.79±0.84 | 6.53 | 25.90±0.49 | 2.10 |
| SM19 | 0–36 cm | 0.70 | 40.10% | 18.70±1.94 | 4.56 | 71.54±1.15 | 5.77 |
| SM22 | 0–16 cm | 0.70 | 43.54% | 38.10±1.38 | 9.29 | 62.86±0.99 | 5.10 |
| | 16–32 cm | 0.80 | 58.00% | 35.82±1.09 | 8.73 | 42.08±0.70 | 3.40 |
| SM23 | 0–10 cm | 0.90 | 62.12% | 22.42±0.65 | 5.47 | 27.93±0.43 | 2.25 |
| | 10–24 cm | 1.01 | 68.21% | 26.02±0.71 | 6.35 | 23.17±0.41 | 1.87 |
| SM29 | 0–15 cm | 0.70 | 47.31% | 23.11±1.01 | 5.63 | 27.30±0.73 | 2.20 |
| | 15–33 cm | 0.77 | 55.46% | 26.25±1.11 | 6.40 | 31.57±0.60 | 2.54 |
| SM30 | 0–15 cm | 0.72 | 53.46% | 23.35±0.77 | 5.69 | 43.99±0.68 | 3.55 |
| | 15–34 cm | 0.89 | 44.84% | 38.32±0.86 | 9.35 | 25.17±0.48 | 2.03 |
| SM36 | 0–05 cm | 1.17 | 77.21% | 25.40±1.17 | 6.19 | 28.52±0.52 | 2.30 |
| SM38 | 0–15 cm | 0.95 | 69.63% | 31.69±0.98 | 7.73 | 38.33±0.65 | 3.10 |
| | 15–34 cm | 0.90 | 76.29% | 39.34±0.65 | 9.59 | 32.08±0.47 | 2.59 |



and other Perciformes of temperate seas[13]. Different predatory habits and the biochemical and physiological adaptations[14] elaborated by the organisms to sustain life in severe environmental conditions are more likely to interfere in the different Cs-137 accumulating mechanisms of the two species of fish. The ability of marine organisms to accumulate radionuclides is described in terms of a concentration factor (CF), equal to the ratio between

**Table 9** Concentrations of anthropogenic and primordial radionuclides and Cs-137 Concentration Factors detected in organisms collected during the 3rd Scientific Expedition (1989–90).

| *Sample* | | *Total sample Percentage W* | *Dry/Fresh Percentage W* | *Cs-137 Bq/kg dry* | *C.F. (FW) Cs-137* | *K-40 Bq/kg dry* |
|---|---|---|---|---|---|---|
| *Pagothenia* | Muscle | 19.98% | 15.61% | 0.35±0.12 | 176.24 | 473.92±5.98 |
| *bernacchii* | Viscera | 22.05% | 14.72% | 0.38±0.13 | 180.44 | 483.05±6.10 |
| | Skeleton | 57.97% | 18.71% | 0.30±0.15 | 181.06 | 315.66±6.01 |
| Total sample (n=11) | | | 12.36% | 0.35±0.12 | 139.55 | 404.12±5.99 |
| *Chionodraco* | Muscle | 17.04% | 19.02% | 0.25±0.11 | 153.39 | 459.86±5.55 |
| *hamatus* | Viscera | 13.81% | 24.92% | 0.22±0.11 | 176.85 | 293.39±4.73 |
| | Skeleton | 61.50% | 21.21% | 0.19±0.06 | 130.00 | 328.22±3.32 |
| Total sample (n=7) | | | 17.78% | 0.25±0.10 | 143.39 | 349.93±4.62 |
| *Adamussium colbecki 01* | Soft part | | 9.98% | 1.46±0.64 | 470.97 | 666.15±19.0 |
| *Adamussium colbecki 03* | Soft part | | 10.01% | 2.87±1.32 | 924.88 | 706.21±35.8 |

**Table 10** Concentrations of anthropogenic and primordial radionuclides and Cs-137 Concentration Factors detected in organisms collected during the 4th Scientific Expedition (1990–91).

| Sample | | Total sample Percentage W | Dry/Fresh Percentage W | Cs-137 Bq/kg dry | C.F. (FW) Cs-137 | K-40 Bq/kg dry |
|---|---|---|---|---|---|---|
| *Pagothenia* | Muscle | 21.25% | 17.07% | 0.26±0.09 | 261.07 | 644.51±08.33 |
| *bernacchii* | Viscera | 14.67% | 16.26% | 0.77±0.41 | 735.29 | 489.28±13.33 |
| | Skeleton | 61.56% | 20.23% | 0.16±0.05 | 190.40 | 360.73±03.58 |
| Total sample (n=9) | | | 18.97% | 0.26±0.09 | 290.13 | 448.86±05.74 |
| *Adamussium colbecki* | Soft part | | 10.39% | 0.26±0.09 | 158.90 | 249.64±05.46 |

the concentration in the organism (Wet Weight) and the concentration of the same in sea water. Concentration factors for Cs-137 (expressed as $Bq \cdot Kg^{-1}$ wet weight/$Bq \cdot l^{-1}$) in our samples ranged between 150 and 925 for the bivalves and 130 and 735 for the teleosts. Once again, higher concentration factors in fish resulted in the internal organs of *Pagothenia*, although all these values were in good agreement with data reported in literature both for singular components and the whole body of similar types of organisms from lower latitudes[13].



## CONCLUSIONS

Significant values concerning anthropogenic Cs-137 were observed in sea water coastal samples collected very close to the shoreline[8], although analysis performed on samples from 60÷70° S latitude showed increasing concentrations moving from Terra Nova Bay further north towards subAntarctic areas. No significant difference was observed between sea water and pack water of the Gerlache Inlet, whereas a slight decrease of the Cs-137 contents in sea water was noticed over the years.

Analysis carried out on different coastal sediments showed the same trends already observed for the coastal seawater samples. That is, sediments rich in silt and clay[12] close to the shoreline demonstrated a higher Cs-137 retention capacity than offshore samples, mostly of sandy composition. On the other hand, it is well known that the major role of clay and silt particles is to bind and tightly retain this radionuclide. With regard to natural radioactivity, high concentrations of U-238 were observed in the off shore area in stations characterized by deep bathymetries (3361 m).

It must be pointed out that the sediment composition and morphology of the Terra Nova Bay continental shelf is very unique[11], therefore it was possible to observe appreciable differences in the contents of both artificial and natural radioactivity over short distances in relation to the presence of canyons, basins, banks and macroripples. In general, concentration levels of Cs-137 in sediment samples of the Ross Sea were about ten times lower than those of the Adriatic Sea before Chernobyl and about twenty times lower than the post Chernobyl levels[15].

As concerns biological specimens, the Antarctic scallop *Adamussium colbecki* turned out to be a better Cs-137 concentrator than *Pagothenia bernacchii* and the "icefish"

*Chionodraco hamatus*, probably a result of different ecological habits. *Pagothenia bernacchii*, on the other hand, had higher concentrations in the visceral component although Cs-137 contamination was expected to occur mainly in the muscular component in relation to the Cs/K abundance and mobility, as has already been observed in temperate waters[13,16]. More investigations are therefore necessary to complete these preliminary data on biologic samples and to make appropriate comparisons with organisms from temperate seas. In general, radiocontamination in fish and clams of Antarctica seemed to occur with ranges about ten times lower than that of the Adriatic Sea before Chernobyl and up to one hundred times lower than levels detected after the Chernobyl accident[16].

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