| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0693 | Deep Channel | Yellow-fin (~100) | Light muscle | 15 ± 1.1 | 3.1 ± 0.1 | 0.14 | NC | 0.09 | 0.06 | 0.04 | 0.02 | |
| 0694 | | | Dark muscle | 9.7 ± 1.2 | 49 ± 0.4 | 8.4 ± 1.3 | NC | < 0.12 | 0.07 | 0.16 | | |
| 0695 | | | Liver | NC | 99 ± 1.1 | 2.1 ± 0.3 | NC | < 0.30 | 0.24 | 0.08 | 0.001 | |
| 0696 | | | Bone | 2.5 ± 0.6 | < 0.06 | < 0.04 | NC | 0.03 | 0.02 | 0.02 | 0.01 ± 0.005 | |
| 0440 | ELMER | Mackerel (47,41) | Viscera | 9.7 ± 1.6 | 240 ± 2.9 | 2.7 ± 0.25 | NC | < 0.20 | 0.98 ± 0.10 | < 0.34 | 0.011 | |
| 0442 | | | Muscle | 20 ± 1.4 | 6.5 ± 0.3 | < 0.23 | NC | 0.17 ± 0.07 | 0.09 ± 0.04 | 0.097 | < 0.002 | |
| 0443 | | | Muscle | 20 ± 1.4 | 10 ± 0.4 | 0.68 ± 0.15 | NC | 0.21 ± 0.07 | < 0.06 | < 0.10 | 0.006 | |
| 0572 | GLENN | Mackerel (~45) | Muscle | 18 ± 1.5 | 11 ± 0.3 | 0.37 ± 0.07 | NC | 0.24 ± 0.06 | 0.05 | 0.20 | 0.009 | |
| 0574 | | | Viscera | NC | 210 ± 6.4 | 5.3 ± 1.6 | NC | 0.36 | 0.34 | 1.3 | 0.002 ± 0.001 | |
| 0573 | | | Bone | 18 ± 4.1 | 580 ± 10 | 0.61 ± 0.18 | NC | < 0.20 | 0.17 | < 1.1 | 0.014 ± 0.002 | |
| 0706 | Wide Pass | Dolphin (~100) | Muscle | 15 ± 1.3 | — | 0.67 ± 0.18 | NC | 0.20 ± 0.07 | 0.09 ± 0.04 | 0.005 ± 0.003 | 0.016 ± 0.001 | |
| 0707 | | | Liver | 10 ± 1.7 | 45 ± 1.3 | 13 ± 0.5 | NC | < 0.16 | < 0.12 | 0.02 | 0.035 ± 0.003 | |
| 0540 | ELMER | Dolphin (80) | Muscle | 19 ± 1.7 | < 0.9 | 0.14 | NC | 0.09 | 0.07 | 0.10 | 0.003 | |
| 0541 | | | Liver | 15 ± 1.6 | 30 ± 5.9 | 0.98 ± 0.37 | NC | 0.30 | 0.67 | | 0.07 ± 0.02 | |
| 0769 | MIKE Crater | Barra-cuda (~60) | Muscle | 16 ± 1.3 | — | 0.55 ± 0.07 | NC | 1.6 ± 0.10 | 28 ± 0.5 | 0.05 ± 0.01 | — | |
| 0770 | | | Bone | 6.3 ± 0.9 | — | 0.38 ± 0.06 | NC | 0.48 ± 0.07 | 2.7 ± 0.1 | 0.15 ± 0.01 | 0.24 ± 0.02 | |

[a]Error values are one-sigma, counting errors.

[b]Each tissue sample is from an individual fish except for No. 0440 which is a composite sample from two fish.

[c]NC = not computed.

difference in the $^{60}Co$ concentration in muscle tissue of skipjack captured near YVONNE as compared to those captured near the southern end of the atoll.

Zinc-65, was found only in the liver of the skipjack. Seven ($^{65}Zn$ in one liver was not computed) skipjack livers had detectable levels of $^{65}Zn$ ranging from 1.5 to 6.6 pCi/g, dry, and averaged 2.9 pCi/g, dry. Two skipjack and one wahoo from Kwajalein Atoll also had average $^{65}Zn$ concentrations of 0.9 pCi/g, dry, in their livers, indicating that at least a part of the $^{65}Zn$ present in the Enewetak skipjack is from worldwide fallout.

Cesium-137 and $^{207}Bi$ were found in about 50% of the samples, usually at levels below 1 pCi/g, dry. Cesium-137 was found mainly in the muscle tissue and was evenly distributed between light and dark muscle. However, the highest $^{137}Cs$ level was found in the liver of a skipjack from the lagoon off WALT Island. Bismuth-207 was also at its highest level (6.1 pCi/g, dry) in the dark muscle tissue of this skipjack. However, $^{207}Bi$ was generally higher in the liver or viscera of a fish than in the muscle.

The only $^{241}Am$ detected in the offshore lagoon fish was also found in the above-mentioned skipjack from WALT. This fish had an $^{241}Am$ concentration of 0.35 pCi/g, dry, in its light muscle and 0.83 pCi/g, dry, in its liver.

Strontium-90 and $^{239,240}Pu$ analyses indicate that these radionuclides are generally found in concentrations < 0.1 pCi/g, dry. The highest $^{90}Sr$ levels in the pelagic fish are found in barracuda bone (0.15 pCi/g, dry), while the highest $^{239,240}Pu$ concentration (1.2 pCi/g, dry) was in the light muscle of a skipjack collected in the Wide Pass.

Summary and Conclusions

Of the man-made radionuclides, $^{60}Co$ and $^{55}Fe$ are found in the greatest abundance in the nearshore fish, followed by $^{207}Bi$, $^{155}Eu$, $^{137}Cs$, and $^{241}Am$ in order of decreasing abundance. All these radionuclides except $^{137}Cs$ are present in greater concentrations in the viscera as compared to eviscerated whole fish. Cesium-137 is about equally distributed in the viscera and eviscerated whole fish.

In general, nearshore fish collected from IRENE had the highest levels of $^{55}Fe$, $^{60}Co$, $^{137}Cs$, $^{155}Eu$, and $^{241}Am$, while $^{207}Bi$ was highest in an ulua from HENRY.

Iron-55 concentrations were generally highest in the liver or dark muscle of the tuna and in the viscera of goatfish, however, a grouper liver from FRED had the highest individual value, 4900 pCi/g, dry, of any sample analyzed. Iron-55 concentrations were higher by a factor of 10 or more in liver or viscera than in light muscle or eviscerated whole fish.

Cobalt-60 concentrations in the nearshore fish ranged from non-detectable amounts to 400 pCi/g, dry, in the viscera of butterfly fish from IRENE. Most $^{60}Co$ values for these fish were less than 5 pCi/g, dry.

Cobalt-60 concentrations in Enewetak lagoon fish ranged up to 36 pCi/g, dry, in the liver of a skipjack from near YVONNE. Although the average $^{60}Co$ concentration in the tissue samples of three skipjack captured near YVONNE was higher than that found in samples from skipjack in the southern part of the atoll, there was no significant difference between the two areas due to the high variability within samples from the same area.

Cobalt-60 concentrations in the liver and muscle of the other lagoon fish was less than it was in the skipjack. No $^{60}$Co was detected in lagoon fish from Kwajalein.

Bismuth-207, $^{155}$Eu, and $^{137}$Cs were the next most abundant radionuclides. Bismuth-207 concentrations in the small nearshore fish and in snappers and groupers ranged from non-detectable levels up to 24 pCi/g, dry, in the viscera of goatfish from BELLE, and most concentrations were less than 5 pCi/g, dry; however, one ulua from HENRY had a $^{207}$Bi concentration of 240 pCi/g, dry. Europium-155 concentrations in all nearshore fish ranged up to 22 pCi/g, dry, found in the viscera of mullet from IRENE, while average values were less than 1 pCi/g, dry. Cesium-137 concentrations ranged up to 9.6 pCi/g, dry, in mullet viscera from IRENE, but most concentrations were less than 0.5 pCi/g, dry.

Cesium-137 was found in muscle tissue of offshore lagoon fish from Enewetak and Kwajalein Atolls in about the same concentrations (less than 0.5 pCi/g, dry) except for one barracuda captured in MIKE Crater and a skipjack taken off WALT. The barracuda had a $^{137}$Cs concentration of 16 pCi/g, dry, in its muscle tissue, while the skipjack had 2.7 pCi/g, dry, in its liver.

The muscle tissue of the barracuda from MIKE Crater also had the highest $^{207}$Bi level (28 pCi/g, dry) of any offshore lagoon fish from Enewetak Atoll. Bismuth-207 was detected in 14 or 20 samples of skipjack muscle in concentrations up to 6.1 pCi/g, dry, and averaged 1.5 pCi/g, dry. All eight skipjack from Enewetak had detectable $^{207}$Bi in their livers in concentrations up to 2.3 pCi/g, dry, and averaged 0.9 pCi/g, dry. No significant differences between $^{207}$Bi content in the tissues of three skipjack from the YVONNE area and five skipjack from the southern end of the Atoll were noted. Yellowfin tuna had no detectable $^{207}$Bi in their tissues, while mackerel and dolphin had low levels in the muscle.

Europium-155 was detected in only one offshore fish sample.

Zinc-65 was found in the liver of skipjack from Enewetak Atoll in concentrations up to 6.6 pCi/g, dry, and averaged 2.9 pCi/g, dry, in the seven skipjack which had detectable levels. Two skipjack livers and one wahoo liver from Kwajalein Atoll also had detectable $^{65}$Zn concentrations which averaged 0.9 pCi/g, dry, tissue. Zinc-65 was detected only in liver tissue.

Other gamma-emitting radionuclides were present in small amounts on a sporadic basis.

Americium-241 was found almost exclusively in the viscera of fish from BELLE, IRENE, TILDA-URSULA, and YVONNE. Concentrations ranged up to 11 pCi/g, dry, in mullet viscera from IRENE, but averaged less than 1 pCi/g, dry. Plutonium-239, 240 and $^{90}$Sr concentrations were also high in the viscera of fish from these areas, with the highest concentrations being in the fish from IRENE and BELLE. Large pelagic lagoon fish had lower concentrations of these radionuclides than did the smaller nearshore fish.

There are some differences in radionuclide content of nearshore fish

Table 38. Comparison of $^{60}Co$ and $^{207}Bi$ in the viscera of convict surgeon collected in 1964 and 1972.

| | $^{60}Co$ in pCi/g, dry | | | $^{207}Bi$ in pCi/g, dry | | |
|---|---|---|---|---|---|---|
| Island | 1964 | 1972 | Fraction remaining | 1964 | 1972 | Fraction remaining |
| BELLE | 120 | 16 | 0.13 | 8.0 | 2.0 | 0.25 |
| JANET | 8.3 | 0.96 | 0.12 | 1.2 | 0.2 | 0.17 |
| GLENN | 19 | 3.3 | 0.17 | 2.6 | 0.7 | 0.27 |
| LEROY | 56 | 3.4 | 0.06 | 5.2 | 3.1 | 0.59 |
| YVONNE | 64 | 5.2 | 0.08 | – | – | – |
| Average | | | 0.11 | | | 0.32 |

associated with feeding habits. The goatfish, a bottom-feeding carnivore, usually contains more $^{55}Fe$, $^{60}Co$, and $^{207}Bi$ than the convict surgeon, a grazing herbivore, or the mullet, a detritus feeder. Convict surgeon from BELLE and IRENE did contain more $^{60}Co$ than goatfish from IRENE, but goatfish from all other areas had higher $^{60}Co$ concentrations than did the convict surgeon from the same area.

A comparison of the present $^{60}Co$ and $^{207}Bi$ levels in the fish to those found in the 1964 collections (Welander, et al. 1967*) gives some indication of the loss rate of those two radionuclides. From the data presented in Table 38, a rough estimate of the effective half-life for $^{60}Co$ (2.7 years) and $^{207}Bi$ (5 years) can be deduced. Using these values in the equation, $e = PE/P-E$, where e = ecological half-life, P = physical half-life, and E = effective half-life, the length of the ecological half-life can be calculated. Ecological half-life is the time required for one-half of the radionuclide in the organism to be lost by processes other than physical decay of the radionuclide during a period when there can be both uptake and loss of the radionuclide but loss is greater than uptake. Thus, the ecological half-life of both $^{60}Co$ and $^{207}Bi$ in the convict surgeon at Enewetak between 1964 and 1972 is about 6 yr. Comparisons of similar samples of mullet and goatfish give a similar value. Hence, these two radionuclides are being eliminated from these fish at a higher rate than would result from physical decay alone.

In conclusion, fish from the northern portion of the Atoll (BELLE to IRENE) had the highest levels of most radionuclides, fish from the southern portion (DAVID to HENRY) had the lowest activity levels, and fish from intermediate areas (JANET to YVONNE, plus LEROY) had intermediate levels of radioactivity. These activity levels generally correspond to the geographical distribution of activity found in the lagoon sediments.

Invertebrates

Introduction

Selected invertebrates were collected for analysis. Tridacna clams were

*A. D. Welander, et al., Bikini-Eniwetok Studies, 1964: Part II. Radiobiological Studies, USAEC, Rept. UWFL-93 (Pt. II) (1967).

sampled, since they are both a food item and an indicator organism for $^{60}Co$. Spiny lobster and top snails are food items, while sea cucumbers might be an indicator organism for plutonium. The invertebrate organisms were not abundant in all locations, but a fair number of Tridacna clams and sea cucumbers were collected from most sampling areas (Table 26). The invertebrates were processed, packaged, gamma-counted, and radiochemically analyzed in the same manner as the fish.

Results and Discussion

The invertebrate samples have been analyzed for gamma-emitting radionuclides, $^{55}Fe$, $^{90}Sr$, and $^{238,239,240}Pu$. The gamma-emitting radionuclides detected by the Ge(Li) diode system included naturally occurring $^{40}K$ and $^{226}Ra$ and 13 fallout radionuclides – $^{54}Mn$, $^{60}Co$, $^{65}Zn$, $^{101}Rn$, $^{102M}Rh$, $^{108M}Ag$, $^{125}Sb$, $^{134}Cs$, $^{137}Cs$, $^{152}Eu$, $^{155}Eu$, $^{207}Bi$, and $^{241}Am$.

Radioactivity values are given as of the date of collection in terms of dry sample weight. Dry weight values may be converted to wet weight values by use of the conversion factors given in Table 25. The Kwajalein invertebrate samples consist of six pooled Tridacna clams, and the data are presented in Table 28. The Enewetak data are presented in Tables 39 (Tridacna), 40 (Sea cucumbers) and 41 (Miscellaneous).

Tridacna Clams – The results of the radiological analyses of the tridacna clams are given in Tables 28 (Kwajalein) and 39 (Enewetak). The large "killer" clam, *Tridacna gigas*, and the smaller clam, *Tridacna crocea* were the two types collected. All of the clams from JANET, KATE, TILDA, REX, WALT, and LEROY were *T. gigas*. Clams from ALICE and BELLE were a mixture of the two types of clams, while clams from DAVID, GLENN, HENRY, and Kwajalein were the smaller *Tridacna crocea*. Although there are known differences in the radionuclide content of a clam, due to age and species, it appeared that collection location was the most important of these three variables. This is probably because most of the clams collected were living during the period of testing and have been accumulating radionuclides for about the same period of time. Where two or more clams of the same species were available from the same area, size was used as a measure of age and the data compared. Although the larger and presumably older clams in some cases had higher radionuclide concentrations, the opposite situation was often true and, on the average, no significant differences were evident. Comparisons between species from the same area were too few to draw any conclusions.

Naturally occurring $^{40}K$ was present at normal levels. Samples averaged 10 pCi/g, dry. The most abundant radionuclide accumulated by the tridacna clams was $^{60}Co$. This radionuclide was found in all samples and was present in high concentrations in the kidney samples from most collection areas. Bismuth-207 and $^{55}Fe$ were also detected in most samples, but at lower levels than $^{60}Co$. Europium-155 was found at low levels in less than one-third of the samples. Strontium-90 was found in most samples. Americium-241 was detected only in the

Table 39. Predominent radionuclides in Tridacna clams collected from Enewetak Atoll, October to December 1972.

| Island | Tissue | No. of samples | No. of clams | Radionuclide, average ± standard deviation[a] in pCi/g, dry: $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{155}Eu$ | $^{207}Bi$ | $^{90}Sr$ | $^{239,240}Pu$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ALICE | Mantle and muscle | 2 | 2 | 10 ± 5.2 | 3.3 ± 4.5 | 3.9 ± 0.9 | 0.08 ± 0.01 | 0.38 ± 0.01 | 0.10 ± 0.13 | 0.05 ± 0.01 |
| | Viscera[b] | 2 | 2 | 9.5 ± 0.2 | 23 ± 11 | 8.5 ± 0.6 | 0.69 ± 0.06 | 3.9 ± 0.6 | 1.10 ± 0.4 | 4.7 ± 0.4 |
| | Kidney | 1 | 2 | 4.9 ± 1.9 | 68 ± 1.1 | 460 ± 3 | < 0.48 | 18 ± 0.6 | 1.1 ± 0.2 | 0.28 ± 0.04 |
| | Entire | 1 | 1 | 8.9 ± 1.3 | 8.3 ± 0.6 | 34 ± 0.5 | 0.44 ± 0.10 | 1.7 ± 0.1 | 0.62 ± 0.05 | 1.2 ± 0.1 |
| BELLE | Mantle and muscle | 3 | 8 | 11 ± 4 | 9.7 ± 3.0 | 18 ± 19 | 0.15 ± 0.13 | 0.82 ± 0.36 | < 0.5 | 0.24 ± 0.2 |
| | Viscera and kidney | 2 | 7 | 8.8 ± 4.6 | 34 ± 3.0 | 150 ± 72 | 0.60 ± 0.26 | 7.9 ± 1.6 | 1.9 ± 1.7 | 1.8 ± 0.1 |
| | Viscera | 1 | 1 | 5.5 ± 1.4 | | 12 ± 0.2 | 1.0 ± 0.1 | 4.5 ± 0.1 | | |
| | Kidney | 1 | 1 | 9.5 ± 3.2 | 86 ± 3.2 | 420 ± 5 | < 2.4 | 20 ± 0.6 | 0.53 ± 0.10 | 0.42 ± 0.03 |
| JANET | Mantle and muscle | 1 | 1 | 14 ± 1.1 | 7.2 ± 0.1 | 20 ± 0.4 | 0.18 ± 0.08 | 1.6 ± 0.1 | 0.02 ± 0.01 | 0.094 ± 0.003 |
| | Mantle | 1 | 1 | 7 ± 0.8 | 1.7 ± 0.1 | 6.4 ± 0.5 | < 0.04 | 0.44 ± 0.04 | 0.07 ± 0.02 | 0.06 ± 0.01 |
| | Muscle | 1 | 1 | 9.4 ± 1.3 | 0.58 ± 0.03 | 1.4 ± 0.1 | < 0.15 | < 0.09 | 0.26 ± 0.003 | – |
| | Viscera | 2 | 2 | 9.4 ± 4.8 | 21 ± 0.4 | 26 ± 26 | 1.5 ± 1.2 | 31 ± 36 | 0.014 ± 0.007 | 0.72 ± 0.02 |
| | Kidney | 2 | 2 | NC[c] | 11 ± 0.1 | 2100 ± 1500 | 3.7 ± 0.8 | 64 ± 52 | 0.28 ± 0.02 | 0.30 ± 0.01 |
| | Gills | 1 | 1 | 7.3 ± 1.2 | 4.7 ± 0.1 | 34 ± 0.9 | < 0.09 | 1.4 ± 0.2 | 0.11 ± 0.01 | 0.27 ± 0.03 |
| KATE | Mantle and muscle | 1 | 1 | 14 ± 2.8 | 1.9 ± 0.4 | 0.5 ± 0.3 | < 0.21 | < 0.12 | 0.01 ± 0.003 | 0.50 ± 0.02 |
| | Mantle | 1 | 1 | 13 ± 2.5 | 2.3 ± 0.5 | 2.4 ± 0.3 | < 0.22 | < 0.15 | 0.010 ± 0.003 | – |
| | Muscle | 1 | 1 | 9.8 ± 1.1 | 0.83 ± 0.07 | 2.3 ± 0.1 | < 0.05 | < 0.04 | < 0.006 | 0.016 ± 0.005 |
| | Viscera | 2 | 2 | 5.9 ± 0.6 | 4.0 ± 0.7 | 4 ± 4 | 0.08 ± 0.01 | 1.7 ± 1.9 | < 0.28 | 0.043 ± 0.003 |
| | Kidney | 2 | 2 | 6.6 ± 0.9[d] | 1.0 ± 0.2 | 280 ± 240 | < 0.53 ± 0.54 | 5.3 ± 5.9 | 0.25 ± 0.04 | 0.06 ± 0.002 |
| TILDA | Mantle and muscle | 1 | 1 | 6.8 ± 1.0 | 0.97 ± 0.08 | 1.3 ± 0.1 | < 0.05 | < 0.05 | 0.009 ± 0.003 | 0.49 ± 0.01 |
| | Viscera and kidney | 1 | 1 | 4.9 ± 1.0 | 7.2 ± 0.1 | 19 ± 0.2 | 0.30 ± 0.05 | 1.5 ± 0.1 | 0.27 ± 0.01 | 2.3 ± 0.1 |
| | Entire | 1 | 1 | 15 ± 2.0 | 5.4 ± 0.9 | 3.4 ± 0.2 | < 0.18 | < 0.11 | 2.5 ± 0.2 | 0.17 ± 0.04 |
| DAVID | Entire | 1 | 3 | 15 ± 1.3 | < 2.6 | 7.3 ± 0.3 | < 0.14 | < 0.09 | < 0.7 | 0.005 ± 0.001 |
| REX | Mantle and muscle | 1 | 1 | 11 ± 1.2 | – | 22 ± 0.5 | < 0.52 | 0.54 ± 0.11 | 0.013 ± 0.005 | 0.015 ± 0.001 |
| | Viscera and kidney | 1 | 1 | 10 ± 2.5 | 3.0 ± 0.1 | 780 ± 2 | < 0.15 | 26 ± 0.5 | 0.018 ± 0.002 | 2.4 ± 0.1 |
| WALT | Mantle and muscle | 1 | 3 | 12 ± 1.2 | 0.70 ± 0.04 | 2.5 ± 0.2 | < 0.10 | 0.14 ± 0.05 | < 0.018 | 0.06 ± 0.01 |
| | Viscera | 1 | 3 | 14 ± 1.3 | 6 ± 0.5 | 11 ± 0.2 | < 0.13 | 2.6 ± 0.1 | < 0.10 | 0.17 ± 0.08 |
| | Kidney | 1 | 3 | 17 ± 5.6 | 22 ± 0.5 | 420 ± 4 | < 0.81 | 8.0 ± 0.6 | 0.06 ± 0.04 | < 0.16 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Kidney | 1 | 3 | 17 ± 5.6 | 22 ± 0.5 | 420 ± 4 | < 0.81 | 8.0 ± 0.6 | 0.06 ± 0.04 | < 0.16 |
| GLENN | Mantle and muscle | 1 | 3 | 1.3 ± 0.4 | 50 ± 1.1 | 7.6 ± 0.2 | < 0.05 | 0.38 ± 0.02 | 0.21 | 0.016 ± 0.00[illegible] |
| | Viscera | 1 | 3 | 12 ± 1.3 | 18 ± 1.1 | 47 ± 0.8 | 0.76 ± 0.40 | 10 ± 0.2 | < 0.7 | 0.28 ± 0.01 |
| | Kidney | 1 | 3 | NC | 40 ± 3.0 | 1250 ± 8 | 3.5 ± 1.1 | 33 ± 1.9 | < 3.0 | 0.11 |
| HENRY | Mantle and muscle | 2 | 3 | 6.8 ± 2.8 | 5.4 ± 0.5 | 13 ± 9 | < 0.11 ± 0.05 | 0.19 ± 0.09 | 0.02 ± 0.01 | 0.90 ± 0.02 |
| | Viscera | 2 | 3 | 8.6 ± 1.6 | 11 ± 0.2 | 43 ± 3 | < 0.18 ± 0.02 | 4.8 ± 3.7 | < 0.018 | 0.28 ± 0.01 |
| | Kidney | 2 | 3 | 22 ± 5[d] | — | 1000 ± 540 | < 0.93 ± 0.04 | 20 ± 3.5 | 0.16 ± 0.05 | 0.22 ± 0.01 |
| LEROY | Mantle and muscle | 1 | 1 | 13 ± 1.7 | 4.8 ± 0.3 | 4.5 ± 0.2 | < 0.09 | 6.7 ± 0.6 | < 0.01 | 0.014 ± 0.001 |
| | Viscera | 1 | 1 | 8.2 ± 1.4 | 16 ± 0.3 | 25 ± 0.4 | NC | 13 ± 0.2 | 0.053 ± 0.02 | 0.86 ± 0.02 |
| | Kidney | 1 | 1 | NC | 68 ± 0.8 | 470 ± 3 | < 0.56 | 22 ± 0.6 | 0.14 ± 0.02 | 0.18 ± 0.01 |

[a]Single sample error values are one-sigma counting errors, while error values for two or more samples are one sample standard deviation without consideration of counting error.

[b]0.79 pCi/g, dry, of $^{241}$Am was also present in these samples. Americium-241 concentrations of 1.0 and 0.5 pCi/g, dry, were also present in the viscera samples from BELLE and TILDA, respectively.

[c]NC = not computed.

[d]Potassium-40 was computed for only one of two samples; hence the error is a one-sigma counting error.

viscera samples from ALICE, BELLE, and TILDA, while plutonium-239,240, was detected in most samples. Cobalt-60 concentrations in the kidney samples ranged from 280 to 2100 pCi/g, dry, and averaged 800 pCi/g, dry. The degree of $^{60}Co$ concentration in the other tissues decreased in the following order: viscera (including kidney), viscera (less kidney), mantle, and muscle (Figs. 49 and 50). Cobalt-60 levels were 100 times higher in the kidney than in the mantle and muscle. Viscera concentrations were also much lower than kidney, although not as low as mantle or muscle tissue.

Tridacna collected from the lagoon off JANET had the highest average $^{60}Co$ concentration in their kidneys (2100 pCi/g, dry). Kidney samples from Tridacna collected on the seaward reef in the GLENN-HENRY area also had a higher than average $^{60}Co$ concentration of about 1100 pCi/g, dry. Other kidney samples averaged 410 pCi/g, dry.

The viscera (including kidney) sample from REX had a very high $^{60}Co$ concentration compared to the other viscera plus kidney samples. Considering that most of the $^{60}Co$ present in this sample was from the kidney portion, which is about 30% of the sample, the $^{60}Co$ concentration in the kidney of this clam, if measured alone, would probably be near that found in the kidney from the JANET clams.

Clams collected at Enewetak Atoll from the reef off DAVID and on the seaward side of TILDA had the lowest concentrations of any of the radionuclides detected in the clams, including $^{60}Co$. This is undoubtedly due to their constant exposure to relatively uncontaminated ocean water passing over the reef on the east side of the atoll.

Tridacna collected from Kwajalein Atoll had a $^{60}Co$ concentration of 2.3 pCi/g, dry, in the viscera plus kidney sample and 0.22 pCi/g, dry, in the mantle plus muscle sample. These levels are below the lowest levels found at Enewetak Atoll.

Iron-55 levels were highest in the kidney, ranging up to 86 pCi/g, dry, in the kidney from a Tridacna collected off BELLE. Kidney samples averaged 33 pCi/g, dry. Viscera and mantle plus muscle samples had lower $^{55}Fe$ levels by factors of 3 and 5, respectively.

Bismuth-207 and $^{155}Eu$ concentrations were also highest in the kidney samples, but were much lower than $^{60}Co$ concentrations. Bismuth-207 in the kidney samples was lower than $^{60}Co$ by a factor of about 40, while $^{155}Eu$ was lower by a factor of over 600. The highest $^{207}Bi$ and $^{155}Eu$ concentrations were also found in Tridacna samples from JANET, GLENN, and HENRY, while low levels were found in Tridacna from DAVID and TILDA.

Strontium-90 concentrations were highest in the kidney and viscera, ranging up to 1.9 pCi/g, dry, in a viscera + kidney sample from BELLE. Most tissue samples had concentrations of < 1.0 pCi/g, dry.

Plutonium-239,240 concentrations averaged < 0.5 pCi/g, dry. The maximum value was 4.7 pCi/g, dry, in the viscera of two clams. Viscera plus kidney samples from BELLE and TILDA also had high Pu levels, plus detectable $^{241}Am$.

Sea Cucumbers – The results of the radiological analyses of the sea cucumbers are given in Table 40. The two genera collected were Actinopygia mauritiana

Table 40. Predominant radionuclides in sea cucumbers collected from Enewetak Atoll, October to December 1972.

| Island | Tissue | No. of samples | Radionuclide, average ± standard deviation[a] in pCi/g, dry: $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{155}Eu$ | $^{207}Bi$ | $^{90}Sr$ | $^{239,240}Pu$ |
|---|---|---|---|---|---|---|---|---|---|
| TILDA | E. whole[b] | 2 | 5.4 ± 0.1 | — | <0.07 | 0.17 ± 0.04 | <0.07 | 0.03 ± 0.03 | 0.033 ± 0.018 |
| | Viscera[c,d] | 2 | 1.4 ± 0.1 | 0.52 ± 0.17 | 0.10 ± 0.02 | 0.32 ± 0.02 | <0.04 | 1.4 ± 0.5 | 0.56 ± 0.10 |
| URSULA | E. whole | 1 | 5.3 ± 1.0 | — | <0.08 | 0.20 ± 0.04 | <0.06 | 0.03 ± 0.01 | 0.09 ± 0.01 |
| | Viscera | 1 | NC[e] | | <0.13 | <0.17 | <0.07 | 0.27 ± 0.01 | 0.044 ± 0.004 |
| YVONNE | E. whole | 2 | 7.7 ± 1.3 | 0.35 ± 0.17 | 0.29 ± 0.21 | 0.19 ± 0.11 | <0.06 | 0.03 ± 0.01 | 0.051 ± 0.55 |
| | Viscera | 2 | 4.3 ± 0.6 | 0.81 ± 0.56 | 0.41 ± 0.26 | 0.53 ± 0.06 | <0.08 | 0.15 ± 0.01 | 0.95 ± 0.50 |
| | Entire | 1 | 3.4 ± 0.85 | 2.5 ± 0.8 | <0.18 | 0.21 ± 0.07 | 0.12 ± 0.4 | 0.15 ± 0.01 | 0.28 ± 0.01 |
| DAVID | E. whole | 1 | 3.6 ± 1.0 | 0.32 ± 0.05 | <0.15 | 0.37 ± 0.11 | <0.07 | 0.04 ± 0.01 | 0.007 ± 0.001 |
| | Viscera | 1 | NC | <2.0 | <0.15 | <1.7 | 4.1 ± 1.0 | 0.16 ± 0.12 | 0.05 ± 0.006 |
| WALT | E. whole | 1 | 6.1 ± 1.3 | <1.7 | <0.23 | <0.15 | <0.09 | <0.42 | <0.018 |
| FRED | W. whole | 1 | 7.0 ± 0.77 | 0.28 ± 0.03 | <0.07 | 0.16 ± 0.04 | <0.04 | 0.03 ± 0.01 | 0.003 ± 0.001 |
| | Viscera | 1 | 2.1 ± 0.74 | 0.69 ± 0.19 | <0.15 | 0.10 ± 0.04 | <0.12 | — | <0.5 |
| GLENN | E. whole | 4 | 5.3 ± 2.2 | — | 6.8 ± 11 | 0.12 ± 0.03 | 1.3 ± 1.7 | 0.05 ± 0.04 | 0.74 ± 1.2 |
| | Viscera | 4 | 1.1 | 6.0 ± 5.2 | 0.29 ± 0.13 | <0.11 ± 0.06 | 0.54 ± 0.46 | 0.20 ± 0.10 | 0.66 ± 1.1 |

[a]Single sample error values are one-sigma counting errors, while error values for two or more samples are one sample standard deviation without consideration of counting error.

[b]E. whole = eviscerated whole, the outer body covering of the sea cucumber.

[c]Viscera includes the gut contents, usually coral sand and fragments.

[d]These viscera samples also had an average $^{241}Am$ concentration of 0.30 pCi/g, dry. One of two viscera samples from YVONNE also had a $^{241}Am$ concentration of 0.23 pCi/g, dry.

[e]NC = not computed.

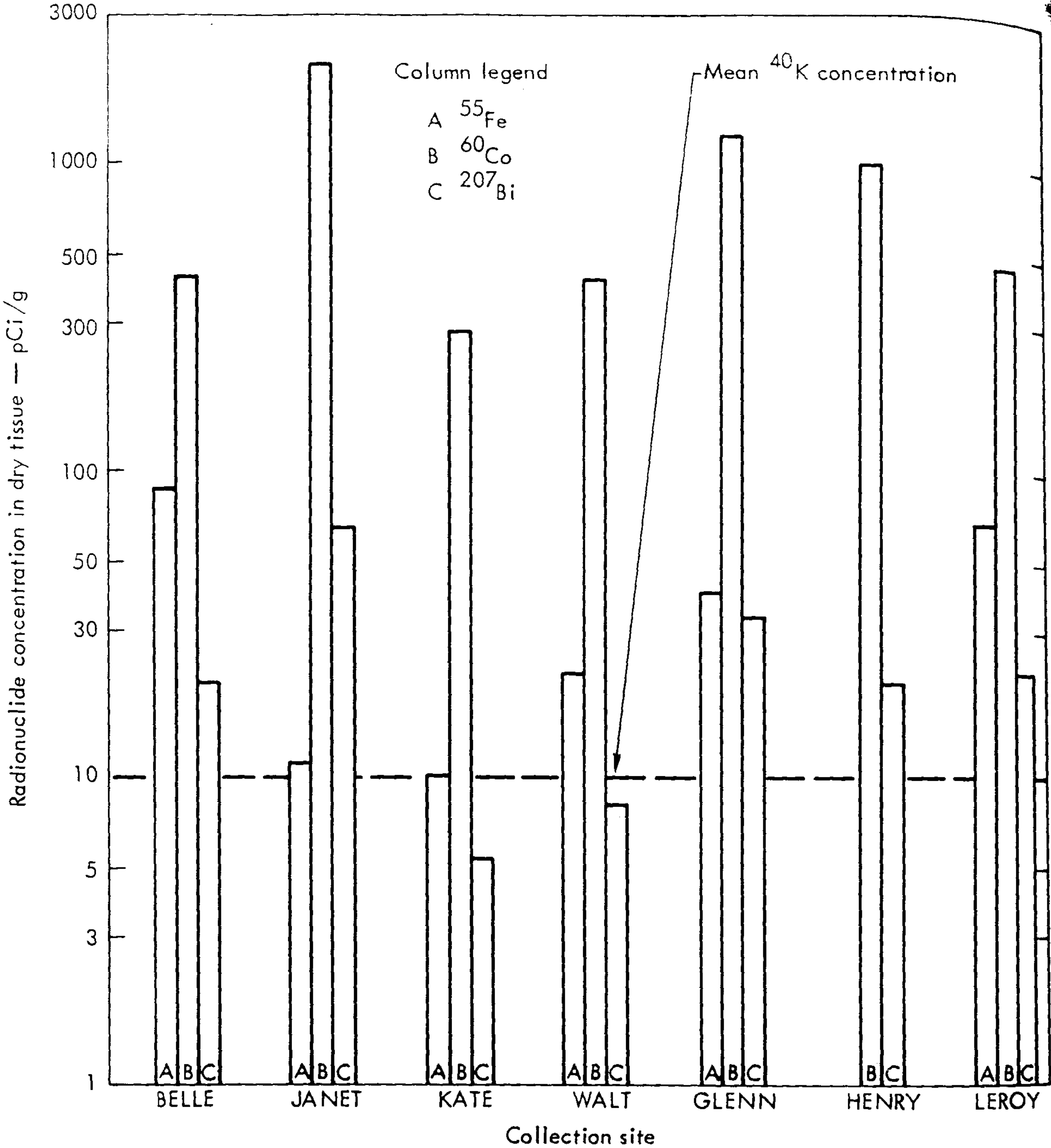


Fig. 49. Average $^{40}$K, $^{55}$Fe, $^{60}$Co, and $^{207}$Bi concentration in the kidney of Tridacna clams collected at Enewetak Atoll, October to December, 1972. The $^{40}$K value is the mean of all Tridacna samples.

(2 samples) and Holothuria sp. (11 samples). Samples of Actinopygia and of Holothuria were made up from an average pool of 5 and 20 individuals, respectively.

Naturally occurring $^{40}$K was the most abundant radionuclide detected in most of the sea cucumber samples. It averaged 2.0 and 5.7 pCi/g, dry, in viscera and eviscerated whole sea cucumber samples, respectively. Of the man-produced, radionuclides, $^{55}$Fe and $^{155}$Eu were present in most samples, while $^{60}$Co and $^{207}$Bi were

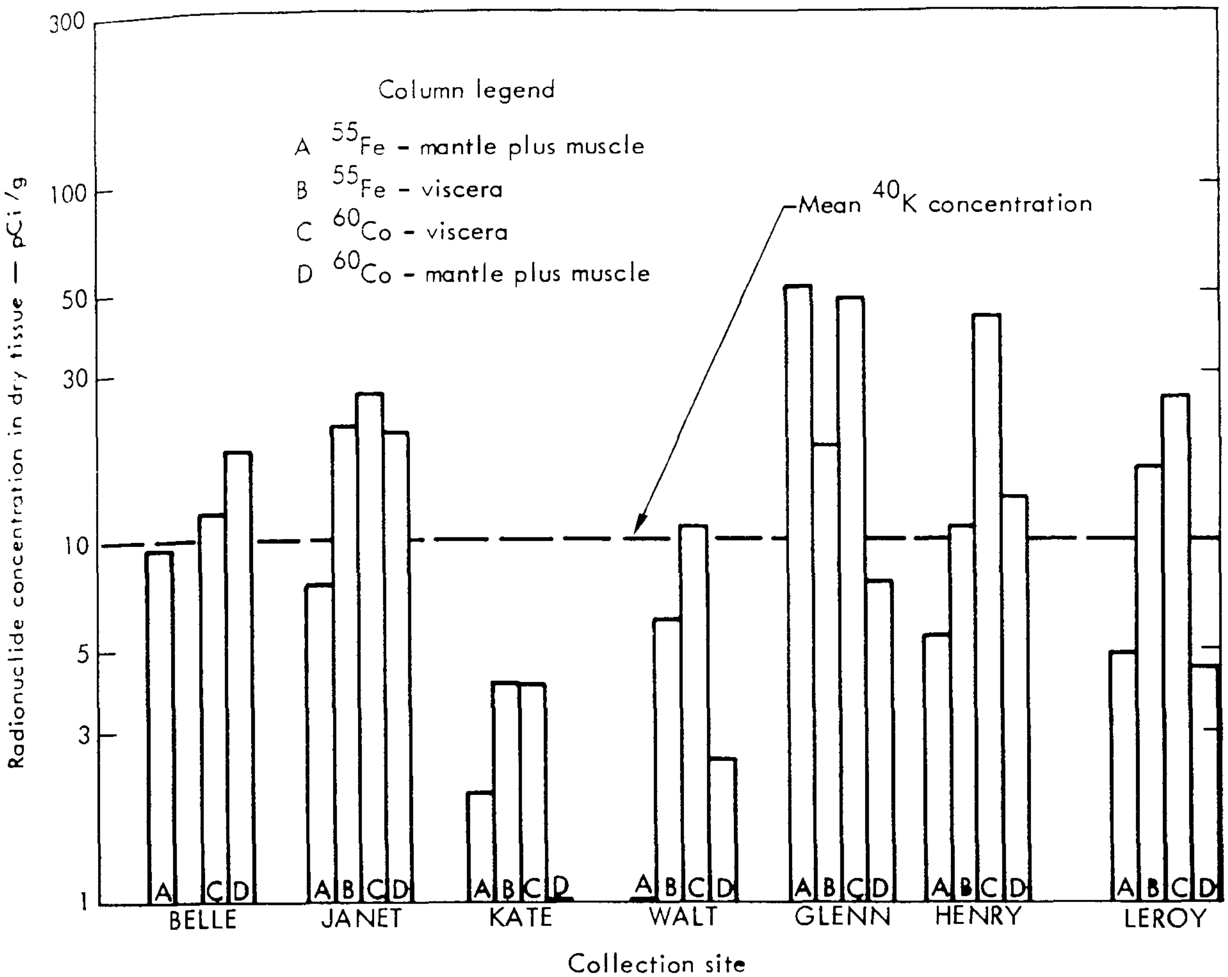


Fig. 50. Average $^{40}K$, $^{55}Fe$, and $^{60}Co$ concentration in the viscera, mantle, and muscle of Tridacna clams collected at Enewetak Atoll, October to December, 1972. The $^{40}K$ value is the mean of all Tridacna samples.

detected in some samples. Three of 11 viscera samples had detectable $^{241}Am$. Plutonium-239, 240 and $^{90}Sr$ were detected in most samples. Iron-55 was present at low levels (< 6.0 pCi/g, dry). Europium-155 was present at low levels (< 0.5 pCi/g, dry) in most samples, with slightly higher levels present in the viscera samples.

Cobalt-60 and $^{207}Bi$ were present in only a few samples. The highest $^{60}Co$ levels were in the eviscerated whole samples from GLENN (6.8 pCi/g, dry) and in the viscera samples from YVONNE (0.4 pCi/g, dry). All other samples had $^{60}Co$ levels of less than 0.30 pCi/g, dry.

The highest $^{207}Bi$ levels were in the viscera samples from DAVID (4.1 pCi/g, dry) and in the GLENN samples (eviscerated whole = 1.3 pCi/g, dry; viscera = 0.54 pCi/g, dry). All other samples had $^{207}Bi$ levels less than 0.12 pCi/g, dry.

Americium-241 was detected in only three samples. The two viscera samples from TILDA had an average $^{241}Am$ concentration of 0.30 pCi/g, dry, and one of two viscera samples from YVONNE had 0.23 pCi/g, dry. Plutonium-239,240 was present in the viscera samples at an average concentration of 0.6 pCi/g, dry. The Pu concentration was at least tenfold

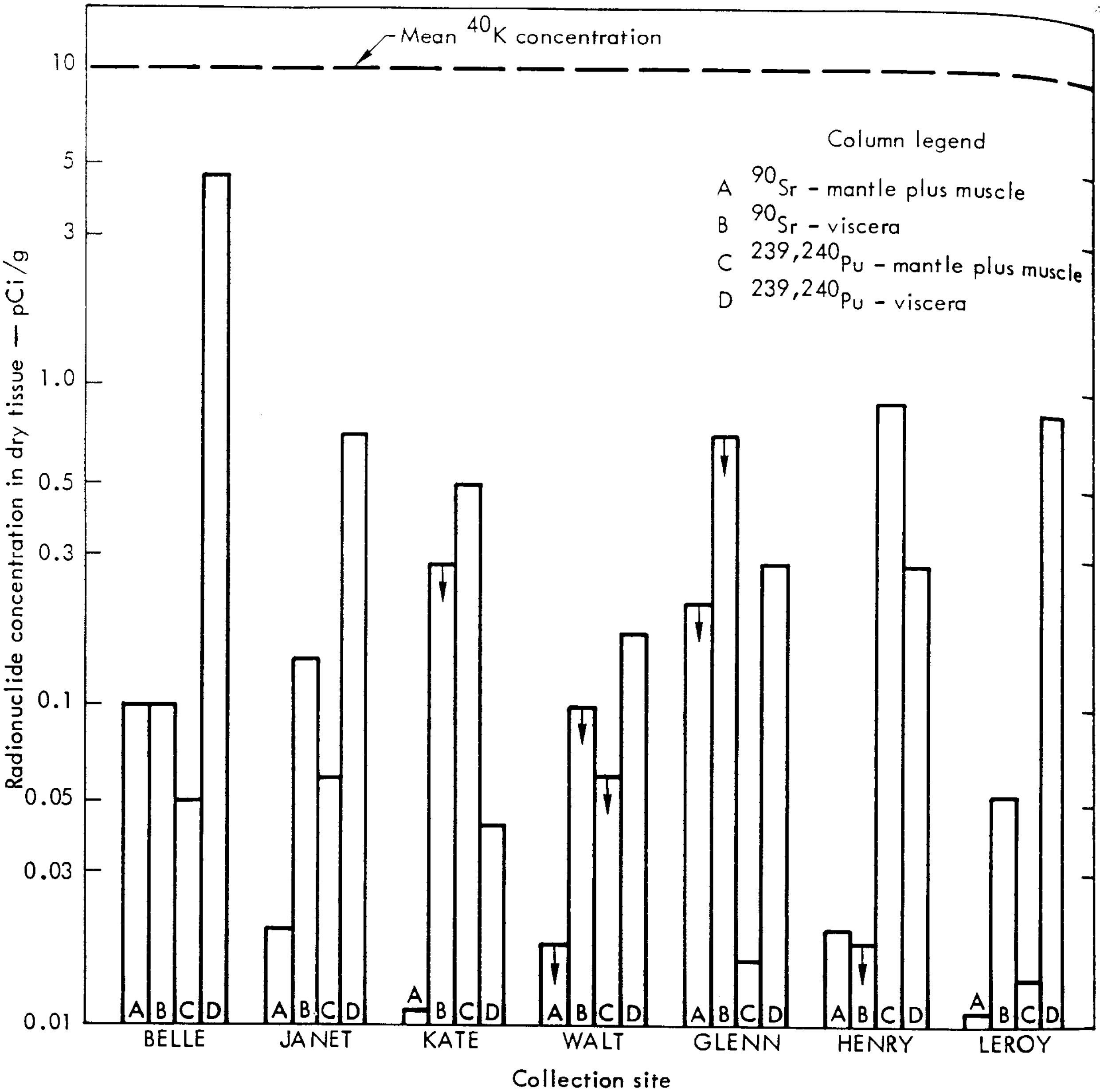


Fig. 50a. Average $^{90}Sr$ and $^{239,240}Pu$ concentration in the viscera, mantle, and muscle of Tridacna clams collected at Enewetak Atoll, October to December, 1972. The $^{40}K$ value is the mean for all Tridacna samples.

lower in the eviscerated whole sea cucumbers. Strontium-90 was highest in the viscera samples from TILDA (1.4 pCi/g, dry), but was less than 0.3 pCi/g, dry in other viscera samples.

Miscellaneous Invertebrates — The results of the radiological analyses of the miscellaneous invertebrate samples are given in Table 41. In the miscellaneous invertebrate category were eight spiny lobsters from YVONNE, nine top snails from LEROY, and six pencil urchins from HENRY. More of these types of samples were not collected because adverse weather conditions (high wind and

Table 41. Predominant radionuclides in miscellaneous invertebrates collected from Enewetak Atoll, October to December 1972.

| Common name | Island | Tissue | Radionuclide, average ± standard deviation[a] in pCi/g, dry: $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{207}Bi$ | $^{90}Sr$ | $^{239,240}Pu$ |
|---|---|---|---|---|---|---|---|---|
| Spiny lobster | YVONNE | Muscle | 12 ± 1.2 | 0.16 ± 0.06 | 0.29 ± 0.14 | < 0.06 | < 0.02 | 0.006 ± 0.001 |
| | | Hepatopancreas | 6 ± 0.8 | 5.3 ± 0.2 | 18 ± 0.3 | 0.16 ± 0.08 | 0.013 ± 0.002 | 0.081 ± 0.004 |
| | | Exoskeleton | 1.8 ± 0.6 | 0.09 ± 0.04 | < 0.14 | < 0.05 | 0.053 ± 0.01 | 0.014 ± 0.001 |
| Pencil urchin | HENRY | Soft parts | 2.9 ± 0.8 | 7.6 ± 0.4 | 4.6 ± 0.2 | 0.59 ± 0.06 | < 0.20 ± 0.01 | < 0.022 |
| | | Hard parts | NC[b] | 1.0 ± 0.1 | < 0.12 | < 0.07 | 0.09 ± 0.01 | 0.007 ± 0.001 |
| Top snail | LEROY | Soft parts | 7.9 ± 1.0 | — | 4.8 ± 0.1 | 6.3 ± 0.1 | 0.14 ± 0.01 | 0.02 ± 0.002 |

[a]Single sample error values are one-sigma counting errors, while error values for two or more samples are one sample standard deviation without consideration of counting error.

[b]NC = not computed.

waves) during the October to December sampling period made collecting on the seaward edge of the reef, where these organisms live, nearly impossible.

Of the gamma-emitting radionuclides only $^{40}K$, $^{55}Fe$, $^{60}Co$, and $^{207}Bi$ were detected in 50% or more of the samples. Potassium-40 was present at background levels. Iron-55 was one abundant man-produced radionuclide detected in the samples. Concentration ranged up to 7.6 pCi/g, dry, in the soft parts of the pencil urchin and 5.3 pCi/g, dry, in the hepatopancreas of the spiny lobster. The highest $^{60}Co$ level (18 pCi/g, dry) was also in the hepatopancreas of the spiny lobster. The soft parts of the pencil urchin and the top snail had similar $^{60}Co$ concentrations at 4.6 and 4.8 pCi/g, dry, respectively. Comparing all miscellaneous samples for $^{207}Bi$, it was found that $^{207}Bi$ was highest, by a factor of 10, in the soft parts of the top snail with a concentration of 6.3 pCi/g, dry.

The highest $^{90}Sr$ concentration was 0.14 pCi/g, dry, in the top snail. All other $^{90}Sr$ and Pu concentrations were less than 0.1 pCi/g, dry.

## Plankton

### Purpose of Collections

Since plankton tend to move with the surface waters and to equilibrate rapidly with them, they can often be used as biological monitors of the radioactivity in their environment. Plankton are also an integral part of the marine food chain, and, because of their ability to very quickly concentrate significant quantities of many radionuclides, they are very useful as indicator species. The radionuclides concentrated by plankton are representative, both in kind and quantity, of those available to other pelagic species of the lagoon.

### Sampling and Analysis

All tows were made at the water surface. They varied in duration, but none was less than 15 min or longer than 30 min. Figure 51 shows the site of collection of each sample. Samples 04119747 and 04120447 were collected with a 1-m, No. 6 (243-micron mesh) net; all other tows were made with a 1-m No. 10 (160-micron mesh) net. The collected sample was washed from the net into a glass jar containing formalin.

The samples in formalin were returned to Lawrence Livermore Laboratory (LLL) where they were drained wet and weighed.

Table 42. Enewetak plankton collections - 1972.

| Sample No. | Wet wt (g) | Dry wt (g) | Ash wt (g) |
|---|---|---|---|
| 04 069710 | 27.9 | 2.77 | 0.96 |
| 04 091253 | 6.0 | 0.66 | 0.39 |
| 04 091053 | 15.7 | 1.48 | 0.81 |
| 04 091153 | 8.5 | 0.94 | 0.51 |
| 04 069854 | 33.4 | 4.34 | 3.27 |
| 04 069954 | 27.1 | 2.91 | 1.88 |
| 04 070054 | 17.9 | 2.01 | 1.66 |
| 04 114646 | 11.0 | 3.17 | 1.43 |
| 04 114524 | 13.3 | 1.28 | 0.77 |
| 04 116324 | 6.9 | 0.84 | 0.49 |
| 04 116524 | 23.6 | 2.33 | 1.65 |
| 04 116247 | 23.2 | 2.05 | 1.24 |
| 04 116447 | 28.7 | 2.88 | 1.65 |
| 04 119747 | 9.37 | 1.56 | 0.98 |
| 04 119847 | 18.8 | 1.82 | 1.48 |
| 04 120447 | 16.6 | 1.68 | 1.18 |

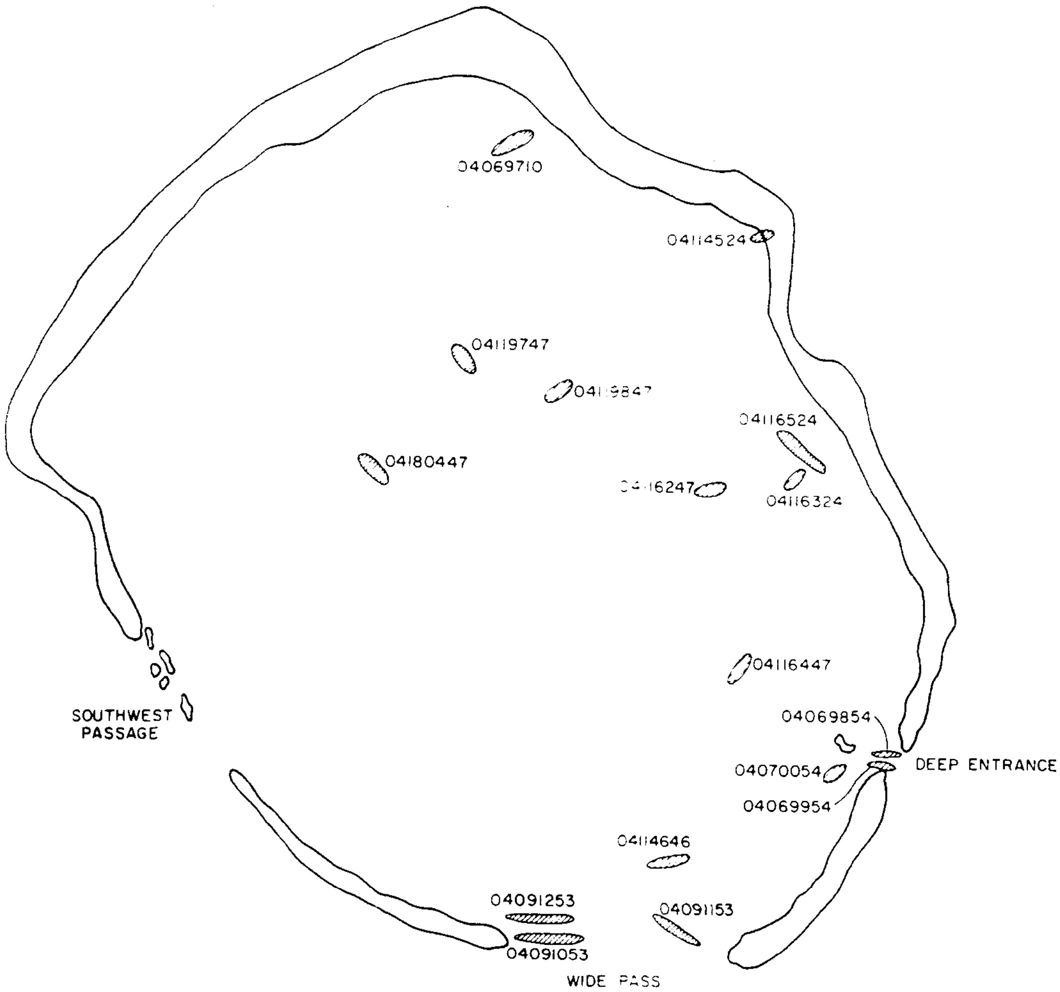


Fig. 51. Location and sample identification of plankton collections at Enewetak Lagoon, 1972.

The samples were dried at 110°C, weighed, ashed at 450°C, and reweighed. Table 42 lists wet, dry, and ash weights of all samples.

The gamma-emitting radionuclides in the plankton were identified by gamma spectrometry at LLL. Samples were processed by wet chemical methods for $^{90}$Sr and $^{239,240}$Pu. Only $^{60}$Co, $^{137}$Cs, $^{155}$Eu, $^{207}$Bi, and $^{241}$Am were positively identified by gamma spectrometry, and these were not detected in all 1972 Enewetak plankton collections. The following radionuclides were undetectable in the plankton at the indicated limits of detection: $^{106}$Ru (1.0 pCi/g wet weight); $^{102}$Rh (0.1 pCi/g); $^{125}$Sb (0.2 pCi/g); $^{152}$Eu (0.1 pCi/g); $^{235}$U (0.1 pCi/g).

Table 43 lists the radionuclide concentrations found in the plankton samples. All data are as of time of collection. The mean level of activity of each radionuclide was determined by averaging the 16 values. The most abundant were $^{90}$Sr and $^{207}$Bi followed, in order of decreasing concentration, by $^{60}$Co, $^{239,240}$Pu, $^{155}$Eu, $^{241}$Am, and $^{137}$Cs. These, the principal gamma-emitting radionuclides found in the 1972 plankton collections, should be those found in all species that

Table 43. Radionuclide concentrations in Enewetak marine plankton in pCi/g (wet weight) at time of collection.

| Sample No. | $^{60}Co$ | $^{137}Cs$ | $^{155}Eu$ | $^{207}Bi$ | $^{241}Am$ | $^{239,240}Pu$ | $^{90}Sr$ |
|---|---|---|---|---|---|---|---|
| 04 069710 | 1.83 | <0.03 | 0.06 | 1.06 | <0.1 | 0.06 | <0.2 |
| 04 091253 | <0.18 | <0.12 | <0.14 | 0.21 | <0.3 | <0.05 | <0.8 |
| 04 091053 | 0.27 | <0.06 | <0.07 | 0.20 | <0.1 | 0.04 | <0.3 |
| 04 091153 | <0.18 | <0.03 | <0.14 | 0.22 | <0.3 | <0.12 | <2.0 |
| 04 069854 | 0.18 | <0.03 | <0.07 | 0.03 | <0.1 | 0.16 | <0.2 |
| 04 069954 | 0.09 | <0.03 | <0.07 | <0.03 | <0.1 | <0.02 | <0.4 |
| 04 070054 | 0.27 | <0.05 | <0.07 | 0.27 | <0.1 | 0.05 | <0.3 |
| 04 114646 | 1.14 | <0.12 | 0.22 | 1.21 | <0.3 | 0.11 | <0.8 |
| 04 114524 | <0.09 | <0.05 | <0.07 | <0.05 | <0.1 | 0.04 | 1.98 |
| 04 116324 | 1.01 | 0.09 | <0.14 | 1.36 | <0.2 | 0.70 | <0.7 |
| 04 116524 | 1.42 | <0.06 | 0.66 | 2.25 | 0.41 | 1.69 | 0.54 |
| 04 116247 | 0.89 | 0.11 | 0.62 | 1.41 | 0.25 | 1.31 | 0.68 |
| 04 116447 | 0.76 | <0.06 | 0.46 | 1.45 | 0.28 | 0.43 | 0.24 |
| 04 119747 | 1.33 | <0.11 | <0.21 | 0.83 | <0.3 | 0.24 | 2.97 |
| 04 119847 | 0.79 | <0.08 | 0.55 | 1.62 | 0.43 | 0.59 | 1.05 |
| 04 120447 | 0.50 | <0.05 | 0.41 | 0.93 | 0.25 | 0.59 | 0.79 |
| Average[a] | 0.68 | 0.07 | 0.24 | 0.83 | 0.23 | 0.39 | 0.86 |
| Average[b] | 0.65 | 0.01 | 0.19 | 0.83 | 0.10 | 0.37 | 0.52 |

[a]Counting upper limit values as a real signal.
[b]Counting upper limit values as zero.

derive trace elements and radioelements from the pelagic environment of the lagoon.

The plankton proved to be sensitive indicators of the environmental radioactivities in the lagoon. High concentrations of $^{207}Bi$ and $^{60}Co$, for example, were found in samples taken near YVONNE and IRENE and from mid-lagoon, while the lowest levels were detected near passes, channels, or reef openings where the atoll is exposed to currents from the open ocean. It is noteworthy that the distributions of some radionuclides in the water coincide with those found for the plankton (see the subsection on lagoon water samples).

It is a useful exercise to compare the present mean activity levels to those found in the 1964 collections. During the 1964 survey of Enewetak (Welander, et al., 1967)* five plankton collections from the lagoon were reported, data for which are shown in Table 44.

Allowing for radioactive decay from August 1964 to December 1972, and

*A. D. Welander, et al., Bikini-Eniwetok Studies, 1964: Part II. Radiobiological Studies, USAEC, Rept. UWFL-93 (Part II) (1967).

Table 44. Gamma-emitting radionuclides in plankton from Enewetak Atoll, August 1964. Values expressed as picocuries per gram of dry weight at time of collection.

| Location | $^{60}Co$ | $^{125}Sb$ | $^{137}Cs$ | $^{207}Bi$ |
|---|---|---|---|---|
| Enewetak Atoll | | | | |
| Runit, lagoon side[a] | 68 | 0 | 0 | 0 |
| Runit, lagoon side | 200 | 50 | 0 | 14 |
| Rigili, lagoon side | 130 | 2.7 | 0 | 19 |
| MIKE Crater | 58 | — | 2.2 | 4.6 |
| Engebi, lagoon side | 47 | 0 | 0 | 5.6 |
| Average | 100 | 13 | 0.44 | 4.8 (sic) (arith av 8.6) |

[a]No. 20 mesh net; all other catches with No. 6 mesh net.

assuming no other processes operating to affect the activity levels in plankton, we should have seen average concentrations of 34 pCi/g ($^{60}Co$), 1.5 pCi/g ($^{125}Sb$), 0.36 pCi/g ($^{137}Cs$), and 7.1 pCi/g ($^{207}Bi$). The average dry weight concentrations found in December 1972 were 5.9 pCi/g ($^{60}Co$), 0.6 ($^{137}Cs$), and 7.3 pCi/g ($^{207}Bi$) if upper-limit values in Table 43 are considered positive signals. If the upper-limit values are considered to be zero, as was done by Welander, the average dry weight concentrations found in December 1972 are 5.7pCi/g ($^{60}Co$), 0.09 pCi/g ($^{137}Cs$), and 7.3 pCi/g ($^{207}Bi$).

Each radionuclide found in plankton was reduced in concentration between 1964 and 1972. The values for $^{207}Bi$ are about those expected if the loss was due mostly to radioactive decay. The $^{125}Sb$ is below detection limits (~ 2 pCi/g dry) in 1972 collections; its loss could be due mostly to radioactive decay. For $^{137}Cs$ and $^{60}Co$, on the other hand, the values for the 1972 collections are significantly less than can be accounted for on the basis of decay alone. Thus, $^{60}Co$ and $^{137}Cs$ are being lost from the lagoon by removal processes, as well as by physical decay. From the data for 1964 and 1972, it is possible to compute a mean residence half-time, or ecological half-life, for $^{60}Co$ and $^{137}Cs$, assuming an exponential loss rate. The equation used to compute the residence time is

$$A_{1972} = A_{1964}\, e^{-(\tau_1 + \tau_2)t},$$

where $\tau_1$ is the radiological disintegration constant and equals $0.693/t_1$, $\tau_2$ is the environmental loss constant and equals $0.693/t_x$, and $t_1$ and $t_x$ are the physical and ecological half-lives, respectively. The observed activity levels in the respective years are $A_{1972}$ and $A_{1964}$. The time, t, is the elasped time between August 1964 and December 1972, or 8.33 yr. In addition to physical decay, $^{60}Co$ and $^{137}Cs$ are being lost from the lagoon with mean residence half-times of 3.3 and 4.1 yr, respectively.

If the computed mean loss continues at the same rate, the mean $^{60}Co$ levels in the water and pelagic biota of the lagoon will be reduced with an effective half-life of approximately 2 yr, and the $^{137}Cs$ concentrations will be reduced by one half every 4 yr. The effective half-life for $^{60}Co$ deduced from plankton data agrees well with the effective half-life computed from the comparison of fish activity levels in 1964 and 1972.

Comparison of the decreases in activity for $^{207}Bi$ with those for $^{137}Cs$ and $^{60}Co$ indicates clearly that the rate of radionuclide removal, other than by physical decay, is unique for each radionuclide and is controlled by complicated biogeochemical processes occurring within the lagoon environment. In the future, assessments such as the above should be attempted for all long-lived radionuclides, and meaningful sampling programs should be established to verify the predicted losses. Since many processes influence the fate of the radionuclides in each environment phase of the Atoll, the rate of loss of radioactivity may accelerate or decline in the future, depending on the time constants of the controlling mechanisms.

## Enewetak Lagoon Sediments

### Purposes of Collections

In all, 133 grab samples, 8 dredge samples, and 37 cores providing 127 subsamples were processed. The number of samples was large enough so that, for the first time, we can assess the quantity and distribution of selected radionuclides in the benthic environment of Enewetak Atoll.

This assessment is an integral part of the Enewetak survey; the radionuclides present in sedimentary deposits are potential contaminants of the atoll environment and thus could contribute to the hazard to man. Marine sediments are usually thought of as the ultimate link for quickly sorbed radionuclides, but in reality there are a number of biological and nonbiological paths through which the radionuclides can be recycled into man's food chain.

In addition, individuals can be exposed directly to external gamma radiation from some surface-bound radionuclides when shallow areas are used for fishing and/or recreation. Near-shore cores were obtained to provide radiological data for assessment of this exposure route.

### Sampling Locations

Figure 52 gives the locations of all sediment samples obtained from Enewetak lagoon; Fig. 53 is a separate chart of the area sampled near MIKE and KOA Craters. The entire lagoon was adequately covered, and more detailed coverage was devoted to the area off YVONNE. Duplicate samples were obtained at several locations to determine the degree of variability of radiological data at an individual sampling site.

Sampling locations were predetermined before each day's cruise. Because weather conditions often made it impossible to sample the designated area, especially the western side of the lagoon, alternate cruise plans were usually available as well. Upon reaching the designated location, the vessel was anchored, and sightings were made with a sighting compass on at least two, but usually three or four, fixed landmarks (tips of islands or recognizable structures). The bearings were replotted on a master chart to locate accurately the site of collection of each sample, which was identified with a field number and a sample number.

All position plottings were made on A. M. S. Series W861, Type C (AMS1), 1947 charts of the Marshall Islands prepared under the direction of the Chief of Engineers by the Army Map Service (LUAM), War Department, Washington,

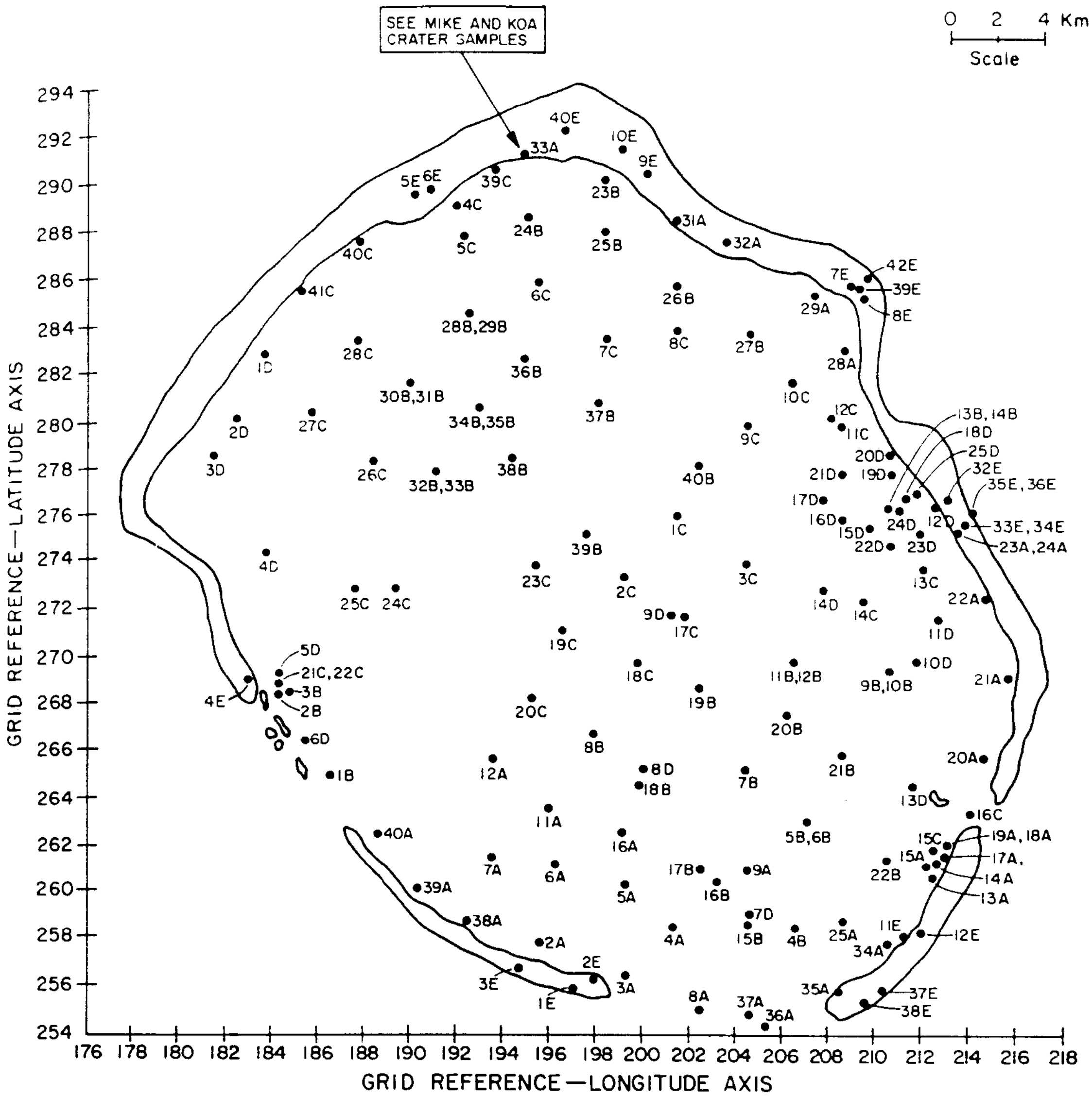


Fig. 52. Location and sample identification of sediment samples at Enewetak Lagoon.

D. C. These charts are provided with a 1000-m universal transverse mercator grid; the horizontal control is based on Enewetak Astro Pier, 11°33'28.48" North, 162°21'10.25" East of Greenwich. The average mercator position or grid position of each sample location was determined by triangulation and provided for reference with the output data. All fixes used to provide these reference points are accurate to within 100 m on the AMS Series W861 charts.

Besides the geographical location, the recorded data usually included the depth of overlying water: Lagoon samples were obtained from depths ranging from 20 to 214 ft.

Thus, the master output of radiological data for marine sediments includes the assigned sample number, the corresponding chart identification number, and the measured depth of water at the sampling location.

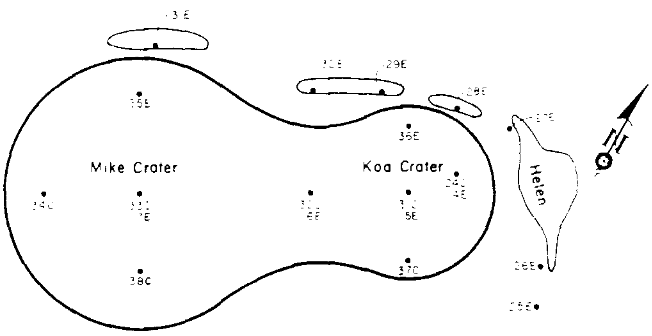


Fig. 53. Location and identification of sediment samples at the MIKE and KOA crater area (crater dimensions are not to scale).

Collection Methods and Sample Types

The original purpose of the program was to provide both grab and core samples in sufficient numbers for assessment of both the horizontal and vertical distributions of radionuclides in the lagoon sediments. Coring was attempted with both 8- and 5-cm-diam gravity corers fitted with positive-action closing valves and core catchers. Several of the participants in this marine program had had considerable experience with these devices in near-shore and off-shore areas of the Atlantic and Pacific Oceans, where it was usual to obtain the top 60- to 90-cm section of an undisturbed sediment column. In Enewetak lagoon, however, coring was almost a complete failure. Because of the characteristics of the sedimentary deposits, it was usually impossible to penetrate to depths of more than a few centimeters, even with a weight stand exceeding 80 kg. More often than not, coral or shell fragments entrapped in the core catcher allowed the collected sediment to drain from the liner before the sampler could be retrieved. Several times, the plastic core liners returned to the surface bent at 90 deg angles, attesting to the presence of numerous coral heads on the lagoon floor. Because of the poor penetration of the corer and the difficulty of retrieving a usable core, it was decided to discontinue the coring attempts and instead to concentrate on grab sampling as the method of collecting sediments. Excellent cores were obtained in both MIKE and KOA craters; here however, the deposit was of uniform consistency and free from shell fragments and coral. Coring was successful also in the near-shore areas, where good visibility permitted positioning of a hand coring device without impaction on submerged objects.

The major objective of defining the levels and distributions of selected radionuclides in the lagoon sediments was realized by analyzing the material collected by the grab samplers. This was not accomplished, however, without difficulties similar to those attending the core sampling. The usual problems were pretriggering of the device on submerged coral knolls and trapping of coral or shells in the closing jaws with resultant loss of collected sediment before the surface was reached. At many locations, the samplers usually had to be lowered several times before an adequate sample was obtained. Field comparisons with the corers showed that the grab samplers not only provided sediment samples of larger surface area but penetrated to equivalant depths in the lagoon floor.

A weighted Ekman grab sampler was used from the Boston Whaler only. It collected a surface sample of 232 $cm^2$ surface area and 2.0 cm mean thickness. The penetration depth was uncontrolled on this as well as on the other grab samplers used. A Ponar grab sampler, used from both the Whaler and the LCU, collected a surface sample 523 $cm^2$ in area and 2.8 cm in mean thickness. A Shipek grab was used from the LCU only. The sampled area depended on the depth of penetration and varied from 250 to 400 $cm^2$ and the mean sediment sample thickness was 4.3 cm.

The mean depth sampled by all three devices was 3.2 cm (1.25 in.). Penetration of the grab was dependent on the composition of the sediment. Penetration was poorest in areas containing high percentages of coarse sediments, shell fragments, and Halimeda, and deepest in areas in which the bottom sediment consisted of fine-grained material. For 83 of the samples, the composition was described qualitatively by the field observers: 34 contained dead Halimeda debris in amounts ranging from 5 to 85% of the sample. The sediment composition was dependent on location and depth of water and included different percentages of fine, coarse, and dark-grained sands, shell fragments, coral pieces, Halimeda, and Foramenifera debris.

Only levels of radioactivity were determined in the entire sediment sample collection; it was not an objective of this program to assess the quantity of each sedimentary phase or the concentration of radionuclides in each phase.

For comparative purposes, all sediment concentration data is expressed as activity per unit area ($mCi/km^2$). Since some samples are diluted in weight with relatively uncontaminated quantities of coral, Halimeda and Forams, this unit better describes the radiological data for relative comparison. There is also evidence that most of the radionuclides are concentrated in the open lagoon sediment surface layers. For example, at several locations, dredge samples were obtained from the anchor of the LCU and provided samples for comparative radiological data with the grab sampler. These two collection methods gave considerably different concentrations of radionuclides per gram, as shown in Table 45. The dredge samples contained less activity per unit weight than the grab samples. This observation supports the idea that radionuclides in those samples from the open lagoon are probably restricted to surface layers of the sediments; the lower activity per unit weight in the dredge samples probably results from sample dilution by relatively uncontaminated subsurface material.

**Table 45. Grab and dredge sample comparative data for selected radionuclides.**

| Sample | pCi/g ± % error | | | | | |
|---|---|---|---|---|---|---|
| | $^{60}$Co | $^{90}$Sr | $^{137}$Cs | $^{155}$Eu | $^{207}$Bi | $^{239}$Pu |
| 34B-Grab | 1.83 ± 4 | 17.1 ± 4 | 1.02 ± 7 | 5.98 ± 3 | 4.5 ± 3 | 15.7 ± 2 |
| 35B-Dredge | 2.53 ± 3 | 12.7 ± 6 | 0.81 ± 7 | 5.88 ± 6 | 4.4 ± 2 | 6.2 ± 3 |
| 30B-Grab | 1.6 ± 3 | 15.3 ± 8 | 1.14 ± 5 | 7.28 ± 3 | 4.04 ± 2 | 14.2 ± 9 |
| 31B-Dredge | 1.88 ± 4 | 7.78 ± 10 | 0.65 ± 10 | 3.89 ± 6 | 2.65 ± 9 | 7.79 ± 4 |
| 29B-Grab | 2.68 ± 2 | 21.9 ± 10 | 1.53 ± 4 | 10.0 ± 4 | 7.4 ± 2 | 22.4 ± 9 |
| 29B-Dredge | 0.83 ± 7 | 2.32 ± 17 | 0.15 ± 27 | 1.2 ± 7 | 1.2 ± 5 | 2.2 ± 5 |

It should, however, be kept in mind that each grab sample collected penetrated the sediment layer to different depths. The activity per unit area is reported only to the depth sampled. The mean depth sampled by all devices has already been reported as 3.2 cm. Since comparative dredge and grab and/or core data is not available for all areas of the lagoon floor, there may be some areas, especially in the northeast section, where significant levels of activity could be present below the sampling depths indicated.

For each sample, the radionuclide data (in pCi/g) is accompanied by all relevant data including cross-sectional area sampled, thickness or surface layer sampled, and total weight of the sample. With these data, the results can be converted to any unit of activity per unit weight, volume, or area.

Processing (Field and Laboratory)

As each grab or dredge sample was recovered, it was transferred to a polyethylene bag and labeled with a field identification number. At the field laboratory, each sample was double-bagged and labeled with a sample number.

At LLL the volume of each sample was determined, and the penetration depth was calculated from the cross-sectional area of the sampler used. The entire sample was dried at 110°C, ground, and mixed in a ball mill. No attempt was made to separate the sediment into its components. The entire dried sample was weighed and fractions of the sediment were prepared for gamma spectrometry and for radiochemical separation and analysis of $^{90}Sr$ and plutonium radionuclides. The sediments were not analyzed for any other radionuclides than those identified by gamma spectrometry and $^{90}Sr$ and some plutonium radionuclides. Processing was done by members of the Radiochemistry Division, LLL. Gamma spectrometry results were obtained from Ge(Li) detector outputs in both the Bio-Medical and the Radiochemistry Divisions of LLL. Plutonium and $^{90}Sr$ were separated and analyzed by contractor laboratories.

A selected number of samples (listed in Table 46) were analyzed in duplicate at one laboratory for $^{239,240}Pu$. It is difficult to assess the accuracy of sets of measurements such as these, but the body of data speaks to the question of sample uniformity. In general, the results are in good agreement, suggesting

Table 46. Plutonium-239,240 analyses of replicate sediment samples

| Sample | $^{239,240}Pu$ (pCi/g, dry) ± % error |
|---|---|
| 35A (a) | <0.72 (upper limit) |
| (b) | 0.13 ± 13 |
| 39A (a) | 0.38 ± 21 |
| (b) | 0.46 ± 9 |
| 7B (a) | 1.09 ± 8 |
| (b) | 0.94 ± 23 |
| 22B (a) | 0.36 ± 9 |
| (b) | 0.44 ± 10 |
| 29B (a) | 2.25 ± 5 |
| (b) | 2.15 ± 3 |
| 1C (a) | 4.78 ± 4 |
| (b) | 4.78 ± 5 |
| 13C (a) | 5.81 ± 6 |
| (b) | 7.88 ± 24 |
| 8D (a) | 0.77 ± 8 |
| (b) | 0.60 ± 19 |
| 19D (a) | 39.2 ± 4 |
| (b) | 53.2 ± 22 |

that at least the processing produced uniformly well-mixed samples. The duplicate set of samples address the precision of analysis; in general the results in Table 46 are in satisfactory agreement. The calibration data affecting the accuracy of the results is discussed in detail in the Analysis Program section of this report.

Cores collected from the craters and near-shore areas were identified by numbers in the field. At the field laboratory, the cores were logged in and stored in an upright freezer chest. The frozen cores were returned to LLL, where they were sectioned in known depth increments and processed by the same procedure used for the grab samples.

## Analysis and Results

Lagoon Sediment—The radionuclides identified in some, but not necessarily all, processed sediments from the lagoon include $^{238}$Pu, $^{239,240}$Pu, $^{90}$Sr, $^{137}$Cs, $^{241}$Am, $^{155}$Eu, $^{60}$Co, $^{152}$Eu, $^{154}$Eu, $^{102m}$Rh, $^{207}$Bi, $^{125}$Sb, $^{101}$Rh, and $^{106}$Ru. In some samples the natural potassium radioisotope, $^{40}$K, and daughter products of the uranium decay series were detected by gamma spectrometry.

The identification of gamma-emitting radionuclides in any sample was dependent on sample size, detector characteristics including background, and the sample counting time. Because of these variables, the lowest limit of positive detection of any gamma-emitting radionuclide was necessarily different for each sample analyzed. Americium-241 was positively identified by spectrometry in marine sediments when the level of activity generally exceeded 3 mCi/km$^2$ or, approximately, 0.1 pCi/g. Examples of other averaged lower limits are 1 mCi/km$^2$ for $^{207}$Bi; 1.5 mCi/km$^2$ for $^{155}$Eu; 2 mCi/km$^2$ for $^{60}$Co; 1 mCi/km$^2$ for $^{137}$Cs; 0.5 mCi/km$^2$ for $^{152}$Eu; and 1 mCi/km$^2$ for $^{102m}$Rh. Ruthenium-106 was positively identified by spectrometry in only three samples. The levels of activity were all less than 1.3 pCi/g. For all practical purposes, therefore, gamma-emitting fission products with half-lives less than 1 yr and fission yields comparable to $^{106}$Ru should no longer be detectable in the lagoon environment. Ruthenium-106 was measured in surface sediments collected from MIKE Crater during the 1964 survey.* The average $^{106}$Ru concentration reported was 100 pCi/g (range—29-170 pCi/g). By 1972 this level has decayed to an average of 0.6 pCi/g. Three 1972 surface sediments from MIKE Crater were found to contain less than 0.5 pCi/g of $^{106}$Ru. This assessment is additional verification that this radionuclide is nearly depleted from the marine environment. The radionuclides, $^{54}$Mn and $^{57}$Co, also reported in marine samples collected during the 1964 survey, were not detected in any 1972 sediment collection.

Europium-154 was identified in only seven bottom sediment samples. The computed mean value of $^{154}$Eu found in the seven samples was 0.5 ± 0.6 pCi/g. Four of the samples were from KOA Crater and the remaining samples were

*A. D. Welander, et al., Bikini-Eniwetok Studies, 1964: Part II. Radiobiological Studies, USAEC, Rept. UWFL-93 (Part II) (1967).

from stations 33A, 24B, and 23B. The three lagoon stations are located in the northeast sector of the lagoon, 1 to 5 km from KOA Crater.

For all other radionuclides identified in the sediments, the deposited activity levels determined at each station were plotted on lagoon charts. Isopleths were constructed and the resulting distributions of $^{90}$Sr, $^{239,240}$Pu, $^{137}$Cs, $^{60}$Co, $^{102m}$Rh, $^{241}$Am, $^{207}$Bi, $^{155}$Eu, $^{152}$Eu, $^{125}$Sb, and $^{101}$Rh in the lagoon sediments are shown in Figs. 54 to 64.

The activity levels in the cross hatched area of each figure were, for the most part, below detection limits. It was impossible to construct isopleths in this region of the lagoon because of the scatter in the data points. Therefore, deposition upper limits were determined for this region and are shown in the boxes enclosed in each figure. Some mean values of the activities in the cross hatched region were computed and are also shown in the enclosed box.

Each radionuclide is nonuniformly distributed over the lagoon floor. The most contaminated area of the lagoon can be roughly separated from a relatively uncontaminated area by an imaginary line extending from the Southwest Passage to the island of TOM on the eastern rim of the Atoll. The sediments in the region north of this line are much more burdened with fission and activation products than the area south of this division. Cobalt-60, $^{207}$Bi, $^{102m}$Rh, and $^{152}$Eu, all activation products, are most intense in deposits off the shore of the IRENE-JANET area, while $^{137}$Cs, $^{90}$Sr, $^{155}$Eu, $^{241}$Am, and $^{239,240}$Pu are most concentrated in north-south oriented elliptical areas, roughly 2 to 3 km east of the islands of ALICE and BELLE. The highest concentration of $^{125}$Sb is found in sediments a few kilometers south of this area. The sediment burdens decrease in a southwesterly direction from the northwest towards the center of the lagoon. A secondary region of contamination, but with significantly lower activity levels than the northwest region, is noted off the shore of YVONNE. The offshore distribution of relatively high activity sediment in this area is restricted to a smaller region than found in the northwest. The concentration levels decrease in all directions from YVONNE but appear to decrease more rapidly toward the south and north than toward the center of the lagoon. Isolated pockets of relatively high concentration levels of some radionuclides are evident in otherwise lesser contaminated areas of the lagoon.

The mean lagoon sediment activity per unit area of each radionuclide was determined from Figs. 54 to 64. These results are tabulated in Table 47 and ranked in order of decreasing mean activity. The most abundant radionuclide detected was $^{90}$Sr, followed by $^{239,240}$Pu, $^{155}$Eu, $^{241}$Am, $^{207}$Bi, $^{137}$Cs, $^{60}$Co, $^{125}$Sb, $^{102m}$Rh, $^{152}$Eu, $^{101}$Rh, $^{154}$Eu, and $^{106}$Ru.

The percent of the lagoon floor containing radionuclides at or above several levels of activity was determined from Figs. 54 to 64. This data is tabulated in Table 48. Approximately 15% to 20% of the area of the lagoon contains $^{90}$Sr, $^{239,240}$Pu, $^{155}$Eu, $^{241}$Am, and $^{125}$Sb at concentrations which exceed their respective computed mean level. Only 11% of the area of the lagoon is contaminated

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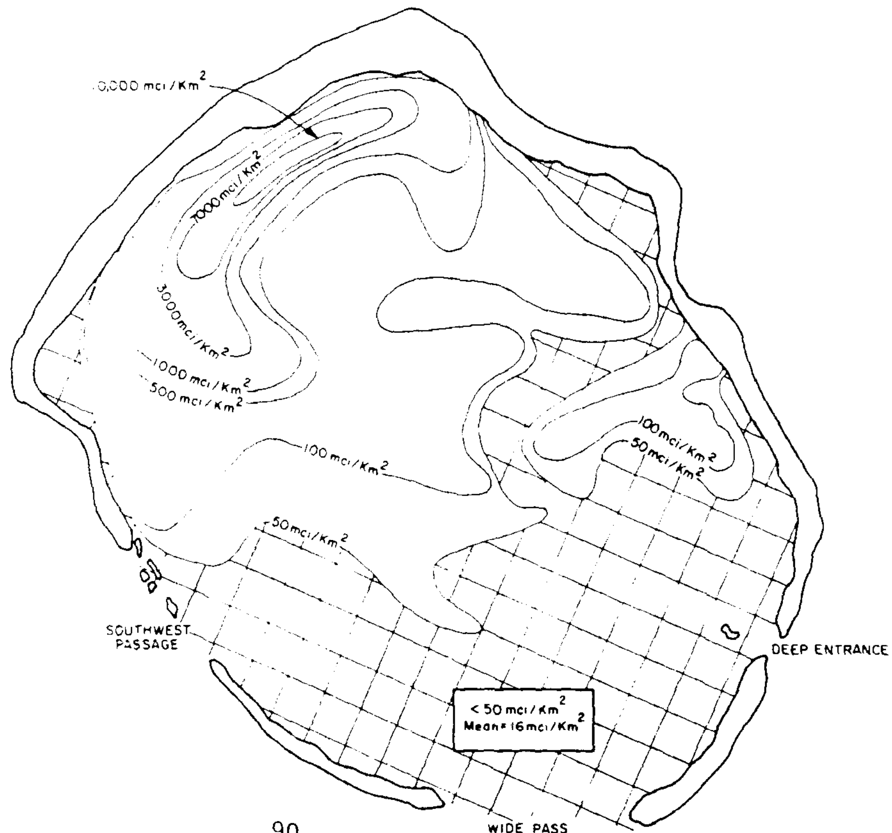


Fig. 54. Activity levels of $^{90}$Sr deposited in the sediments of Enewetak Lagoon.

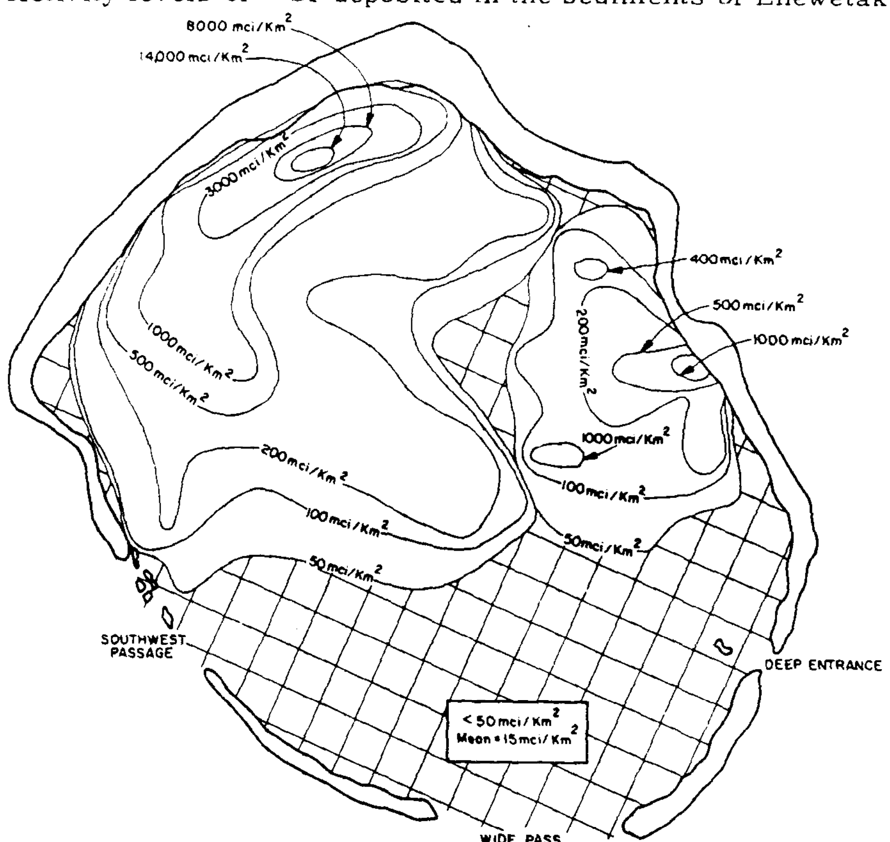


Fig. 55. Activity levels of $^{239,240}$Pu deposited in the sediments of Enewetak Lagoon.

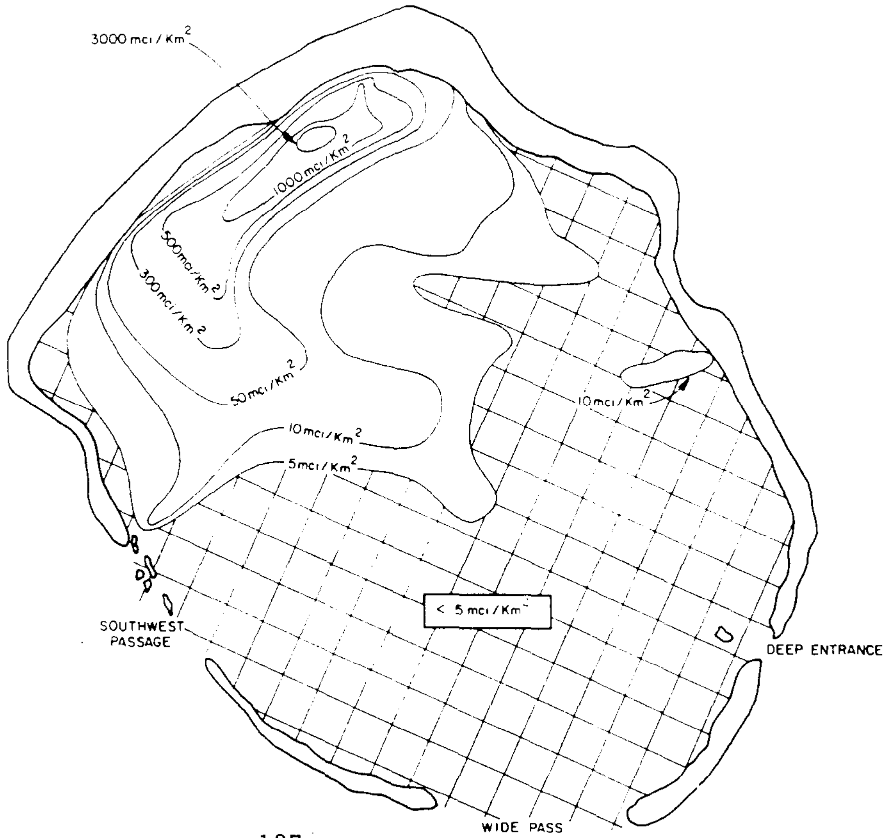


Fig. 56. Activity levels of $^{137}$Cs deposited in the sediments of Enewetak Lagoon.

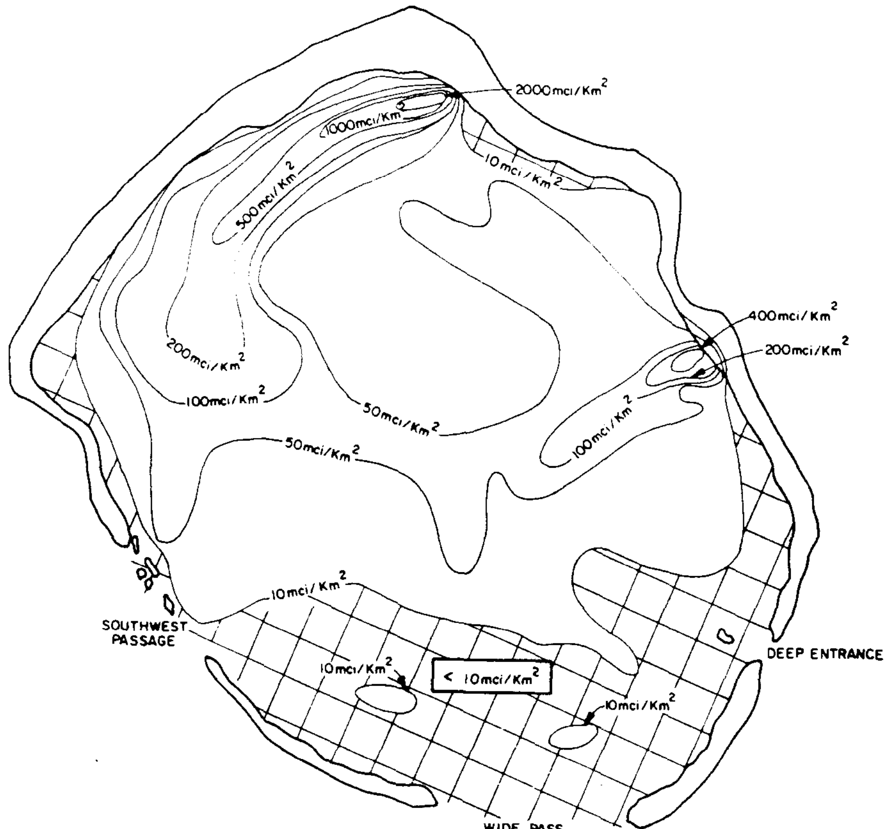


Fig. 57. Activity levels of $^{60}$Co deposited in the sediments of Enewetak Lagoon.

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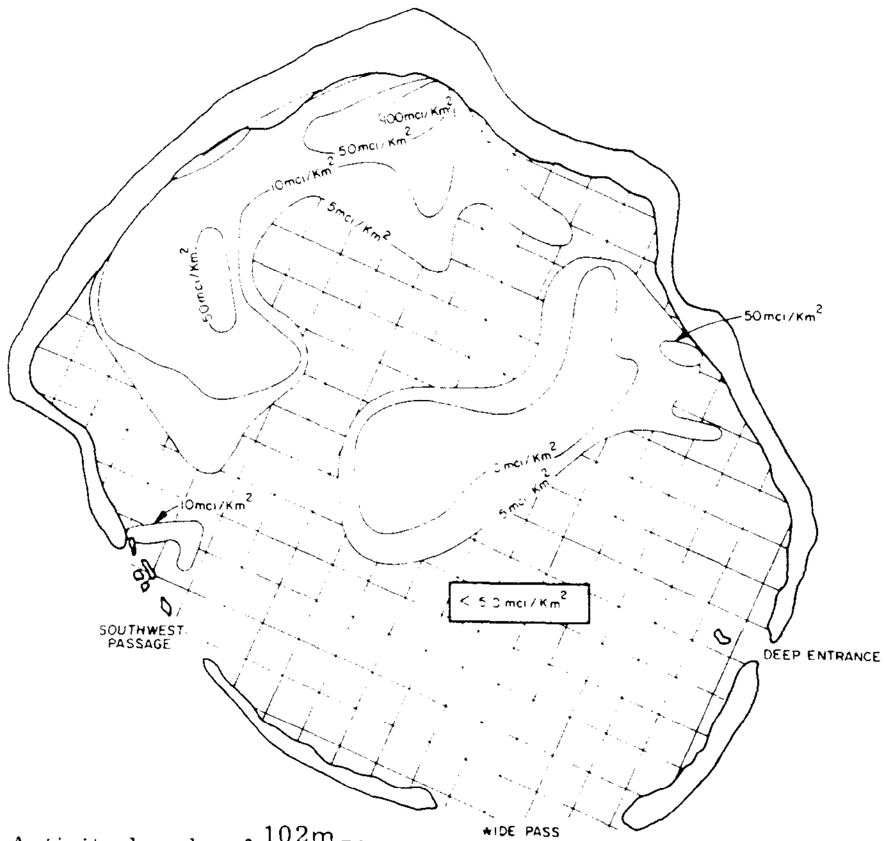


Fig. 58. Activity levels of $^{102m}$Rh deposited in the sediments of Enewetak Lagoon.

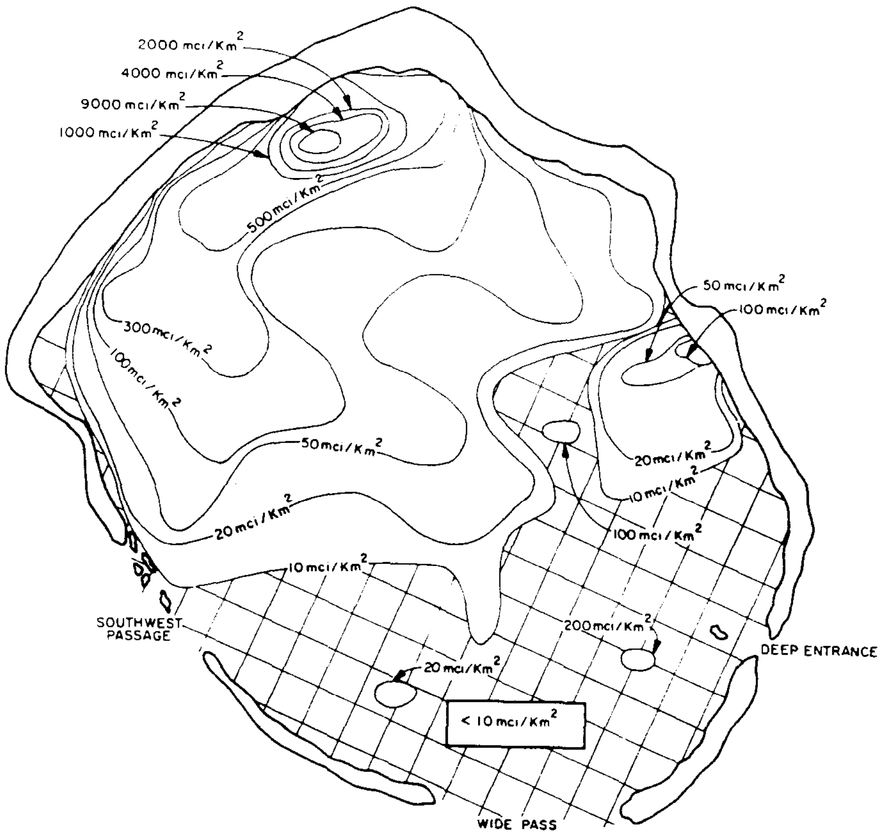


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Fig. 59. Activity levels of $^{241}$Am deposited in the sediments of Enewetak Lagoon.


Fig. 60. Activity levels of $^{207}Bi$ deposited in the sediments of Enewetak Lagoon.

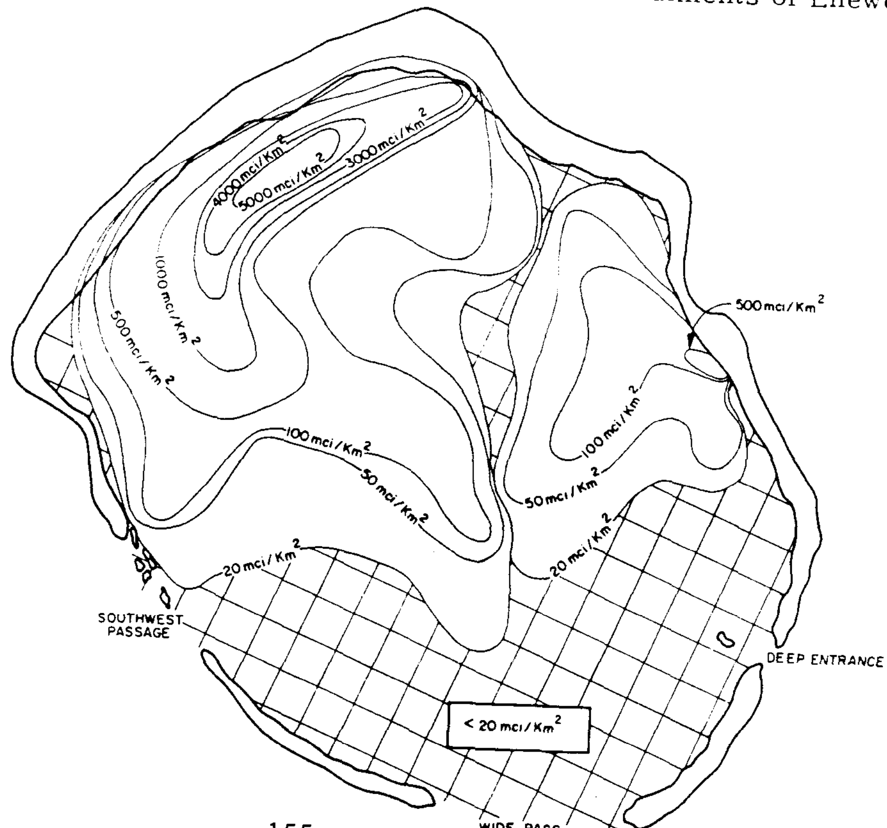


Fig. 61. Activity levels of $^{155}Eu$ deposited in the sediments of Enewetak Lagoon.

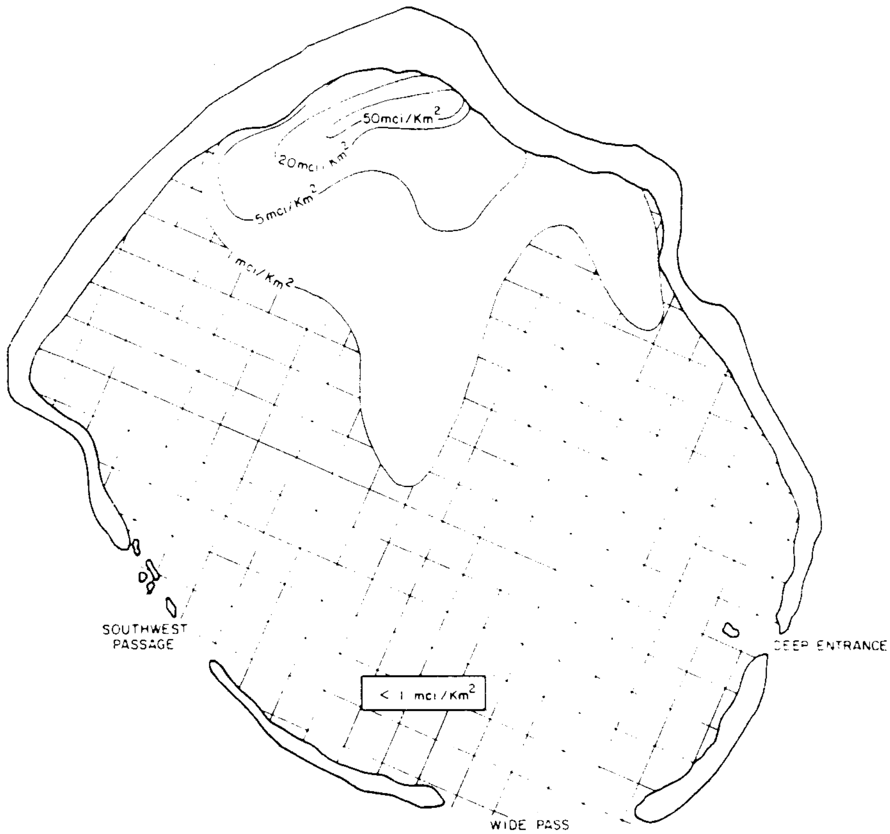


Fig. 62. Activity levels of $^{152}Eu$ deposited in the sediments of Enewetak Lagoon.

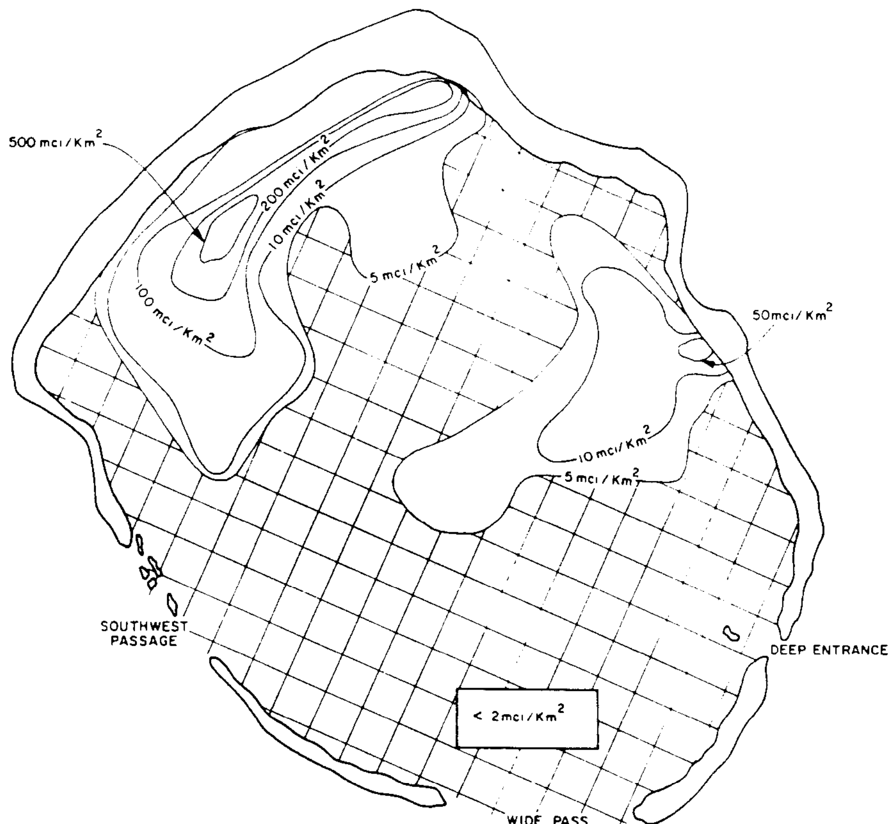


Fig. 63. Activity levels of $^{125}Sb$ deposited in the sediments of Enewetak Lagoon.

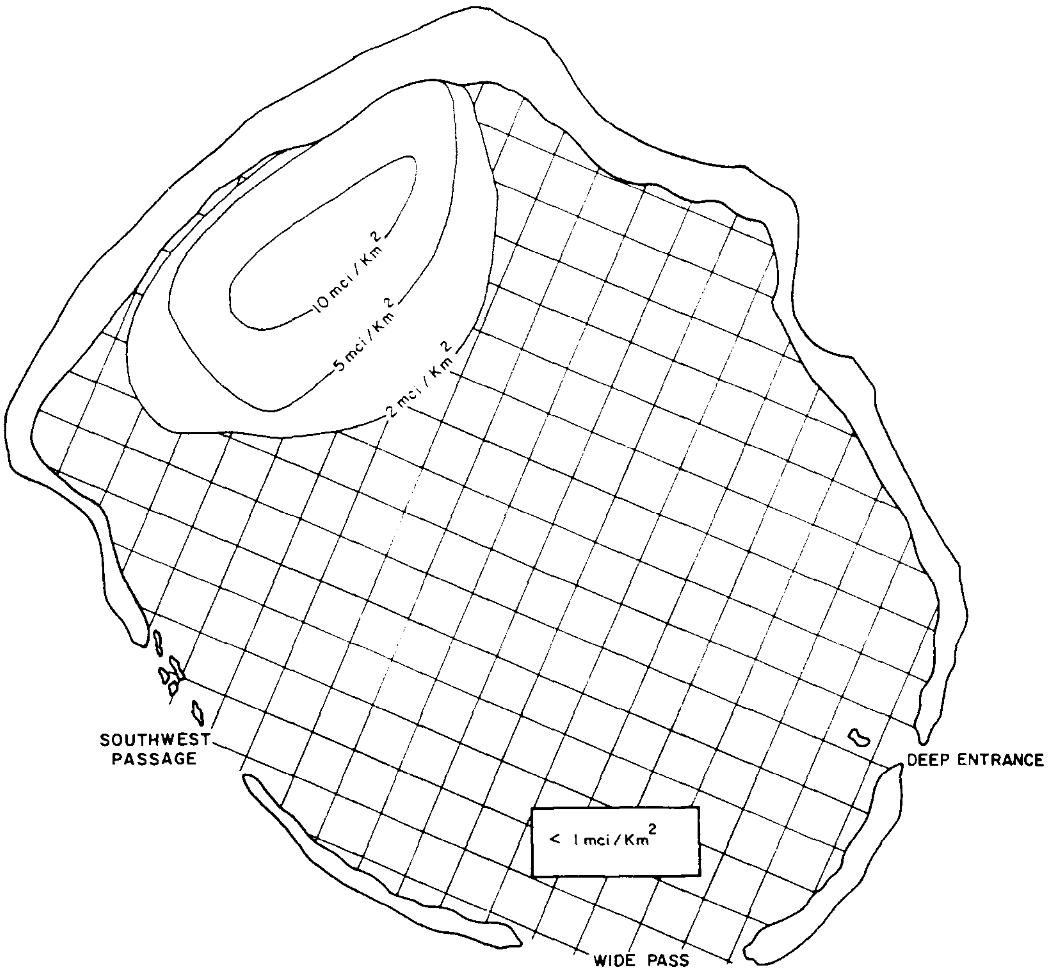


Fig. 64. Activity levels of $^{101}Rh$ deposited in the sediments of Enewetak Lagoon.

Table 47. Mean radionuclide concentrations in Enewetak Lagoon sediments.

| Radionuclide | Activity/unit area ($mCi/km^2$) |
|---|---|
| $^{90}Sr$ | 586 |
| $^{239,240}Pu$ | 463 |
| $^{155}Eu$ | 369 |
| $^{241}Am$ | 172 |
| $^{207}Bi$ | 163 |
| $^{137}Cs$ | 78 |
| $^{60}Co$ | 73 |
| $^{125}Sb$ | 22 |
| $^{102m}Rh$ | 8.4 |
| $^{152}Eu$ | 2.5 |
| $^{101}Rh$ | 1.2 |

with $^{137}Cs$ at a level which exceeds the mean value of 78 $mCi/km^2$ while 20 to 25% of the lagoon floor contains $^{207}Bi$, $^{60}Co$, and $^{102m}Rh$ at levels which exceed their mean level of activity. The activation products appear more widespread in Enewetak sediments than either the transuranics or detected fission products.

For comparative purposes, a few selected radionuclide concentrations found in aquatic sediments elsewhere in the world are shown Table 49. Only values for a few of the radionuclides present in Enewetak are available for comparison but it is immediately apparent from the data in Table 49 that Enewetak sediments

Table 48. Percentage of lagoon bottom area burdened with radionuclides above several levels of activity.

| Concentration level ($mCi/km^2$) | Percent of lagoon sediment contaminated[a] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $^{90}Sr$ | $^{239}Pu$ | $^{155}Eu$ | $^{241}Am$ | $^{207}Bi$ | $^{137}Cs$ | $^{60}Co$ | $^{125}Sb$ | $^{102m}Rh$ | $^{152}Eu$ | $^{101}Rh$ |
| 14000 | 0 | 0.01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10000 | 0.4 | — | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9000 | —[b] | — | 0 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8000 | — | 0.7 | 0 | — | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7000 | 2.1 | — | 0 | — | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6000 | — | — | 0 | — | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5000 | — | — | 1.0 | — | — | 0 | 0 | 0 | 0 | 0 | 0 |
| 4000 | — | — | — | — | — | 0 | 0 | 0 | 0 | 0 | 0 |
| 3000 | 4.9 | 2.9 | — | — | — | 0 | 0 | 0 | 0 | 0 | 0 |
| 2000 | — | — | — | 1.3 | — | 0.3 | 0.3 | 0 | 0 | 0 | 0 |
| 1000 | 11.6 | 8.5 | 7.8 | 2.5 | 1.7 | 1.3 | 0.6 | 0 | 0 | 0 | 0 |
| 500 | 16.5 | 14.1 | 15.6 | 5.6 | 2.5 | 4.3 | 1.9 | 0.7 | 0 | 0 | 0 |
| 400 | — | 14.3 | — | — | — | — | — | — | 0 | 0 | 0 |
| 300 | — | — | — | — | — | — | — | — | 0 | 0 | 0 |
| 200 | — | 33.9 | — | — | — | — | — | 2.5 | 0 | 0 | 0 |
| 100 | 40.3 | 47.9 | 32.9 | 20.5 | 27.4 | — | 12.6 | 6.0 | 0.5 | 0 | 0 |
| 50 | 56.3 | 59.7 | 47.7 | 34.2 | 49.1 | 12.1 | 31.9 | 6.3 | 2.7 | 0.6 | 0 |
| 20 | — | — | 65.5 | 51.1 | — | — | — | — | — | 2.4 | 0 |
| 10 | ~100 | — | — | 59.5 | — | 26.1 | 70.5 | 1.85 | 20.0 | — | 2.7 |
| 5 | ~100 | ~100 | — | >90 | — | 38.8 | — | 32.1 | 35.5 | 7.8 | 10.7 |
| 1 | ~100 | ~100 | ~98 | — | 100 | >60 | ~98 | — | — | 23.5 | 17.4 |

[a] Lagoon area = 932 $km^2$.

[b] Value not computed.

contain substantially higher deposits of artificially produced radionuclides than any other geographic area for which we have data.

MIKE and KOA Crater Sediments — The locations of the sediment samples collected from the area of MIKE and KOA Craters are shown in Fig. 53. Results of analyses for the gamma-emitting radionuclides, $^{90}Sr$, and plutonium radionuclides in the surface grab samples are presented in Table 50. Shown also in Table 50 are the mean values and standard deviations for the radionuclides in both craters; the mean surface concentrations in MIKE and KOA Craters; and the mean concentrations at the three sampling water-depth intervals: (a) greater than 90 ft, (b) from depths greater than 4 ft but less than 90 ft, and (c) from surface sediments around the rim of the craters (samples 25E to 31E). The mean sediment thickness of the crater grab samples was 6.0 cm. Concentrations of the radionuclides in the crater surface sediments are extremely variable. With the exception of $^{207}Bi$, there are higher concentrations of all radionuclides in MIKE Crater surface sediments than are found in KOA Crater deposits.

There appears to be a correlation between sediment radionuclide content and sampling depth. The surface sediments from the deeper depths within the craters

Table 49. Some selected radionuclide data in aquatic sediments.

| Radionuclide | Collection date | Location | $mCi/km^2$ |
|---|---|---|---|
| $^{239,240}Pu$ | 1968-1970-71 | Buzzards Bay, Mass. | 2.3 ± 0.2 |
| $^{239,240}Pu$ | 1971 | Lake Ontario | 0.6 ± 0.2 |
| $^{239,240}Pu$ | 1968 | Bylot Sound, Greenland | 3.9 |
| $^{239,240}Pu$ | 1968 | Bylot Sound, Greenland | 135 |
| $^{90}Sr$ | 1970-71 | Buzzards Bay, Mass. | 0.6 ± 0.1 |
| | 1969 | Lake Superior | 4.4 |
| | 1966 | Lake Michigan | 3.7 |
| | 1966 | Ligurian Sea | 3.0 |
| $^{137}Cs$ | 1970-71 | Buzzards Bay, Mass. | 7.6 |
| | 1973 | Humboldt Bay, Calif. | 21 |
| | 1969 | Lake Superior | 155 |
| | 1971 | Lake Ontario | 14 |
| $^{60}Co$ | 1963 | 11 km off mouth of Columbia River, USA | 64 |
| | 1973 | Humboldt Bay, Calif. | 3.5 |
| $^{155}Eu$ | 1966 | Ligurian Sea | 18 |

contain higher levels of radionuclides than do sediments from shallower and surface deposits. In the past, any extreme turbulence or large scale mixing of the sediments should have produced a much more uniform distribution of radionuclides than that presently observed. The crater bottom sediments are, therefore, probably not subjected to severe scouring or resuspension, and the principle loss of activity from the deposits may only be from the slow release to the overlying waters and diffusion upward where the activities then mix with the surface waters and are diluted by advective processes. Since 1964, the concentration levels of several radionuclides in the crater sediments have not diminished at rates substantially faster than predicted by radioactive decay alone. In Table 51 are the mean concentrations of $^{60}Co$, $^{125}Sb$, $^{137}Cs$, and $^{207}Bi$ in the crater sediments from both the 1964 and 1972 survey. The value of each 1964 radionuclide detected, when decay corrected, agrees with the value found in the 1972 samples.

Roughly the same ordering of the principal radionuclides is found in the crater deposits as were found in the lagoon sediments. Strontium-90 is the most abundant radionuclide in the surface layers, followed by, in order of decreasing concentration, $^{239,240}Pu$, $^{155}Eu$, $^{241}Am$,

**Table 50. Radionuclides in the surface sediments of MIKE and KOA Craters.**

| Sample No. | Location | Water depth (ft) | Radionuclide concentration (pCi/g)[a] $^{60}Co$ | $^{90}Sr$ | $^{101}Rh$ | $^{102m}Rh$ | $^{125}Sb$ | $^{137}Cs$ | $^{152}Eu$ | $^{155}Eu$ | $^{207}Bi$ | [illegible]Pu | [illegible]Pu | $^{241}Am$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35C | MIKE | 90 | 14.5 ± 1.7 | 82.4 ± 4.7 | 0.82 ± 7.5 | 3.09 ± 5.0 | 1.79 ± 17 | 18.2 ± 1.9 | 0.62 ± 21 | 47.5 ± 3.9 | 2.45 ± 9.7 | 67.1 ± 8.4 | 3.08 ± 17 | [illegible] |
| 34C | MIKE | 65 | 1.98 ± 2.2 | 35.4 ± 4.2 | N. R.[b] | 0.14 ± 19 | 0.30 ± 24 | 7.89 ± 1.3 | 0.13 ± 24 | 6.8 ± 4 | 0.36 ± 11 | 32.1 ± 16 | 1.08 ± 100 | 8.61 ± 1.5 |
| 38C | MIKE | 61 | 2.86 ± 1.4 | 43.5 ± 4.2 | 0.19 ± 7 | 0.82 ± 4 | 0.56 ± 11 | 9.90 ± 1.7 | 0.21 ± 13 | 28.4 ± 2 | 1.3 ± 3 | 47.3 ± 8 | 1.67 ± 18 | 15.4 ± 6 |
| 33C | MIKE | 92 | 8.61 ± 1.2 | 55 ± 5 | 0.45 ± 5 | 2.03 ± 4 | 1.40 ± 12 | 12.5 ± 1 | 0.35 ± 25 | 28.8 ± 3 | 2.71 ± 2 | 49.1 ± 6 | 2.36 ± 10 | 12.1 ± 11 |
| 32C | Junction MIKE and KOA | 91 | 12.0 ± 1.0 | 52.3 ± 5 | 0.60 ± 3 | 2.22 ± 2 | 2.03 ± 4 | 10.4 ± 2 | 0.28 ± 19 | 30.3 ± 2 | 2.78 ± 2 | 37.5 ± 8 | 2.49 ± 17 | 10.2 ± 6 |
| 36C | KOA | 102 | 1.61 ± 5 | 27.5 ± 4 | 0.09 ± 22 | 0.53 ± 10 | 0.64 ± 31 | 2.24 ± 4 | <0.09 | 9.20 ± 4 | 1.77 ± 6 | 12.0 ± 8 | 1.21 ± 12 | 3.37 ± 18 |
| 31C | KOA | 112 | 8.68 ± 3 | 42.8 ± 4 | 0.50 ± 8 | 2.22 ± 3 | 1.54 ± 10 | 6.41 ± 2 | 0.20 ± 18 | 30.6 ± 6 | 6.69 ± 2 | 37.7 ± 7 | 5.49 ± 9 | 7.03 ± 25 |
| 37C | KOA | 60 | 1.04 ± 7 | 13.4 ± 5 | 0.07 ± 12 | 0.29 ± 7 | 0.23 ± 20 | 1.62 ± 2 | 0.14 ± 19 | 6.1 ± 3 | 0.92 ± 3 | 7.66 ± 8 | 1.04 ± 12 | 1.66 ± 12 |
| 29C | KOA | 110 | 7.89 ± 2 | 45.1 ± 3 | 0.41 ± 6 | 1.73 ± 3 | 1.44 ± 7 | 5.96 ± 2 | 0.36 ± 18 | 23.5 ± 3 | 5.62 ± 1 | 3.35 ± 7 | 0.56 ± 7 | 4.78 ± 14 |
| mean, all samples | | | 6.5 ± 4.6 | 44 ± 19 | 0.4 ± 0.3 | 1.5 ± 1.0 | 1.1 ± 0.7 | 8.3 ± 5.1 | 0.3 ± 0.2 | 24 ± 14 | 2.7 ± 2.1 | 33 ± 21 | 2.1 ± 1.5 | 9.7 ± 6.7 |
| mean, MIKE Crater | | | 8.0 ± 5.5 | 54 ± 18 | 0.5 ± 0.3 | 1.7 ± 1.1 | 1.2 ± 0.8 | 11.8 ± 3.9 | 0.3 ± 0.2 | 28 ± 14 | 1.9 ± 1.1 | 47 ± 13 | 2.1 ± 0.8 | 14.0 ± 6.1 |
| mean, KOA Crater | | | 6.2 ± 4.8 | 36 ± 16 | 0.3 ± 0.2 | 1.4 ± 0.9 | 1.2 ± 0.7 | 5.3 ± 3.6 | 0.2 ± 0.1 | 20 ± 12 | 3.6 ± 2.5 | 20 ± 17 | 2.2 ± 2.0 | 5.4 ± 3.3 |
| mean, all samples >90 ft | | | 8.9 ± 4.4 | 51 ± 18 | 0.5 ± 0.2 | 2.0 ± 0.8 | 1.5 ± 0.5 | 9.3 ± 5.6 | 0.3 ± 0.2 | 28 ± 12 | 3.7 ± 2.0 | 34 ± 24 | 2.5 ± 1.7 | 10.2 ± 7.4 |
| mean, all samples <90 ft | | | 2.0 ± 0.9 | 31 ± 16 | 0.1 ± 0.1 | 0.4 ± 0.4 | 0.4 ± 0.2 | 6.5 ± 4.3 | 0.2 ± 0.0 | 14 ± 13 | 0.9 ± 0.5 | 29 ± 20 | 1.3 ± 0.4 | 8.6 ± 6.8 |
| mean, all surface sediments around craters (0-6 cm) | | | 1.0 ± 0.9 | | N. R. | 0.1 ± 0.1 | 0.3 ± 0.3 | 4.7 ± 6.1 | 0.2 ± 0.2 | 4.7 ± 2.9 | 0.5 ± 0.3 | | | 10.4 ± 10.0 |

[a] Error expressed in % of value given.

[b] N. R.—not reported.

Table 51. Comparison of the concentrations of several radionuclides in MIKE Crater sediment, 1964 to 1972.

| Date of sampling | Water depth, ft | Crater location | Mean concentration, pCi/g | | | |
|---|---|---|---|---|---|---|
| | | | $^{60}Co$ | $^{125}Sb$ | $^{137}Cs$ | $^{207}Bi$ |
| 7/64 | ~90 | MIKE | 29 ± 17 | 11 ± 7 | 12 ± 7 | 5.9 ± 4.5 |
| Decay corrected to Dec. 1972 | | | 9.7 ± 5.7 | 1.3 ± 0.8 | 9.9 ± 5.8 | 4.9 ± 3.7 |
| 12/72 | all | MIKE | 7.1 ± 4.9 | 0.9 ± 0.6 | 11.6 ± 3.8 | 1.9 ± 1.1 |
| 12/72 | >90 | MIKE and KOA | 7.9 ± 3.9 | 1.2 ± 0.4 | 9.1 ± 5.5 | 3.6 ± 2.0 |
| 12/72 | >90 | MIKE | 10.3 ± 3.7 | 1.3 ± 0.2 | 15.0 ± 3.9 | 2.5 ± 0.2 |

$^{137}Cs$, $^{60}Co$, $^{207}Bi$, $^{238}Pu$, $^{102m}Rh$, $^{125}Sb$, $^{101}Ru$, and $^{152}Eu$. Bismuth-207, more abundant than $^{137}Cs$ and $^{60}Co$ in the open lagoon, is less abundant in the surface layers of the crater sediments.

The radionuclide concentrations in subsections of 4 cores obtained from the craters are shown in Table 52. With the exception of $^{207}Bi$ and $^{152}Eu$, all other radionuclides are found distributed the length of the sediment column sampled. The levels of $^{60}Co$, $^{102m}Rh$, $^{125}Sb$, and $^{137}Cs$, in general, increase down the sediment column. $^{241}Am$ and $^{155}Eu$ concentrations, although variable near the surface, only slowly decrease in value down the sediment column. The sediment profiles of $^{207}Bi$ are shown in Fig. 65. For comparison, $^{60}Co$, $^{137}Cs$, $^{241}Am$, and $^{155}Eu$ concentrations in core 15E are plotted as a function of depth in Fig. 66. The different vertical distribution patterns are obvious, probably indicative of differential movement of one radionuclide relative to another. Unlike the other radionuclides, $^{207}Bi$ is not detected below depths of 30 to 40 cm in the sediment column. There also appears to be a discontinuity in the concentration profiles of $^{241}Am$, $^{137}Cs$, $^{155}Eu$, and $^{60}Co$ at the 30- to 35-cm level in the core. These and other observations to be discussed indicate that the sediment surface layers in MIKE and KOA Craters are possibly ejecta from other nuclear events held in the Atoll. Holmes and Narver profiled the postevent depths of MIKE Crater in 1952 and found the maximum crater depth to be near 180 ft below sea level, During 1964, the Holmes and Narver survey indicated the bottom depth of MIKE Crater was then at 90 ft below sea level. Between 1952 and 1964, there was either considerable slippage of the crater slopes to fill in the crater bottom or tests held after 1952, such as KOA or others, contributed fill to the crater area. Clearly natural sedimentation can be ruled out since between the years 1964 to 1972, a period of no testing, there has been no measurable change in the bottom depth of the crater. Presently, at least 30 to 40 cm of sediment, richer in $^{207}Bi$, covers a $^{207}Bi$ depleted sediment region in both craters. Rhodium radionuclides, $^{101}Rh$ and $^{102m}Rh$, are also found in the crater sediments. In sample 15E of the mean

**Table 52.** Radionuclide concentrations in core samples from the crater.

| Core No. | Depth increment (cm) | $^{60}Co$ | $^{102m}Rh$ | $^{101}Rh$ | $^{125}Sb$ | $^{137}Cs$ | $^{152}Eu$ | $^{155}Eu$ | $^{207}Bi$ | $^{241}Am$ | $^{239}Pu$ | $^{90}Sr$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | pCi/g[a] | | | | | | | | | | |
| 17E(92 ft) | | | | | | | | | | | | |
| 05789247 | 0-5 | 10.8 ± 3 | 2.4 ± 6 | 0.59 ± 9 | 2.4 ± 14 | 13.1 ± 2 | 0.3 ± 70 | 42.9 ± 2 | 3.17 ± 4 | 20.1 ± 8 | 51.4 ± 13 | 56.3 ± 12 |
| 7893 | 5-10 | 11.3 ± 2 | 2.8 ± 5 | 0.68 ± 10 | 2.1 ± 16 | 13.5 ± 2 | 0.5 ± 30 | 46.6 ± 2 | 4.65 ± 3 | 19.6 ± 8 | 50.5 ± 10 | 73.4 ± 8 |
| 7894 | 10-15 | 27.1 ± 1 | 4.3 ± 3 | 0.98 ± 6 | 8.1 ± 4 | 16.4 ± 1 | 0.4 ± 30 | 63.0 ± 2 | 11.4 ± 1 | 22.4 ± 8 | 60.8 ± 6 | 91.4 ± 7 |
| 7895 | 15-20 | 47.3 ± 1 | 5.7 ± 4 | 1.45 ± 5 | 16.9 ± 3 | 18.6 ± 2 | 0.5 ± 27 | 60.4 ± 3 | 8.2 ± 3 | 16.4 ± 11 | 56.3 ± 4 | 112.2 ± 5 |
| 7896 | 20-25 | 53.7 ± 1 | 5.4 ± 4 | 1.41 ± 4 | 16.4 ± 3 | 17.2 ± 2 | 0.1 ± 100 | 54.3 ± 2 | 2.5 ± 7 | 14.1 ± 5 | 51.4 ± 3 | 117.1 ± 6 |
| 7897 | 25-30 | 59.4 ± 1 | 5.8 ± 2 | 1.60 ± 3 | 22.6 ± 2 | 17.9 ± 2 | 0.3 ± 28 | 54.7 ± 1 | 1.6 ± 8 | 12.2 ± 4 | 47.3 ± 4 | 159 ± 7 |
| 7898 | 30-35 | 55.5 ± 2 | 5.1 ± 4 | 1.48 ± 5 | 25.8 ± 3 | 15.9 ± 3 | 0.2 ± 100 | 46.0 ± 1 | 0.7 ± 20 | 10.4 ± 5 | 40.9 ± 6 | 104 ± 10 |
| 7899 | 35-40 | 83.8 ± 2 | 7.0 ± 5 | 1.95 ± 7 | 27.9 ± 4 | 24.0 ± 3 | 0.4 ± 100 | 59.6 ± 3 | 0.3 ± 100 | 12.2 ± 13 | 47.8 ± 5 | 126 ± 8 |
| 7900 | 40-45 | 83.5 ± 1 | 7.0 ± 5 | 1.90 ± 7 | 29.1 ± 4 | 23.9 ± 4 | 0.4 ± 100 | 61.2 ± 2 | 0.3 ± 100 | 13.6 ± 10 | 45.5 ± 6 | 132 ± 6 |
| 7901 | 45-50 | 88.9 ± 2 | 7.1 ± 5 | 1.99 ± 8 | 29.2 ± 4 | 24.5 ± 1 | 0.4 ± 100 | 59.4 ± 2 | 0.3 ± 100 | 13.7 ± 11 | 45.5 ± 6 | 146 ± 7 |
| 7902 | 50-56 | 71.3 ± 2 | 6.3 ± 10 | 1.77 ± 12 | 19.5 ± 8 | 20.0 ± 6 | 0.6 ± 100 | 47.8 ± 4 | 0.5 ± 100 | 12.6 ± 21 | 91.4 ± 44 | 113 ± 9 |
| 16E(91 ft) | | | | | | | | | | | | |
| 05790347 | 0-5 | 1.2 ± 100 | 3.4 ± 11 | 0.77 ± 14 | 3.9 ± 18 | 14.3 ± 5 | <0.4 | 40.4 ± 4 | 4.45 ± 9 | 15.3 ± 17 | 34.6 ± 6 | 49.6 ± 16 |
| 7904 | 5-10 | 60.7 ± 3 | 7.2 ± 11 | 1.91 ± 17 | 15.2 ± 11 | 20.1 ± 6 | <0.7 | 57.6 ± 4 | 4.93 ± 14 | 16.1 ± 18 | 51.4 ± 8 | 60.4 ± 9 |
| 7905 | 10-15 | 62.1 ± 2 | 6.3 ± 9 | 1.72 ± 14 | 19.7 ± 8 | 19.4 ± 5 | <0.7 | 49.5 ± 6 | 0.5 ± 100 | 12.7 ± 25 | 46.4 ± 8 | 88.7 ± 10 |
| 7906 | 15-20 | 54.3 ± 2 | 4.5 ± 10 | 1.25 ± 16 | 20.1 ± 8 | 19.6 ± 5 | <0.6 | 44.9 ± 5 | 1.6 ± 25 | 11.3 ± 25 | 39.8 ± 8 | 93.7 ± 9 |
| 7907 | 20-25 | 68.3 ± 2 | 6.2 ± 9 | 1.54 ± 13 | 22.9 ± 7 | 21.0 ± 5 | <0.7 | 49.4 ± 6 | 0.5 ± 100 | 10.7 ± 25 | 42.0 ± 10 | 81.9 ± 11 |
| 7908 | 25-30 | 64.1 ± 3 | 5.5 ± 9 | 1.63 ± 14 | 25.2 ± 6 | 20.6 ± 5 | <0.6 | 46.3 ± 6 | 0.5 ± 100 | 8.9 ± 25 | 40.2 ± 5 | 131 ± 6 |
| 7909 | 30-38 | 64.2 ± 1 | 5.7 ± 9 | 1.61 ± 10 | 22.4 ± 6 | 20.8 ± 4 | <0.6 | 45.1 ± 6 | 0.4 ± 100 | 7.9 ± 26 | 44.3 ± 5 | 106 ± 6 |
| 14E(110 ft) | | | | | | | | | | | | |
| 05788347 | 0-5 | 7.2 ± 2 | 1.7 ± 5 | 0.42 ± 7 | 1.5 ± 14 | 5.72 ± 3 | 0.27 ± 30 | 28.1 ± 1 | 5.28 ± 2 | 5.59 ± 6 | 25.6 ± 6 | 31.5 ± 11 |
| 7884 | 5-10 | 8.2 ± 9 | 2.1 ± 7 | 0.52 ± 8 | 2.0 ± 16 | 6.46 ± 4 | 0.48 ± 31 | 31.9 ± 1 | 6.92 ± 5 | 6.13 ± 6 | 42.3 ± 2 | 42.1 ± 1 |
| 7885 | 10-15 | 11.7 ± 3 | 2.6 ± 7 | 0.62 ± 10 | 3.9 ± 10 | 6.71 ± 4 | 0.1 ± 100 | 37.0 ± 1 | 10.7 ± 4 | 6.31 ± 6 | 53.9 ± 2 | 45.6 ± 1.0 |
| 7886 | 15-25 | 25.4 ± 2 | 3.3 ± 7 | 0.79 ± 14 | 10.7 ± 7 | 7.08 ± 5 | 0.4 ± 100 | 38.3 ± 6 | 12.5 ± 5 | 8.46 ± 27 | 51.8 ± 3 | 59.9 ± 4 |
| 7887 | 25-35 | 44.7 ± 2 | 4.8 ± 6 | 1.23 ± 11 | 15.5 ± 5 | 9.44 ± 4 | 0.4 ± 100 | 35.4 ± 6 | 3.35 ± 9 | 6.73 ± 28 | 36.1 ± 2 | 49.5 ± 5 |
| 7888 | 35-39 | 50.4 ± 2 | 5.7 ± 7 | 1.49 ± 12 | 17.6 ± 7 | 11.6 ± 5 | 0.5 ± 100 | 38.8 ± 6 | 1.14 ± 25 | 6.11 ± 28 | 44.2 ± 2 | 73.9 ± 6 |
| 15E(112 ft) | | | | | | | | | | | | |
| 05791047 | 0-5 | 13.5 ± 5 | 2.5 ± 23 | 0.47 ± 34 | 4.21 ± 26 | 7.14 ± 7 | 0.5 ± 100 | 40.5 ± 7 | 10.5 ± 7 | 8.7 ± 29 | 36.4 ± 4 | 58.6 ± 7 |
| 7911 | 5-10 | 34.5 ± 1 | 5.2 ± 5 | 1.14 ± 7 | 16.8 ± 3 | 8.50 ± 5 | 0.2 ± 100 | 62.6 ± 5 | 23.4 ± 2 | 8.9 ± 12 | 50.0 ± 4 | 75.2 ± 6 |
| 7912 | 10-15 | 42.4 ± 2 | 4.6 ± 7 | 1.04 ± 11 | 15.2 ± 5 | 10.5 ± 6 | 0.3 ± 100 | 45.9 ± 3 | 6.7 ± 8 | 8.3 ± 12 | 37.1 ± 8 | 27.2 ± 12 |
| 7913 | 15-20 | 46.7 ± 1 | 4.5 ± 4 | 1.14 ± 6 | 15.4 ± 4 | 10.9 ± 3 | 0.37 ± 70 | 36.8 ± 3 | 1.7 ± 9 | 7.2 ± 10 | 28.6 ± 7 | 78.4 ± 8 |
| 7914 | 20-25 | 49.6 ± 2 | 4.6 ± 4 | 1.27 ± 6 | 20.0 ± 3 | 11.6 ± 3 | 0.37 ± 70 | 37.7 ± 3 | 1.7 ± 9 | 7.5 ± 10 | 28.9 ± 2 | |
| 7915 | 25-30 | 44.9 ± 2 | 4.5 ± 6 | 1.06 ± 10 | 15.6 ± 5 | 10.9 ± 4 | 0.3 ± 100 | 35.2 ± 3 | 1.3 ± 15 | 7.5 ± 11 | 27.5 ± 3 | 88.7 ± 8 |
| 7916 | 30-35 | 46.5 ± 4 | 5.1 ± 12 | 1.30 ± 18 | 13.9 ± 10 | 11.0 ± 9 | 0.5 ± 100 | 29.6 ± 5 | 0.4 ± 100 | 5.7 ± 22 | 28.5 ± 3 | |
| 7917 | 35-40 | 47.8 ± 3 | 5.2 ± 10 | 1.29 ± 16 | 19.5 ± 9 | 12.7 ± 7 | 0.6 ± 100 | 32.7 ± 5 | 0.5 ± 100 | 7.6 ± 22 | | 81.5 ± 5 |
| 7918 | 40-45 | 47.1 ± 1 | 4.4 ± 4 | 1.29 ± 5 | 17.5 ± 3 | 11.9 ± 3 | 0.2 ± 100 | 37.3 ± 3 | 0.61 ± 18 | 6.9 ± 12 | 30.1 ± 3 | 79.7 ± 7 |
| 7919 | 45-50 | 48.2 ± 1 | 4.8 ± 5 | 1.34 ± 8 | 20.0 ± 3 | 12.8 ± 3 | 0.2 ± 100 | 39.9 ± 2 | 2.2 ± 8 | 7.1 ± 22 | 29.4 ± 3 | 154 ± 4 |
| 7920 | 50-55 | 47.6 ± 1 | 5.0 ± 6 | 1.34 ± 5 | 18.3 ± 3 | 11.5 ± 3 | 0.1 ± 100 | 38.2 ± 1 | 1.12 ± 14 | 5.5 ± 16 | 29.5 ± 4 | 151 ± 3 |
| 7921 | 55-63 | 46.9 ± 2 | 4.5 ± 6 | 1.32 ± 8 | 17.6 ± 5 | 10.5 ± 4 | 0.2 ± 100 | 32.2 ± 2 | 0.2 ± 100 | 5.3 ± 10 | 33.6 ± 4 | 197 ± 2 |

[a]Error expressed in % of quoted value.

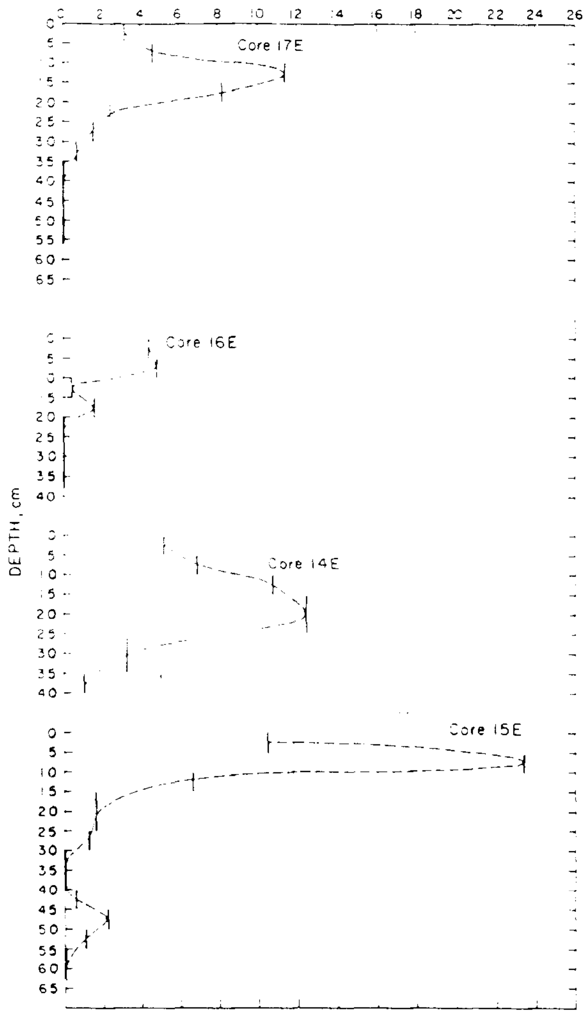


Fig. 65. Profiles of the $^{207}Bi$ concentration in crater cores.

ratio of the two rhodium radionuclides, to the maximum depth sampled, is 0.253 ± 0.032. The ratios in samples 17E, 14E, and 16E are, respectively, 0.265 ± 0.019, 0.249 ± 0.009, and 0.267 ± 0.024. To within one standard deviation, these values are identical and are distinct from ratios of 0.12 to 0.17 found in some open lagoon sediments. It would be extremely coincidental if $^{101}Rh$ and $^{102m}Rh$ were produced in both the MIKE and KOA Events, separated in time by 6 yr, in quantities which today yield identical ratios. Rather, the results suggest a single source for the rhodium isotopes

now found in the sediments of bc ters. The origin of the differen zons of the surface crater sedin unknown, but are probably eject other events held in the northwe of the Atoll. Rhodium isotopic r identical in value to those found and KOA craters are detected in from JANET, IRENE, DAISY, ar while quite different and distinct are found in soils from ALICE a BELLE.

Near-Shore Sediments—The concentrations of the principal g emitting radionuclides in near-s iments are tabulated in Table 53 sediment cores were obtained fr surf-zone in no more than 3 ft o ing water. Highest levels of act found in samples from IRENE, I and the sand bars surrounding M KOA craters. The areal distrib activity is similar to that found shore sediments.

Surprisingly there appears to difference in the radionuclide co tion of lagoon and ocean near-sh ments. This observation again that the bottom lagoon sediments subjected to large-scale resuspe and subsequent redistribution wi lagoon. These latter mechanism necessarily act as driving force duce significantly higher concen of radionuclides in the near-sho deposits relative to the ocean-si sediments.

In Situ Probe Survey—An in gamma-spectrometry survey of goon bottom off YVONNE, ELMI

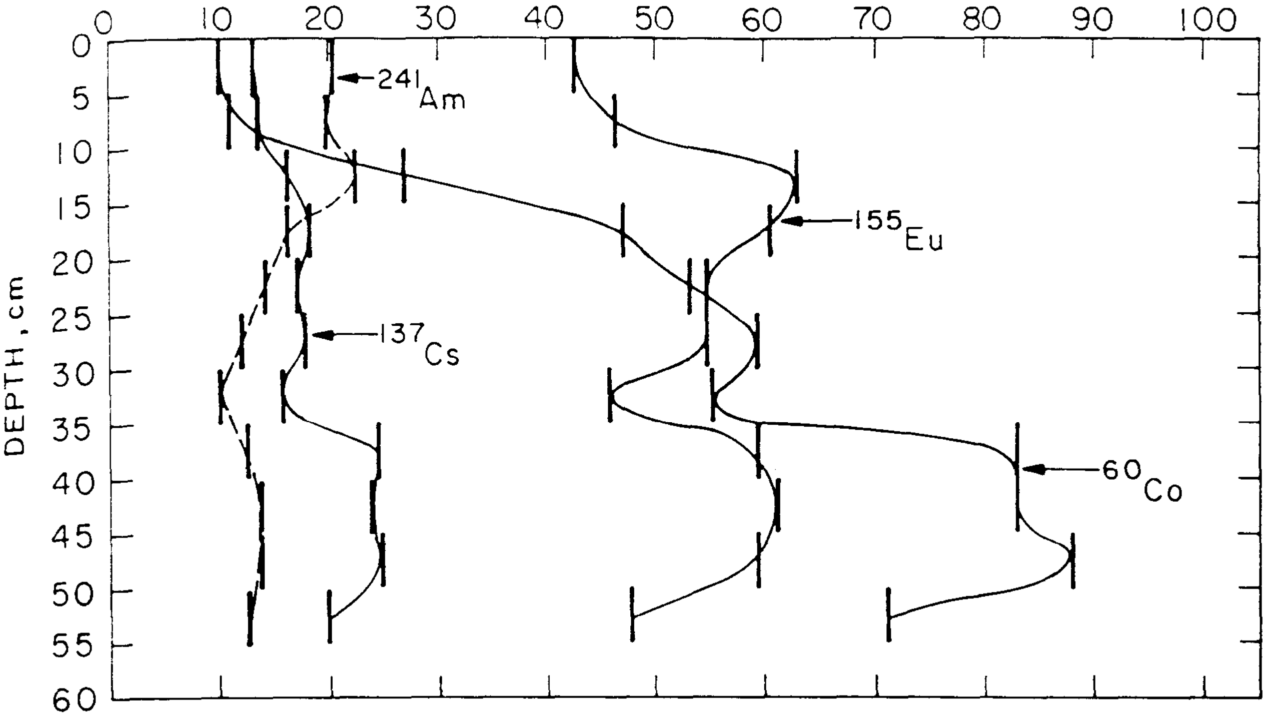


Fig. 66. Selected radionuclide concentration distributions in core 17E-KOA crater.

FRED was made during December, 1972. This survey was conducted to obtain data for the comparison of the results of field measurements with the results of the more sophisticated and time-consuming laboratory analyses of water and sediments. If the field measurements were acceptable, areas of high gamma activity in the lagoon sediments could be identified and the sampling program could be immediately adjusted in accordance with the findings. The gamma probe was built at the Laboratory of Radiation Ecology, University of Washington, and is a modification of an in situ probe originally designed by Gordon Riel of the United States Naval Ordnance Laboratory, White Oak, Maryland. The probe is composed of a 3 in. × 3 in. sodium iodide crystal, a photomultiplier, and a preamplifier, all encased in a brass waterproof housing. Power was supplied by a pair of 12-V batteries, and the signal cables were connected to a 200-channel analyzer with video display and tape printout subunits, all of which were carried on the AEC 24-ft launch. The probe was capable of operating to depths of 300 ft and of withstanding the shocks associated with its use aboard ships.

Prior to making a probe reading, the boat was anchored and its position determined by taking bearings on known landmarks. The probe was then lowered on a hand-held steel cable to the bottom of the lagoon and a 10- to 20-min count was taken and recorded on paper tape. Using a pipe dredge, a sediment sample was taken from as near to the in situ probe location as was possible. After the count was completed, the probe was raised to just below the water's surface and the

Table 53. Concentration levels of principal gamma emitting radionuclides in nearshore sediments.

| Island – location | Chart No. | Mean dry density ($g/cm^3$) | Length of core (cm) | pCi/g[a] dry $^{60}Co$ | $^{137}Cs$ | $^{207}Bi$ | $^{155}Eu$ |
|---|---|---|---|---|---|---|---|
| FRED – lagoon | (missing), marine pier | | 15 | <0.04 | <0.04 | 0.09 ± 0.03 | <0.07 |
| FRED – ocean | 38E | 1.22 ± 0.04 | 15 | <0.04 | <0.03 | 0.55 ± 0.15 | 0.18 ± 0.10 |
| FRED – ocean | 37E | 1.38 ± 0.35 | 15 | <0.04 | <0.03 | <0.04 | 0.07 ± 0.04 |
| WALT – lagoon w/end | 11E | 1.55 ± 0.08 | 15 | <0.02 | <0.02 | <0.02 | <0.05 |
| WALT – lagoon e/end | 12E | 1.16 ± 0.03 | 15 | <0.03 | <0.02 | <0.02 | 0.07 ± 0.04 |
| YVONNE – lagoon | 32E | 1.49 ± 0.02 | 14 | 0.67 ± 0.49 | <0.06 | 0.36 ± 0.07. | 0.71 ± 0.22 |
| YVONNE – lagoon s/end | 33E | 1.31 ± 0.11 | 15 | <0.03 | <0.01 | 0.06 ± 0.03 | 0.09 ± 0.03 |
| YVONNE – lagoon s/end | 34E | 1.50 ± 0.08 | 15 | <0.03 | <0.02 | 0.11 ± 0.06 | 0.11 ± 0.06 |
| YVONNE – oceanside s/end | 35E | 1.40 ± 0.05 | 15 | 0.05 ± 0.05 | <0.02 | 0.03 ± 0.03 | 0.15 ± 0.04 |
| YVONNE – oceanside s/end | 36E | 1.24 ± 0.22 | 15 | <0.03 | <0.01 | <0.01 | 0.15 ± 0.03 |
| URSULA – lagoon s/tip | 8E | 1.06 ± 0.07 | 15 | <0.06 | <0.04 | <0.02 | 0.63 ± 0.29 |
| URSULA – lagoon (center of island) | 39E | 1.08 ± 0.21 | 14 | <0.04 | <0.03 | <0.02 | 0.32 ± 0.16 |
| URSULA – oceanside | 42E | 0.97 ± 0.11 | 15 | <0.02 | 0.10 ± 0.04 | <0.02 | 0.20 ± 0.07 |
| TILDA – lagoon e/tip | 7E | 1.08 ± 0.08 | 16 | 0.18 ± 0.15 | 0.21 ± 0.04 | <0.03 | 0.63 ± 0.05 |
| JANET – lagoon se/end | 9E | 1.14 | 15 | 0.26 ± 0.08 | 0.64 ± 0.20 | 0.17 ± 0.10 | 1.01 ± 0.20 |
| JANET – lagoon nw/end | 10E | 1.11 | 16 | 0.10 ± 0.04 | <0.3 | 0.47 ± 0.20 | 1.46 ± 0.51 |
| IRENE – Seminole crater area | 40E | 1.23 ± 0.06 | 15 | 4.73 ± 0.74 | 1.23 ± 0.25 | 0.25 ± 0.05 | 2.48 ± 0.43 |
| HELEN – lagoon w/tip | 41E | 1.13 ± 0.19 | 12 | 0.84 ± 0.10 | 1.19 ± 0.49 | 1.02 ± 0.23 | 4.14 ± 1.24 |
| HELEN – lagoon sand bar | 25E | 1.19 ± 0.05 | 12 | 0.46 ± 0.15 | 0.12 ± 0.03 | <0.04 | 1.15 ± 0.11 |
| HELEN – lagoon s/tip | 26E | 1.30 ± 0.07 | 17 | 0.60 ± 0.23 | 0.47 ± 0.19 | 0.23 ± 0.05 | 3.12 ± 0.73 |
| HELEN – n/end | 27E | 1.16 ± 0.03 | 12 | 0.66 ± 0.12 | 0.59 ± 0.16 | 0.74 ± 0.07 | 2.26 ± 0.48 |
| Sand bars around MIKE and KOA Craters | 28E | 1.20 ± 0.09 | 12 | 0.79 ± 0.22 | 4.72 ± 2.35 | 0.62 ± 0.20 | 4.55 ± 2.03 |
| | 29E | 1.36 ± 0.02 | 12 | 1.02 ± 0.25 | 5.12 ± 0.34 | 4.80 ± 1.01 | 0.54 ± 0.08 |
| | 30E | 1.21 ± 0.05 | 17 | 1.29 ± 0.17 | 6.21 ± 1.61 | 0.45 ± 0.09 | 5.64 ± 0.71 |
| | 31E | 1.06 ± 0.14 | 13 | 2.32 ± 0.70 | 10.4 ± 10.1 | 0.89 ± 0.08 | 6.58 ± 3.57 |
| BELLE – lagoon e/end | 6E | 1.07 ± 0.09 | 15 | 0.24 ± 0.04 | 0.39 ± 0.21 | 0.17 ± 0.04 | 1.42 ± 0.21 |
| BELLE – lagoon w/end | 5E | 1.18 ± 0.15 | 14 | 0.39 ± 0.34 | 0.54 ± 0.22 | 0.11 ± 0.06 | 2.06 ± 1.22 |
| LEROY – n/end | 4E | 1.15 | 23 | 0.03 ± 0.03 | <0.02 | 0.29 ± 0.06 | <0.03 |
| HENRY – w/end | 3E | 1.16 | 17 | < 0.05 | <0.03 | 0.13 ± 0.04 | <0.08 |
| GLENN – lagoon | 2E | 1.12 | 20 | <0.04 | <0.02 | 0.26 ± 0.18 | <0.07 |
| GLENN – oceanside | 1E | 1.12 | 10 | <0.03 | <0.02 | 0.18 ± 0.11 | <0.04 |

boat was moved to the next station. The probe remained in the water during a day's operation in order to maintain the detector at a near-constant temperature and thus prevent a shift in the gain component of the analyzer (a change in "gain" affects the identification of the radionuclide).

Sixty-seven probe readings were made on 6 days in the lagoon off YVONNE and six readings were made in the lagoon off ELMER and FRED. Station locations off YVONNE and the depths at each station are shown in Figs. 67 and 68, respectively.

Near YVONNE, gamma peaks of $^{40}K$, $^{60}Co$, $^{137}Cs$, and $^{207}Bi$ could be readily identified from the video display and the tape printout of the probe data. However, only $^{40}K$ and $^{207}Bi$ were readily detected off FRED and ELMER. Since $^{207}Bi$ and $^{60}Co$ were detected at most stations off YVONNE, relative concentrations of these radionuclides were determined for the probe readings taken there. The relative concentration of $^{60}Co$ was calculated from its 1.33-MeV photon by summing the values from the five channels closest to the 1.33-MeV channel. Relative concentrations of $^{207}Bi$ were determined by summing the 1.06-MeV peak channel, one channel below the peak, and the two channels above the peak, and subtracting the value of the sum of the two channels (four total) on each side of the four channels summed for $^{207}Bi$. The results of the relative concentration calculations, standardized to 1-min counts, are shown in Figs. 69 ($^{60}Co$) and 70 ($^{207}Bi$).

These results indicated that $^{60}Co$ concentrations were greatest when the probe was on the bottom at a depth of 60 to 75 ft in an area bounded on the south by a line parallel to the personnel pier and on the north by a line perpendicular to HARDTACK Bunker No. 1610. Bismuth-207 concentrations were also high in this area, but the highest $^{207}Bi$ levels occurred at a depth of 60 to 70 ft in an area 600 m offshore of craters at the north end of the island. Near-shore $^{207}Bi$ levels were high in an area ranging north from just off CACTUS Crater. Cesium-137 concentrations were also high in this area.

Whereas $^{60}Co$ showed steadily increasing concentrations out to a depth of 75 ft, $^{207}Bi$ concentrations were at low (3.5 to 9.9 relative counts per minute) and moderate (10 to 29 relative counts per minute) levels near the shore, with a band of nonsignificant readings (relative count < background count) at intermediate depths (20 to 50 ft) followed by moderate and high levels at greater depths. Potassium-40 levels were relatively constant throughout the survey area.

The sediment samples which were taken simultaneously with the <u>in situ</u> probe readings were prepared and analyzed in the same manner as discussed in the section on lagoon sediments. Results of these analyses are shown in Figs. 71 ($^{60}Co$), 72 ($^{207}Bi$), 73 ($^{155}Eu$), 74 ($^{241}Am$), 75 ($^{239,240}Pu$), and 76 ($^{238}Pu$). Americium-241/$^{239,240}Pu$ ratios found in the sediment samples are plotted in Fig. 77, while $^{238}Pu/^{239,240}Pu$ ratios are plotted in Fig. 78. Potassium-40, $^{102m}Rh$, $^{125}Sb$, $^{137}Cs$, and $^{152}Eu$ were detected in more than 50% of the samples; $^{154}Eu$, $^{226}Ra$, and $^{235}U$ in 15 to 40% of the samples; and $^{101}Rh$, $^{106}Ru$, $^{134}Cs$, and $^{144}Ce$ were detected in an occasional

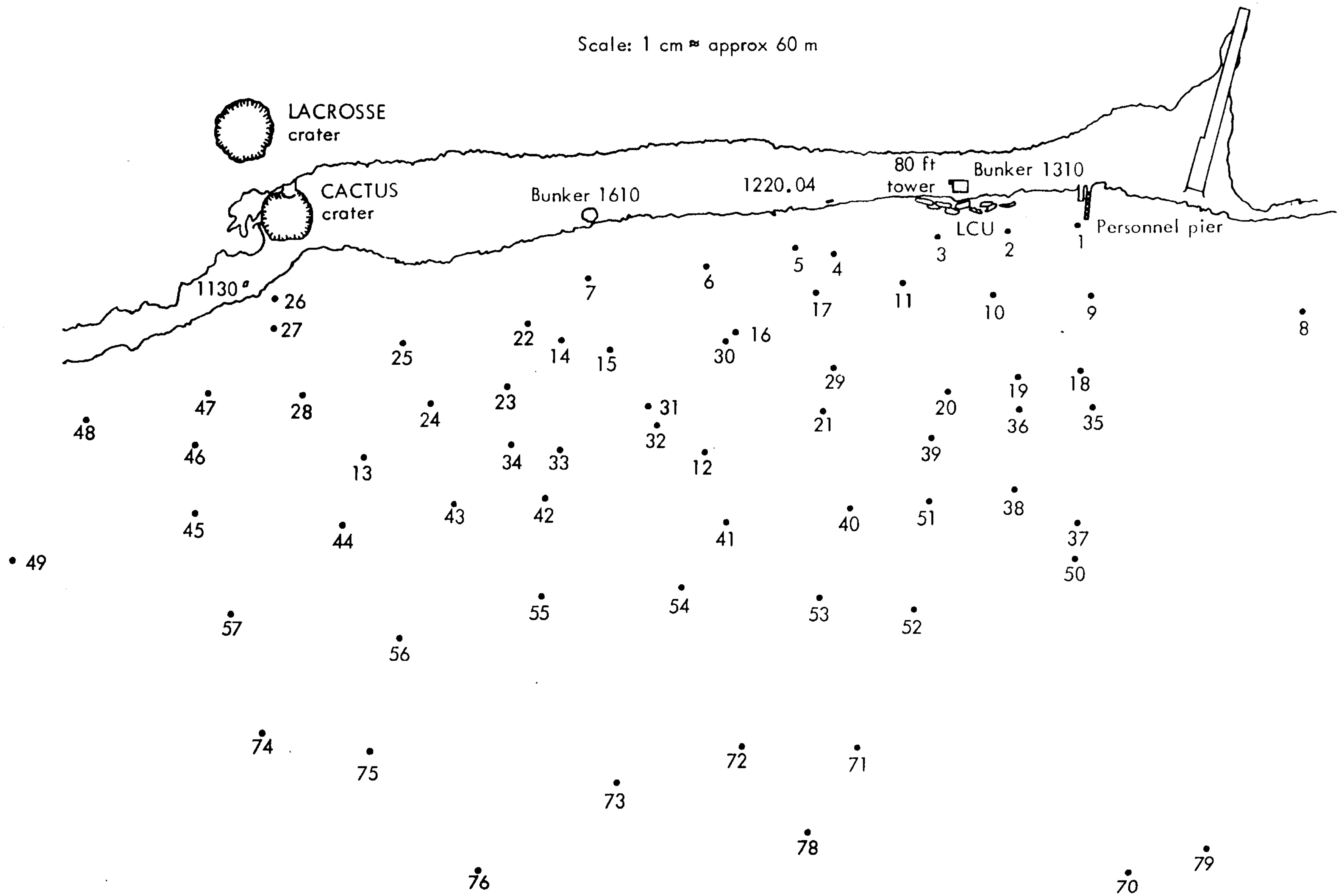


Fig. 67. Station locations for *in situ* gamma probe reading and sediment samples taken in the lagoon of YVONNE, Enewetak Atoll, December, 1972.

Fig. 67. Station locations for in situ gamma probe reading and sediment samples taken in the lagoon of YVONNE, Enewetak Atoll, December, 1972.

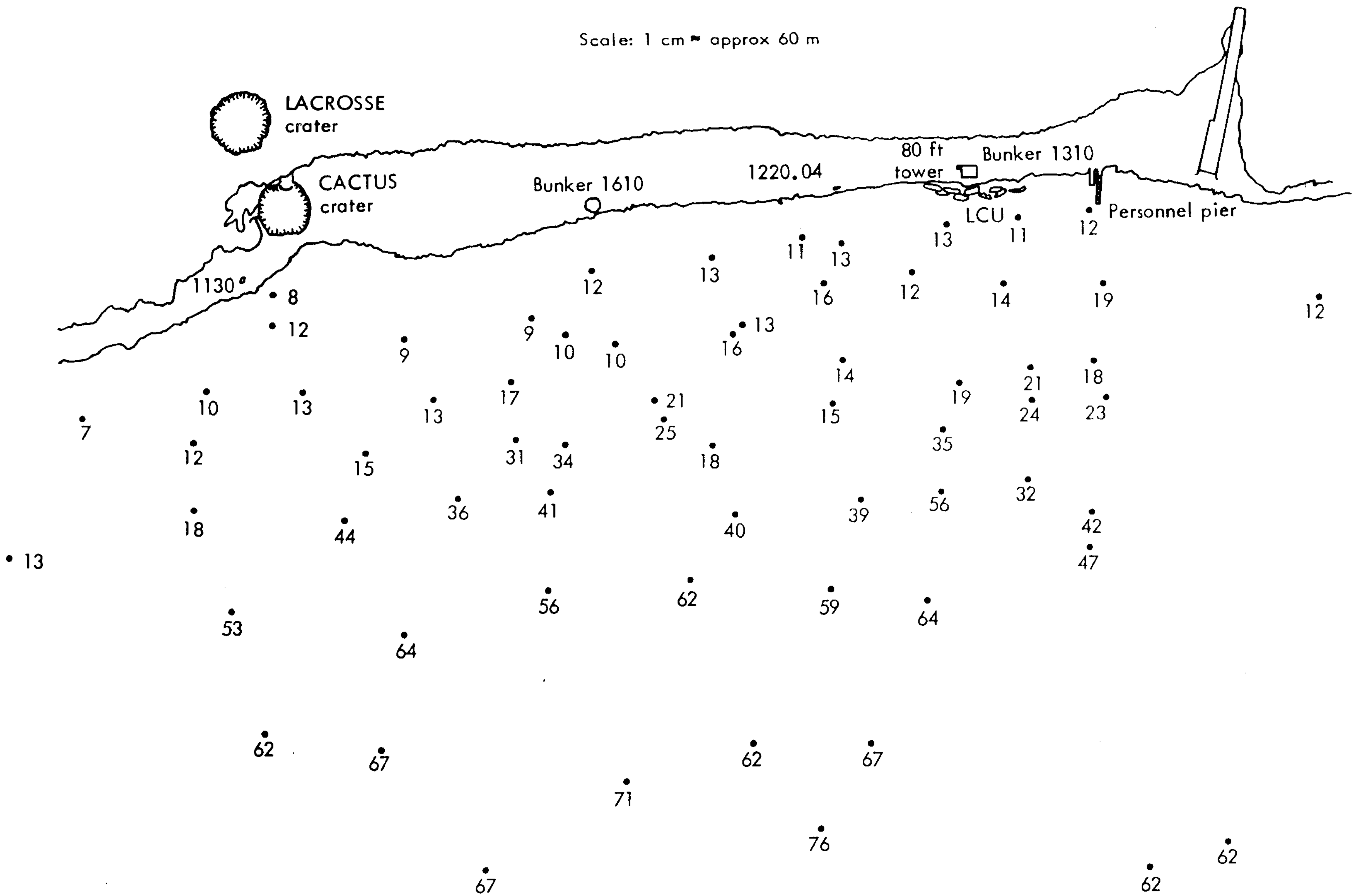


Fig. 68. Depth in feet at in situ probe stations in the lagoon off YVONNE, Enewetak Atoll, December, 1972.

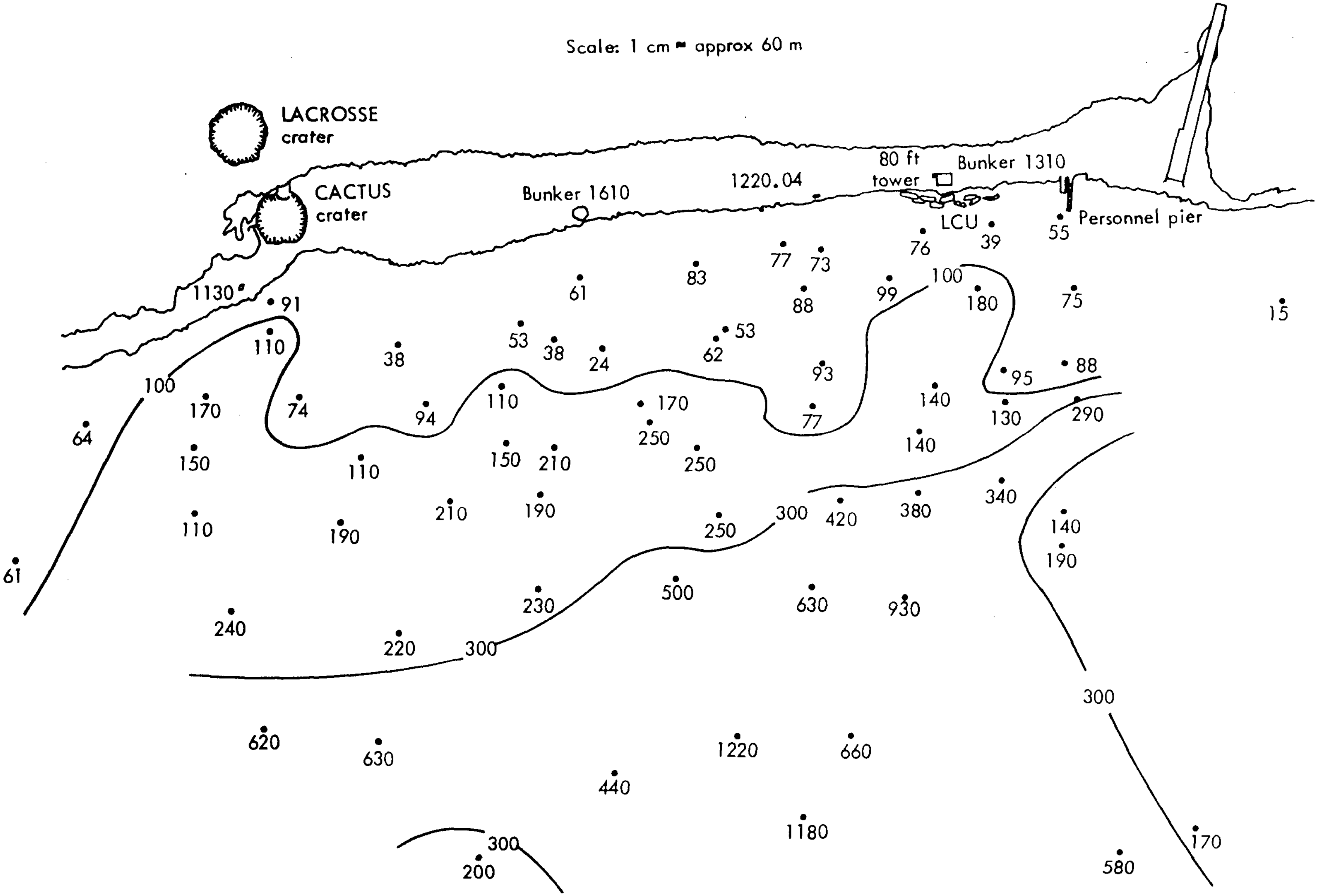


Fig. 69. Relative $^{60}Co$ concentration in cpm, measured with an in situ gamma probe on the lagoon bottom off YVONNE, Enewetak Atoll, December, 1972.

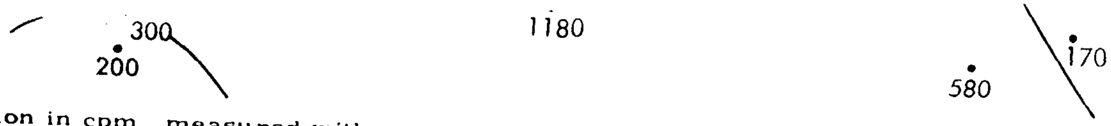


Fig. 69. Relative $^{60}$Co concentration in cpm, measured with an in situ gamma probe on the lagoon bottom off YVONNE, Enewetak Atoll, December, 1972.

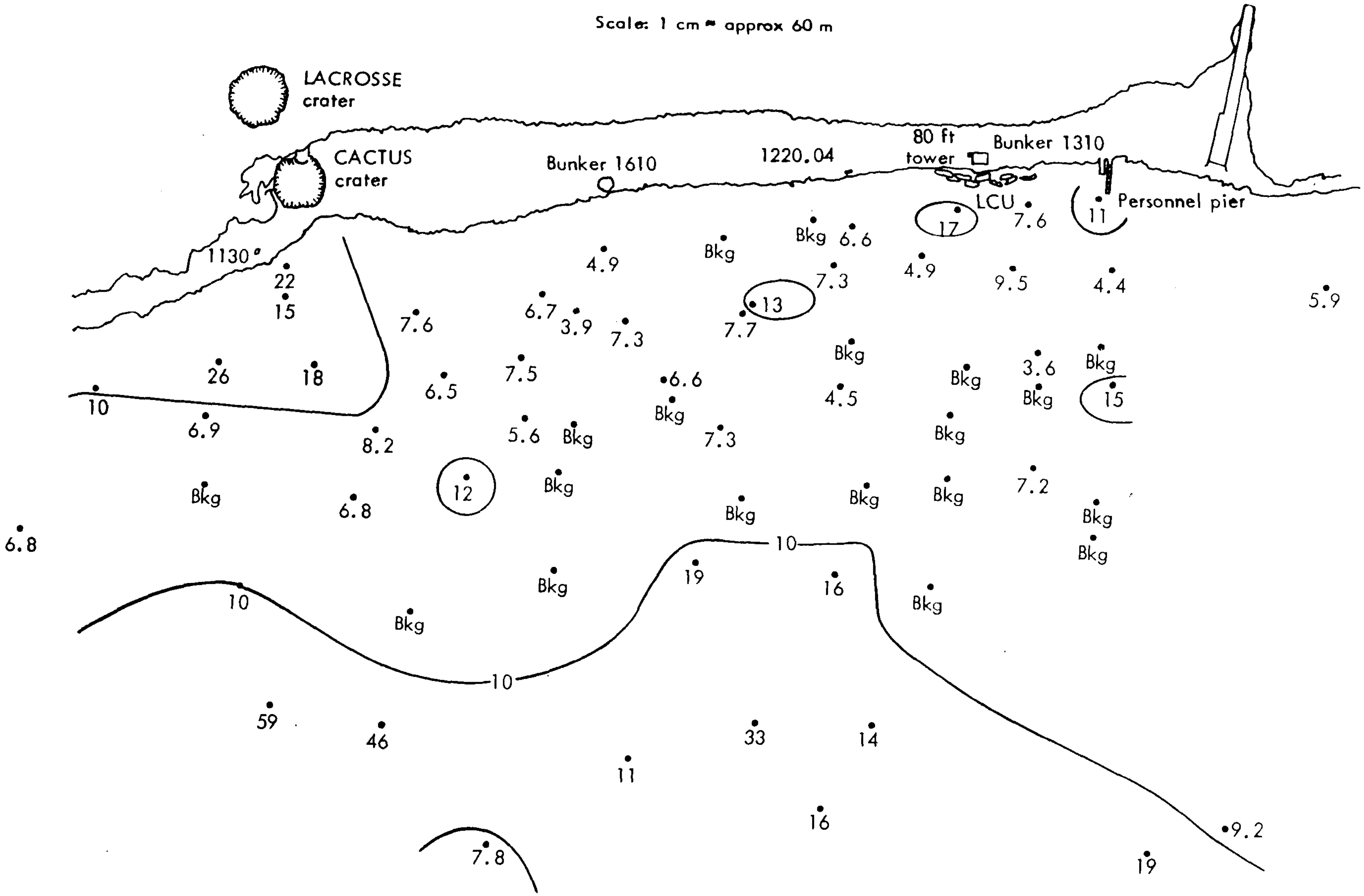


Fig. 70. Relative $^{207}$Bi concentrations in cpm, measured with an in situ gamma probe on the lagoon bottom off YVONNE, Enewetak Atoll, December, 1972.

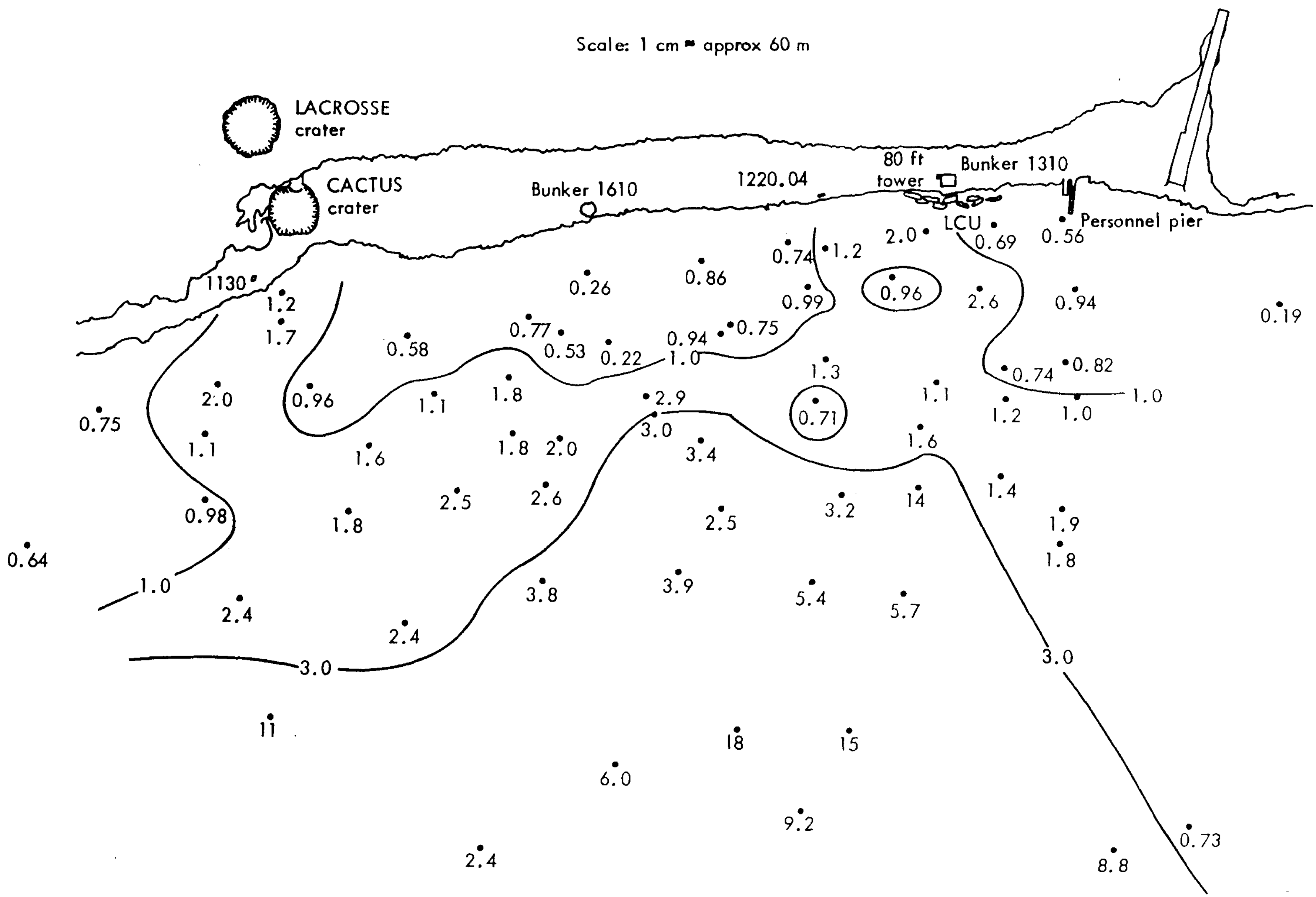


Fig. 71. Cobalt-60 concentration (pCi/g, dry) in sediment samples taken simultaneously with in situ probe readings in the lagoon off YVONNE, Enewetak Atoll, December, 1972.



Scale: 1 cm = approx 60 m

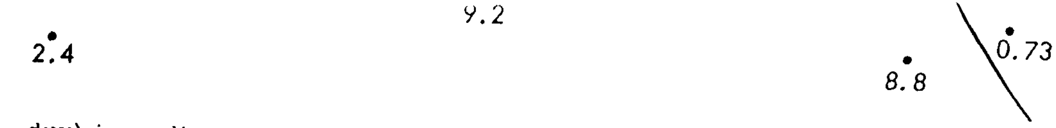


Fig. 71. Cobalt-60 concentration (pCi/g, dry) in sediment samples taken simultaneously with in situ probe readings in the lagoon off YVONNE, Enewetak Atoll, December, 1972.

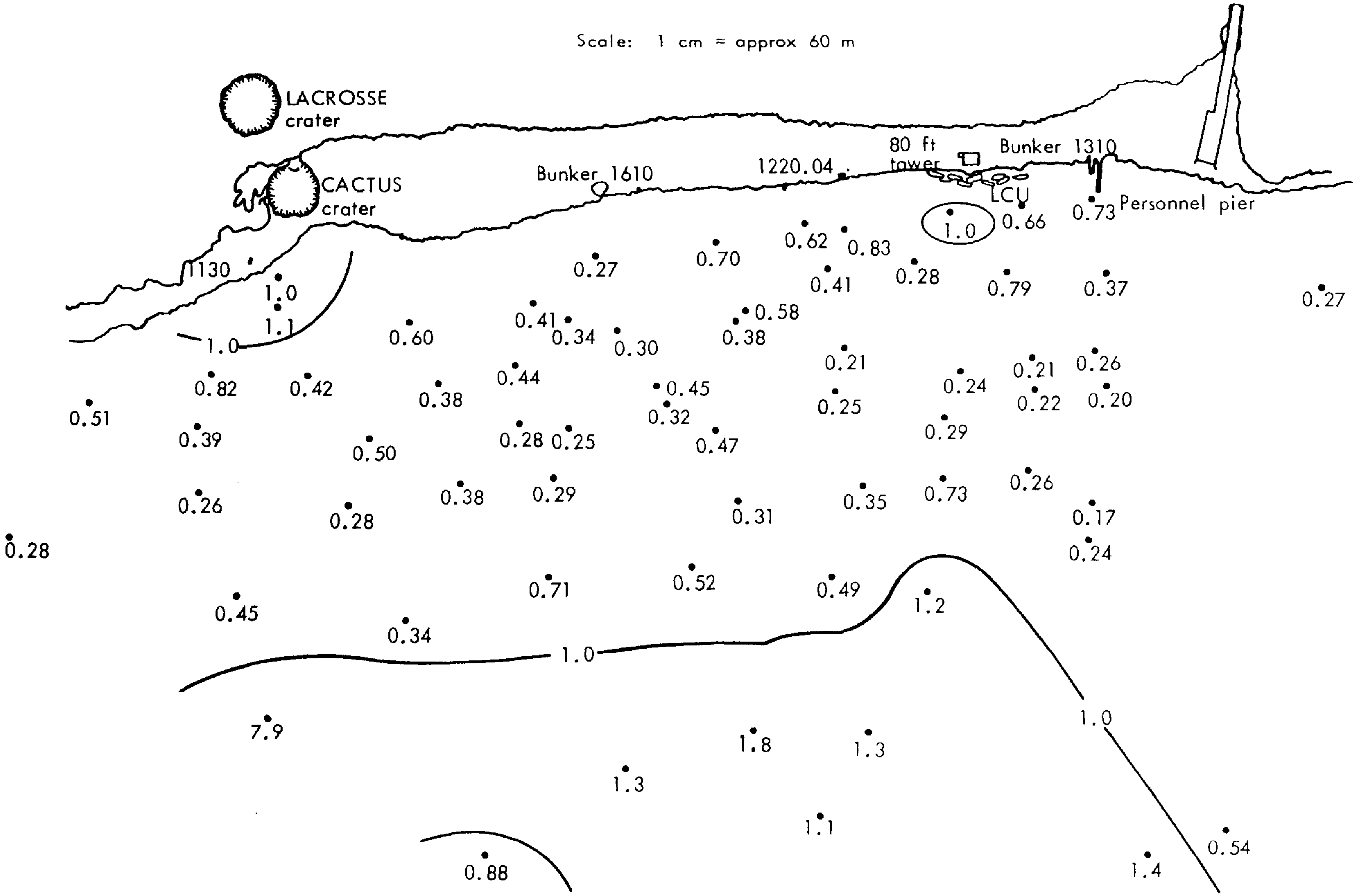


Fig. 72. Bismuth-207 concentration (pCi/g, dry) in sediment samples taken simultaneously with in situ probe readings in the lagoon off YVONNE, Enewetak Atoll, December, 1972.

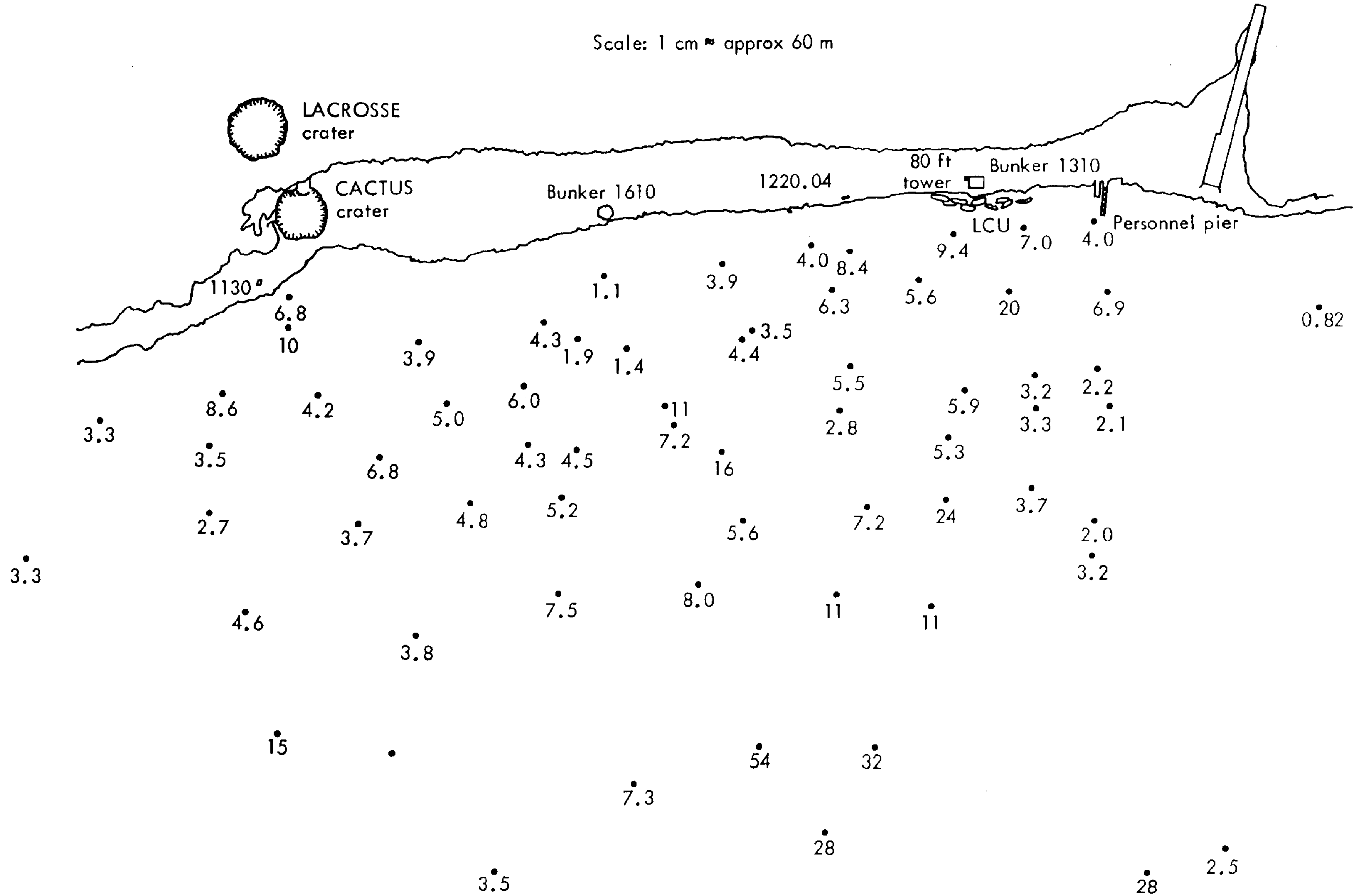


Fig. 73. Europium-155 concentration (pCi/g, dry) in sediment samples taken simultaneously with *in situ* probe readings in the lagoon off YVONNE, Enewetak Atoll, December, 1972.


Fig. 73. Europium-155 concentration (pCi/g, dry) in sediment samples taken simultaneously with in situ probe readings in the lagoon off YVONNE, Enewetak Atoll, December, 1972.

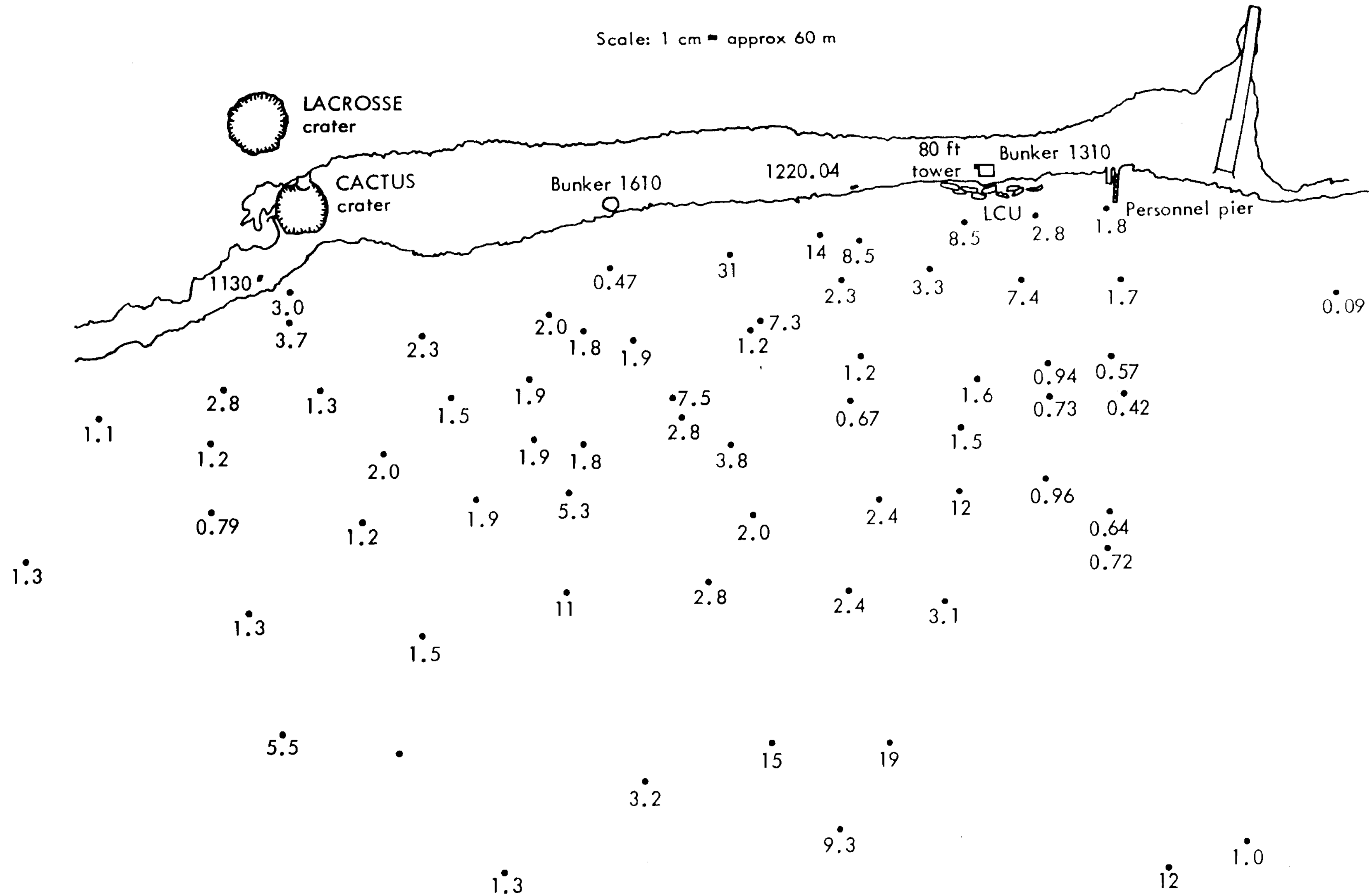


Fig. 74. Americium-241 concentration (pCi/g, dry) in sediment samples taken simultaneously with in situ probe readings in the lagoon off YVONNE, Enewetak Atoll, December, 1972.

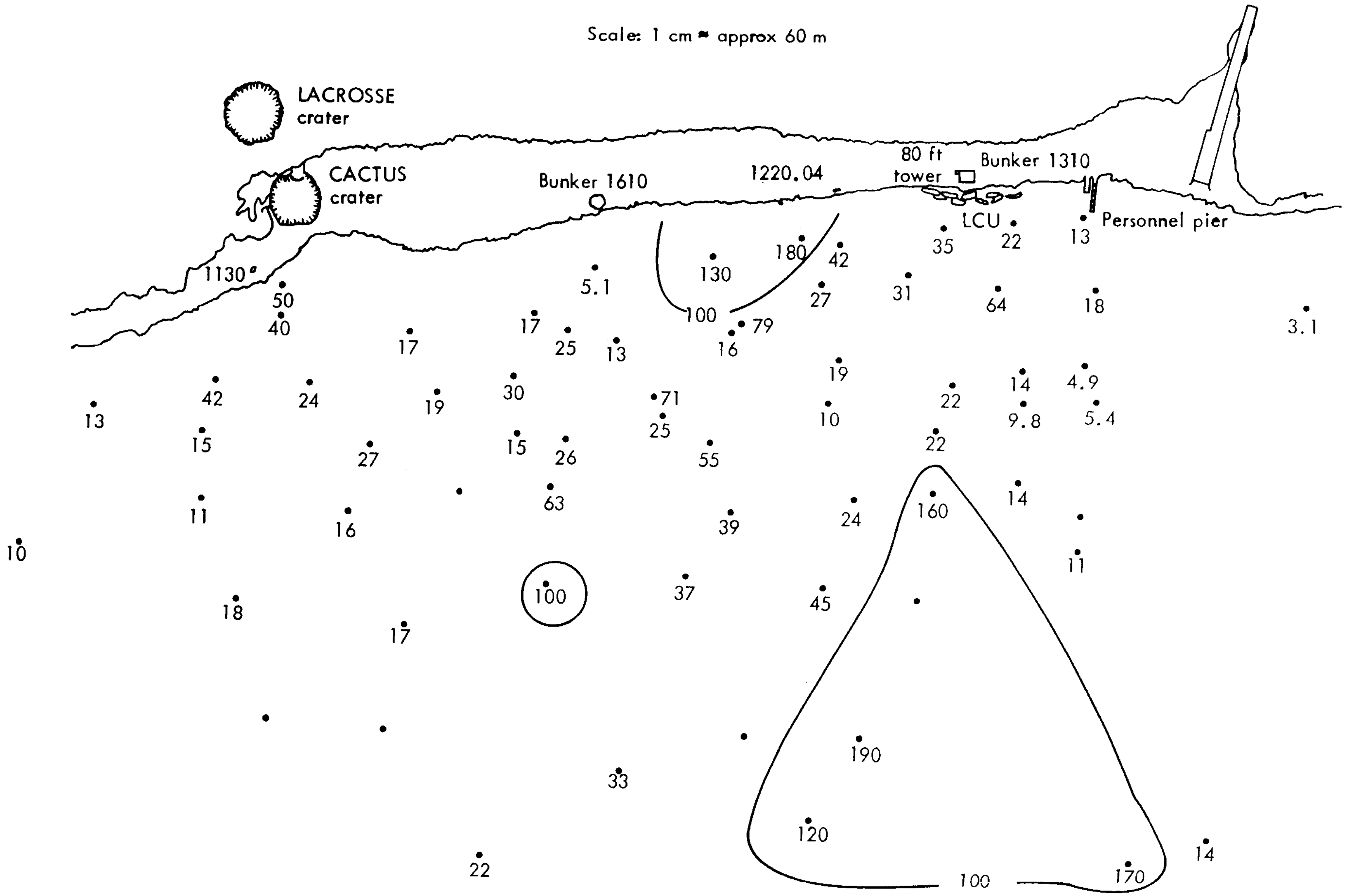


Fig. 75. Plutonium-239,240 concentration (pCi/g, dry) in sediment samples taken simultaneously with *in situ* probe readings in the lagoon off YVONNE, Enewetak Atoll, December, 1972.

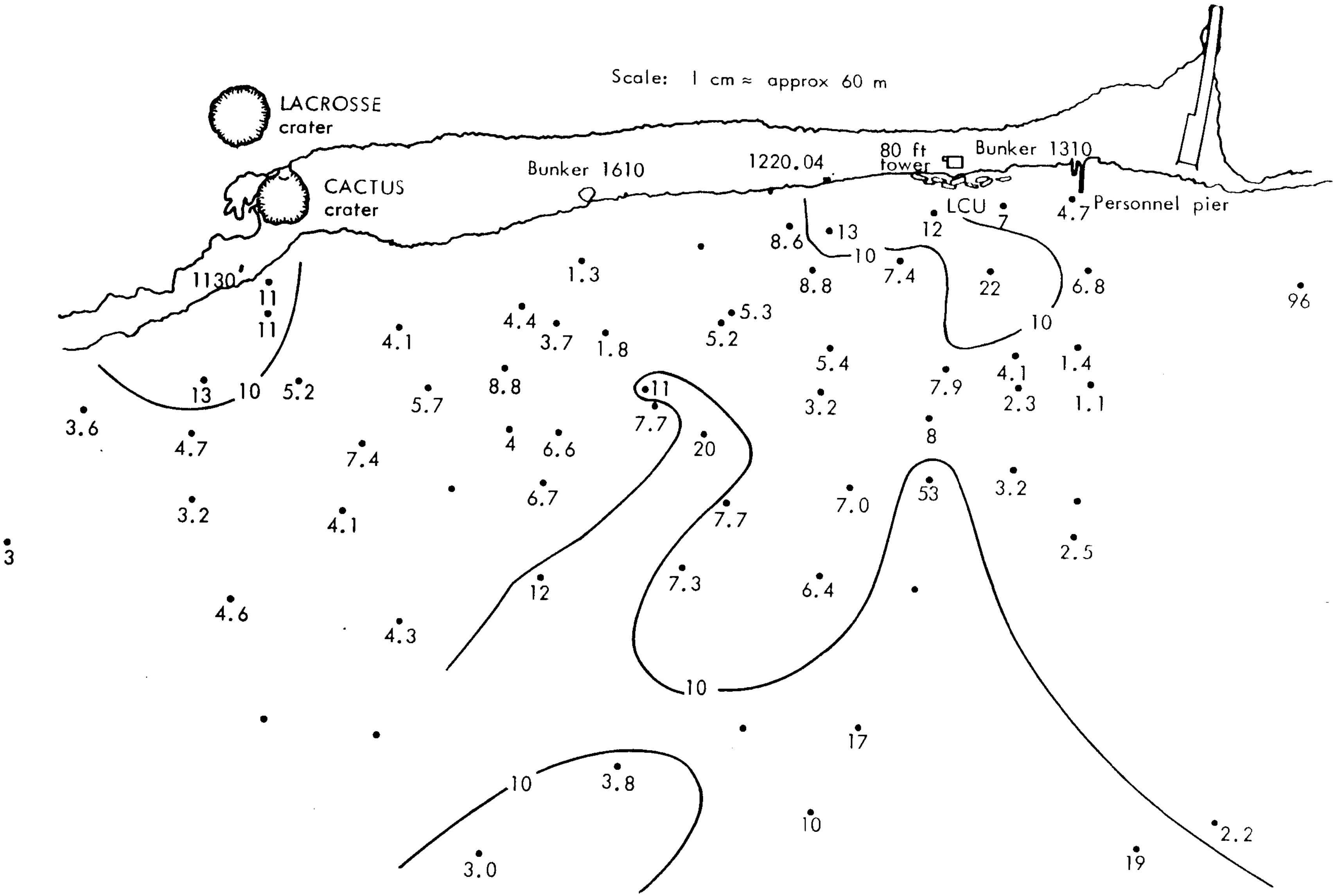


Fig. 76. Plutonium-238 concentration (pCi/g, dry) in sediment samples taken simultaneously with <u>in situ</u> probe readings in the lagoon off YVONNE, Enewetak Atoll, December, 1972.

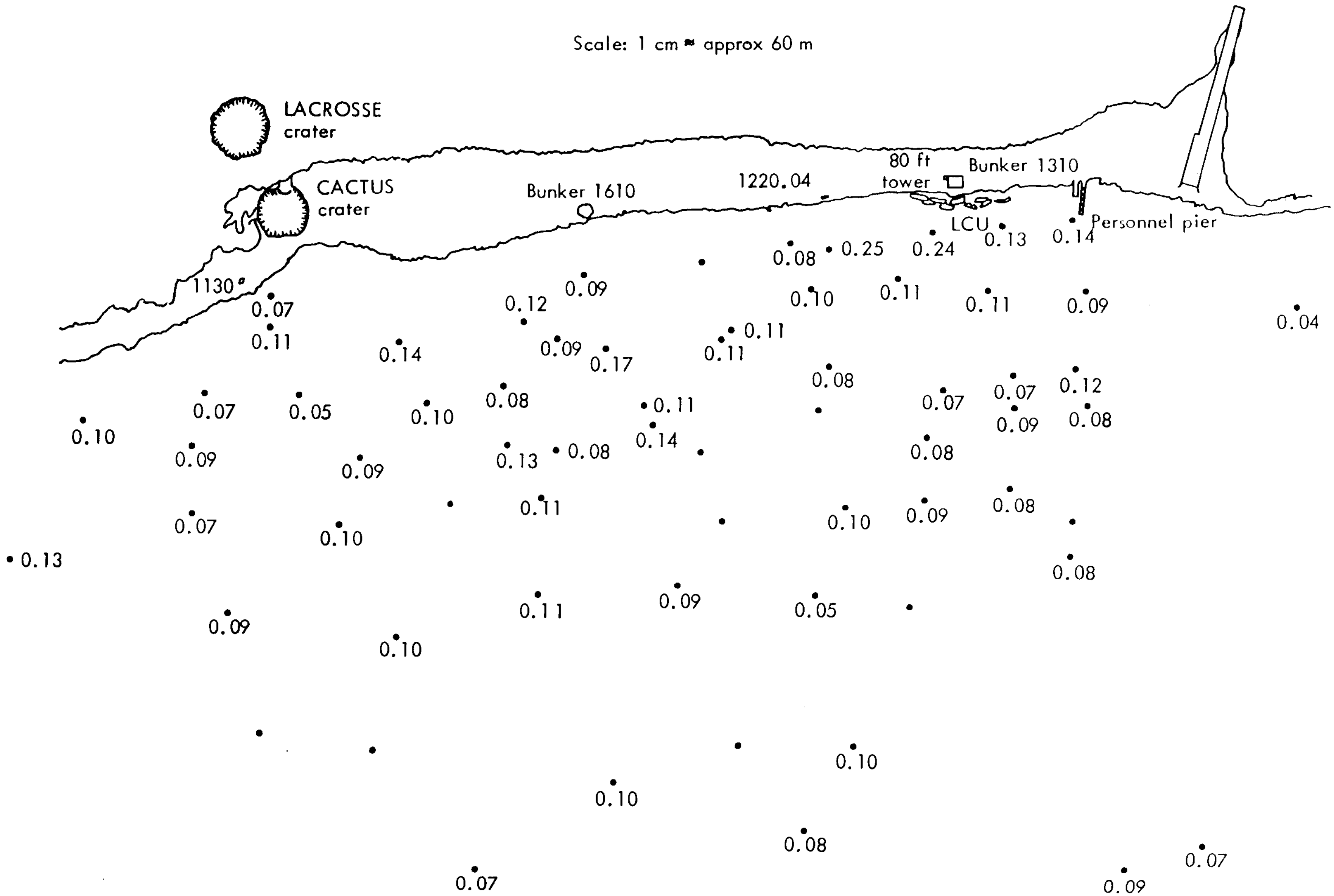


Fig. 77. The $^{241}Am/^{239,240}Pu$ ratio in sediment samples taken simultaneously with *in situ* probe readings in the lagoon off YVONNE, Enewetak Atoll, December, 1972.

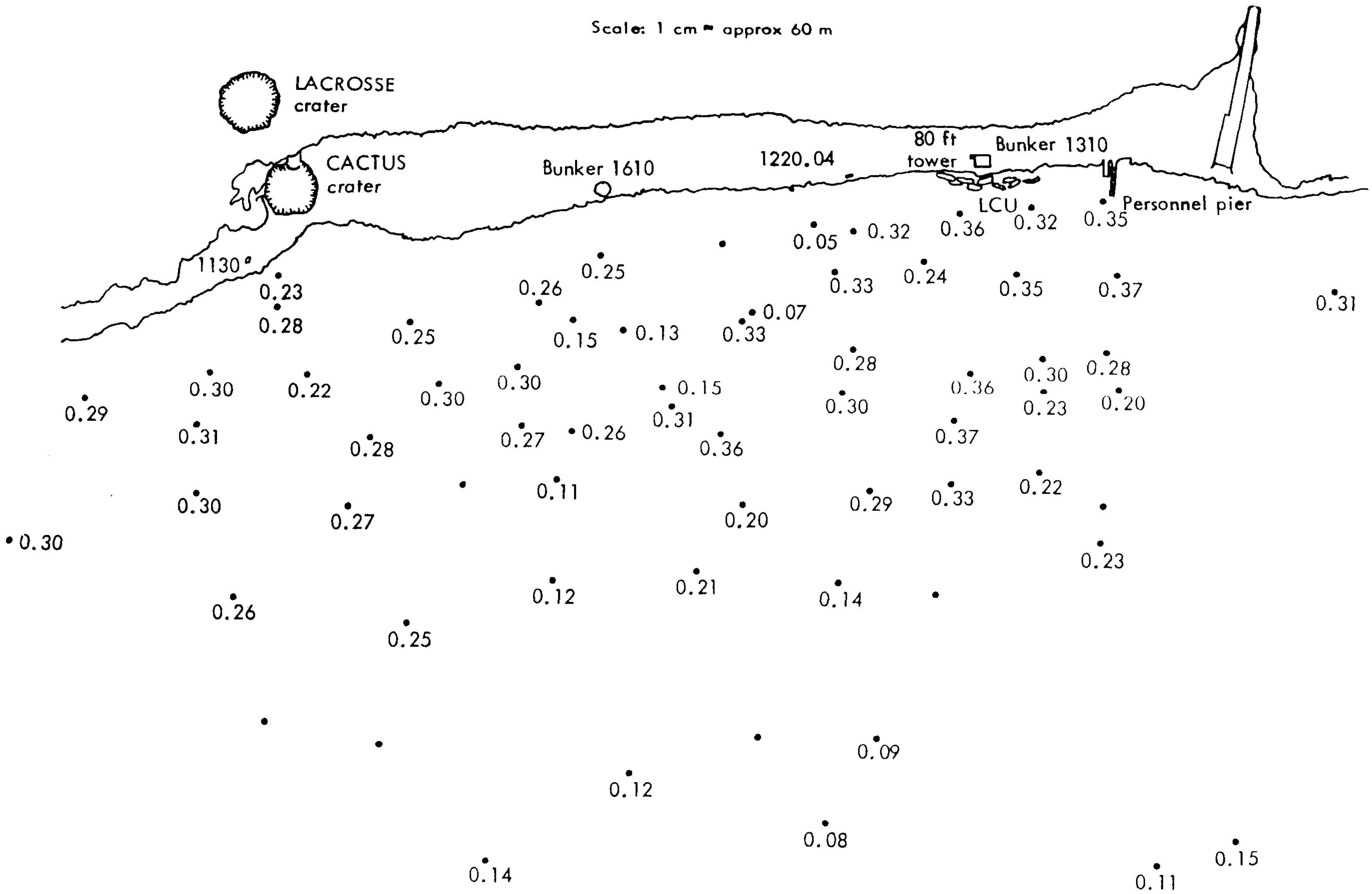


Fig. 78. The ratio $^{238}Pu/^{239,240}Pu$ in sediment samples taken simultaneously with <u>in situ</u> probe readings in the lagoon off YVONNE, Enewetak Atoll, December, 1972.

sample. Radionuclides other than $^{40}K$, $^{60}Co$, and $^{207}Bi$ were generally present at levels less than 1 pCi/g, dry.

It can be seen by comparing Figs. 69 and 71 and Figs. 70 and 72 that a good correlation exists between the degree of $^{60}Co$ and $^{207}Bi$ contamination indicated by the relative counts and the actual $^{60}Co$ and $^{207}Bi$ concentration measured in the sediment samples. A rough estimate of the concentration of $^{60}Co$ and $^{207}Bi$ in sediments, in terms of pCi/g, dry, can be obtained at stations where the gross relative count is greater than background by dividing the net relative count by a factor of 85 for $^{60}Co$ and 15 for $^{207}Bi$. Factors ranged from 38 (Station 3) to 290 (Station 38) for $^{60}Co$ and from 7 (Station 74) to 72 (Station 35) for $^{207}Bi$. These ranges are not surprising, since the sediments analyzed were surface samples taken within 10 ft of the in situ probe at shallow stations and within 30 ft at deep stations during counting, not at the exact location of the probe.

There are no direct comparisons available between $^{155}Eu$, $^{241}Am$, and Pu levels in the sediments and in the in situ readings since the NaI crystal and associated components used in the survey were not capable of detecting these isotopes. The distribution (Figs. 73 to 76) of these radionuclides does, however, correlate fairly well with the distribution of $^{207}Bi$, which can be measured with the in situ probe. In general, $^{155}Eu$, $^{241}Am$, and $^{239,240}Pu$ concentrations are high in the sediments from three areas: (1) the shallow near-shore area off CACTUS Crater, (2) the shallow near-shore area from HARDTACK Bunker 1310, northeast along the shore for 400 m and (3) in an area offshore, from the personnel pier, HARDTACK Bunker 242, at a depth of [illegible] to 70 ft. The highest concentration of $^{241}Am$ was found in a sediment sample taken from shallow water off the center of the northern part of the island, while the highest $^{155}Eu$ concentration was found in sediment from a deep-water (62 ft) station, 600 m off the same area of the island.

In summary, the highest levels of the radionuclides detected in the lagoon sediments off YVONNE with the in situ probe and in sediment samples analyzed in the laboratory are found in an area 500 to 700 m offshore at a depth of 60 to 70 ft. Good correlation between the relative counts obtained with the in situ probe and the concentration of $^{60}Co$ and $^{207}Bi$ found in sediment samples taken simultaneously with the probe readings indicates that the in situ gamma probe can be used effectively to delineate relative levels (i.e., relative to the actual amount of radionuclide present, not relative to other isotopes) of contamination in the lagoon basin.

## Lagoon Water Samples

### Purpose of Collections

These samples were taken to assess the present concentrations and distribution of specific radionuclides in the lagoon and craters. From the water and biota data, it will be possible to compute the "concentration factors" of specific radionuclides in marine species, an index which will be useful in models designed to predict future levels of activities in pelagic species.

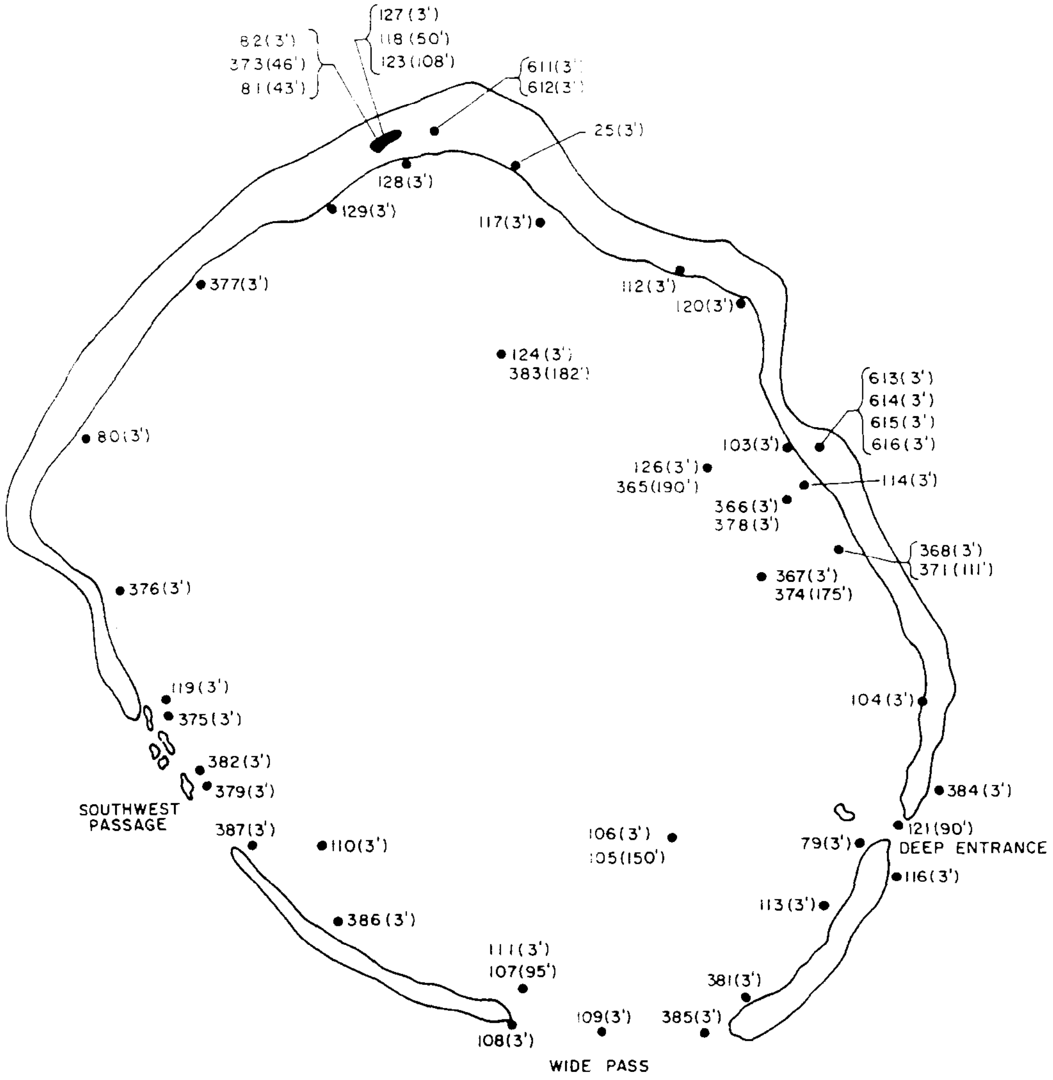


Fig. 79. Location and identification of 55-liter water samples. The depth of the water sampled is shown in parenthesis.

## Sampling Locations and Collection Methods

Figure 79 indicates the location and depth of all water samples collected at Enewetak Atoll during October to December 1972. At those locations where more than one sample was obtained, the deepest was collected within 1 to 2 m of the bottom. All samples were pumped without filtering into 55-liter "Deldrum" containers, acidified to pH 1.5 with HCℓ, and shipped to LLL for processing.

## Processing and Analysis

A known quantity of carrier or tracer for each radionuclide to be measured was added to the sample. Cesium was first removed by coprecipitation on ammonium molybdophosphate (AMP) and $^{137}Cs$ determined on a low-level gamma spectrometer. Strontium, the lanthanides, the transuranics, and transition metals were then precipitated with sodium carbonate. After dissolution of the carbonate, a hydroxide precipitation separated all the lanthanides, transuranics, and transition metals from strontium (and calcium). Plutonium radionuclides were isolated from the hydroxide fraction and determined by alpha spectrometry, the residual fraction was concentrated and counted on a Ge(Li) diode for gamma emitters, and the $^{90}Sr$ fraction was sent to a participating laboratory for further analysis.

Many of the gamma-emitting radionuclides found in the marine sediments were not detected in the water samples by gamma spectrometry. The following radionuclides were below detection limits in all samples: $^{102m}Rh$ < 80 fCi/liter; $^{125}Sb$ < 220 fCi/liter; $^{106}Ru$ < 580 fCi/liter; $^{152}Eu$ < 104 fCi/liter; $^{235}U$ < 70 fCi/liter. Fifteen samples from the northern half of the lagoon did contain detectable amounts of $^{60}Co$, $^{155}Eu$, $^{207}Bi$, and $^{241}Am$ (see Table 54). In no other samples were these nuclides above their detection limits.

$^{137}Cs$ and $^{239,240}Pu$, radiochemically separated and analyzed by more sensitive analytical techniques, were positively identified and determined in all samples. Greater sensitivity for the other radionuclides could have been realized in this way, but it was not economically justifiable. The cesium and plutonium results are listed in Table 55. Table 56 gives the mean surface water concentrations of $^{137}Cs$ and $^{239}Pu$ in the four quadrants of the lagoon and in the ocean close to the east side of the Atoll. The difference in concentrations between the lagoon and ocean clearly indicates the Atoll to be the

Table 54. Gamma-emitting radionuclides identified in separated hydroxide fraction of water samples.

| Sample No. | Concentration, fCi/liter ± % error | | | |
|---|---|---|---|---|
| | $^{60}Co$ | $^{155}Eu$ | $^{207}Bi$ | $^{241}Am$ |
| 103 | 116 ± 35 | | <224 | |
| 112 | 146 ± 67 | | <53 | |
| 114 | 518 ± 29 | | | |
| 123 | 354 ± 16 | 1433 ± 5 | 420 ± 21 | 346 ± 15 |
| 124 | <68 | | 734 ± 10 | |
| 126 | <67 | | 261 ± 16 | |
| 129 | <40 | | 570 ± 10 | |
| 365 | 842 ± 8 | 940 ± 7 | 1266 ± 9 | 314 ± 18 |
| 366 | 121 ± 33 | | 258 ± 23 | |
| 368 | 138 ± 22 | | 204 ± 22 | |
| 373 | 136 ± 38 | | <88 | |
| 374 | 118 ± 34 | | <242 | |
| 377 | <51 | | 413 ± 42 | |
| 383 | <50 | 67 ± 50 | 683 ± 10 | 36 ± 50 |
| 386 | <61 | | 154 ± 26 | |
| Detection limits (average) | 75 | 100 | 80 | 100 |

Table 55. Radiocesium and plutonium in seawater samples.

| Sample No. (see Fig. 79) | Activity, fCi/kg ± 1σ | | | Ratio | | Water depth, ft | |
|---|---|---|---|---|---|---|---|
| | $^{137}Cs$ | $^{239,240}Pu$ | $^{238}Pu$ | 239/137 | 238/239 | Bottom | Sample |
| 79 | 296 ± 19 | 6.0 ± 1.1 | 1.1 ± 0.3 | 0.020 | 0.183 | —[a] | 3 |
| 80 | 471 ± 22 | 32.5 ± 3.0 | 2.7 ± 0.5 | 0.069 | 0.083 | 36 | 3 |
| 81 | 3200 ± 21 | 54.6 ± 3.8 | 1.9 ± 0.4 | 0.017 | 0.035 | 95 | 93 |
| 82 | 730 ± 20 | 23.4 ± 2.0 | 2.0 ± 0.4 | 0.032 | 0.085 | 95 | 3 |
| 103 | 486 ± 17 | 43.6 ± 1.4 | 6.8 ± 0.3 | 0.090 | 0.156 | 60 | 3 |
| 104 | 241 ± 18 | 13.1 ± 0.7 | 1.9 ± 0.2 | 0.054 | 0.145 | —[a] | 3 |
| 105 | 300 ± 19 | 17.4 ± 0.7 | 2.5 ± 0.2 | 0.058 | 0.144 | —[a] | 150 |
| 106 | 342 ± 19 | 22.4 ± 0.7 | 2.2 ± 0.1 | 0.065 | 0.098 | —[a] | 3 |
| 107 | 190 ± 14 | 9.6 ± 0.5 | 0.9 ± 0.1 | 0.051 | 0.094 | 100 | 95 |
| 108 | 229 ± 16 | 10.2 ± 0.5 | 1.1 ± 0.2 | 0.045 | 0.108 | 20 | 3 |
| 109 | 228 ± 17 | 9.6 ± 0.5 | 1.0 ± 0.1 | 0.042 | 0.104 | 70 | 3 |
| 110 | 377 ± 18 | 28.9 ± 0.9 | 3.8 ± 0.2 | 0.077 | 0.131 | >100 | 3 |
| 111 | 258 ± 20 | 11.6 ± 0.4 | 1.4 ± 0.9 | 0.045 | 0.121 | —[a] | 3 |
| 112 | 163 ± 19 | 15.4 ± 0.7 | 1.9 ± 0.2 | 0.094 | 0.123 | 22 | 3 |
| 113 | 170 ± 18 | 4.8 ± 0.3 | 0.6 ± 0.1 | 0.028 | 0.125 | 80 | 3 |
| 114 | 462 ± 17 | 51.9 ± 1.9 | 7.1 ± 0.4 | 0.112 | 0.137 | 100 | 3 |
| 116 | 32 ± 19 | 0.43 ± 0.25 | 0.01 ± 0.01 | 0.013 | 0.023 | —[a] | 3 |
| 117 | 107 ± 30 | 11.8 ± 0.9 | 1.7 ± 0.2 | 0.110 | 0.144 | 34 | 3 |
| 118 | 1100 ± 17 | 26.4 ± 1.4 | 3.2 ± 0.3 | 0.024 | 0.121 | 110 | 50 |
| 119 | 290 ± 17 | 18.0 ± 0.9 | 2.3 ± 0.2 | 0.062 | 0.128 | 48 | 3 |
| 120 | 228 ± 14 | 7.4 ± 0.6 | 1.1 ± 0.1 | 0.032 | 0.149 | —[a] | 3 |
| 121 | 251 ± 22 | 2.8 ± 0.7 | 0.14 ± 0.05 | 0.011 | 0.050 | 93 | 90 |
| 123 | 8910 ± 40 | 1510 ± 60 | 236 ± 9 | 0.169 | 0.156 | 110 | 108 |
| 124 | 579 ± 18 | 71.2 ± 2.3 | 10.0 ± 0.5 | 0.123 | 0.140 | 190 | 3 |
| 125 | 59 ± 9 | 6.8 ± 1.0 | 1.6 ± 0.2 | 0.115 | 0.235 | 40 | 3 |
| 126 | 322 ± 18 | 30.4 ± 1.2 | 3.9 ± 0.3 | 0.094 | 0.128 | 197 | 3 |
| 127 | 1170 ± 19 | 19.0 ± 0.8 | 1.7 ± 0.2 | 0.016 | 0.089 | 110 | 3 |
| 128 | 532 ± 25 | 33.1 ± 1.5 | 3.0 ± 0.3 | 0.062 | 0.091 | 35 | 3 |
| 129 | 538 ± 20 | 44.4 ± 1.7 | 4.4 ± 0.3 | 0.083 | 0.099 | 175 | 3 |
| 365 | 427 ± 21 | 3780 ± 210 | 1280 ± 70 | 8.852 | 0.338 | 197 | 195 |
| 366 | 499 ± 28 | 77.0 ± 3.1 | 13.3 ± 0.8 | 0.154 | 0.173 | 171 | 3 |
| 367 | 482 ± 25 | 66.2 ± 3.0 | 7.9 ± 0.6 | 0.137 | 0.119 | 175 | 3 |
| 368 | 410 ± 23 | 96.1 ± 3.7 | 14.9 ± 0.8 | 0.234 | 0.155 | 114 | 3 |
| 371 | 305 ± 20 | 75.2 ± 3.1 | 11.2 ± 0.7 | 0.247 | 0.149 | 114 | 111 |
| 373 | 4220 ± 40 | 71.9 ± 5.8 | 7.0 ± 1.0 | 0.017 | 0.097 | 95 | 46 |
| 374 | 462 ± 22 | 63.2 ± 2.8 | 9.0 ± 0.6 | 0.137 | 0.142 | 175 | 175 |
| 375 | 305 ± 23 | 29.0 ± 1.7 | 3.7 ± 0.4 | 0.095 | 0.128 | 90 | 3 |

Table 55 (continued).

| Sample No. (see Fig. 79) | Activity, fCi/kg ± 1σ | | | Ratio | | Water depth, ft | |
|---|---|---|---|---|---|---|---|
| | $^{137}Cs$ | $^{239,240}Pu$ | $^{238}Pu$ | 239/137 | 238/239 | Bottom | Sample |
| 376 | 250 ± 20 | 18.6 ± 1.2 | 2.6 ± 0.3 | 0.074 | 0.140 | 54 | 3 |
| 377 | 364 ± 21 | 62.9 ± 2.7 | 9.7 ± 0.7 | 0.173 | 0.154 | 6 | 3 |
| 378 | 497 ± 25 | 43.1 ± 1.4 | 7.1 ± 0.3 | 0.087 | 0.165 | 171 | 167 |
| 379 | 246 ± 19 | 14.5 ± 0.7 | 2.1 ± 0.2 | 0.059 | 0.145 | 100 | 3 |
| 381 | 176 ± 19 | 6.8 ± 0.5 | 0.7 ± 0.1 | 0.039 | 0.103 | 70 | 3 |
| 382 | 766 ± 30 | 54.3 ± 2.2 | 4.0 ± 0.3 | 0.071 | 0.074 | 30 | 3 |
| 383 | 295 ± 25 | 53.3 ± 2.0 | 4.6 ± 0.3 | 0.181 | 0.086 | 190 | 182 |
| 384 | 146 ± 26 | 0.21 ± 0.04 | 0 ± 0.05 | 0.001 | — | — | 3 |
| 385 | 130 ± 20 | 1.60 ± 0.14 | 0.5 ± 0.1 | 0.012 | 0.312 | 65 | 3 |
| 386 | 291 ± 30 | 13.9 ± 0.6 | 2.0 ± 0.2 | 0.048 | 0.144 | 40 | 3 |
| 387 | 109 ± 32 | 0.38 ± 0.10 | 0.03 ± 0.01 | 0.003 | 0.079 | 30 | 3 |
| 611 | 970 ± 40 | 1330 ± 70 | 411 ± 22 | 1.37 | 0.31 | | |
| 612 | 212 ± 35 | 302 ± 4 | 65 ± 2 | 1.42 | 0.22 | | |
| 613 | 118 ± 62 | 57 ± 3 | 26 ± 2 | 0.48 | 0.46 | | |
| 614 | 935 ± 46 | 185 ± 7 | 98 ± 3 | 0.197 | 0.53 | | |
| 615 | 108 ± 54 | 46 ± 2 | 24 ± 2 | 0.426 | 0.52 | | |
| 616 | 302 ± 57 | 105 ± 9 | 52 ± 5 | 0.347 | 0.50 | | |

[a]Bottom depth not determined.

Table 56. Concentration of $^{137}Cs$ and $^{239}Pu$ in comparative, surface water samples.

| Location | Concentration, fCi/liter | |
|---|---|---|
| | $^{137}Cs$ | $^{239}Pu$ |
| Enewetak Lagoon | | |
| SE quadrant | 226 | 9.1 |
| NE quadrant | 334 | 42.6 |
| NW quadrant | 579 | 33.4 |
| SW quadrant | 332 | 21.6 |
| Ocean, east of Enewetak Atoll | 89 | 0.3 |
| Lake Michigan (1971) | 88 | 1.1 |
| Humboldt Bay, Calif. (1973) | 300 | |
| 14°N 180°W (1972) | 143 | 0.44 |
| 12°N 170°E (1972) | 170 | 0.35 |
| Windscale vicinity (1969) | 105,000 | |
| Mean surface, Atlantic 0-31°N (1968) | | 0.7 |

Table 57. Comparison of radionuclide concentrations in surface and bottom water samples from Enewetak Lagoon.

| Sample No. (Surface sample)/(Bottom sample) | Ratio | |
|---|---|---|
| | $^{239,240}Pu$ | $^{137}Cs$ |
| 124/383 | 1.33 | 1.96 |
| 366/378 | 1.78 | 1.00 |
| 367/374 | 1.05 | 1.04 |
| 368/371 | 1.27 | 1.34 |
| 106/105 | 1.29 | 1.14 |
| 111/107 | 1.20 | 1.36 |
| Mean ± std dev | 1.32 ± 0.24 | 1.31 ± 0.35 |

source of the radionuclides in the lagoon water. For comparison, the concentrations of these nuclides from several other locations in the world are also presented. It is interesting that while the highest plutonium concentrations in water are found in the northeast quadrant, the highest concentrations in the sediments are found in the northwest.

Table 57 gives the surface-to-bottom concentration ratios of $^{137}Cs$ and $^{239,240}Pu$ at six lagoon stations. (Sample 365 is suspected to be contaminated with bottom sediment and is not included in Table 57.) The surface waters, on the average, contain 30% more $^{239}Pu$ and $^{137}Cs$ than the bottom waters. The higher surface-to-bottom ratio indicates that during the sampling period, the water in the lagoon was not well mixed vertically. Furthermore, the finding of the considerably lower concentrations in the bottom waters contradicts the prediction that the sediments are the principal source of radionuclides found in the lagoon water. If they were, leaching or resuspension processes would be expected to concentrate radionuclides in the bottom relative to the surface waters. The higher concentrations at the surface may be caused, in part, by leaching processes or surface runoff from the exposed reef areas.

Table 58 gives the water concentrations of $^{137}Cs$ and $^{239,240}Pu$ in the five craters on the Atoll. The concentration

Table 58. Concentrations of $^{137}Cs$ and $^{239,240}Pu$ in crater water samples.

| Sample No. | Crater and location | Depth | Collection date | fCi/liter ± 1σ: $^{239,240}Pu$ | fCi/liter ± 1σ: $^{137}Cs$ |
|---|---|---|---|---|---|
| 82 | MIKE (center) | Surface | 12/12/72 | 23.4 ± 2.0 | 730 ± 20 |
| 373 | MIKE (center) | 46 ft | 12/12/72 | 71.9 ± 5.8 | 4220 ± 40 |
| 81 | MIKE (center) | 93 ft | 12/12/72 | 54.6 ± 3.8 | 3200 ± 21 |
| 127 | KOA (center) | Surface | 12/11/72 | 19.0 ± 0.8 | 1170 ± 19 |
| 118 | | 50 ft | 12/11/72 | 26.4 ± 1.4 | 1100 ± 17 |
| 123 | | 108 ft | 12/11/72 | 1510 ± 60 | 8910 ± 40 |
| 611 | SEMINOLE (south edge) | Surface | 12/15/72 | 1330 ± 70 | 970 ± 40 |
| 614 | CACTUS (windward—east) | Surface | 2/8/73 | 185 ± 7 | 935 ± 46 |
| 616 | CACTUS (leeward—west) | Surface | 2/8/73 | 105 ± 9 | 302 ± 57 |
| 615 | LA CROSSE (windward—east) | Surface | 2/8/73 | 46 ± 2 | 108 ± 54 |
| 613 | LA CROSSE (leeward—west) | Surface | 2/8/73 | 57 ± 3 | 118 ± 62 |
| Background | East of Atoll | Surface | 12/9/72 | 0.32 ± 0.15 | 89 ± 80 |

levels in the bottom waters of both MIKE and KOA Craters are higher than the surface, and, surprisingly, the mid-depth sample from MIKE Crater contains more $^{137}Cs$ and $^{239,240}Pu$ than the bottom sample. The latter observation suggests that there may be localized concentrations of fine particulates resuspended in the water above the bottom of the crater.

Water samples from the leeward and windward sides of CACTUS Crater contain more plutonium and cesium than samples from LA CROSSE Crater. The plutonium-238/239 values in the water samples from both CACTUS and LA CROSSE are similar to but larger than the values found in any other lagoon water sample. Note also that the concentrations of $^{137}Cs$ and $^{239}Pu$ in the water from both sides of LA CROSSE Crater are similar in value, while there is a definite difference between the two sides of CACTUS Crater.

To put in proper perspective the concentrations of the radionuclides measured in the lagoon water, a comparison with the natural concentration of $^{40}K$ is useful. $^{40}K$ in seawater is, on the average, $2.95 \times 10^5$ fCi/liter, a concentration several orders of magnitude higher than that for any fission or activation product measured in any Atoll water sample in this survey.


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# TERRESTRIAL BIOTA SURVEY

John J. Koranda, John R. Martin,
Stanley E. Thompson, Jr.,
Marshall L. Stuart, and David R. McIntyre
Lawrence Livermore Laboratory
Livermore, California

Gilbert Potter
Environmental Protection Agency
Las Vegas, Nevada

The Terrestrial Biota Survey had as its objective the collection and analysis of all available terrestrial vegetation and animal species which could be used as a basis for estimating population doses through dietary pathways. Not all vegetable and animal components of the anticipated Enewetakese diet are currently available on the Atoll; of those that are, not all are available on every island. Sampling was carried out on an as-available basis and extrapolations were made when required. This chapter describes the sampling and analytical portions of the Terrestrial Biota Survey; dose estimates and extrapolations are discussed in the Dose Assessment chapter.

## Ecological Description of Islands on Enewetak Atoll

A general description of each island on the Atoll is given to provide an ecological background to the biota survey. A more comprehensive description of Enewetak Atoll ecology may be found in other publications (e.g., Woodbury, 1962)*. Color photographs of each island are presented on the "a" series, vegetation sampling locations are shown on the "g" series, and animal and bird sampling locations are shown on the "p" series of figures in Appendix II.

### ALICE (Bogallua)

ALICE is covered with a dense to scattered growth of the two common trees on the Atoll: *Messerschmidia argentea* and *Scaevola frutescens*.* These, plus another woody plant, *Guettarda speciosa*, were collected. The typical beach association of plant species was found in open areas, such as the southwest end of the island, and was composed of *Ipomoea pes-caprae*, *Fimbristylis atollensis*, *Triumfetta procumbens*, and *Lepturus repens*. An introduced grass, *Cynodon dactylon*, was also present in sandy disturbed areas, probably the result of man's previous activities on the island. At the southwest and northeast ends of the island, the low scrub growth of *Messerschmidia* and *Scaevola* opens up and the vegetation assumes a more scattered appearance, especially at the southwest end, where a sedge-grass meadow prevails. Vegetation is rather dense on the entire seaward side of the island.

Animal species encountered at the time of collections (January 8, 1973) were the long-tailed tropicbird, noddy terns, and fairy terns, which were all nesting. A soil sample was collected from a 12 × 12-in. area to a depth of 2 in.

### BELLE (Bogombogo)

Vegetation of Bogombogo Island consists of a dense scrubby growth of

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*A. M. Woodbury, *A Review of the Ecology of Enewetak Atoll, Pacific Ocean*. University of Utah, Institute of Environmental Biological Research, (1962).

*Plant taxonomy according to H. St. John, "Flora of Enewetak Atoll," *Pacific Science 14*, 313 (1960).

Messerschmidia argentea and Scaevola frutescens. This growth thins at the northeast end of the island where an open scattered growth of these tree species occurs. The ground in this open area is vegetated by the usual complex of disturbed-area beach or strand species described on Bogallua Island. Other woody species which contributed only a small amount to the vegetative cover of Bogombogo Island were Guettarda speciosa and a species of Pandanus. The Pandanus plant was bearing fruit and a collection was made.

Soil on this island was coral sand with a small amount of organic matter in it.

### CLARA (Ruchi)

Vegetation of Ruchi Island is mainly a scattered growth of Messerschmidia argentea and Scaevola frutescens. The vegetation pattern is more open than on Bogallua or Bogombogo Island to the west, and probably indicates an earlier stage in vegetation development, possibly because of less time for recovery after destruction by testing. Tests conducted just to the east of these islands as late as 1958 produced blast and thermal effects which removed most of the vegetation from these islands.

Samples collected on Ruchi Island were Messerschmidia and Scaevola and a 300-in.$^3$ soil sample.

### DAISY (Cochiti)

Vegetation of Cochiti Island is a scattered to open scrubby growth of Messerschmidia argentea and Scaevola frutescens. The density of vegetation is reduced on the northeastern tip of the island and somewhat so along the entire lagoon side of the island. Coconut palms (Cocos nucifera) with fruit were found on the island. Open ground between the scattered clumps of Messerschmidia and Scaevola was covered with Fimbristylis atollensis, Triumfetta procumbens, and Ipomoea ssp. In addition to the Messerschmidia, Scaevola, and Cocos, a 250 to 300-in.$^3$ soil sample was collected from the island. Messerschmidia and Scaevola was covered with Fimbristylis atollensis, Triumfetta procumbens, and Ipomoea ssp. In addition to the Messerschmidia, Scaevola, and Cocos, a 250 to 300-in.$^3$ soil sample was collected from the island.

### EDNA (Sanildefonso)

EDNA is hardly more than a sandbar occurring on the northern part of the reef. It lies just west of the MIKE Crater and may represent coral ejecta from that shot. The only vegetation on the island, except for algae in the surf, is the tree Messerschmidia argentea which, even with a low salt tolerance, is usually one of the initial invaders of a new land surface. Trees are present on the northern half of the island. A rather large population of hermit crabs is also present, apparently subsisting on the vegetal debris from these plants.

The only sample collected from this island was from Messerschmidia.

### HELEN (Bogairikk)

HELEN is a small vegetated sandbar contiguous with IRENE (Bogon), extending from the northwest to the southeast, and connected to Bogon by a sandbar. It is covered with an open growth of

Messerschmidia argentea and Scaevola frutescens. Some rank growth of the grass Lepturus repens has occurred in the open areas, encouraged by the manuring effects of the small bird rookery present on the island. A small plant of the tree, Guettarda speciosa, was seen on Bogairikk Island.

The grass, Lepturus repens, and a soil sample were collected on this island.

IRENE (Bogon)

The vegetation of IRENE is composed of scattered to open scrubby growth of Messerschmidia argentea and Scaevola frutescens. Other woody species are present on the island but contribute only in a small way to the vegetative biomass. Tree growth is slightly more dense around the eastern rim of SEMINOLE crater than in other areas. Open expanses of ground between tree clumps is covered with the usual ground cover species: Fimbristylis atollensis, Triumfetta procumbens, Ipomoea pes-caprae, and related species. The parasitic Cassytha filiformis was particularly abundant in these areas. Other species observed were Guettarda speciosa, Suriana maritima, and a single group of coconut palms, Cocos nucifera. Collections were made of these species and of two kinds of animals present on the island; noddy terns and eggs were obtained, as well as hermit crabs from the central part of the island. Soil samples were obtained from the three corners of the island. A slightly more radioactive area was present on the northwest corner of the island, and this was sampled by both soil and plant collections.

JANET (Engebi)

Vegetation of Engebi is dense to open scrubby growth of Messerschmidia argentea and Scaevola frutescens, with a few other woody species assuming only local importance. Scaevola dominates the vegetation on much of the interior of the island but occurs with Messerschmidia in mixed stands on other parts of the island, such as along the north side of the airstrip. In old cleared areas, shrubs such as Pluchea odorata are abundant and form large clumps 10 to 30 ft in diameter. Fimbristylis atollensis (sedge) forms tussocks 4 to 6 in. in diameter in open areas between shrub and tree clumps, with the ground-cover species, Ipomoeae pes-caprae and Triumfetta procumbens. A small clump of coconut palms with young fruit was present to the east of the large concrete building in the center of the island. Other woody species observed were Morinda citrifolia and Sida fallax. Plant samples were collected along two transects of the island. One transect of the island was made along the axis of the lagoon side, and both Messerschmidia and Scaevola were sampled along this transect. Another transect was made from the northwestern tip parallel to the airstrip toward the northeastern corner of the island.

Rats were trapped in three areas on Engebi Island, the first near a slightly more radioactive area on the north side of the airstrip, the second near a bunker at the northwest tip of the island, and a third near the main building at the center of the island. Noddy tern eggs and birds were obtained on the north side of the airstrip.

KATE (Muzinbaaikku)

Vegetation of KATE is composed of scattered to dense growth of Messerschmidia argentea and Scaevola frutescens. Stands of the tree Pisonia grandis occur on the southern and northeastern portions of the island, with an open Messerschmidia-Scaevola scrub occupying the central portion. This is the northernmost island on which Pisonia grandis trees occur, and it will very likely act as a dispersal center for this species in the northern half of the Atoll. The significance of Pisonia is that it is an indicator species of the mature climax vegetation of the Atoll. Higher organic matter content of the coral sand soil is observed in Pisonia stands, and the nesting of fairy and noddy terns in Pisonia trees results in higher levels of nutrients in the terrestrial ecosystem.

Other species encountered on Muzinbaaikku Island were Morinda citrifolia and the ubiquitous ground-cover species, Fimbristylis atollensis, Ipomoea pes-caprae, Lepturus repens, and Triumfetta procumbens.

The red-tailed tropicbirds (Phaethon rubricauda) were sampled, and a 12 × 12 × 1-in. deep soil sample was obtained on this island.

LUCY (Kirinian)

The vegetation of LUCY is composed of a dense Messerschmidia argentea-Scaevola frutescens growth which assumes an open, scattered aspect on the southern tip of the island. Scaevola typically occupies the island margins, apparently being more salt-tolerant, with Messerschmidia occurring inland and persisting in the vegetation type even when a Pisonia stand develops. Salt damage can be seen in both Scaevola and Messerschmidia.

Noddy terns, hermit crabs (Coenobita perlatus), and a soil sample (250 to 300 in.) were obtained on this land.

MARY (Bokonaarappu)

The vegetation of Bokonaarappu is an open Messerschmidia argentea-Scaevola frutescens scrub which is densest on the central and northern parts of the island. Several coconut palms (Cocos nucifera) are present and bearing fruit. Other woody species on the island were Morinda citrifolia and Guettarda speciosa. Morinda leaves and fruit were collected, as well as coconuts from six palm trees. A soil sample was collected from a 12 × 12 × 1-in. (depth) area. Noddy terns were also obtained.

NANCY (Yeiri)

This small island is covered with a dense growth of Messerschmidia argentea and Scaevola frutescens along the shorelines, with Pisonia grandis occupying the interior. The vegetation apparently has not been modified as much as some adjacent islands, and species indicative of a more advanced successional stage are present. Pisonia grandis, Guettarda speciosa, Cordia subcordata, and Morinda grandis occur on this island with the coconut palm, Cocos nucifera. It appears that the condition of islands in this part of the Atoll must be very similar to conditions prevailing before World War II.

All plant species listed above were sampled, and a soil sample was obtained. Two young coconut crabs (Birgus latro) approximately 6 in. long were found but were released to populate the island since they were too small to constitute a sample.

## OLIVE (Aitsu)

The vegetation of OLIVE is composed of scattered to dense scrubby growth of Messerschmidia argentea and Scaevola frutescens. The south end of the island is more open. In addition to Messerschmidia and Scaevola, other species found and collected on the island were Morinda citrifolia and Cordia subcordata.

A soil sample was collected on the island, and noddy terns were obtained along the beaches.

## PEARL (Rujoru)

The vegetation of PEARL is composed of scattered Messerschmidia argentea and Scaevola frutescens growth, less dense than on Aitsu or Yeiri Islands to the north. This island was subjected to physical effects from a test, and the vegetation is in a relatively immature successional stage. In addition to Messerschmidia and Scaevola, a sample of Morinda citrifolia was collected on PEARL. A 12 × 12 × 1-in. (deep) soil sample, a sample of noddy terns, and eight rats (Rattus exulans) were also collected on the island.

## RUBY (Eberiru)

This small island is composed primarily of coral sand and coralline limestone. The only woody vegetation found on the island was Messerschmidia argentea, which is usually the primary invader species on bare sandbars. Fimbristylis atollensis sedge is present between the trees.

## SALLY (Aomon)

SALLY has been modified by recent earthmoving activities connected with the PACE experiments. Between a third and a half of the island has been cleared of vegetation, and bare coral sand and limestone are exposed on most of its southern half.

Remnants of the pre-PACE Program vegetation appear to be the typical Messerschmidia argentea-Scaevola frutescens scrub growth. Scattered clumps or trees of these species occur on the northern half of the island. Pandanus sp. plants were found on SALLY but no fruits were present. Revegetation studies could be conducted on the cleared areas to obtain data on recovery rates of the atoll vegetation because the date of clearing is known.

Noddy and sooty terns and eggs were collected, and a soil sample was obtained from an undisturbed part of the island.

## TILDA (Biijiri)

The vegetation of TILDA is composed of scattered to dense stands of Messerschmidia argentea and Scaevola frutescens, with vegetation in the center of the island more dense than that on the north side of the runway. Other species found on the island which make a significant contribution to the plant biomass are Pisonia grandis, Guettarda speciosa, Morinda citrifolia and Pandanus sp. Pisonia trees on the northeast corner of the island showed some damaged foliage, probably due to salt spray. A young coconut palm, Cocos nucifera, was found on the island, but only small, green, immature fruit was available.

A soil sample was collected.

URSULA (Rojoa)

The vegetation of URSULA is composed of scattered to dense growth of Messerschmidia argentea-Scaevola frutescens. Vegetation on the north and western parts of the island was dense and essentially continuous, while trees on the southeast third of the island were scattered. Guettarda speciosa was the only other woody species observed on the island.

Rats (Rattus exulans) were abundant on on URSULA, and a large sample of animals was obtained in a daytime trapping trip. A soil sample was also obtained.

VERA (Aaraanbiru)

The vegetation of VERA is an example of mature Atoll vegetation, similar to that seen on islands in the southeastern sector of the Atoll. Along the shorelines, Scaevola frutescens and Messerschmidia argentea occur in dense, scrubby growth. The west central part of the island supports a stand of mature coconut palms, Cocos nucifera. In the central part of the island the vegetation is dominated by large trees of Pisonia grandis. Within the stands of Pisonia, old stems of Messerschmidia may persist but do not show much reproduction except by vegetative means such as stem shoots. Morinda citrifolia and Pandanus sp. were also present in the dense forest type on Aaraanbiru Island.

The soil on Aaraanbiru Island had a large amount of organic matter in it. Raw organic matter and organically stained coral sand extended as deep as 20 cm.

WILMA (Piiraai)

The vegetation of WILMA is scattered to dense growth of Messerschmidia argentea and Scaevola frutescens. The southern half of the island is more open, which may be related to the test activity on the next island to the south, YVONNE. Guettarda speciosa was the only other woody plant observed in addition to those mentioned above. The usual ground-cover species, such as Fimbristylis atollensis, Triumfetta procumbens, and Ipomoea pes-caprae were present in open or disturbed areas, such as near the helicopter pad and in the central portion of the island.

YVONNE (Runit)

The vegetation of YVONNE is primarily scattered, scrubby growth of Messerschmidia argentea and Scaevola frutescens, although other woody plants, such as Guettarda speciosa, an early invader of disturbed sites, and the coconut palm, Cocos nucifera, were also found. Open spaces are generally vegetated by typical ground-cover species such as Fimbristylis atollensis, Triumfetta procumbens, Lepturus repens, and Ipomoea pes-caprae.

Several series of vegetation samples were collected on Runit Island. At the north end of the island, south of Cactus and Lacrosse craters, Messerschmidia, Scaevola, and Guettarda were collected. A soil sample was also collected here, and rats were trapped in this area of higher radioactivity. We have called this group of samples Series A.

Farther south, but still north of the metal tower, Series B samples were collected, including Messerschmidia, Scaevola, Cocos, a soil sample, and a rat sample. Noddy terns and their eggs were also obtained.

Slightly south of the landing dock another series of samples, designated Series C was obtained, including samples of Messerschmidia, Scaevola, Cocos (fruits), and soil collected along the old airstrip runway. Noddy tern eggs and a series of rats were also obtained in the "C" area.

The "D" area of Runit was at the southern end in an area of old buildings at the end of a long sand spit. Messerschmidia, Scaevola, and Cocos (fruits) were collected. In addition, noddy tern eggs were collected, rats were trapped, and two soil samples were obtained for Series "D".

A fourth area, designated the "E" area, was also sampled. This area was located mid-island, but on the seaward side. Messerschmidia, Scaevola, and a soil sample were obtained.

## Small Islands Between YVONNE (Runit) and ALVIN (Chinieero)

Four small islands, hardly more than sand spits, occur on the reef between YVONNE (Runit) and ALVIN (Chinieero). These islands apparently had no geographic or native names; perhaps they have formed in recent years. Vegetation of these small islands represents initial stages of plant succession.

### SAM

This small sandbar or spit is located just south of YVONNE (Runit) and has several small clumps of Messerschmidia argentea and small patches of grasses between them. No samples were collected on SAM.

### TOM

This is a small triangular island on the reef south of YVONNE with sandbars extending from the north and south ends of the island. Two species of woody plants occur on TOM -- Messerschmidia argentea and Scaevola frutescens. These two plants occurred in separated clumps on the island with little ground vegetation in between, and samples of each were collected.

### URIAH

This long, narrow island is covered with scattered to dense growth of Messerschmidia argentea and Scaevola frutescens. Ground-cover species are present between the tree clumps in the more open areas, and the south end of the island. Messerschmidia and Scaevola were collected.

### VAN

VAN is a small, densely vegetated island just north of ALVIN (Chinieero). Sandbars are present at the northern and southern ends of the island, and coral limestone occurs at the water's edge along the lagoon. Messerschmidia argentea and Scaevola frutescens dominate the vegetation, which also includes Pisonia grandis, the large, soft-wooded tree found on islands with mature, undisturbed vegetation. The sea side of the island at the southern end has vegetation which is more scattered than on the northern and lagoon sides. Noddy terns and eggs were collected from the small rookery of birds.

### ALVIN (Chinieero)

ALVIN is a small island in the center of an elongate sandbar located on the lagoon edge of the reef. Broad sand beaches are present on the lagoon side and to the north and south of the vegetated area.

The vegetation of Chinieero Island is composed mainly of *Messerschmidia argentea* with a few clumps of *Scaevola frutescens*.

BRUCE (Aniyaanii)

The main portion of BRUCE is covered with an intermediate-age *Pisonia grandis* forest. There does not appear to have been large-scale destruction of habitat on this island, although test-period activity is apparent on the north end.

Scattered coconut palms are present in the central and eastern part of the island. The island edges, and old cleared areas support clumps of *Messerschmidia argentea* and *Scaevola frutescens*, and a thicket of *Cordia subcordata* is present along the lagoon beach. *Ipomoea* ssp. and *Triumfetta procumbens* vines and clumps of *Lepturus repens* and *Fimbristylis atollensis* occur in the limited number of open meadow-like areas.

Coconut crabs, *Birgus latro*, and the roof rat, *Rattus rattus*, were seen, and coconut crabs were collected for analysis. All the plant species listed above except *Ipomoea*, *Triumfetta*, *Lepturus*, *Fimbristylis*, and *Cordia* were sampled.

CLYDE (Chinimi)

CLYDE is a small, rectangular islet with large lagoon beaches and a broad coral reef exposed on the sea side, scarcely more than a spit. A large population of sooty terns was nesting there in January.

The vegetation of CLYDE is scattered to open scrub of *Messerschmidia argentea* and *Scaevola frutescens* with grasses, mainly *Lepturus repens*, occurring in the areas not occupied by shrubs. Several basin-like depressions, possibly solution pits, occur on the island, which receives large amounts of bird guano during the course of one or more nesting periods.

Birds (sooty terns) and eggs, and *Messerschmidia* and *Scaevola* were collected.

DAVID (Japtan)

DAVID is one of the largest islands on the Atoll, lying just north of the deep passage on the southeastern portion of the reef. On the western half of the island, a coconut palm plantation is present, but much of the area has been recclonized by the two ubiquitous shrub species, *Messerschmidia* and *Scaevola*. Vines, grasses, and sedges which typically invade bare ground, were found throughout the island.

Small clumps of arrowroot, *Tacca leontopetaloides*, were found in openings and among the palms on the western half of the island.

The eastern half of DAVID is covered with a dense growth of *Pisonia grandis*, *Ochrosia oppositifolia*, *Messerschmidia argentea*, and *Scaevola frutescens*. Occasionally *Guettarda speciosa* and *Morinda citrifolia* are found at the edges of this forest. A single large specimen of *Pandanus* sp. was found in the central part of the island at the eastern edge of the coconut grove.

There is a large number of weedy plant species on DAVID. This island was at least partially covered in the pre-World War II period of colonization by imported soil.

The island supports a modest population of roof rats. The monitor lizard is common. Fairy terns nest in the mature Pisonia forests, and the reef heron was seen along the southern beach.

Samples taken on DAVID included Messerschmidia, Scaevola, Pisonia, Guettarda, Morinda, Tacca, Pandanus, Coenobita, Rattus exulans, Demigretta, Erolia, and Sterna.

REX

This small, arcuate island and spit lies in the deep passage at the southeast end of the lagoon. A large sand beach is present at its northwest end, while the eastern and southern shores have narrow beaches and broad exposed reefs.

REX is covered with heavy growth of Messerschmidia argentea and Scaevola frutescens, with some large specimens of Pisonia grandis. The west end of the island has several large open areas which support scattered clumps of grasses and sedges. A few birds were nesting on this part of the island (sooty terns), and birds and eggs were collected.

ELMER (Parry)

Parry Island was the scene of intense test-period activity at the Atoll and is still covered with metal and wooden buildings, concrete pads, and miscellaneous structures. A small airstrip, partially overgrown with Ipomoea and Triumfetta vines, is located on the southern half of the island.

Scattered Messerschmidia argentea and Scaevola frutescens shrubs occur between the buildings, especially on the eastern or seaward side of the island. Young coconut palms, Cocos nucifera, are present around some buildings. Ipomoea and Triumfetta vines and the parasitic Cassytha filiformis are invading most of the bare sand and gravel areas between buildings.

The roof rat, Rattus rattus, occurs on Parry Island, where it must subsist mainly on the few coconuts produced there and the seeds of flowering plants.

FRED (Enewetak)

FRED is an elongated island at the southeast end of the Atoll, separated from the islands in the southwestern quadrant of the Atoll by the wide passage through the reef. Most of the recent activity (1960-1973) at Enewetak Atoll has been on this island, which has a long airstrip at its southern end. Bombardment and ground fighting on Enewetak Island during World War II destroyed most of the original vegetation and natural features. Subsequent support and construction activities during the nuclear test period further modified the island with building complexes, concrete pads, and roads.

The present vegetation of FRED consists of the widely distributed species of the Atoll — some of which were replanted by man — and weedy species introduced from North America. The coconut palm has apparently been replanted by man on Enewetak Island during the nuclear test period and thereafter. Other species include the Pandanus and various horticultural, agricultural, and weedy species.

Messerschmidia argentea and Scaevola frutescens are the most common woody plants on Enewetak Island. Large Messerschmidia trees are estimated to be 10-20 yr old, but only a few specimens of this age are present.

Ground cover includes species of Ipomoea, Triumfetta procumbens, Lepturus repens, Fimbristylis atollensis, and the parasitic Cassytha filiformis. None of the commoner woody species found on islands to the north or west, such as Guettarda speciosa and Morinda citrifolia was seen on FRED.

Mammals were represented on the island by the house mouse, Mus musculus, which was trapped in small numbers around buildings being used for habitation. Several cats and dogs were present on the island, and it is possible that their predation upon the larger roof and Polynesian rats kept their numbers low.

GLENN (Igurin), HENRY (Mui), IRWIN (Pokon), JAMES (Ribaion), and KEITH (Giriinian)

These five islands in the southwest quadrant of the Atoll can be considered as a group with a similar ecological setting, history, and biota. The description to follow therefore applies to all of the islands, with few minor differences. Except for two nuclear tests conducted in the adjacent lagoon or in the sea just south of the Atoll, these islands have not been disturbed, as have the islands on the northern part of the Atoll. Only a few test-related structures are present on these islands, and these are almost obscured by the heavy growth of vines, shrubs, and trees.

Vegetation of these islands is primarily the Pisonia grandis forest, with such subdominant species as Ochrosia oppositifolia, Morinda citrifolia, and Guettarda speciosa. Suriana maritima and Pemphis acidula are found occasionally at the edges of the beach. Messerschmidia argentea and Scaevola frutescens are typically found at the edges of the Pisonia forest stands, with old stems of Messerschmidia occasionally persisting under the complete canopy of the Pisonia forest. Tacca leontopetaloides, the arrowroot, was found on several of the islands in small patches. A few small Pandanus trees were seen. On some islands, such as GLENN and KEITH, large coconut palms are present among the Pisonia trees, while on smaller islands younger palms are found, mainly on the lagoon sides of the islands.

The terrestrial biota of this series of islands is the most interesting of those found on the Atoll. Coconut crabs, Birgus latro, are usually found wherever producing coconut palms are present. On Igurin and Giriinian Islands coconut crabs are quite abundant, together with the land form of the hermit crab, Coenobita brevimanus and the related C. perlatus.

In the Pisonia forest, the fairy tern and the common noddy are found nesting without any serious predation. A considerable amount of bird guano is deposited in these forest stands, and the coral substratum has become darkly stained through the action of organic matter accumulation.

The Polynesian rat, Rattus exulans, was found on GLENN, where it is apparently able to subsist on coconuts and other plant and animal materials. On HENRY, a narrow, spit-like extension of the island (east end) has a small rookery of sooty terns nesting in the grassy ridge just above the beach.

It is quite possible that the vegetation of this series of southwestern islands is affected by storm waves and spray. Sto[rm] of this age are present.

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It is quite possible that the vegetation of this series of southwestern islands is affected by storm waves and spray. Storm waves from the lagoon can deposit significant amounts of salt spray on the islands. Numerous plants with symptoms of salt spray damage were observed along the lagoon side.

LEROY (Rigili)

LEROY is a small, rectangular land mass located on the southwestern part of the Atoll, separated from ALICE to the north by 21 km, and from KEITH to the east by 12 km of open water and coral reefs. The approach to LEROY from the lagoon is complicated by extensive reefs and tidal flats.

LEROY can be considered unique among islands on the southern half of the Atoll from a radioecological standpoint for two reasons, the second of which is probably more important: (1) Two nuclear tests were conducted relatively close to the island, one in the lagoon and one in the sea to the south; and (2) the island received close-in fallout from tests conducted in the northeast quadrant of the Atoll because fallout clouds frequently left the Atoll in a southwesterly direction.

LEROY has a well-developed sand beach on the lagoon, or northeast, side of the island. A narrow beach with exposed coral limestone occurs on the other three sides of the island. The island is densely vegetated, except for a few openings on the northeast side of the island. Large specimens of Pisonia grandis and coconut palm, Cocos nucifera, form the dense forest which extends almost to the beaches on all sides. The usual transition zone composed of Messerschmidia argentea and Scaevola frutescens occurs at the edges of the forest, with a few mature trunks of Messerschmidia located in the outer edges of the Pisonia forest.

On the southwest side of the island dense Cordia subcordata thickets occurred at the outer edge of the Pisonia forest. Pemphis acidula, a tall shrub, was seen among the Scaevola and Messerschmidia just above the storm line on the lagoon beach. A large specimen of Pandanus sp. was found on the southeast beach among the Scaevola and Messerschmidia. No fruit was present but foliage samples were collected. Mature coconut-producing palms were scattered through the island in the Pisonia forest.

Fairy terns and the common brown noddy were nesting in the Pisonia trees at the time of sampling in January. Coconut crabs (Birgus latro) were abundant on the island, and several large specimens were obtained for radionuclide analysis. Except for migratory birds and the hermit crab, Coenobita perlatus and C. brevimanus, no other animals were seen on the island.

Sampling and Sample Preparation

The collection of terrestrial biota on Enewetak Atoll was based on three main criteria: (1) plant or animal species comprising the anticipated diet, (2) plant or animal species not usually considered as food, but included in the Marshallese pharmacopoeia or used as famine food, whose distribution over most of the Atoll permits comparison on an inter-island basis, and (3) plant or animal species not forming part of the Marshallese diet, but considered as "indicator" organisms bearing some relationship to species that might be introduced later. Examples of the first category include Pandanus tectoris, coconuts (Cocos nucifera), arrowroot (Tacca leontopetaloides), and coconut crabs (Birgus latro). Examples of the second category include Morinda citrifolia, Messerschmidia argentea, and Scaevola frutescens. An example of the third category is the rat, the only mammal inhabiting the islands at present.

Representatives of less widely disseminated plant species were collected wherever adequate samples were available. For example, only two stands of tacca were observed, one on DAVID and the other on LEROY; the first was mature and had numerous tubers, but the second was immature and had inadequate tubers for sampling. Specimens of pandanus leaves were collected on 10 of the islands, but only two of the plants were bearing fruit.

Terrestrial animals on the Atoll were limited to large hermit crabs (Coenobita perlatus), coconut crabs (B. latro), rats (Rattus rattus and R. exulans), and monitor lizards introduced by the Japanese on Japtan (DAVID). The lizards are not eaten by the natives; they are a protected species and were not collected. Rats are not eaten by the natives but are useful as indicator organisms since they are the only mammals on the Atoll. The coconut crab, a terrestrially adapted species, is considered a delicacy. These animals in turn derive their nutrients primarily from land vegetation. The supply of coconut crabs is severely limited.

Birds and their eggs constitute important food items for the natives; both are plentiful and were collected on many of the islands. These birds are primarily ocean or reef feeders (small fish, squid, shrimp, etc.) and are far-ranging in their feeding habits.

## Collection and Preparation for Analysis

Plant Samples — Immediately after collection plant samples were placed in forced-air drying ovens at 125 to 150°C for approximately 24 hr or until dry. Coconuts were drained of milk, and the meats dried. All samples were packaged in plastic bags for shipping. At LLL they were ground in a Wiley mill, redried, packed in aluminum tuna cans with a hydraulic press, and sealed for counting. The cans were submitted for gamma counting with lithium-drifted germanium [Ge(Li)] detectors and wet chemistry. Most of the samples were larger than required for canning; the excess provided a duplicate sample to keep in reserve for other procedures as required.

A number of green drinking coconuts were collected in July 1973 from selected islands for analysis of the milk. The milk was drained from the nuts and freeze-dried. This was packed in small plastic jars for gamma counting and subsequent radiochemical analyses. The meats from these nuts were dried as above and also submitted for analyses.

Mammals — Rats were collected with snap traps. Our own collections on some islands were supplemented from the EMBL*-Bowling Green collection of rats in return for data on the reproductive organs of the rats collected by our group. Two species were obtained: Rattus exulans (Polynesian rat) and Rattus rattus (roof rat). On all the islands except DAVID, the rat population appeared to be

*Enewetak Marine Biological Laboratory.

exclusively either one species or the other. Rats were frozen in deep-freeze chests on Enewetak, returned to LLL packed in dry ice, and stored frozen until dissection and analysis. Thawed specimens were dissected for organ samples (skin, liver, kidney, lung, viscera, and carcass), which were then freeze-dried. Bone and muscle were separated. Bone was ashed at 150°C. All samples were canned for analysis. Species identification of Rattus rattus and Rattus exulans was confirmed by Dr. Jackson at Bowling Green University.

Birds — Birds were shot with a shotgun or captured by hand. The principal species collected were the common noddy (Anous stolidus), the white-capped noddy (Anous tenuirostris), and the sooty tern (Sterna fuscata). A few specimens of the red-tailed tropic bird (Phaeton rubricauda), reef herons, and curlews were taken, but some of these provided inadequate sample sizes for analysis. The birds were frozen with dry ice for shipment. At LLL they were thawed, skinned, and dissected into samples of carcass, liver, and viscera. Individual organ samples were pooled by species and freeze-dried. Muscle and bone were separated; the bone was ashed in muffle furnaces at 150°C, washed with distilled water to remove muscle residue, and redried. Liver, muscle, bone, and viscera were canned or packed in smaller plastic containers and submitted for analysis.

Eggs were collected from nests on the ground, where large numbers were available. They were frozen for shipment. For analysis, the shells were separated, washed, and dried. The edible contents were freeze-dried and canned.

Identification of the birds collected on the islands was confirmed by George Watson at the Smithsonian Institute.

Terrestrial Crustaceans — Coconut crabs (Birgus latro) were freeze-dried whole with the exoskeleton cracked to facilitate drying. At LLL they were dissected into samples of exoskeleton, muscle, tail (hepatopancreas and reproductive organs), and a miscellaneous fraction containing other viscera. These were then canned for analysis. Coenobita perlatus (hermit crabs) were frozen at Enewetak and partially defrosted at LLL so that they could be removed from their shells. They were separated into tails (hepatopancreas) and anterior portions and freeze-dried. Anterior portions were crushed, and muscle and exoskeleton were separated. The fractions were canned for counting.

Soil Samples — Intensive soil-profile sampling of the Atoll was in progress concurrently, but we collected additional samples near areas of intensive sampling of vegetation, in order to determine the soil-plant transfer ratios for specific isotopes. They consisted of 12 × 12 × 2 in. samples, which were dried, homogenized, and canned in aluminum tuna cans for counting. They were processed along with the samples from the soil-profile studies.

## Radionuclide Concentration Levels in Terrestrial Biota Samples.

A total of 1103 specimens were collected in the field as part of the terrestrial biota survey, distributed as follows:

| | |
|---|---|
| Soils | 42 |
| Plants | 208 |
| Birds | 116 |
| Eggs | 217 |
| Rats | 249 |
| Crabs | 271 |
| Total | 1103 |

Because many of the individual samples of birds, eggs, rats, and crabs were too small to yield statistically meaningful analytical results, specimens of the same species from a single area were pooled, resulting in the analysis of a total of 273 samples in these four categories.

Radiochemical analytical data for the terrestrial biota samples are shown in Table 59, listed by island, starting with ALICE. Results for all radionuclides whose analytical errors are less than 30% are tabulated. Nuclides with errors greater than 30% are present at close to the analytical sensitivity limit and are therefore considered to have negligible value for dose-assessment purposes. Those who wish to use data for these nuclides, plus upper limit estimates for each sample where a specific nuclide was not observed, are referred to the microfiche tables in Appendix II.

These basic survey data have been arrayed in two additional ways to facilitate their interpretation and use. In Tables 60 to 75 the survey data are ordered on the species of organism. In Tables 76 to 103 the basic survey data are arranged by island and include the soil, plant, and animal data obtained from the site.

Table 59. Terrestrial biota samples collected at Enewetak Atoll, Oct. 1972 - Jan. 1973.
Radionuclide concentration levels, pCi/g ovendry wt (error, %)

| Sample No. | Type | $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| ALICE | | | | | | | | |
| 10188501 | Messerschmidia argentea | 13.38±6.4 | | | 138.3±1.0 | 222.8±0.3 | 0.025±8.0 | |
| 10189101 | Guettarda speciosa | 11.03±4.3 | | | | 7.41±1.1 | | |
| 10188601 | Scaevola frutescens | 12.82±5.5 | | | 32.7±2.1 | 66.53±0.5 | | |
| 11919001 | Anous stolidus liver | 10.20±18.8 | 127.0±2.0 | | | | 0.062±13.0 | |
| 11921201 | Anous stolidus viscera | | 47.30±4.6 | | | | | |
| 11922801 | Anous stolidus muscle | 9.66±8.3 | 49.55±2.0 | 0.321±21.7 | 0.0099±25.0 | | | |
| 11926001 | Anous stolidus bone | 5.302±12.1 | 25.68±7.6 | | 20.59±9.9 | 1.16±4.3 | | |
| BELLE | | | | | | | | |
| 10226602 | Guettarda speciosa leaves | 12.48±5.8 | | | 152.7±1.0 | 109.1±0.4 | | |
| 10226402 | Messerschmidia argentea leaves | 15.86±5.8 | | | 25.2±1.1 | 5.83±2.1 | 0.036±9.7 | |
| 10226502 | Scaevola frutescens leaves | 12.45±5.8 | | | 2.27±3.6 | 1.42±4.1 | 0.072±6.3 | $^{238}Pu$ (0.013±12.0) |
| 10226702 | Pandanus tectorius leaves | 6.70±15.4 | 0.438±5.0 | | 391.0±1.0 | 679.30±0.3 | | |
| 10226802 | Pandanus tectorius fruit | 14.38±5.8 | | | 206.30±1.0 | 923.0±0.1 | | $^{3}H$ (0.86±5.2) |

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| CLARA | | | | | | | | |
| 10225503 | *Messerschmidia argentea* leaves | 13.33±5.0 | | | 127.5±1.0 | 149.10±0.3 | | |
| 10225603 | *Scaevola frutescens* leaves | 12.37±5.5 | 3.37±8.6 | | 51.8±1.0 | 15.04±0.6 | 0.048±13.0 | |
| DAISY | | | | | | | | |
| 10245504 | *Cocos nucifera* fruit | 6.65±10.6 | | | 0.20±2.0 | 7.17±1.4 | | $^{3}H$ (0.41±10.6) |
| 10224304 | *Messerschmidia argentea* leaves | 11.10±4.9 | | 1.45±5.1 | 12.21±1.0 | 5.90±1.4 | 0.055±9.8 | $^{102m}Rh$ (0.313±27.2) |
| 10224404 | *Scaevola frutescens* leaves | 20.26±4.4 | | 0.484±3.8 | 50.90±1.0 | 38.80±0.7 | 0.046±8.6 | $^{238}Pu$ (0.0085±16.0) |
| 10930104 | *Cocos nucifera* milk | 45.50±24.7 | | | 1.40±12.0 | 1.75±47.0 | | |
| EDNA | | | | | | | | |
| 10720405 | *Messerschmidia argentea* | 11.1±5.3 | | 0.24±22.8 | | 6.73±1.4 | | |
| HELEN | | | | | | | | |
| 10411308 | *Lepturus repens* grass | 4.901±12.0 | | 0.936±5.4 | 1.44±3.1 | 2.51±3.0 | 0.0435±21.0 | |
| IRENE | | | | | | | | |
| 10930309 | *Cocos nucifera* | | | | | | | |
| 10930409 | *Cocos nucifera* | 99.9±14.8 | 86.49±6.8 | | 1.608±19.0 | 5.11±29.1 | | |
| 10370909 | *Cocos nucifera* | 7.05±7.2 | | | 0.0667±8.0 | 1.769±3.2 | 0.0362±8.0 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10930409 | Cocos nucifera | 99.9±14.8 | 86.49±6.8 | | 1.608±19.0 | 5.11±29.1 | | |
| 10370909 | Cocos nucifera | 7.05±7.2 | | | 0.0667±8.0 | 1.769±3.2 | 0.0362±8.0 | |

Table 59 (continued).

| Sample No. | Type | $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| | | Radionuclide concentration levels, pCi/g ovendry wt (error, %) | | | | | | |
| IRENE | | | | | | | | |
| 10411709 (E-18) | Guettarda speciosa | 8.14±6.9 | | 9.18±5.0 | 53.60±1.0 | 27.33±1.9 | | |
| 10411909 (C-16) | Lepturus repens | 1.95±25.3 | | 0.258±12.6 | 1.15±3.4 | 2.57±3.3 | 0.0112±20.0 | |
| 10329209 (B-5) | Messerschmidia argentea | 13.04±4.6 | | 23.86±1.1 | 536.0±1.0 | 62.6±0.4 | | |
| 10329509 (C-7) | Messerschmidia argentea | 18.16±4.7 | | 0.138±38.8 | | 2.197±3.1 | 0.0045±12.0 | |
| 10329609 (A-1) | Messerschmidia argentea | 14.6±5.1 | | 2.77±4.1 | 21.76±1.0 | 4.10±2.3 | 0.0157±2.1 | |
| 10411609 (E-15) | Messerschmidia argentea | 12.74±4.5 | | 3.39±3.9 | 159.0±1.0 | 407.3±1.8 | 0.00192±8.0 | |
| 10466309 (A-20) | Messerschmidia argentea wood | 1.94±16.1 | | 1.59±3.2 | 16.98±1.1 | 13.02±2.2 | 0.00617±18.0 | |
| 10329309 (B-6) | Scaevola frutescens | 17.09±4.7 | 33.7±2.2 | 47.4±0.9 | 110.4±1.0 | 43.14±0.6 | 0.0044±19.0 | $^{241}Am$ (0.0044±19.0) |
| 10329409 (C-8) | Scaevola frutescens | 14.08±5.2 | | | 1.14±5.5 | 1.67±3.6 | 0.0031±1.0 | |
| 10329709 (A-2) | Scaevola frutescens | 12.68±5.9 | 26.4±2.8 | 17.07±1.6 | 8.56±1.0 | 4.28±2.8 | 0.0277±7.3 | $^{241}Am$ (0.00883±14.0) |
| 10411809 (E-14) | Scaevola frutescens | 10.41±6.7 | | 21.14±1.2 | 57.21±1.0 | 205.2±0.8 | 0.00296±29.0 | |
| 10466409 (A-21) | Scaevola frutescens wood | 1.817±15.6 | | 0.912±3.5 | 4.60±2.4 | 2.219±2.8 | 0.00295±22.0 | |
| 10411409 (A-17) | Fimbristylis atollensis sedge | 4.87±11.3 | | 14.7±1.2 | 4.42±1.7 | 55.0±1.6 | 0.878±5.2 | $^{238}Pu$ (0.280±6.0) |
| 10411509 (A-19) | Suriana maritima | 5.586±10.7 | | 121.3±0.7 | 8.514±2.8 | 26.34±1.5 | 0.02865±16. | $^{238}Pu$ (0.00905±29.) |

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| IRENE | | | | | | | | |
| 11900709 | *Anous stolidus* egg shell | | 1.18±22.0 | | 7.34±1.6 | | 0.0081±14.0 | |
| 11901409 | *Anous stolidus* egg | 6.374±7.5 | 23.0±2.0 | | 0.095±5.0 | | 0.0015±19.0 | |
| 11902509 | Hermit crab hepatopancreas and gonad | 7.045±10.3 | 12.8±3.0 | 82.8±0.8 | 29.7±2.0 | 124.3±0.5 | 0.196±3.0 | $^{3}H$ (0.58±5.1) |
| 11902707 | Hermit crab muscle | 7.365±8.8 | 3.32±5.0 | 62.43±0.9 | 22.6±1.0 | 130.7±0.4 | 0.0694±4.0 | $^{3}H$ (0.89±3.6) |
| 11902809 | Hermit crab exoskeleton | 1.94±15.2 | 0.321±5.0 | 1.66±5.0 | 491.0±1.0 | 27.2±0.7 | 0.0172±11.0 | |
| 11917709 | *Anous stolidus* muscle | 9.419±9.9 | | 0.25±39.3 | | | | |
| 11919109 | *Anous stolidus* liver | 7.883±15.4 | 49.6±3.0 | 0.324±21.9 | 0.509±3.0 | | 0.0091±24.0 | |
| 11927409 | *Anous stolidus* bone | | 57.66±3.0 | | | 0.171±40.2 | | |
| 11921309 | *Anous stolidus* viscera | | 57.7±3.6 | | | | | |
| JANET | | | | | | | | |
| 10368310 | *Scaevola frutescens* I-18 | 17.44±4.8 | | | 12.16±1.0 | 30.50±0.8 | 0.01635±20.0 | |
| 10368410 | *Scaevola frutescens* | 18.12±3.9 | | | 37.25±1.0 | 258.60±0.2 | | |
| 10368510 | *Scaevola frutescens* | 14.31±5.0 | | | 17.34±1.0 | 63.29±0.5 | | |
| 10368610 | *Scaevola frutescens* | 13.65±5.1 | | 0.446±13.3 | 35.72±1.0 | 223.4±0.3 | 0.00267±28.0 | |
| 10368710 | *Scaevola frutescens* | 16.73±4.8 | | | 31.53±1.0 | 294.60±0.2 | 0.01036±13.0 | |

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| JANET | | | | | | | | |

10368710 Scaevola frutescens 16.73±4.8 31.55±1.0 294.60±0.2 0.01036±13.0

Table 59 (continued).

| Sample No. | Type | $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| | | Radionuclide concentration levels, pCi/g ovendry wt (error, %) | | | | | | |
| JANET | | | | | | | | |
| 10368810 | Scaevola frutescens | 12.96±5.4 | | 0.2139±24.0 | 32.66±1.0 | 54.95±0.6 | 0.0067±5.8 | $^{238}Pu$ (0.00676±8.7) |
| 10368910 | Scaevola frutescens | 20.57±4.1 | | 0.236±23.8 | 83.33±1.0 | 405.90±1.0 | 0.00432±17.0 | |
| 10369010 | Scaevola frutescens | 18.28±4.5 | | | 16.71±1.0 | 134.10±0.4 | 0.00496±28.0 | |
| 10369110 | Messerschmidia argentea | 12.72±5.8 | | | 18.38±1.0 | 36.42±0.7 | 0.0152±6.0 | |
| 10369210 | Messerschmidia argentea | 10.50±6.5 | | | 46.40±2.0 | 385.80±0.2 | 0.00345±21.0 | |
| 10369310 | Messerschmidia argentea | 9.95±7.2 | | | 43.51±1.0 | 124.80±0.4 | 0.00554±1.9 | $^{152}Eu$ (0.204±33.3) |
| 10369410 | Messerschmidia argentea | 142.5±5.1 | | | 48.20±2.0 | 299.40±0.2 | 0.0042±80.0 | |
| 10369510 | Messerschmidia argentea | 12.17±5.4 | | | 83.78±1.0 | 298.70±0.2 | 0.005±30.0 | |
| 10369610 | Messerschmidia argentea | 15.30±4.4 | | | 121.20±1.0 | 158.30±0.3 | 0.0029±26.0 | |
| 10369710 | Messerschmidia argentea | 10.43±6.5 | | 0.221±25.2 | 100.9±1.0 | 526.1±0.2 | | |
| 10369810 | Messerschmidia argentea | 18.32±4.5 | | 0.246±24.1 | 40.36±1.0 | 545.9±0.2 | 0.0103±24.0 | |
| 10369910 | Messerschmidia argentea | 13.29±5.8 | | | 45.95±2.0 | 322.7±0.2 | | |
| 10370010 | Pandanus tectorius leaves | 8.12±9.10 | | | 4.41±2.0 | 0.62±8.5 | | $^{207}Bi$ (0.11±29.0) |
| 10370110 | Pluchea odorata | 10.80±6.9 | | 1.25±9.2 | 46.85±1.0 | 1553.00±0.1 | | |
| 10370210 | Cocos nucifera | 8.04±6.4 | | | 0.21±5.0 | 84.68±0.4 | | $^{3}H$ (0.34±8.3) |
| 11901010 | Anous stolidus egg shell | | 1.28±20.0 | | 16.04±1.4 | | | |
| 11901510 | Anous stolidus egg | 6.21±9.4 | 57.21±2.0 | | 0.203±3.0 | | 0.0148±5.0 | |
| 11906610 | Rattus rattus viscera | 12.63±8.0 | | 2.35±6.5 | 14.14±2.0 | 880.60±0.2 | 0.46±6.0 | |
| 11906810 | Rattus rattus viscera | 11.38±16.8 | | 1.97±13.4 | 6.85±2.0 | 768.00±0.3 | 0.36±3.0 | |

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| JANET | | | | | | | | |
| 11907310 | Rattus rattus muscle | 8.74±8.4 | 30.9±2.0 | 0.29±24.5 | 1.28±4.0 | 764.00±0.2 | | $^{3}H$(6.7±1.1) |
| 11909410 | Rattus rattus liver | 13.42±9.4 | 77.9±3.0 | 3.23±4.6 | 0.004±9.0 | 632.9±0.8 | | |
| 11910810 | Rattus rattus viscera | 16.23±9.9 | 24.3±5.5 | 4.95±3.9 | 55.86±1.1 | 954.50±0.7 | 0.729±6.1 | |
| 11910910 | Rattus rattus muscle | | 8.69±5.0 | 0.41±12.3 | 3.44±3.0 | 696.80±1.0 | 0.0076±13.0 | |
| 11911010 | Rattus rattus muscle | | 10.5±5.0 | 0.23±24.3 | 2.29±2.0 | 286.5±1.0 | 0.0097±10.0 | |
| 11911110 | Rattus rattus viscera | | | 1.72±6.2 | 17.0±1.0 | 273.2±1.1 | 1.40±2.0 | |
| 11911210 | Rattus rattus muscle | 13.87±10.4 | 16.3±6.0 | 0.638±15.9 | 3.14±4.0 | 765.8±0.8 | 0.0023±18.0 | |
| 11911310 | Rattus rattus viscera | 18.54±8.7 | | 2.93±5.3 | 8.74±5.0 | 999.5±0.7 | 0.41±3.0 | |
| 11912610 | Rattus rattus liver | 33.00±18.3 | 105.4±4.0 | 2.56±14.7 | 0.015±8.0 | 741.9±1.0 | | |
| 11912710 | Rattus rattus liver | 18.17±11.0 | 30.9±6.0 | 3.97±5.9 | | 604.1±0.8 | | |
| 11912910 | Rattus rattus liver | | 24.4±1.0 | 2.21±10.8 | 0.0073±8.0 | 211.5±1.2 | | |
| 11913010 | Rattus rattus liver | | 86.9±4.0 | 6.31±9.4 | 0.0072±18.0 | 897.7±0.9 | 0.018±21.0 | $^{151}Sm$ (34.3±3.0) |
| 11916410 | Rattus rattus bone | 8.69±7.6 | | 0.304±13.0 | 115.8±1.0 | 661.2±1.6 | 0.26±4.0 | |
| 11916510 | Rattus rattus bone | 5.97±29.5 | | | 133.8±1.0 | 357.9±1.9 | 0.17±9.0 | |

Table 59 (continued).

| Sample No. | Type | $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| | | Radionuclide concentration levels, pCi/g ovendry wt (error, %) | | | | | | |
| JANET | | | | | | | | |
| 11917310 | Anous stolidus muscle | 9.19±8.1 | 104.5±2.0 | 0.51±15.1 | 0.008±24.0 | | 0.002±26.0 | |
| 11917410 | Anous stolidus viscera | 10.68±19.3 | 63.96±4.0 | | | | | |
| 11917510 | Terns: common noddy - W.C., S.T. pooled muscle | 8.77±6.0 | 59.5±2.0 | 0.159±30.6 | 0.005±21.0 | | 0.005±9.0 | |
| 11917610 | Terns: pooled - C.N., W.C., S.T. viscera | 9.62±12.1 | 52.2±3.3 | | | 0.18±9.9 | | |
| 11918110 | Rattus rattus bone | 9.06±11.3 | | 0.218±27.9 | 68.9±2.0 | 129.2±1.6 | 0.030±23.0 | |
| 11918210 | Rattus rattus bone | | | 0.51±15.2 | 121.2±3.0 | 627.5±0.7 | 3.25±3.0 | |
| 11919210 | Anous stolidus liver | 7.83±22.3 | 258.1±2.0 | | 0.066±12.0 | | | |
| 11921410 | Terns: pooled C.N., W.C., S.T., liver | | 171.6±2.0 | | | | 0.0015±23.0 | |
| 11924810 | Rattus rattus bone | 10.32±15.5 | | 0.45±21.2 | 324.3±1.0 | 545.5±1.6 | 0.168±16.0 | |
| 11926110 | Anous stolidus bone | 3.04±39.2 | 50.0±4.8 | | 0.39±17.0 | 0.733±13.8 | | |
| 11926210 | Terns: pooled C.N., W.C., S.T., bone | 3.32±23.9 | 39.95±7.5 | | | | | |
| 10930510 | Cocos nucifera fruit | 60.05±10.0 | | | 1.57±6.0 | 210.7±1.8 | | |
| 11907810 | Rattus rattus skin | | | | | 352.9±0.5 | | |
| 11907910 | Rattus rattus skin | 6.05±19.6 | | | | 389.8±0.4 | | |
| 11908010 | Rattus rattus skin | 7.8±20.7 | | | | 180.8±0.6 | | |

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| JANET | | | | | | | | |
| 11908110 | Rattus rattus skin | 10.7±16.4 | | 0.916±23.3 | | 515.3±0.4 | | |
| 11909510 | Rattus rattus kidney | 26.1±19.5 | | 2.60±17.3 | | 655.9±1.0 | | |
| 11909610 | Rattus rattus lungs | 21.5±21.7 | | | 0.45±9.0 | 587.4±1.0 | 0.51±10.0 | |
| 11911910 | Rattus rattus skin | 4.94±9.9 | | | | 405.7±1.8 | | |
| 11912810 | Rattus rattus lungs | 76.6±20.1 | 98.7±11.0 | | 4.11±21.0 | 1272±1.4 | | |
| 11914110 | Rattus rattus kidney | | | 5.78±21.2 | | 821.6±1.5 | | |
| 11914210 | Rattus rattus lungs | | | | 2.93±8.0 | 1069±1.0 | | |
| 11914310 | Rattus rattus kidney | | | 4.94±15.1 | | 467.1±1.1 | | |
| 11914410 | Rattus rattus kidney | | | 2.63±22.1 | | 274.7±1.3 | | |
| 11914510 | Rattus rattus lungs | 48.3±23.7 | | 0.55±13.0 | | 308.1±1.9 | 1.32±10.0 | |
| 11914610 | Rattus rattus kidney | 62.3±26.6 | | 6.0±18.5 | | 838.3±1.6 | | |
| 11914710 | Rattus rattus lungs | 29.7±8.0 | | 2.17±24.2 | 1.80±5.0 | 830.2±1.9 | 0.865±15.0 | |
| 11924210 | Rattus rattus muscle | | 26.2±2.0 | | 3.13±3.0 | 886.9±1.7 | 0.0128±13.0 | |



Table 59 (continued).

Table 59 (continued).

| Sample No. | Type | $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| | | Radionuclide concentration levels, pCi/g ovendry wt (error, %) | | | | | | |
| KATE | | | | | | | | |
| 10189211 | *Messerschmidia argentea* leaves | 9.62±6.5 | | | 3.75±1.0 | 4.26±2.1 | 0.0049±9.0 | |
| 10189311 | *Scaevola frutescens* leaves | 14.6±5.4 | | | | 16.36±1.1 | | |
| 10189411 | *Pisonia grandis* leaves | 9.59±6.7 | | 3.85±3.4 | 23.60±1.0 | 221.1±0.3 | 0.0045±21.0 | |
| 10189511 | *Morinda citrifolia* leaves | 14.50±5.5 | | | 23.56±1.0 | 34.09±0.7 | | |
| 11917811 | *Phaethon rubricauda* viscera | 7.81±13.0 | | | | | | |
| 11921511 | *Phaethon rubricauda* liver | | | | | | | |
| 11923111 | *Phaethon rubricauda* muscle | 8.79±6.1 | | | | | | |
| 11926311 | *Phaethon rubricauda* bone | | | | | 0.10±28.0 | | $^{65}Zn$ (0.64±30.1) |
| LUCY | | | | | | | | |
| 10187112 | *Messerschmidia argentea* leaves | 10.73±6.2 | | | | 6.36±1.7 | | $^{155}Eu$ (0.05±44.2) |
| 10187212 | *Scaevola frutescens* leaves | 13.01±5.5 | | | | 12.73±1.2 | | |
| 11919312 | *Anous stolidus* viscera | 13.08±10.3 | 108.6±9.5 | | | | | |
| 11919412 | *Anous stolidus* liver | | 199.1±2.0 | | | 0.187±11.0 | | |
| 11923212 | *Anous stolidus* muscle | 12.23±10.9 | 8.78±4.0 | | | | 0.022±10.0 | |

Table 59 (continued).

| Sample No. | Type | $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| | | Radionuclide concentration levels, pCi/g ovendry wt (error, %) | | | | | | |
| LUCY | | | | | | | | |
| 11925112 | Crab hepatopancreas and gonad | 10.42±36.2 | | 2.95±9.2 | | 125.7±1.9 | | |
| 11925212 | Crab exoskeleton | | | 0.967±10.9 | | 39.15±1.3 | | |
| 11926412 | *Anous stolidus* bone | | 38.5±11.0 | | 0.712±15.0 | 7.45±4.3 | | |
| MARY | | | | | | | | |
| 10244114 | *Morinda citrifolia* leaves | 16.27±6.9 | | | 45.05±1.0 | | 0.034±13.0 | |
| 10244214 | *Messerschmidia argentea* leaves | 13.24±5.4 | | | 7.57±1.9 | 7.12±1.6 | | |
| 10244314 | *Scaevola frutescens* leaves | 16.14±4.4 | | | 16.76±1.1 | 12.77±1.0 | | |
| 10244414 | *Guettarda speciosa* leaves | 7.70±4.7 | | | 36.85±1.0 | 98.69±1.8 | | |
| 10244514 | *Morinda citrifolia* fruit | 12.45±3.0 | | | 4.01±3.0 | 192.3±0.7 | 0.012±5.0 | |
| 10329814 | *Cocos nucifera* fruit | 7.52±6.5 | 1.18±8.3 | | 0.136±5.4 | 14.27±1.0 | | |
| 10466714 | *Morinda citrifolia* fruit | 13.45±3.7 | | 0.057±29.2 | 3.35±2.3 | 97.43±0.8 | 0.0022±24.0 | |
| 10466814 | *Lepturus repens* leaves | | | | 17.39±1.0 | 105.7±0.9 | 0.0093±11.0 | |
| 11919514 | *Anous stolidus* liver | 6.626±27.0 | 2.51±2.0 | 0.567±18.5 | | | | |
| 11921614 | *Anous stolidus* viscera | 11.41±24.6 | 53.60±1.8 | | | | | |



Table 59 (continued).

Radionuclide concentration levels, pCi/g ovendry wt (error, %)

viscera

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| MARY | | | | | | | | |
| 11923314 | Anous stolidus muscle | 6.77±13.6 | 14.2±3.0 | 0.316±25.7 | 0.48±3.0 | | | |
| 11927514 | Anous stolidus bone | 5.74±13.3 | 59.9±2.7 | | | | | |
| 10930714 | Cocos nucifera fruit | 39.25±8.3 | | | 0.635±10.0 | 67.75±1.4 | | |
| 10930814 | Cocos nucifera fruit | 3.80±6.1 | 76.58±9.5 | | 14.14±9.6 | 5.59±1.5 | | |
| NANCY | | | | | | | | |
| 10243615 | Guettarda speciosa leaves | 8.79±5.4 | | | 30.86±1.0 | 8.73±1.4 | 0.0097±28.0 | |
| 10243715 | Pisonia grandis leaves | 16.51±4.4 | | 0.237±14.0 | 36.67±1.0 | 43.87±1.0 | 0.0195±14.0 | |
| 10243815 | Scaevola frutescens leaves | 10.74±4.2 | 0.05±17 | | 11.89±1.0 | 4.12±1.7 | 0.0125±16.0 | |
| 10243915 | Morinda citrifolia | 11.16±4.0 | | | 43.47±1.0 | 55.05±0.9 | 0.0056±26.0 | |
| 10329915 | Cocos nucifera fruit | 6.54±6.9 | 1.95±6.3 | | 0.167±6.4 | | 18.83±0.8 | $^{3}H$ (0.333±6.3) |
| 10371215 | Messerschmidia argentea leaves | 7.81±7.6 | | | 27.30±1.0 | 40.24±0.7 | 0.023±12.0 | |
| 10930915 | Cocos nucifera fruit | 73.51±17.9 | 5.95±16.0 | | 1.15±11.0 | 148.8±4.0 | | |
| OLIVE | | | | | | | | |
| 10244616 | Morinda citrifolia fruit | 18.74±4.0 | | | 4.48±2.0 | 30.42±0.7 | | |

Table 59 (continued).

| Sample No. | Type | $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| | | Radionuclide concentration levels, pCi/g ovendry wt (error, %) | | | | | | |
| OLIVE | | | | | | | | |
| 10244716 | Morinda citrifolia leaves | 12.48±5.5 | 0.063±18 | 0.33±17.4 | 37.66±1.0 | 66.58±0.5 | 0.011±12 | $^{152}Eu$ (0.13±43.1) |
| 10244816 | Morinda citrifolia leaves | 18.73±4.4 | | | 39.50±1.0 | 29.57±0.7 | 0.0036±25.0 | |
| 10244916 | Messerschmidia argentea leaves | 10.73±5.4 | | | | 9.54±1.2 | | |
| 10330016 | Scaevola frutescens leaves | 13.30±5.5 | | | | 4.35±2.1 | | |
| 11919616 | Anous stolidus liver | | 332.4±2.0 | | 0.036±16.0 | | 0.010±20.0 | |
| 11921716 | Anous stolidus viscera | 8.81±16.3 | 57.21±2.4 | | | | | |
| 11923416 | Anous stolidus muscle | 7.69±13.5 | 92.8±2.0 | | | | 0.092±8.0 | |
| 11927616 | Anous stolidus bone | 4.07±21.9 | 46.40±3.4 | 0.31±16.7 | 0.39±13.0 | | | |
| PEARL | | | | | | | | |
| 10224517 | Scaevola frutescens leaves | 16.50±4.6 | | | 0.348±8.2 | 0.342±10.3 | 0.0023±19.0 | |
| 10224617 | Messerschmidia argentea leaves | 14.66±8.0 | | | 0.473±5.7 | 0.295±26.6 | | |
| 10245417 | Scaevola frutescens leaves | 12.52±5.2 | | 0.159±28.6 | 20.99±1.4 | 30.82±0.7 | 0.0031±2.7 | |
| 11909717 | Rattus exulans liver | 32.33±12.7 | 82.0±5.0 | 5.07±7.7 | 164.90±6.0 | 33.30±2.7 | 0.0119±8.0 | |
| 11913117 | Rattus exulans viscera | | | 7.45±2.9 | 1.79±4.0 | 30.80±1.3 | 1.77±8.0 | |

Table 59 (continued).

Radionuclide concentration levels, pCi/g ovendry wt (error, %)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | liver | | | | | | | |
| 11913117 | *Rattus exulans* viscera | | | 7.45±2.9 | 1.79±4.0 | 30.80±1.3 | 1.77±8.0 | |

Table 59 (continued).

| Sample No. | Type | $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| | | Radionuclide concentration levels, pCi/g ovendry wt (error, %) | | | | | | |
| PEARL | | | | | | | | |
| 11908217 | *Rattus exulans* skin | 8.4±16.2 | | 1.58±12.7 | | 15.0±2.3 | | |
| 11909817 | *Rattus exulans* kidney | 51.5±29.5 | | 5.46±17.6 | | 27.9±5.5 | | |
| 11910517 | *Rattus exulans* lungs | | | | 0.84±28.0 | 51.22±3.7 | 8.15±6.0 | |
| 11919717 | Terns liver | | 317.1±2.0 | 0.65±26.5 | | | | |
| 11921817 | Terns, pooled viscera | | 61.71±2.7 | 0.435±27.2 | | | | |
| 11923517 | Terns, pooled muscle | 8.67±13.5 | | 0.659±20.0 | | | | |
| 11924917 | *Rattus exulans* muscle | 11.60±12.4 | 23.2±8.0 | 0.888±10.60 | 0.037±11.0 | 37.07±1.4 | 0.117±13.0 | |
| 11925017 | *Rattus exulans* bone | 9.57±34.1 | | 2.59±10.3 | 36.1±4.0 | 53.60±1.4 | | |
| 11927717 | Terns, pooled bone | | 46.9±5.4 | | | 0.793±16.9 | | |
| RUBY | | | | | | | | |
| 10225118 | *Messerschmidia argentea* leaves | 9.19±11.6 | | 0.995±10.3 | | 19.19±2.0 | | |
| 10225318 | *Messerschmidia argentea* leaves | 6.23±5.7 | | 0.905±3.4 | | 39.01±1.7 | | |
| SALLY | | | | | | | | |
| 10188019 | *Pandanus tectorius* leaves | 14.02±10.3 | 0.703±2.0 | | 1.97±2.0 | 14.98±2.1 | 0.015±13.0 | |

Table 59 (continued).

| Sample No. | Type | $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| | | Radionuclide concentration levels, pCi/g ovendry wt (error, %) | | | | | | |
| SALLY | | | | | | | | |
| 10188119 | Lepturus repens leaves | 3.74±15.9 | | | 1.98±1.8 | 83.20±0.9 | 0.0227±16.0 | |
| 10188219 | Messerschmidia argentea leaves | 8.28±5.2 | | 0.10±17.4 | 4.86±1.4 | 12.63±1.0 | 0.059±6.7 | $^{238}Pu$ (0.0022±17.0) |
| 10188319 | Scaevola frutescens leaves | 10.78±6.5 | | | 6.67±1.4 | 13.38±1.3 | 0.096±14.0 | $^{238}Pu$ (0.0027±26.0) |
| 11900219 | Sterna fuscata eggshell | | | | 0.265±13.0 | | 0.005±26 | |
| 11901619 | Sterna fuscata egg | 4.57±11.1 | 37.57±2.0 | | 0.0042±19.0 | | 0.015±4.0 | |
| 11906919 | Rattus exulans viscera | 9.63±9.0 | | 1.48±9.6 | 14.6±1.0 | 92.97±0.5 | 1.30±4.0 | |
| 11911419 | Rattus exulans liver | 10.73±12.3 | 35.5±4.0 | 2.54±6.3 | 0.0021±22.0 | 63.83±1.2 | 0.008±15.0 | |
| 11915819 | Rattus exulans muscle | 5.82±17.6 | | | | 60.86±0.9 | | $^{3}H$ (18.7±1.3) |
| 11917917 | Sterna fuscata viscera | 4.79±22.40 | 22.43±5.1 | | | | | |
| 11919819 | Sterna fuscata liver | | 155.0±3.0 | | | | | |
| 11919919 | Anous tenui liver | | | | | | 0.011±19 | |
| 11921919 | Anous tenui viscera | 5.89±17.30 | 64.4±1.0 | | | | | |
| 11923619 | Anous tenui muscle | 6.31±11.50 | 36.6±2.0 | | | | 0.005±11 | |
| 11923819 | Rattus exulans bone | 7.01±15.0 | | 0.81±15.3 | 25.9±2.0 | 65.77±0.7 | 0.039±15.0 | |

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| SALLY | | | | | | | | |
| 11908319 | *Rattus exulans* skin | 4.52±11.9 | | 0.49±16.0 | | 49.1±0.6 | | |
| 11926519 | Sooty tern bone | | 61.3±4.5 | 0.34±14.1 | 1.68±7.6 | 0.14±27.0 | | |
| 11927819 | Sooty tern bone | | 35.7±4.7 | | | | | |
| 11913219 | *Rattus exulans* lungs | 13.2±21.4 | | 0.67±23.9 | 0.22±11.0 | 73.9±1.8 | 0.198±6.0 | |
| 11914819 | *Rattus exulans* kidney | | | 2.28±14.2 | | 73.3±1.4 | | |
| 11923719 | Noddy tern muscle | 7.63±10.8 | 109.5±2.0 | | 0.014±18.0 | | 0.020±8.0 | |
| TILDA | | | | | | | | |
| 10330420 | *Guettarda speciosa* leaves | 10.10±5.2 | | | 12.57±1.0 | 5.90±1.4 | 0.0091±19.0 | |
| 10330520 | *Pandanus tectorius* leaves | 13.29±7.2 | 2.94±5.0 | | 15.50±2.0 | 152.2±0.4 | 0.0069±18.0 | |
| 10330620 | *Scaevola frutescens* leaves | 11.39±5.7 | | | 9.05±1.7 | 24.94±0.8 | 0.0042±26.0 | |
| 10330720 | *Morinda citrifolia* leaves | 13.94±5.1 | | | 12.48±1.1 | 13.90±1.1 | | |
| 10330820 | *Messerschmidia argentea* leaves | 10.13±5.7 | | | 10.27±1.5 | 58.78±1.9 | | |
| URSULA | | | | | | | | |
| 10187521 | *Messerschmidia argentea* leaves | 10.09±3.7 | | | 13.60±1.0 | 104.9±1.7 | | |

Table 59 (continued).

| Sample No. | Type | $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| | | Radionuclide concentration levels, pCi/g ovendry wt (error, %) | | | | | | |
| URSULA | | | | | | | | |
| 10187621 | *Scaevola frutescens* leaves | 5.45±10.7 | | | 6.13±1.0 | 91.49±0.8 | 0.0031±11.0 | |
| 10187721 | *Scaevola frutescens* leaves | 13.47±9.4 | | | | 0.293±29.1 | | |
| 10187821 | *Guettarda speciosa* leaves | 14.23±9.0 | | | 7.30±1.2 | 13.27±2.0 | | |
| 11907021 | *Rattus exulans* viscera | 10.87±12.5 | | 1.13±18.5 | 2.17±1.9 | 43.14±1.1 | 0.29±3.0 | |
| 11913321 | *Rattus exulans* liver | 6.72±31.7 | 42.2±5.0 | 3.59±6.2 | | 39.41±3.1 | 0.041±9.0 | $^{207}Bi$ (0.375±29.9) |
| 11908421 | *Rattus exulans* skin | 7.58±11.3 | | 0.41±21.6 | | 18.5±1.4 | | |
| 11914921 | *Rattus exulans* kidney | | | | | 38.4±6.6 | | |
| 11915021 | *Rattus exulans* lungs | | | | | 45.0±3.0 | | |
| 11915921 | *Rattus exulans* muscle | 9.22±18.6 | | | | 37.86±1.3 | | |
| 11916621 | *Rattus exulans* bone | 7.26±25.0 | | | 19.6±4.0 | 61.58±1.2 | 0.146±9.0 | |
| VERA | | | | | | | | |
| 10225822 | *Messerschmidia argentea* leaves | 7.07±6.5 | | | 12.79±1.4 | 10.77±1.1 | 0.0024±19.0 | |
| 10225922 | *Scaevola frutescens* leaves | 8.18±6.4 | | | 4.49±1.7 | 1.686±3.4 | | |
| 10226022 | *Morinda citrifolia* leaves | 10.46±6.8 | | | 11.85±2.5 | 12.12±1.4 | | |

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Table 59 (continued).

Radionuclide concentration levels, pCi/g ovendry wt (error, %)

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| URSULA | | | | | | | | |
| 10226122 | Pisonia grandis leaves | 28.58±4.8 | | | 23.11±1.1 | 56.94±1.0 | | |
| 10226222 | Pandanus tectorius | 9.171±8.8 | | | 4.24±2.8 | 17.58±1.5 | 0.0076±15.0 | |
| 10245622 | Cocos nucifera fruit | 5.64±7.6 | | | 0.134±6.0 | 9.297±1.2 | | |
| WILMA | | | | | | | | |
| 10224823 | Messerschmidia argentea leaves | 5.00±11.0 | | | | 6.19±2.9 | | |
| 10224923 | Scaevola frutescens leaves | 10.31±6.8 | | | | 1.245±3.7 | | |
| 10225023 | Guettarda speciosa leaves | 10.60±4.3 | | | | 3.14±1.9 | | |
| YVONNE | | | | | | | | |
| 10327224 | Scaevola frutescens leaves | 13.2±5.4 | | 0.511±11.8 | 1.76±1.6 | 11.88±1.2 | 0.0265±20.0 | $^{238}Pu$ (0.0068±32.0) |
| 10327324 | Scaevola frutescens | 14.16±5.3 | | | 0.442±5.4 | 1.575±3.7 | 0.0042±3.9 | |
| 10327424 | Messerschmidia argentea leaves | 14.19±5.8 | | | 0.6396±5.9 | 2.28±3.3 | 0.0036±5.1 | |
| 10327524 | Scaevola frutescens | 15.0±5.1 | | 0.246±22.3 | 0.662±4.9 | 8.06±1.5 | 1.293±5.0 | $^{238}Pu$ (0.061±9.7), $^{241}Am$ (0.146±5.0) |
| 10327624 | Scaevola frutescens | 10.68±6.3 | | 20.26±1.4 | 159.0±1.0 | 609.9±0.2 | 0.323±5.0 | |
| 10327724 | Guettarda speciosa | 11.15±5.9 | | 4.52±3.2 | 64.4±1.0 | 795.0±0.1 | 0.0253±1.8 | |
| 10327824 | Messerschmidia argentea | 14.46±5.7 | | | 1.428±3.9 | 3.81±2.4 | 0.0108±2.9 | |

Table 59 (continued).

| Sample No. | Type | $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| | | Radionuclide concentration levels, pCi/g ovendry wt (error, %) | | | | | | |
| YVONNE | | | | | | | | |
| 10327924 | Messerschmidia argentea | 10.91±5.6 | | | 8.6±2.0 | 95.3±0.4 | 0.129±3.0 | |
| 10328024 | Scaevola frutescens | 15.93±4.3 | | | 1.94±1.4 | 28.25±0.7 | 0.19±5.4 | $^{238}Pu$ (0.076±9.0) |
| 10330124 | Scaevola frutescens | 18.77±4.1 | | 6.26±2.5 | 80.63±1.0 | 658.0±0.1 | 0.196±2.0 | |
| 10330224 | Messerschmidia argentea | 10.33±7.0 | | | 1.941±3.4 | 17.30±1.1 | 0.766±1.0 | |
| 10330324 | Messerschmidia argentea | 9.928±6.0 | | 1.16±7.7 | 257.2±1.0 | 5644.0±0.0 | 0.114±6.0 | |
| 10371024 | Cocos nucifera fruit | 6.392±7.2 | | | | 1.986±2.8 | | |
| 10371124 | Cocos nucifera fruit | 8.243±5.8 | | | 0.011±5.0 | 3.96±1.8 | | $^{3}H$ (0.66±8.3) |
| 11900824 | Anous stolidus eggshell | | 1.10±27.0 | | 0.22±18.0 | | | |
| 11900924 | Anous stolidus eggshell | | | | | | 0.0086±17.0 | |
| 11901724 | Anous stolidus egg | 4.53±15.5 | | | 1.06±6.0 | | | |
| 11901824 | Anous stolidus egg | 4.129±17.2 | 56.76±2.0 | | | | 0.0232±6.0 | |
| 11901924 | Anous stolidus egg | 7.221±9.3 | 54.5±2.0 | | 0.073±11.0 | 0.079±46.0 | | |
| 11906724 | Rattus rattus viscera | 13.33±8.2 | | 230.0±0.5 | 4.09±2.0 | 3531.0±0.1 | 0.58±3.0 | |
| 11907124 | Rattus rattus viscera | 9.667±12.6 | | 1.99±10.7 | 0.57±5.0 | 76.7±0.8 | 0.393±3.0 | |
| 11909924 | Rattus rattus liver | | 126.1±3.0 | 70.3±3.2 | | 2559.0±0.9 | 0.0271±12.0 | $^{151}Sm$ (18.7±3.0) |
| 11911524 | Rattus rattus | 14.15±14.8 | 135.6±2.0 | 86.13±1.5 | 0.0046±7.0 | 2215.0±0.7 | 0.0129±13.0 | |

Table 59 (continued).

| Sample No. | Type | $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| | | Radionuclide concentration levels, pCi/g ovendry wt (error, %) | | | | | | |
| YVONNE | | | | | | | | |
| 11911624 | *Rattus rattus* viscera | | 3.46±18.0 | 4.186±3.7 | 0.327±19.0 | 55.8±1.4 | 0.211±7.2 | $^{238}Pu$ (0.0964±8.3) |
| 11911724 | *Rattus rattus* viscera | 17.77±14.4 | | | 0.20±10.0 | 5.7±5.7 | 0.0206±11.0 | |
| 11911824 | *Rattus rattus* viscera | 7.608±15.4 | | 112.6±0.9 | | 2928.0±1.8 | 1.05±3.0 | $^{134}Cs$ (1.9±19.2) |
| 11913624 | *Rattus rattus* | | 25.1±2.0 | 2.9±6.5 | | 56.2±1.7 | 0.0078±24.0 | $^{151}Sm$ (23.0±3.0) |
| 11913724 | *Rattus rattus* liver | | 13.8±18.0 | 5.63±7.9 | 0.0024±27.0 | 38.7±2.7 | 0.011±26.0 | |
| 11915424 | *Rattus rattus* liver | | 17.3±8.0 | | 10.5±12.0 | 4.62±15.0 | 0.0398±8.0 | |
| 11916024 | *Rattus rattus* muscle | 12.35±15.7 | 32.8±3.0 | 12.83±4.5 | 5.09±4.0 | 4240.0±0.1 | 0.052±9.0 | $^{3}H$ (1.8±2.3) |
| 11916124 | *Rattus rattus* muscle | 13.07±7.3 | 78.8±2.0 | 8.51±2.9 | 37.8±1.0 | 3824.0±0.1 | | |
| 11916224 | *Rattus rattus* muscle | 16.82±9.9 | | | | 86.0±0.9 | | |
| 11916724 | *Rattus rattus* bone | | | 5.92±2.8 | 146.4±1.0 | 1833.0±0.7 | | $^{134}Cs$ (1.12±18.8) |
| 11916824 | *Rattus rattus* bone | 7.932±12.2 | | 10.57±3.7 | 135.1±1.0 | 2200.0±0.7 | 0.29±5.0 | $^{134}Cs$ (1.36±13.9) |
| 11916924 | *Rattus rattus* bone | 9.739±12.2 | | 0.327±28.0 | 16.7±2.0 | 48.8±1.2 | 0.304±11.0 | |
| 11918024 | *Anous stolidus* viscera | 8.338±24.3 | 64.4±3.6 | 0.51±35.3 | | | | |
| 11920024 | *Anous stolidus* liver | | 385.6±2.0 | 0.37±25.8 | | | | |

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| YVONNE | | | | | | | | |
| 11923924 | *Anous stolidus* muscle | 7.387±11.1 | 22.6±2.0 | 0.23±36.6 | 0.0073±28.0 | | 0.020±37.0 | |
| 11924324 | *Rattus rattus* muscle | 5.77±25.3 | 4.1±6.0 | 0.554±24.9 | 6.76±5.0 | 49.2±1.7 | | $^{3}H$ (1.1±5.6) |
| 11924424 | *Rattus rattus* muscle | 15.87±6.8 | 1.23±22.0 | | 0.631±3.0 | 3.74±3.1 | 0.0077±21.0 | |
| 11925324 | *Rattus rattus* bone | 23.95±13.7 | | | 1.32±8.0 | 23.8±3.0 | 0.059±15.0 | |
| 11925424 | *Rattus rattus* bone | | | 0.514±9.7 | 6.40±13.0 | 38.78±1.1 | 0.059±11.0 | |
| 11926624 | *Anous stolidus* bone | | 63.5±1.0 | | | 5.51±4.8 | 0.021±26.0 | |
| 11908924 | *Rattus rattus* skin | 10.7±19.9 | | | | 3.94±7.0 | | |
| 11900624 | *Anous tenuirostris* eggs | | | | | | | |
| 11908624 | *Rattus rattus* skin | 6.92±18.4 | | 7.43±4.0 | | 1875±0.1 | | |
| 11908724 | *Rattus rattus* skin | 4.74±21.0 | | | | 42.6±0.9 | | |
| 11908524 | *Rattus rattus* skin | 6.7±10.9 | | 14.0±2.2 | | 2088±0.1 | | |
| 11908824 | *Rattus rattus* skin | | | 0.69±22.3 | | 28.4±1.2 | | |
| 11910024 | *Rattus rattus* kidney | | | 257.7±2.9 | | 3427±1.8 | | |
| 11910124 | *Rattus rattus* lungs | 33.1±14.2 | 252.3±2.4 | 11.1±5.2 | 16.2±6.4 | 2760±0.8 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| lungs | [illegible] | [illegible] | 11.1±5.2 | 16.2±6.4 | 2760±0.8 | |

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| YVONNE | | | | | | | | |
| 11910224 | Rattus rattus lungs | | | | | 53.3±3.9 | 0.57±15.0 | |
| 11910324 | Rattus rattus kidney | 167.2±17 | | | | 6.19±23.4 | | |
| 11910424 | Rattus rattus lungs | | | | | 11.6±19.3 | 0.20±24.0 | |
| 11913424 | Rattus rattus kidney | | | 261.8±1.1 | | 3286±1.0 | | |
| 11913524 | Rattus rattus lungs | 14.3±28.7 | | 10.5±6.1 | 0.24±11.0 | 3306±1.7 | 0.11±9.0 | $^{134}Cs$ (1.5±28.5) |
| 11915124 | Rattus rattus kidney | | | 4.96±17.1 | | 59.6±3.7 | | |
| 11915224 | Rattus rattus lungs | | | | | 39.7±3.4 | 0.023±34.0 | |
| 11915324 | Rattus rattus kidney | 30.64±24.2 | | 8.03±7.3 | | 29.0±3.5 | | |
| ALVIN | | | | | | | | |
| 10156130 | Messerschmidia argentea | 11.57±10.4 | | | | 0.846±10.1 | | |
| 11918330 | Terns, pooled liver | 20.37±10.7 | | | | | | |
| 11922030 | Terns, pooled muscle | 10.44±12.0 | | | | | | |
| 11925630 | Terns, pooled bone | 10.32±15.1 | | | | 5.71±4.8 | | |
| TOM | | | | | | | | |
| 10187027 | Messerschmidia argentea | 9.16±4.9 | | | | 0.26±8.0 | | |

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}$K | $^{55}$Fe | $^{60}$Co | $^{90}$Sr | $^{137}$Cs | $^{239,240}$Pu | Other |
|---|---|---|---|---|---|---|---|---|
| TOM | | | | | | | | |
| 10155327 | *Scaevola frutescens* | 11.5±3.7 | | | | 0.74±4.0 | | |
| URIAH | | | | | | | | |
| 10155428 | *Messerschmidia argentea* | 11.9±12.5 | | | | 0.73±10.0 | | |
| VAN | | | | | | | | |
| 10155529 | *Messerschmidia argentea* | 6.81±8.0 | | | | 0.35±10.7 | | |
| 10155729 | *Pisonia grandis* | 12.9±5.3 | | 0.17±28.2 | | 1.99±3.2 | | |
| 10155629 | *Scaevola frutescens* | 7.11±7.9 | | | | 0.73±6.3 | | |
| 11925929 | *Anous stolidus* bone | 6.96±20.2 | 40.3±1.6 | | 0.14±3.0 | 0.74±2.4 | | |
| 11900429 | *Anous stolidus* egg shell | | 1.68±17.0 | | | | | |
| 11902029 | *Anous stolidus* egg | 6.31±10.8 | 63.5±2.0 | | | 0.14±30.7 | 0.0004±29.0 | |
| 11917229 | *Anous stolidus* muscle | 10.5±8.2 | 99.55±2.0 | 0.29±26.7 | | | 0.0014±20.0 | |
| 11918929 | *Anous stolidus* liver | | 278.9±2.0 | 0.19±33 | 0.04±8.0 | | | |
| 11921129 | *Anous stolidus* viscera | | 50.5±1.6 | | | | | |
| BRUCE | | | | | | | | |
| 10156931 | *Cocos nucifera* | 5.93±7.1 | | | | 0.582±5.6 | | |
| 10186731 | *Messerschmidia argentea* | 8.027±6.3 | | | 0.328±5.3 | 1.158±4.0 | | |
| 10186831 | *Scaevola frutescens* | 9.32±5.5 | | | 0.878±2.5 | 0.751±5.5 | | |

**Table 59 (continued).**

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| BRUCE | | | | | | | | |
| 10186931 | Pisonia grandis | 17.76±2.8 | | | 0.50±4.0 | 1.456±2.6 | | |
| 11903931 | Birgus latro muscle | 11.28±6.4 | 0.98±37.0 | 0.20±27.3 | 0.185±6.0 | 1.978±3.5 | | $^{3}H$ (0.42±5.2) |
| 11918431 | Anous tenuirostris liver | 8.369±28.5 | 326.6±2.0 | | | | | |
| 11922131 | Anous tenuirostris muscle | 7.095±12.4 | 41.3±2.0 | 0.392±19.9 | | | 0.0069±8.0 | |
| 11924531 | Rattus rattus bone | 18.81±12.0 | | | 1.69±4.0 | 13.25±3.1 | 3.279±4.0 | |
| 11925731 | Anous tenuirostris bone | | 44.2±1.3 | | 0.66±12.0 | | | |
| 11904031 | Birgus latro exoskeleton | 2.59±10.4 | 0.07±28.0 | | 6.08±3.0 | 0.287±8.1 | 0.001±4.0 | |
| 11904131 | Birgus latro hepatopancreas and gonad | 3.018±10.4 | 5.7±3.0 | 0.402±10.4 | 0.133±2.0 | 0.42±7.1 | | $^{3}H$ (0.16±2.4) |
| 11909031 | Rattus rattus liver | 30.2±17.0 | 46.4±7.0 | 1.617±23.5 | | 1.07±32.6 | 0.013±11.0 | |
| 11912231 | Rattus rattus viscera | | | | | 1.09±132.0 | 0.035±12.0 | |
| 11915531 | Rattus rattus muscle | 5.207±38.6 | 2.21±16.0 | | 0.074±9.0 | 1.472±12.8 | 0.0086±13.0 | |
| 11904231 | Birgus latro skin, gills, green gland | 7.25±17.7 | | | | 1.68±8.6 | | |
| 11904331 | Birgus latro shell, gill, dust, gut blood | 6.15±14.5 | | | | 1.34±7.4 | | |
| 11907531 | Rattus rattus hide | 8.07±18.7 | | | | 0.61±23.1 | | |

Table 59 (continued).

| Sample No. | Type | $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| | | Radionuclide concentration levels, pCi/g ovendry wt (error, %) | | | | | | |
| BRUCE | | | | | | | | |
| 11909131 | Rattus rattus kidney | | | 3.19±20.5 | | | | |
| 11913831 | Rattus rattus lungs | 35.9±34.3 | | | | | | |
| 11920331 | Anous tenuirostris viscera | | 73.9±1.1 | | | | | |
| CLYDE | | | | | | | | |
| 10155932 | Messerschmidia argentea | 10.9±5.7 | | | | 0.426±8.3 | | |
| 10156032 | Scaevola frutescens | 11.19±5.7 | | | | 0.273±12.9 | | |
| 11900132 | Sterna fuscata eggshells | 1.365±13.0 | | | | | | |
| 11901132 | Sterna fuscata eggs | 5.41±9.8 | | | | | | |
| 11920432 | Sterna fuscata viscera | 7.937±13.0 | 49.1±4.9 | | | | | |
| 11920532 | Sterna fuscata liver | | 146.4±2.0 | | 0.015±8.0 | | 0.0017±29.0 | |
| 11922432 | Sterna fuscata muscle | 7.374±8.7 | 20.4±2.0 | | 0.00635±17.0 | | | |
| 11925832 | Sterna fuscata bone | 2.36±36.0 | 36.0±12.0 | | | | | |
| DAVID | | | | | | | | |
| 10019933 | Messerschmidia argentea | 13.55±5.1 | | | 0.464±4.8 | 1.086±4.3 | 0.0061±22.0 | |
| 10020533 | Tacca leontopetaloides | 6.635±9.8 | | | 0.096±3.0 | 8.60±1.5 | 0.0011±32.0 | $^{3}H$(0.52±4.9) |
| 10020633 | Cocos nucifera | 6.441±8.1 | | | 0.01387±6.0 | 2.593±2.5 | | $^{3}H$(0.31±13.7) |
| 10020833 | Scaevola frutescens | 17.59±4.8 | | | 0.341±7.4 | 1.114±4.7 | 0.0005±5.7 | |
| 10021133 | Pisonia grandis | 19.02±4.7 | | | 0.77±3.1 | 3.118±2.6 | 0.0013±25.0 | |
| 10020033 | Pisonia grandis | 10.2±6.6 | | | 0.56±6.2 | 1.80±3.4 | 0.0002±9.8 | |
| 10021333 | Cocos nucifera | 3.761±14.4 | | | 0.1784±6.8 | 1.688±4.0 | | $^{102}Rh$ (0.1234±26.2) |

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| DAVID | | | | | | | | |
| 10022633 | Morinda citrifolia | 12.59±3.7 | | | 0.0251±4.0 | 3.84±1.5 | 0.0127±6.00 | |
| 10370333 | Pandanus tectorius | 9.74±7.9 | 0.13±19.0 | | 3.56±1.0 | 15.9±1.2 | | |
| 10370433 | Scaevola frutescens | 10.69±5.1 | | | 0.3716±5.2 | 4.82±1.6 | | |
| 10371333 | Messerschmidia argentea | 11.02±5.1 | | | 0.757±8.0 | 7.243±1.3 | | |
| 10371433 | Pisonia grandis | 18.10±3.6 | | | 0.608±4.3 | 1.677±2.9 | | |
| 10371533 | Guettarda speciosa | 3.996±11.1 | | | 0.322±7.6 | 3.157±2.5 | | |
| 10412033 | Fimbrystilis atollensis sedge | 3.383±22.3 | | | | 7.396±2.1 | | |
| 10412133 | Cocos nucifera | 4.694±6.6 | | | 0.0263±10.0 | 0.399±5.9 | 0.00343±5.0 | |
| 10412233 | Scaevola frutescens | 13.02±9.2 | | | 0.314±7.6 | 5.18±3.2 | | |
| 10412433 | Messerschmidia argentea | 13.22±5.3 | | | 1.059±5.3 | 2.581±3.4 | | |
| 10412333 | Scaevola frutescens | 16.33±9.4 | | | 0.5586±6.6 | 2.014±7.0 | | |
| 10412533 | Messerschmidia argentea | 3.882±16.3 | | | 0.748±6.8 | 15.84±1.3 | | |
| 11902133 | Coenobita perlatus hepatopancreas and gonad | 7.613±9.6 | 0.57±34.0 | 0.23±28.8 | 0.191±8.0 | 1.946±4.3 | 4.82±33.0 | $^{3}H$ (0.95±6.1) |
| 11902933 | Coenobita perlatus muscle | 7.518±8.2 | | 0.284±19.5 | 0.366±3.0 | 2.064±3.5 | 0.0031±8.0 | $^{3}H$ (0.58±3.5) |
| 11903033 | Coenobita perlatus exoskeleton | 1.764±12.8 | 0.039±37.0 | | 4.05±3.0 | 0.601±4.2 | 0.010±6.0 | |
| 10931133 | Cocos nucifera milk | 30.93±8.4 | | | | 23.32±2.0 | | |
| 11924133 | Sterna fuscata muscle | 7.459±20.1 | 59.0±2.0 | | | | 0.119±30.0 | |
| 11924733 | Erolia cuminata liver | 17.57±32.1 | | | | | | |

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| DAVID | | | | | | | | |
| 11925533 | *Demigretta sacra* bone | 8.761±13.0 | | 0.41±16.0 | | | | |
| 11926733 | *Erolia cuminata* bone | 28.16±8.5 | | | | 0.789±19.5 | | |
| 11926833 | *Demigretta sacra* bone | | | | | 1.34±6.9 | | |
| 11926933 | *Sterna fuscata* bone | | 37.4±9.2 | | | 0.745±11.3 | | $^{134}Cs$ (0.413±21.5) |
| 11906233 | *Rattus exulans* viscera | 12.24±7.1 | | | 0.24±6.0 | 21.97±0.9 | 0.0087±9.0 | |
| 11910633 | *Rattus exulans* liver | | 3.67±6.0 | | | 16.36±2.4 | 0.00424±18.0 | |
| 11918533 | *Sterna fuscata* liver | 20.36±16.0 | 153.2±3.0 | | | | | |
| 11922233 | *Rattus exulans* muscle | 7.802±17.2 | 0.98±12.0 | | 0.604±6.0 | 18.78±1.6 | 0.044±7.0 | |
| 11922333 | *Rattus exulans* bone | 11.46±13.0 | | | 1.37±2.0 | 28.37±1.3 | 0.065±10.0 | |
| 11924033 | *Demigretta sacra* muscle | 4.653±38.0 | | | | 1.59±10.5 | | |
| 10020033 | *Pisonia grandis* | 10.2±6.6 | | | 0.56±6.2 | 1.8±3.4 | 0.0002±9.8 | |
| 11907633 | *Rattus exulans* hide | 6.49±9.1 | | | | 9.13±1.6 | | |
| 11912333 | *Rattus exulans* kidney | | | | | 17.0±3.0 | | |
| 11913933 | *Rattus exulans* lungs | | | | | 18.5±5.8 | 0.031±16.0 | |
| 11924633 | *Erolia cuminata* viscera | | | | | | | |



Table 59 (continued).

| 11924633 | Erolia cuminata viscera | | | | | | | |
|---|---|---|---|---|---|---|---|---|

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| DAVID | | | | | | | | |
| 11920133 | Sterna fuscata viscera | 8.9±26.7 | 63.5±5.2 | | | | | |
| REX | | | | | | | | |
| 10157034 | Scaevola frutescens | 6.964±8.3 | | | | 0.495±8.3 | | |
| 10186534 | Messerschmidia argentea | 8.896±7.2 | | | | 2.451±2.9 | | |
| 10186634 | Pisonia grandis | 16.0±4.1 | | 0.091±23.1 | | 2.642±2.2 | | |
| 11900534 | Anous stolidus eggshell | | 0.73±16.0 | | | | | |
| 11920934 | Anous stolidus viscera | | 50.0±3.7 | | | | | |
| 11901334 | Anous stolidus egg | 7.689±8.9 | 51.4±2.0 | | | | 0.0077±19.0 | |
| 11902434 | Coenobita perlatus hepatopancreas and gonad | 5.833±10.1 | 1.82±8.0 | 0.566±12.5 | 0.289±4.0 | 0.783±7.2 | 0.00346±11.0 | |
| 11903134 | Coenobita perlatus muscle | 6.676±8.8 | 1.47±12.0 | 1.436±6.6 | 0.319±3.0 | 1.05±5.8 | 0.0026±12.0 | |
| 11903234 | Coenobita perlatus exoskeleton | 1.838±13.0 | 0.085±29.0 | | 3.62±2.0 | 0.249±8.2 | 0.001±16.0 | |
| 11921034 | Anous stolidus liver | 4.887±35.2 | 117.6±2.0 | | | | | |
| 11922734 | Anous stolidus muscle | 10.81±8.2 | 43.5±2.0 | | 0.00649±19.0 | | 0.0056±11.0 | |
| 11927334 | Anous stolidus bone | | 44.77±3.7 | | | | | |

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| **ELMER** | | | | | | | | |
| 10156235 | Messerschmidia argentea | | | | 0.982±2.5 | 2.386±5.0 | | |
| 10156335 | Scaevola frutescens | 13.6±9.2 | | | 0.272±4.8 | 2.405±5.1 | | |
| 10156435 | Cocos nucifera | 9.734±12.4 | | | 0.032±4.0 | 2.14±5.3 | | $^{3}H$(0.31±14.4) |
| 10156535 | Messerschmidia argentea | 9.04±5.4 | | | 0.626±2.8 | 1.657±3.2 | | |
| 10156635 | Scaevola frutescens | 11.83±4.0 | | | 0.617±2.9 | 1.475±2.8 | | |
| 10156735 | Cocos nucifera | 5.505±8.6 | | | | 3.451±2.5 | | |
| 10156835 | Pandanus tectorius | 8.856±6.6 | 0.41±13.0 | | 25.14±3.0 | 3.091±2.4 | 0.002±22.0 | |
| 11906335 | Rattus rattus viscera | 11.19±6.0 | | 1.39±6.3 | 0.16±1.0 | 19.0±1.0 | 0.0074±14.0 | |
| 11907235 | Rattus rattus muscle | 10.3±6.2 | 0.10±29.0 | | 0.06±4.0 | 18.4±1.0 | 0.016±31.0 | $^{3}H$ (11.3±1.3) |
| 11907435 | Rattus rattus liver | 11.1±12.0 | 0.93±36.0 | | 0.018±15.0 | 15.6±2.0 | | |
| 11907735 | Rattus rattus hide | 6.5±8.7 | | | | 7.6±1.7 | | |
| 11909235 | Rattus rattus lungs | 14.7±20.1 | | | 1.0±4.0 | 16.9±3.8 | 0.14±10.0 | |
| 11909335 | Rattus rattus kidney | 21.8±9.5 | | 1.74±8.7 | | 15.0±2.3 | | |
| 11916335 | Rattus rattus bone | 9.04±7.2 | | | 1.42±5.0 | 9.96±2.4 | 0.23±6.0 | |
| **WALT** | | | | | | | | |
| 10411036 | Guettarda speciosa | 9.82±4.0 | | | | 0.18±10.3 | | |
| 10411136 | Scaevola frutescens | 6.986±8.2 | | | | 1.44±2.4 | | |

Table 59 (continued).

| Sample No. | Type | $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| | | Radionuclide concentration levels, pCi/g ovendry wt (error, %) | | | | | | |
| ELMER | | | | | | | | |
| 10156235 | Messerschmidia argentea | | | | 0.982±2.5 | 2.386±5.0 | | |
| 10156335 | Scaevola frutescens | 13.6±9.2 | | | 0.272±4.8 | 2.405±5.1 | | |
| 10156435 | Cocos nucifera | 9.734±12.4 | | | 0.032±4.0 | 2.14±5.3 | | $^{3}H$(0.31±14.4) |
| 10156535 | Messerschmidia argentea | 9.04±5.4 | | | 0.626±2.8 | 1.657±3.2 | | |
| 10156635 | Scaevola frutescens | 11.83±4.0 | | | 0.617±2.9 | 1.475±2.8 | | |
| 10156735 | Cocos nucifera | 5.505±8.6 | | | | 3.451±2.5 | | |
| 10156835 | Pandanus tectorius | 8.856±6.6 | 0.41±13.0 | | 25.14±3.0 | 3.091±2.4 | 0.002±22.0 | |
| 11906335 | Rattus rattus viscera | 11.19±6.0 | | 1.39±6.3 | 0.16±1.0 | 19.0±1.0 | 0.0074±14.0 | |
| 11907235 | Rattus rattus muscle | 10.3±6.2 | 0.10±29.0 | | 0.06±4.0 | 18.4±1.0 | 0.016±31.0 | $^{3}H$ (11.3±1.3) |
| 11907435 | Rattus rattus liver | 11.1±12.0 | 0.93±36.0 | | 0.018±15.0 | 15.6±2.0 | | |
| 11907735 | Rattus rattus hide | 6.5±8.7 | | | | 7.6±1.7 | | |
| 11909235 | Rattus rattus lungs | 14.7±20.1 | | | 1.0±4.0 | 16.9±3.8 | 0.14±10.0 | |
| 11909335 | Rattus rattus kidney | 21.8±9.5 | | 1.74±8.7 | | 15.0±2.3 | | |
| 11916335 | Rattus rattus bone | 9.04±7.2 | | | 1.42±5.0 | 9.96±2.4 | 0.23±6.0 | |
| WALT | | | | | | | | |
| 10411036 | Guettarda speciosa | 9.82±4.0 | | | | 0.18±10.3 | | |
| 10411136 | Scaevola frutescens | 6.986±8.2 | | | | 1.44±2.4 | | |

Radionuclide concentration levels, pCi/g ovendry wt (error, %)

| Sample No. | Type | $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| WALT | | | | | | | | |
| 10411236 | *Messerschmidia argentea* | 6.658±7.6 | | | | 0.38±8.3 | | |
| FRED | | | | | | | | |
| 10000637 | *Messerschmidia argentea* | 11.23±6.2 | | | 0.43±4.6 | 0.558±7.5 | | |
| 10008637 | *Scaevola frutescens* | 10.36±6.8 | | | 0.234±6.8 | 0.652±7.2 | 0.0006±11.0 | |
| 10155837 | *Messerschmidia argentea* | 8.829±5.1 | | | 0.487±3.2 | 1.78±2.5 | | |
| 10188837 | *Cocos nucifera* | 6.387±6.7 | | | 0.0296±7.0 | 2.386±3.6 | | $^{3}H$(0.39±11.6) |
| 10188937 | *Scaevola frutescens* | 7.14±6.6 | | | 0.806±3.3 | 3.801±2.3 | | |
| 10189037 | *Cocos nucifera* | 5.59±6.9 | | | 0.367±18.0 | 0.53±6.0 | | |
| 10466937 | *Pandanus tectorius* | 3.382±13.1 | 0.85±6.0 | | 0.422±2.0 | 4.29±2.3 | 0.0077±38.0 | |
| GLENN | | | | | | | | |
| 10021238 | *Cocos nucifera* | 6.13±6.1 | | | 0.02±4.0 | 0.87±3.7 | | |
| 10370538 | *Messerschmidia argentea* | 9.752±6.1 | | | 2.51±1.6 | 1.27±4.1 | | |
| 10370638 | *Cocos nucifera* | 8.279±4.9 | | | | 1.3±2.9 | | |
| 10370738 | *Scaevola frutescens* | 13.74±5.2 | | | 1.342±5.0 | 0.53±8.0 | | |
| 10370838 | *Pisonia grandis* | 30.28±3.5 | | | 1.74±3.0 | 3.91±2.3 | | |
| 11902638 | *Coenobita perlatus* hepatopancreas and gonad | 8.68±11.4 | 1.55±7.0 | 1.124±11.2 | 0.432±8.0 | 1.51±6.8 | 0.006±32 | |
| 10008038 | *Morinda citrifolia* | 15.7±3.1 | | | 0.405±5.3 | 0.450±5.0 | | |
| 10008138 | *Pisonia grandis* | 25.79±4.3 | 0.81±19.0 | | 2.88±2.2 | 1.86±3.8 | | $^{102}Rh$ (0.17±21.2) |
| 10008238 | *Cocos nucifera* | 7.527±9.1 | | | 0.326±6.8 | 1.655±4.1 | | |
| 10008338 | *Morinda citrifolia* | 22.29±4.3 | | | 1.58±3.0 | 0.638±7.2 | | |

Table 59 (continued).

| Sample No. | Type | $^{40}$K | $^{55}$Fe | $^{60}$Co | $^{90}$Sr | $^{137}$Cs | $^{239,240}$Pu | Other |
|---|---|---|---|---|---|---|---|---|
| | | Radionuclide concentration levels, pCi/g ovendry wt (error, %) | | | | | | |
| GLENN | | | | | | | | |
| 10008438 | Messerschmidia argentea | 21.81±4.7 | | | 2.05±1.8 | 1.245±4.9 | | |
| 10008538 | Scaevola frutescens | 12.84±5.7 | | | 1.54±2.2 | 0.637±7.0 | | |
| 11903338 | Coenobita perlatus muscle | 7.856±11.3 | 1.32±18.0 | 1.97±7.5 | 0.91±5.0 | 1.51±6.6 | 0.11±7.0 | |
| 11903438 | Coenobita perlatus exoskeleton | 1.519±19.2 | | | 9.14±2.0 | 0.252±10.3 | 0.0011±14.0 | |
| 11905338 | Birgus latro muscle | 10.45±7.1 | 0.68±13.0 | | | 1.88±3.7 | | $^{3}$H (0.69±4.8) |
| 11905438 | Birgus latro exoskeleton | 1.06±29.0 | | | 10.4±1.0 | 0.313±9.3 | 0.0035±10.0 | |
| 11905538 | Birgus latro hepatopancreas and gonad | 2.338±15.0 | | 0.276±15.7 | 0.269±3.0 | 0.545±6.1 | | $^{3}$H (0.27±10.7) |
| 11906538 | Rattus exulans viscera | 11.75±6.4 | | 2.06±5.3 | 0.28±6.0 | 1.88±4.0 | 0.036±13.0 | |
| 11910738 | Rattus exulans liver | 12.79±10.2 | 19.28±4.0 | 1.81±6.9 | | 1.455±8.5 | 0.035±6.0 | |
| 11915638 | Rattus exulans bone | 10.61±9.0 | | 0.711±15.8 | 2.67±2.0 | 6.02±2.2 | 0.87±4.0 | |
| 11915738 | Rattus exulans muscle | 8.18±8.3 | 4.49±4.0 | 0.48±15.4 | 1.03±3.0 | 1.76±3.7 | 0.017±7.0 | |
| 10021538 | Pisonia grandis wood | 7.26±7.8 | | | | 0.37±10.2 | | |
| 11905638 | Birgus latro skin, gills, green gland | 7.35±18.6 | | 0.83±22.8 | | 1.74±7.8 | | |
| 11906438 | Rattus exulans hide | 2.3±11.9 | | | | 0.33±8.0 | | |
| 11912438 | Rattus exulans kidney | | | 2.4±14.0 | | 1.46±19.1 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Rattus exulans hide | [illegible] | | | | [illegible] | | |
| 11912438 | Rattus exulans kidney | | | 2.4±14.0 | | 1.46±19.1 | | |

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| GLENN | | | | | | | | |
| 11912538 | Rattus exulans lungs | 20.7±11.9 | | | | 1.74±11.0 | 0.30±7.0 | |
| HENRY | | | | | | | | |
| 10020739 | Messerschmidia argentea | 12.77±5.8 | | | 1.98±2.9 | 0.52±8.0 | | |
| 10021039 | Lepturus repens | 11.29±7.1 | | | 0.059±13.0 | 0.099±37.4 | 0.0021±20.0 | |
| 10021439 | Scaevola frutescens | 12.64±5.8 | | | | 0.195±17.1 | | |
| 10021639 | Morinda citrifolia | 17.3±3.3 | | | 0.325±5.1 | 1.28±3.2 | | |
| 10022739 | Cocos nucifera | 3.39±5.5 | | | | 0.59±2.5 | | |
| 11902239 | Coenobita perlatus hepatopancreas and gonad | 5.725±9.9 | | 0.98±8.4 | 0.496±3.0 | 1.17±5.3 | | |
| 11903539 | Coenobita perlatus muscle | 7.694±7.8 | 0.98±12.0 | 1.996±5.2 | 0.64±1.0 | 1.08±5.5 | 0.0066±7.0 | |
| 11903639 | Coenobita perlatus exoskeleton | 2.344±13.5 | 0.08±17.0 | | 9.64±1.0 | 0.24±10.5 | 0.0009±20.0 | |
| 11912139 | Anous stolidus egg | 3.385±9.9 | 54.1±2.0 | | | | | $^{65}Zn$ (0.79±23.1) |
| 11912039 | Anous stolidus eggshell | | 8.6±1.9 | | | | | |
| IRWIN | | | | | | | | |
| 10245040 | Messerschmidia argentea | 13.54±5.9 | | | 1.73±2.6 | 0.533±8.6 | | |
| 10245140 | Pisonia grandis | 21.77±4.1 | | | 0.595±5.4 | 1.88±3.3 | 0.0015±15.0 | |
| 10245240 | Cocos nucifera | 6.995±7.0 | | | | 0.329±9.5 | | |
| 10245340 | Terminalia samoensis | 11.36±5.8 | | | 0.923±4.6 | 0.772±5.7 | 0.0013±7.9 | |
| 11901240 | Anous stolidus egg | 7.49±10.2 | 5.14±6.0 | | | | 0.0009±21.0 | |

Table 59 (continued).

| Sample No. | Type | $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| | | Radionuclide concentration levels, pCi/g ovendry wt (error, %) | | | | | | |
| IRWIN | | | | | | | | |
| 11902340 | Coenobita perlatus hepatopancreas and gonad | 7.752±9.3 | 1.78±5.0 | 0.893±10.0 | 0.446±4.0 | 0.579±10.0 | 0.0053±13.0 | |
| 11903740 | Coenobita perlatus muscle | 6.743±9.3 | 0.75±17.0 | 1.77±6.2 | 0.309±4.0 | 0.553±10.0 | 0.01248±13.0 | |
| 11903840 | Coenobita perlatus exoskeleton | 2.73±13.9 | 0.11±11.0 | | 4.78±1.0 | 0.098±24.6 | 0.00078±19.0 | |
| 11918640 | Anous stolidus liver | 15.84±14.5 | 423±2.0 | 0.63±22.4 | 0. 23±15.0 | | 0.0242±26.0 | |
| 11922540 | Anous stolidus | 9.279±15.9 | 169±2.0 | 0.61±27.9 | | | 0.0434±8.0 | |
| 11927040 | Anous stolidus bone | | 49.1±5.3 | | | | | |
| 11900340 | Anous stolidus eggshell | | | | | | | |
| 11920640 | Anous stolidus viscera | | 46.0±9.9 | | | | | |
| JAMES | | | | | | | | |
| 10242541 | Messerschmidia argentea | 17.7±3.5 | | 0.25±23.3 | | 1.76±2.7 | | |
| 10242641 | Pisonia grandis | 12.66±5.8 | | | | 1.55±3.9 | | |
| 10242741 | Guettarda speciosa | 13.74±5.7 | | | | 0.683±6.9 | | |
| 10242841 | Morinda citrifolia | 16.99±5.2 | | | 1.85±3.5 | 2.23±3.4 | | |
| 10242941 | Scaevola frutescens | 9.419±7.6 | | | | 0.517±8.8 | | |
| 11905741 | Birgus latro muscle | 9.617±6.2 | 1.84±6.0 | 1.05±8.7 | 0.079±5.0 | 1.25±4.1 | | |
| 11905841 | Birgus latro exoskeleton | 1.445±18.2 | 0.30±8.0 | 0.11±4.5 | 5.9±2.0 | 0.223±10.4 | 0.00195±12.0 | |
| 11905941 | Birgus latro hepatopancreas and gonad | 4.005±12.8 | 12.8±2.0 | 1.56±6.6 | | 0.317±14.2 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | muscle | | | | | | | |
| 11905841 | Birgus latro exoskeleton | 1.445±18.2 | 0.30±8.0 | 0.11±4.5 | 5.9±2.0 | 0.223±10.4 | 0.00195±12.0 | |
| 11905941 | Birgus latro hepatopancreas and gonad | 4.005±12.8 | 12.8±2.0 | 1.56±6.6 | | 0.317±14.2 | | |

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| JAMES | | | | | | | | |
| 11906041 | Birgus latro skin, gills, green gland | 7.13±20.1 | | 2.3±9.6 | | 1.15±11.2 | | |
| 11906141 | Birgus latro miscellany | 5.35±16.2 | | 0.98±15.5 | | 0.79±10.4 | | |
| KEITH | | | | | | | | |
| 10226942 | Pandanus tectorius | 12.7±5.9 | 12.2±3.0 | | 13.11±4.0 | 0.86±6.1 | | $^{3}H$(2.0±4.0) |
| 10243042 | Messerschmidia argentea | 12.45±5.8 | | 0.20±24.6 | 0.318±9.2 | 0.255±14.0 | 0.00445±27.0 | |
| 10243142 | Pisonia grandis | 30.81±3.6 | | | 3.0±2.6 | 3.65±2.4 | | |
| 10243242 | Cocos nucifera | 7.689±6.6 | | | | 0.95±4.5 | | |
| 10243342 | Guettarda speciosa | 12.87±5.7 | | | 1.74±4.6 | 0.471±8.7 | | |
| 10243442 | Pandanus tectorius | 8.18±5.2 | 0.36±29.0 | | | 0.569±5.4 | | |
| 10243542 | Scaevola frutescens | 15.52±8.2 | | | 0.64±4.6 | 0.427±17.4 | | |
| 11904442 | Birgus latro muscle | 10.11±6.0 | 1.46±6.0 | 0.42±13.2 | 1.19±4.0 | 1.92±3.2 | | |
| 11904542 | Birgus latro exoskeleton | 3.349±12.4 | 0.18±10.0 | | 9.96±1.0 | 0.512±8.1 | 0.00067±26.0 | |
| 11904642 | Birgus latro hepatopancreas and gonad | 3.205±13.3 | 6.17±3.0 | 1.03±8.1 | 0.401±6.0 | 0.496±8.6 | 0.0098±6.0 | |
| 11920742 | Anous stolidus viscera | 8.968±16.3 | 80.2±3.0 | | | | | |
| 11922642 | Anous stolidus muscle | 12.96±7.9 | | 0.452±20.9 | | | 0.001±18.0 | |
| 11927142 | Anous stolidus bone | 3.797±31.6 | 68.5±3.4 | 0.312±23.5 | | | | |
| 11918742 | Anous stolidus liver | | | 0.69±17.5 | | | | |

Table 59 (continued).

| Sample No. | Type | $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| | | Radionuclide concentration levels, pCi/g ovendry wt (error, %) | | | | | | |
| KEITH | | | | | | | | |
| 11904742 | *Birgus latro* skin, gills, green gland | 7.37±13.2 | | 2.54±7.0 | | 3.87±3.2 | | |
| 11904842 | *Birgus latro* shell, gills, dust, gut blood | 11.4±18.4 | | | | 1.60±11.6 | | |
| LEROY | | | | | | | | |
| 10020443 | *Pandanus tectorius* | 7.995±7.9 | 0.21±16.0 | | 1.69±3.0 | 9.14±1.5 | 0.0022±11.0 | |
| 10020343 | *Pandanus tectorius* fruit | 30.2±4.9 | | | 16.26±1.0 | 26.2±1.1 | | |
| 10020143 | *Scaevola frutescens* | 13.29±5.6 | | | 3.74±1.3 | 1.80±3.6 | | |
| 10020243 | *Pisonia grandis* | 34.27±3.4 | | | 14.86±1.0 | 10.17±14.0 | | |
| 10020943 | *Messerschmidia argentea* | 15.09±5.3 | | 0.21±25.5 | 14.37±1.0 | 4.71±2.1 | | |
| 10022543 | *Cocos nucifera* | 4.07±5.1 | | | 0.189±5.0 | 3.83±1.9 | | $^{102}Rh$ (0.13±24.9) |
| 11904943 | *Birgus latro* muscle | 8.797±5.9 | 1.59±5.0 | 1.234±6.5 | 1.577±2.0 | 12.6±1.0 | 0.0031±19.0 | $^{3}H$ (0.88±3.4) |
| 11905043 | *Birgus latro* exoskeleton | 1.579±19.9 | 0.17±10.0 | 0.171±21.3 | 89.6±1.0 | 2.52±2.2 | 0.025±17.0 | |
| 11905143 | *Birgus latro* hepatapancreas and gonad | 2.47±11.8 | 5.05±3.0 | 0.45±8.2 | 2.58±2.0 | 3.67±1.4 | 0.0038±21.0 | $^{3}H$ (0.21±14.8) |
| 11917143 | *Anous tenuirostris* muscle | 10.95±10.4 | 64.4±2.0 | 2.065±8.4 | | | 0.0033±22.0 | |
| 11918843 | *Anous tenuirostris* liver | | 810.8±2.0 | 2.83±13.7 | 0.402±9.0 | | 0.0072±31.0 | |
| 11920843 | *Anous tenuirostris* viscera | 7.824±19.0 | 71.6±1.3 | 1.01±15.6 | | | | |

| | | | | |
|---|---|---|---|---|
| 11920843 | Anous tenuirostris viscera | 7.824±19.0 | 71.6±1.3 | 1.01±15.6 |

Table 59 (continued).

| Sample No. | Type | Radionuclide concentration levels, pCi/g ovendry wt (error, %) $^{40}K$ | $^{55}Fe$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|---|
| LEROY | | | | | | | | |
| 11927243 | Anous tenuirostris bone | | 109.5±4.4 | 0.94±22.3 | | | | |
| 11905243 | Birgus latro miscellany | 5.16±12.1 | | 1.78±5.6 | | 11.14±1.2 | | |

Table 60. Radionuclide concentrations in *Messerschmidia argentea* collected at Enewetak Atoll, 1972-1973.

| Island | Activity, pCi/g, dry wt | | | | |
|---|---|---|---|---|---|
| | $^{40}K$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ |
| ALICE | 13.38 | ---- | 138.3 | 222.8 | 0.025 |
| BELLE | 15.86 | ---- | 25.2 | 5.83 | 0.036 |
| CLARA | 13.33 | ---- | 127.5 | 149.10 | ---- |
| DAISY | 11.10 | 1.45 | 12.21 | 5.90 | 0.055 |
| EDNA | 11.1 | 0.24 | ---- | 6.73 | ---- |
| IRENE | 13.04 | 23.86 | 536.0 | 62.60 | ---- |
| IRENE | 18.16 | ---- | ---- | 2.20 | 0.004 |
| IRENE | 14.61 | 2.77 | 21.76 | 4.10 | 0.0157 |
| IRENE | 12.74 | 3.39 | 159.0 | 407.30 | 0.002 |
| IRENE (wood) | 1.94 | 1.59 | 16.98 | 13.02 | 0.006 |
| JANET | 12.72 | ---- | 18.4 | 36.42 | 0.015 |
| JANET | 10.50 | ---- | 46.4 | 385.80 | 0.003 |
| JANET | 9.95 | ---- | 43.51 | 124.80 | 0.005 |
| JANET | 14.25 | ---- | 48.20 | 299.40 | 0.004 |
| JANET | 12.17 | ---- | 83.78 | 298.70 | 0.005 |
| JANET | 15.30 | ---- | 121.2 | 158.30 | 0.003 |
| JANET | 10.43 | 0.22 | 106.0 | 526.10 | ---- |
| JANET | 18.32 | 0.25 | 40.36 | 545.90 | 0.010 |
| JANET | 13.29 | ---- | 45.75 | 322.70 | ---- |
| KATE | 9.62 | ---- | 3.75 | 4.26 | 0.005 |
| LUCY | 10.73 | ---- | ---- | 6.36 | ---- |
| MARY | 13.24 | ---- | 7.57 | 7.12 | ---- |
| MARY/NANCY | 12.62 | 0.67 | ---- | 55.05 | ---- |
| NANCY | 7.81 | ---- | 27.30 | 40.24 | 0.023 |
| OLIVE | 10.73 | ---- | ---- | 9.54 | ---- |
| PEARL | 14.66 | ---- | 0.47 | 0.29 | ---- |
| RUBY | 9.19 | 0.99 | ---- | 19.19 | ---- |
| RUBY | 6.23 | 0.90 | ---- | 39.01 | ---- |
| SALLY | 8.28 | 0.10 | 4.86 | 12.63 | 0.059 |
| TILDA | 10.13 | ---- | 10.27 | 58.78 | ---- |
| URSULA | 10.09 | ---- | 13.60 | 104.90 | ---- |
| VERA | 7.07 | ---- | 12.79 | 10.77 | 0.002 |
| WILMA | 5.00 | ---- | ---- | 6.19 | ---- |

Table 60 (continued).

| Island | Activity, pCi/g, dry wt | | | | |
|---|---|---|---|---|---|
| | $^{40}K$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ |
| YVONNE | 14.19 | ---- | 0.64 | 2.28 | 0.004 |
| YVONNE | 14.26 | ---- | 1.43 | 3.81 | 0.011 |
| YVONNE | 10.91 | ---- | 8.60 | 95.30 | 0.129 |
| YVONNE | 10.33 | ---- | 1.94 | 17.30 | 0.766 |
| YVONNE | 9.33 | 1.16 | 257.20 | 5644.00 | 0.114 |
| TOM | 9.16 | ---- | ---- | 0.26 | ---- |
| VAN | 6.81 | ---- | ---- | 0.34 | ---- |
| URIAH | 11.90 | ---- | ---- | 0.73 | ---- |
| ALVIN | 11.57 | ---- | ---- | 0.85 | ---- |
| BRUCE | 8.03 | ---- | 0.33 | 1.16 | ---- |
| CLYDE | 10.90 | ---- | ---- | 0.43 | ---- |
| DAVID | 13.55 | ---- | 0.46 | 1.09 | 0.0061 |
| DAVID | 11.02 | ---- | 0.76 | 7.24 | ---- |
| DAVID | 13.22 | ---- | 1.06 | 2.58 | ---- |
| DAVID | 3.88 | ---- | 0.75 | 15.84 | ---- |
| REX | 8.89 | ---- | ---- | 2.45 | ---- |
| ELMER | ---- | ---- | 0.98 | 2.39 | ---- |
| ELMER | 9.04 | ---- | 0.63 | 1.66 | ---- |
| WALT | 6.66 | ---- | ---- | 0.38 | ---- |
| FRED | 11.23 | ---- | 0.43 | 0.56 | ---- |
| FRED | 8.83 | ---- | 0.49 | 1.78 | ---- |
| GLENN | 21.81 | ---- | 2.05 | 1.24 | ---- |
| GLENN | 9.75 | ---- | 2.51 | 1.27 | ---- |
| HENRY | 12.77 | ---- | 1.98 | 0.52 | ---- |
| IRWIN | 13.54 | 0.25 | 1.73 | 0.53 | ---- |
| JAMES | 17.95 | ---- | ---- | 1.76 | ---- |
| KEITH | 12.45 | 0.20 | 0.32 | 0.25 | ---- |
| LEROY | 15.09 | ---- | 14.37 | 4.71 | ---- |

Table 61. Radionuclide concentrations in Scaevola frutescens collected at Enewetak Atoll, 1972-1973.

| | Activity, pCi/g, dry wt | | | | | |
|---|---|---|---|---|---|---|
| Island | $^{40}K$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | $^{55}Fe$ |
| ALICE | 12.82 | ---- | 32.7 | 66.53 | ---- | ---- |
| BELLE | 12.45 | ---- | 2.27 | 1.42 | 0.072 | ---- |
| CLARA | 12.37 | ---- | 51.80 | 51.04 | 0.048 | 3.37 |
| DAISY | 20.26 | 0.48 | 50.9 | 38.80 | 0.046 | ---- |
| IRENE | 17.09 | 47.40 | 110.40 | 43.14 | 0.0044 | 33.7 |
| IRENE | 14.08 | ---- | 1.14 | 1.67 | 0.031 | ---- |
| IRENE | 12.68 | 17.07 | 8.56 | 4.28 | 0.028 | 26.4 |
| IRENE | 10.41 | 21.14 | 57.21 | 205.20 | 0.003 | ---- |
| IRENE (wood) | 1.82 | 0.91 | 4.60 | 2.22 | 0.003 | ---- |
| JANET | 17.44 | ---- | 12.16 | 30.50 | 0.016 | ---- |
| JANET | 18.12 | ---- | 36.93 | 258.60 | ---- | ---- |
| JANET | 14.31 | ---- | 17.34 | 63.29 | ---- | ---- |
| JANET | 13.65 | 0.45 | 35.72 | 223.40 | 0.003 | ---- |
| JANET | 16.73 | ---- | 31.53 | 294.60 | 0.010 | ---- |
| JANET | 12.96 | 0.21 | 32.66 | 54.95 | 0.007 | ---- |
| JANET | 20.57 | 0.24 | 83.33 | 405.90 | 0.004 | ---- |
| JANET | 18.28 | ---- | 16.61 | 134.10 | 0.005 | ---- |
| KATE | 14.60 | ---- | ---- | 16.36 | ---- | ---- |
| LUCY | 13.01 | ---- | ---- | 12.73 | ---- | ---- |
| MARY | 16.14 | ---- | 16.76 | 12.77 | ---- | ---- |
| NANCY | 10.74 | ---- | 11.89 | 4.12 | 0.012 | 0.05 |
| OLIVE | 13.30 | ---- | ---- | 4.35 | ---- | ---- |
| PEARL | 16.50 | ---- | 0.35 | 0.34 | ---- | ---- |
| PEARL | 12.52 | 0.16 | 20.99 | 30.82 | ---- | ---- |
| SALLY | 10.78 | ---- | 6.67 | 13.38 | 0.096 | ---- |
| TILDA | 11.39 | ---- | 9.05 | 24.94 | 0.0042 | ---- |
| URSULA | 5.45 | ---- | 6.13 | 91.49 | ---- | ---- |
| URSULA | 13.47 | ---- | ---- | 0.29 | ---- | ---- |
| VERA | 8.18 | ---- | 4.49 | 1.69 | ---- | ---- |
| WILMA | 10.31 | ---- | ---- | 1.24 | ---- | ---- |

Table 61 (continued).

| Island | Activity, pCi/g, dry wt | | | | | |
|---|---|---|---|---|---|---|
| | $^{40}K$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | $^{55}Fe$ |
| YVONNE | 13.20 | 0.511 | 1.76 | 11.88 | 0.026 | ---- |
| YVONNE | 14.16 | ---- | 0.44 | 1.57 | 0.004 | ---- |
| YVONNE | 15.00 | 0.25 | 0.66 | 8.06 | 1.293 | ---- |
| YVONNE | 10.68 | 20.26 | 159.00 | 609.90 | 0.323 | ---- |
| YVONNE | 15.93 | ---- | 1.94 | 28.25 | 0.190 | ---- |
| YVONNE | 18.77 | 6.26 | 80.63 | 658.00 | 0.196 | ---- |
| TOM | 11.49 | ---- | ---- | 0.73 | ---- | ---- |
| VAN | 7.11 | ---- | ---- | 0.73 | ---- | ---- |
| BRUCE | 9.32 | ---- | 0.88 | 9.75 | ---- | ---- |
| CLYDE | 11.19 | ---- | ---- | 0.27 | ---- | ---- |
| DAVID | 17.59 | ---- | 0.34 | 1.11 | 0.0005 | ---- |
| DAVID | 10.69 | ---- | 0.37 | 4.82 | ---- | ---- |
| DAVID | 13.02 | ---- | 0.31 | 5.80 | ---- | ---- |
| DAVID | 16.33 | ---- | 0.56 | 2.01 | ---- | ---- |
| REX | 6.94 | ---- | ---- | 0.49 | ---- | ---- |
| ELMER | 13.60 | ---- | 0.27 | 2.40 | ---- | ---- |
| ELMER | 11.83 | ---- | 0.62 | 1.47 | ---- | ---- |
| WALT | 6.99 | ---- | ---- | 1.44 | ---- | ---- |
| FRED | 10.36 | ---- | 0.23 | 0.65 | 0.0006 | ---- |
| FRED | 7.14 | ---- | 0.81 | 3.80 | ---- | ---- |
| GLENN | 12.84 | ---- | 1.54 | 0.64 | ---- | ---- |
| GLENN | 13.74 | ---- | 1.34 | 0.53 | ---- | ---- |
| HENRY | 12.64 | ---- | ---- | 0.19 | ---- | ---- |
| HENRY | 9.42 | ---- | ---- | 0.52 | ---- | ---- |
| KEITH | 15.52 | ---- | 0.64 | 0.43 | ---- | ---- |
| LEROY | 13.29 | ---- | 3.74 | 1.80 | ---- | ---- |

Table 62. Mean concentrations of $^{137}Cs$ and $^{90}Sr$ in Messerschmidia and Scaevola on IRENE, JANET, and YVONNE.

| Island | Mean $^{137}Cs$ concentration, pCi/g, dry wt | |
|---|---|---|
| | Messerschmidia | Scaevola |
| IRENE | 93.84 | 51.29 |
| JANET | 299.79 | 183.16 |
| YVONNE | 1152.53[a] | 219.61 |
| | **Mean $^{90}Sr$ concentration, pCi/g, dry wt** | |
| | Messerschmidia | Scaevola |
| IRENE | 82.20 | 57.21[b] |
| JANET | 61.51 | 33.29 |
| YVONNE | 53.96 | 40.72 |

[a]One high value of 5644 pCi/g influences this value (N = 5, see Table 60).
[b]N = 1.

Table 63. Radionuclide concentrations in Cocos nucifera collected at Enewetak Atoll, 1972-1973.

| Island | Activity, pCi/g, dry wt | | | | | |
|---|---|---|---|---|---|---|
| | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{55}Fe$ | $^{239,240}Pu$ | $^{3}H$ |
| DAISY | 5.65 | 7.17 | 0.195 | ---- | ---- | ---- |
| DAISY[a] | 45.50 | ---- | 1.405 | ---- | ---- | ---- |
| IRENE[a] | 99.90 | 5.11 | 1.610 | 86.49 | ---- | ---- |
| IRENE | 7.05 | 1.77 | 0.067 | ---- | 0.036 | ---- |
| JANET | 8.04 | 84.68 | 0.210 | ---- | ---- | 0.34 |
| JANET[a] | 60.05 | 210.70 | 1.570 | ---- | ---- | ---- |
| MARY | 7.52 | 14.27 | 0.136 | 1.18 | ---- | ---- |
| MARY[a] | 39.25 | 67.75 | 0.635 | ---- | ---- | ---- |
| MARY | 3.75 | 5.59 | 14.140 | 76.58 | ---- | ---- |
| NANCY | 6.54 | 18.83 | 0.167 | 1.95 | ---- | ---- |
| NANCY[a] | 73.51 | 148.80 | 1.150 | 5.95 | ---- | ---- |
| VERA | 5.64 | 9.30 | 0.134 | ---- | ---- | ---- |
| YVONNE | 6.39 | 1.99 | ---- | ---- | ---- | ---- |
| YVONNE | 8.24 | 3.96 | 0.011 | ---- | ---- | 0.66 |
| BRUCE | 5.93 | 0.58 | ---- | ---- | ---- | ---- |
| DAVID | 6.44 | 2.59 | 0.014 | ---- | ---- | 0.31 |
| DAVID | 3.76 | 1.67 | 0.178 | ---- | ---- | ---- |
| DAVID | 4.69 | 0.40 | 0.026 | ---- | ---- | ---- |
| DAVID[a] | 30.93 | 23.32 | ---- | ---- | ---- | ---- |
| ELMER | 9.73 | 2.14 | 0.032 | ---- | ---- | 0.31 |
| ELMER | 5.50 | 3.45 | ---- | ---- | ---- | ---- |
| FRED | 6.39 | 2.39 | 0.029 | ---- | ---- | 0.39 |
| FRED | 5.59 | 0.53 | 0.367 | ---- | ---- | ---- |
| GLENN | 7.53 | 1.65 | 0.326 | ---- | ---- | ---- |
| GLENN | 6.12 | 0.86 | 0.020 | ---- | ---- | ---- |
| GLENN | 8.28 | 1.30 | ---- | ---- | ---- | ---- |
| HENRY | 3.95 | 0.70 | ---- | ---- | ---- | ---- |
| KEITH | 7.69 | 0.95 | ---- | ---- | ---- | ---- |
| LEROY | 4.12 | 3.54 | 0.189 | ---- | ---- | ---- |

[a]Milk.

Table 64. Radionuclide concentrations in *Morinda citrifolia* collected at Enewetak Atoll, 1972-1973.

| Island | Activity, pCi/g, dry wt | | | | | |
|---|---|---|---|---|---|---|
| | $^{40}K$ | $^{137}Cs$ | $^{60}Co$ | $^{90}Sr$ | $^{239,240}Pu$ | $^{55}Fe$ |
| KATE | 14.50 | 34.09 | ---- | 23.56 | 0.0010 | ---- |
| MARY | 16.27 | ---- | ---- | 45.05 | 0.0340 | ---- |
| MARY[a] | 12.45 | 192.30 | ---- | 4.01 | 0.0120 | ---- |
| MARY[a] | 13.45 | 97.43 | 0.057 | 3.35 | 0.0022 | ---- |
| NANCY | 11.16 | 55.05 | ---- | 43.47 | 0.0056 | ---- |
| OLIVE[a] | 18.74 | 30.42 | ---- | 4.48 | ---- | ---- |
| OLIVE | 12.48 | 66.58 | 0.33 | 37.66 | 0.011 | 0.063 |
| OLIVE | 18.73 | 29.57 | ---- | 39.50 | ---- | ---- |
| TILDA | 13.94 | 13.90 | ---- | 12.48 | ---- | ---- |
| VERA | 10.46 | 12.12 | ---- | 11.85 | ---- | ---- |
| DAVID | 12.82 | 4.10 | ---- | 0.02 | 0.013 | ---- |
| GLENN | 22.29 | 0.64 | ---- | 1.58 | ---- | ---- |
| GLENN | 19.16 | .58 | ---- | 0.40 | ---- | ---- |
| HENRY | 17.50 | 1.26 | ---- | 0.32 | ---- | ---- |
| IRWIN | 6.99 | 0.33 | ---- | ---- | ---- | ---- |
| JAMES | 16.99 | 2.23 | ---- | 1.85 | ---- | ---- |

[a]Fruit.

Table 65. Radionuclide concentrations in *Guettarda speciosa* collected at Enewetak Atoll, 1972-1973.

| Island | Activity, pCi/g, dry wt | | | | |
|---|---|---|---|---|---|
| | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{239,240}Pu$ | $^{60}Co$ |
| ALICE | 11.03 | 7.41 | ---- | ---- | ---- |
| BELLE | 12.48 | 109.10 | 152.7 | ---- | ---- |
| IRENE | 8.14 | 27.33 | 53.6 | ---- | 9.18 |
| MARY | 7.70 | 98.69 | 36.85 | ---- | ---- |
| NANCY | 8.79 | 8.73 | 30.86 | 0.0097 | ---- |
| TILDA | 10.10 | 5.90 | 12.57 | 0.0091 | ---- |
| URSULA | 14.23 | 13.27 | 7.30 | ---- | ---- |
| WILMA | 10.60 | 3.14 | ---- | ---- | ---- |
| YVONNE | 11.15 | 795.00 | 64.40 | 0.0253 | 4.52 |
| DAVID | 3.99 | 3.16 | 0.32 | ---- | ---- |
| WALT | 9.82 | 0.18 | ---- | ---- | ---- |
| JAMES | 13.74 | 0.68 | ---- | ---- | ---- |
| KEITH | 12.87 | 0.47 | 1.74 | ---- | ---- |

Table 66. Radionuclide concentrations in Pisonia grandis collected at Enewetak Atoll, 1972-1973.

| Island | Activity, pCi/g, dry wt | | | | | |
|---|---|---|---|---|---|---|
| | $^{40}K$ | $^{137}Cs$ | $^{60}Co$ | $^{90}Sr$ | $^{239,240}Pu$ | $^{55}Fe$ |
| KATE | 9.59 | 221.10 | 3.85 | 23.60 | 0.0045 | ---- |
| NANCY | 16.51 | 43.87 | 0.24 | 36.67 | 0.0195 | ---- |
| VERA | 28.58 | 56.94 | ---- | 23.11 | ---- | ---- |
| BRUCE | 17.76 | 1.46 | ---- | 0.50 | ---- | ---- |
| VAN | 12.92 | 1.99 | 0.17 | ---- | ---- | ---- |
| DAVID | 19.02 | 3.12 | ---- | 0.77 | 0.0013 | ---- |
| DAVID | 18.10 | 1.67 | ---- | 0.61 | ---- | ---- |
| DAVID | 10.2 | 1.80 | ---- | 0.56 | 0.0002 | ---- |
| REX | 16.00 | 2.64 | 0.091 | ---- | ---- | ---- |
| GLENN | 25.79 | 1.86 | ---- | 2.88 | ---- | 0.81 |
| GLENN | 30.28 | 3.91 | ---- | 1.74 | ---- | ---- |
| GLENN (wood) | 7.26 | 0.37 | ---- | ---- | ---- | ---- |
| IRWIN | 21.77 | 1.88 | ---- | 0.59 | 0.0015 | ---- |
| JAMES | 12.66 | 1.55 | ---- | ---- | ---- | ---- |
| KEITH | 30.81 | 3.65 | ---- | 3.00 | ---- | ---- |
| LEROY | 34.27 | 10.17 | ---- | 14.86 | ---- | ---- |

Table 67. Radionuclide concentrations in Pandanus tectorius collected at Enewetak Atoll, 1972-1973.

| Island | Activity, pCi/g, dry wt | | | | | |
|---|---|---|---|---|---|---|
| | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{239,240}Pu$ | $^{55}Fe$ | $^{3}H$ |
| BELLE (fruit) | 14.38 | 923.00 | 206.30 | ---- | ---- | 0.86 |
| BELLE (leaves) | 6.70 | 679.30 | ---- | ---- | 0.438 | ---- |
| JANET (leaves) | 8.12 | 0.62 | 4.41 | ---- | ---- | ---- |
| SALLY (leaves) | 14.02 | 14.98 | 1.97 | 0.015 | 0.703 | ---- |
| TILDA (leaves) | 13.29 | 152.20 | 15.50 | 0.0069 | 2.94 | ---- |
| VERA (leaves) | 9.17 | 17.58 | 4.24 | 0.0076 | ---- | ---- |
| DAVID (leaves) | 9.74 | 15.0 | 3.56 | ---- | 0.13 | ---- |
| ELMER (leaves) | 8.86 | 3.09 | 25.14 | 0.0020 | 0.41 | ---- |
| FRED (leaves) | 3.38 | 4.29 | 0.42 | 0.0077 | 0.85 | ---- |
| KEITH (leaves) | 12.70 | 0.86 | 13.11 | ---- | 12.2 | 2.0 |
| KEITH (leaves) | 8.18 | 0.57 | ---- | ---- | 0.36 | ---- |
| LEROY (leaves) | 7.99 | 9.14 | 1.69 | 0.0022 | 0.21 | ---- |
| LEROY (fruit) | 30.2 | 26.2 | 16.26 | ---- | ---- | ---- |

Table 68. Radionuclide concentrations in miscellaneous plant species collected at Enewetak Atoll, 1972-1973.

| Island | | Activity, pCi/g, dry wt | | | | | |
|---|---|---|---|---|---|---|---|
| | | $^{40}K$ | $^{137}Cs$ | $^{60}Co$ | $^{90}Sr$ | $^{239,240}Pu$ | $^{3}H$ |
| HELEN[a] | *Lepturus repens* | 4.90 | 2.51 | 0.94 | 1.44 | 0.0435 | ---- |
| IRENE[a] | *Lepturus repens* | 1.95 | 2.57 | 0.26 | 1.15 | 0.0112 | ---- |
| IRENE[b] | *Fimbristylis atollensis* | 4.87 | 55.00 | 14.70 | 4.42 | 0.8780 | ---- |
| IRENE[c] | *Suriana maritima* | 5.59 | 26.34 | 121.30 | 8.51 | 0.0286 | ---- |
| JANET[c] | *Pluchea odorata* | 10.80 | 1553.00 | 1.25 | 46.85 | ---- | ---- |
| MARY[a] | *Lepturus repens* | ---- | 105.70 | ---- | 17.39 | 0.0093 | ---- |
| SALLY[a] | *Lepturus repens* | 3.74 | 83.20 | ---- | 1.98 | 0.0227 | ---- |
| DAVID[d] | *Tacca leontopetaloides* | 6.63 | 1.09 | ---- | 0.46 | 0.0011 | 0.52 |
| DAVID[b] | *Fimbristylis atollensis* | 3.38 | 7.40 | ---- | ---- | ---- | ---- |
| HENRY[a] | *Lepturus repens* | 11.29 | 0.10 | ---- | 0.059 | 0.0021 | ---- |
| IRWIN[c] | *Terminalia samoensis* | 11.36 | 0.77 | ---- | 0.932 | 0.0013 | ---- |

[a]Grass.
[c]Shrub.
[b]Sedge.
[d]Herb.

Table 69. Radionuclide concentrations in Coenobita (hermit crab)[a] at Enewetak Atoll, 1972-1973.

| | Activity, pCi/g, dry wt | | | | | | |
|---|---|---|---|---|---|---|---|
| Island/organ | $^{40}K$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | $^{55}Fe$ | $^{3}H$ |
| LUCY | | | | | | | |
| Hepatop.[b] | 10.42 | 2.95 | ---- | 125.70 | ---- | ---- | ---- |
| Exoskel.[c] | ---- | 0.97 | ---- | 39.15 | ---- | ---- | ---- |
| IRENE | | | | | | | |
| Hepatop. | 7.04 | 82.80 | 29.60 | 124.30 | 0.196 | 12.8 | 0.58 |
| Muscle | 7.36 | 62.40 | 22.6 | 130.70 | 0.069 | 3.32 | ---- |
| Exoskel. | 1.94 | 1.66 | ---- | 27.20 | 0.017 | 0.32 | ---- |
| DAVID | | | | | | | |
| Hepatop. | 7.61 | 0.23 | 0.19 | 1.95 | 4.82 | 0.57 | 0.95 |
| Muscle | 7.52 | 0.28 | 0.33 | 2.06 | 0.0031 | ---- | 0.58 |
| Exoskel. | 1.76 | ---- | 4.05 | 0.60 | 0.010 | 0.039 | ---- |
| REX | | | | | | | |
| Hepatop. | 5.83 | 0.57 | 0.30 | 2.06 | 0.0031 | 1.82 | ---- |
| Muscle | 6.68 | 1.44 | 0.32 | 1.05 | 0.0026 | 1.47 | ---- |
| Exoskel. | 1.84 | ---- | 3.62 | 0.25 | 0.001 | 0.085 | ---- |
| GLENN | | | | | | | |
| Hepatop. | 8.68 | 1.12 | 0.43 | 1.51 | 0.006 | 1.55 | ---- |
| Muscle | 7.86 | 1.97 | 0.91 | 1.51 | 0.011 | 1.32 | ---- |
| Exoskel. | 1.52 | ---- | 9.14 | 0.25 | 0.001 | ---- | ---- |
| HENRY | | | | | | | |
| Hepatop. | 5.72 | 0.98 | 0.50 | 1.17 | ---- | ---- | ---- |
| Muscle | 7.69 | 2.00 | 0.64 | 1.08 | 0.0066 | 0.98 | ---- |
| Exoskel. | 2.34 | ---- | 9.64 | 0.24 | ---- | 0.08 | ---- |
| IRWIN | | | | | | | |
| Hepatop. | 7.75 | 0.89 | 0.45 | 0.58 | 0.0053 | 1.78 | ---- |
| Muscle | 6.74 | 1.77 | 0.31 | 0.55 | 0.0125 | 0.75 | ---- |
| Exoskel. | 2.73 | ---- | 4.78 | 0.01 | 0.0008 | 0.11 | ---- |

[a]Collection contained both C. perlatus and C. brevimannus.
[b]Hepatopancreas/gonad.
[c]Exoskeleton.

Table 70. Radionuclide concentrations in *Birgus latro* (coconut crab) collected at Enewetak Atoll, 1972-1973.

| | Activity, pCi/g, dry wt | | | | | | |
|---|---|---|---|---|---|---|---|
| Island organ | $^{40}K$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239,240}Pu$ | $^{55}Fe$ | $^{3}H$ |
| BRUCE | | | | | | | |
| Muscle | 11.28 | 0.20 | 0.18 | 1.98 | ---- | 0.98 | 0.42 |
| Exoskeleton | 2.59 | ---- | 6.08 | 0.29 | 0.001 | 0.07 | ---- |
| Hepatopancreas | 3.02 | 0.40 | 0.13 | 0.42 | ---- | 5.70 | 0.16 |
| GLENN | | | | | | | |
| Muscle | 10.45 | ---- | ---- | 1.88 | ---- | 0.68 | 0.69 |
| Exoskeleton | 1.06 | ---- | 10.4 | 0.31 | 0.0035 | ---- | ---- |
| Hepatopancreas | 2.34 | 0.27 | ---- | 0.54 | ---- | ---- | 0.27 |
| JAMES | | | | | | | |
| Muscle | 9.62 | 1.05 | 0.079 | 1.25 | ---- | 1.84 | ---- |
| Exoskeleton | 1.44 | 0.11 | 5.9 | 0.22 | 0.002 | 0.30 | ---- |
| Hepatopancreas | 4.00 | 1.56 | ---- | 0.32 | ---- | 12.8 | ---- |
| KEITH | | | | | | | |
| Muscle | 10.11 | 0.42 | 1.19 | 1.92 | ---- | 1.46 | ---- |
| Exoskeleton | 3.35 | ---- | 9.96 | 0.51 | 0.007 | 0.18 | ---- |
| Hepatopancreas | 3.20 | 1.03 | 0.40 | 0.50 | 0.0098 | 6.17 | ---- |
| LEROY | | | | | | | |
| Muscle | 8.80 | 1.23 | 1.58 | 12.60 | 0.0031 | 1.59 | 0.88 |
| Exoskeleton | 1.58 | 0.17 | 89.6 | 2.52 | 0.025 | 0.17 | ---- |
| Hepatopancreas | 2.55 | 0.84 | 2.58 | 3.85 | 0.0038 | 5.05 | ---- |

Table 71. Distribution of radionuclides in *Rattus exulans* (rice rat) collected at Enewetak Atoll, 1972-1973.

| | Activity, pCi/g, dry wt | | | | | |
|---|---|---|---|---|---|---|
| Island/organ | $^{40}K$ | $^{137}Cs$ | $^{60}Co$ | $^{90}Sr$ | $^{55}Fe$ | $^{239,240}Pu$ |
| PEARL | | | | | | |
| Liver | 32.33 | 33.30 | 5.07 | 164.90 | 82.0 | 0.012 |
| Viscera | ---- | 30.80 | 7.45 | 1.79 | ---- | 1.77 |
| Muscle | 11.60 | 37.07 | 0.89 | 0.37 | 23.2 | 0.117 |
| Bone | 9.57 | 53.60 | 2.59 | 36.1 | ---- | ---- |
| SALLY | | | | | | |
| Liver | 10.73 | 63.83 | 2.54 | 0.002 | 35.5 | 0.008 |
| Viscera | 9.63 | 92.97 | 1.48 | 14.6 | ---- | 1.30 |
| Muscle | 5.82 | 60.86 | ---- | ---- | ---- | ---- |
| Bone | 7.01 | 65.77 | 0.81 | 25.9 | ---- | 0.039 |
| URSULA | | | | | | |
| Liver | 6.72 | 39.41 | 3.59 | ---- | 42.2 | 0.041 |
| Viscera | 10.87 | 43.14 | 1.13 | 2.17 | ---- | ---- |
| Muscle | 9.22 | 37.86 | ---- | ---- | ---- | ---- |
| Bone | 7.26 | 61.58 | ---- | 19.6 | ---- | 0.146 |
| DAVID | | | | | | |
| Viscera | 12.24 | 21.97 | ---- | 0.24 | ---- | 0.0087 |
| Liver | ---- | 16.36 | ---- | ---- | 3.67 | 0.004 |
| Muscle | 7.80 | 18.78 | ---- | 0.60 | 0.98 | 0.044 |
| Bone | 11.46 | 28.37 | ---- | 1.37 | ---- | 0.065 |
| Skin | 6.49 | 9.13 | ---- | ---- | ---- | ---- |
| Kidney | ---- | 17.0 | ---- | ---- | ---- | ---- |
| Lung | ---- | 18.5 | ---- | ---- | ---- | 0.031 |
| GLENN | | | | | | |
| Liver | 12.79 | 1.45 | 1.81 | ---- | 19.28 | 0.035 |
| Muscle | 8.18 | 1.76 | 0.48 | 1.03 | 4.49 | 0.017 |
| Viscera | 11.75 | 1.88 | 2.06 | 0.28 | ---- | 0.036 |
| Bone | 10.61 | 6.02 | 0.71 | 2.67 | ---- | 0.87 |
| Skin | 2.3 | 0.33 | ---- | ---- | ---- | ---- |
| Kidney | ---- | 1.46 | 2.40 | ---- | ---- | ---- |
| Lung | 20.7 | 1.74 | ---- | ---- | ---- | 0.30 |

Table 72. Distribution of radionuclides in Rattus rattus (roof rat) collected on Enewetak Atoll, 1972-1973.

| Island/organ | Activity, pCi/g, dry wt $^{40}K$ | $^{137}Cs$ | $^{60}Co$ | $^{90}Sr$ | $^{55}Fe$ | $^{239,240}Pu$ | $^{3}H$ |
|---|---|---|---|---|---|---|---|
| JANET | | | | | | | |
| Viscera[a] | 12.63 | 880.60 | 2.35 | 14.14 | ---- | 0.46 | ---- |
| Muscle[a] | 8.74 | 764.00 | 0.29 | 1.28 | 30.9 | ---- | ---- |
| Liver[a] | 13.42 | 632.90 | 3.23 | 0.004 | 77.9 | ---- | ---- |
| Bone[a] | 8.69 | 661.20 | 0.30 | 115.8 | ---- | 0.26 | ---- |
| Viscera | 11.38 | 768.00 | 1.97 | 6.85 | ---- | 0.36 | ---- |
| Muscle | ---- | 696.80 | 0.41 | 3.44 | 8.69 | 0.0073 | ---- |
| Liver | 18.17 | 604.10 | 3.97 | ---- | 30.9 | ---- | ---- |
| Bone | 5.97 | 357.20 | ---- | 133.8 | ---- | 0.17 | ---- |
| Viscera | 16.23 | 954.50 | 4.95 | 55.86 | 24.32 | 0.729 | ---- |
| Liver | 33.00 | 741.90 | 2.56 | 0.01 | 105.4 | ---- | ---- |
| Bone | 10.32 | 545.50 | 0.45 | 324.3 | ---- | 0.168 | ---- |
| Viscera | ---- | 273.20 | 1.72 | ---- | ---- | ---- | ---- |
| Muscle | ---- | 286.50 | 0.23 | 2.29 | 10.5 | 0.0097 | ---- |
| Liver | ---- | 211.5 | 2.21 | 0.07 | 24.4 | ---- | ---- |
| Bone | 9.06 | 129.20 | 0.22 | 68.92 | ---- | 0.0302 | ---- |
| Viscera | 18.54 | 999.50 | 2.93 | 8.74 | ---- | 0.410 | ---- |
| Muscle | 13.87 | 765.80 | 0.64 | 3.14 | 16.3 | 0.0023 | ---- |
| Liver | ---- | 897.70 | 6.31 | 0.007 | 86.9 | 0.018 | ---- |
| Bone | ---- | 627.50 | 0.51 | 121.2 | ---- | 3.250 | ---- |
| BRUCE | | | | | | | |
| Skin | 8.07 | 0.61 | ---- | ---- | ---- | ---- | ---- |
| Kidney | ---- | ---- | 3.19 | ---- | ---- | ---- | ---- |
| Lung | 35.9 | ---- | ---- | ---- | ---- | ---- | ---- |
| Viscera | ---- | 1.09 | ---- | ---- | ---- | 0.035 | ---- |
| Muscle | 5.21 | 1.47 | ---- | 0.07 | 2.21 | 0.009 | ---- |
| Liver | 30.20 | 1.07 | 1.62 | ---- | 46.40 | 0.013 | ---- |
| Bone | 18.81 | 13.25 | ---- | 1.69 | ---- | 3.278 | ---- |

[a] Collected by Enewetak Marine Biological Laboratory personnel, February, 1973.

Table 72 (continued).

| Island/organ | $^{40}K$ | $^{137}Cs$ | $^{60}Co$ | $^{90}Sr$ | $^{55}Fe$ | $^{239,240}Pu$ | $^{3}H$ | Other |
|---|---|---|---|---|---|---|---|---|
| | Activity, pCi/g, dry wt | | | | | | | |
| ELMER | | | | | | | | |
| Viscera | 11.19 | 18.98 | 1.39 | 0.16 | ---- | 0.0074 | ---- | |
| Muscle | 10.30 | 18.40 | ---- | 0.05 | 0.10 | 0.016 | 11.3 | |
| Liver | 11.12 | 15.60 | ---- | 0.02 | 0.93 | ---- | ---- | |
| Bone | 9.04 | 9.96 | ---- | 1.42 | ---- | 0.23 | ---- | |
| Skin | 6.50 | 7.60 | ---- | ---- | ---- | ---- | ---- | |
| Lung | 14.7 | 16.90 | ---- | 1.0 | ---- | 0.14 | ---- | |
| Kidney | 21.8 | 15.0 | 1.74 | ---- | ---- | ---- | ---- | |
| YVONNE, Sector A | | | | | | | | |
| Muscle | 12.35 | 4240.00 | 12.35 | 5.09 | 32.80 | 0.052 | 1.8 | |
| Bone | ---- | 1833.00 | 5.92 | 146.40 | ---- | 0.057 | ---- | $^{134}Cs$ 1.12 |
| Viscera | 7.61 | 2928.00 | 112.60 | ---- | ---- | 1.05 | ---- | $^{134}Cs$ 1.90 |
| Skin | 6.69 | 2088.00 | 14.00 | ---- | ---- | ---- | ---- | |
| Liver | ---- | 2559.00 | 7.03 | ---- | 126.10 | 0.027 | ---- | $^{151}Sm$ 18.70 |
| Kidney | ---- | 3427.00 | 257.70 | ---- | ---- | ---- | ---- | |
| Lung | 14.26 | 3306.00 | 10.53 | 0.24 | ---- | 0.107 | ---- | |
| Muscle | 13.07 | 3824.00 | 8.51 | 37.79 | 78.83 | 0.003 | ---- | |
| Bone | 7.93 | 2199.00 | 10.57 | 135.10 | ---- | 0.29 | ---- | |
| Viscera | 13.33 | 3531.00 | 230.00 | 4.09 | ---- | 0.581 | ---- | |
| Skin | 6.92 | 1875.00 | 7.43 | ---- | ---- | ---- | ---- | |
| Liver | 14.15 | 2215.00 | 86.13 | 0.005 | 135.60 | 0.013 | ---- | |
| Kidney | ---- | 3286.00 | 261.80 | ---- | ---- | ---- | ---- | |
| Lung | 33.12 | 2760.00 | 11.08 | 16.17 | ---- | ---- | ---- | |
| YVONNE, Sector B | | | | | | | | |
| Muscle | 16.82 | 86.04 | ---- | ---- | ---- | ---- | ---- | |
| Bone | 9.74 | 48.78 | 0.33 | 16.67 | ---- | 0.304 | ---- | |
| Viscera | 9.67 | 76.71 | 1.99 | 0.57 | ---- | 0.393 | ---- | |
| Skin | 4.74 | 42.64 | ---- | ---- | ---- | ---- | ---- | |
| Liver | ---- | 56.22 | 2.90 | ---- | 25.01 | 0.008 | | $^{151}Sm$ 23.00 |
| Kidney | ---- | 59.64 | 4.95 | ---- | ---- | ---- | ---- | |
| Lung | ---- | 39.72 | ---- | ---- | ---- | ---- | ---- | |

Table 72 (continued).

| Island/organ | Activity, pCi/g, dry wt | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $^{40}K$ | $^{137}Cs$ | $^{60}Co$ | $^{90}Sr$ | $^{55}Fe$ | $^{239,240}Pu$ | $^{3}H$ | Other |
| YVONNE, Sector C | | | | | | | | |
| Skin | ---- | 29.39 | 0.69 | ---- | ---- | ---- | ---- | |
| Lung | ---- | 53.33 | ---- | ---- | ---- | 0.568 | ---- | |
| Viscera | ---- | 55.81 | ---- | ---- | 3.46 | 0.211 | ---- | $^{238}Pu$ 0.096 |
| Liver | ---- | 38.68 | 5.63 | 0.002 | 13.83 | 0.011 | ---- | |
| Kidney | 30.64 | 29.00 | 8.03 | ---- | ---- | ---- | ---- | |
| Muscle | 5.77 | 49.19 | 0.55 | 6.76 | 4.12 | ---- | ---- | |
| Bone | ---- | 38.78 | 0.51 | 6.40 | ---- | 0.058 | ---- | |
| YVONNE, Sector D | | | | | | | | |
| Muscle | 15.87 | 3.74 | ---- | 0.63 | 1.23 | 0.008 | ---- | |
| Bone | 23.95 | 23.80 | 1.32 | ---- | ---- | 0.058 | ---- | |
| Lung | ---- | 11.55 | ---- | ---- | ---- | 0.201 | ---- | |
| Viscera | 17.77 | 5.69 | 0.20 | ---- | ---- | 0.020 | ---- | |
| Liver | ---- | 4.62 | ---- | 10.54 | 17.30 | 0.398 | ---- | |

Table 73. Distribution of $^{90}Sr$ and $^{239,240}Pu$ in birds collected at Enewetak Atoll, 1972-1973.

| | Activity, pCi/g, dry wt | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $^{90}Sr$ | | | | | $^{239,240}Pu$ | | | | |
| | Liver | Muscle | Bone | Eggshell | Egg | Liver | Muscle | Egg | Eggshell | Bone |
| Common noddy (*Anous stolidus*) | | | | | | | | | | |
| ALICE | | 0.01 | 20.6 | | | 0.06 | | | | |
| IRENE | 0.51 | | | 7.34 | 0.095 | 0.009 | | 0.0015 | 0.0081 | |
| JANET | 0.066 | 0.008 | 0.39 | 16.04 | 0.203 | | 0.0018 | 0.0148 | | |
| LUCY | 0.187 | | 0.71 | | | | 0.022 | | | |
| MARY | | 0.48 | | | | | | | | |
| YVONNE | | 0.0073 | | 0.49 | 1.06 | | 0.02 | 0.0232 | 0.0086 | 0.021 |
| | | | | 0.22 | 0.073 | | | | | |
| VAN | 0.04 | 0.04 | 0.143 | | 0.002 | | 0.0014 | 0.00047 | | |
| REX | | 0.0065 | | | | | 0.0056 | 0.00077 | | |
| IRWIN | 0.23 | | | | | 0.0242 | 0.0434 | 0.00088 | | |
| KEITH | | | | | | | 0.001 | | | |
| White-capped noddy (*Anous tenuirostris*) | | | | | | | | | | |
| SALLY | | | | | | 0.011 | 0.005 | | | |
| BRUCE | | | 0.66 | | | | 0.0069 | | | |
| LEROY | 0.402 | | | | | 0.0072 | 0.0033 | | | |
| Sooty tern (*Sterna fuscata*) | | | | | | | | | | |
| SALLY | | | 1.68 | 0.265 | 0.0042 | | | | | 0.005 |
| CLYDE | 0.015 | 0.0063 | | | | 0.0017 | | | | |
| DAVID | | | | | | | 0.119 | | | |
| Pooled terns | | | | | | | | | | |
| JANET | | 0.005 | | | | 0.0015 | | | | |

Table 74. Distribution of $^{60}Co$ and $^{55}Fe$ in birds collected at Enewetak Atoll, 1972-1973.

| | Activity, pCi/g, dry wt | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $^{60}Co$ | | | | $^{55}Fe$ | | | | | |
| | Viscera | Liver | Muscle | Bone | Viscera | Liver | Muscle | Bone | Egg | Eggshell |
| Common noddy (*Anous stolidus*) | | | | | | | | | | |
| ALICE | | | 0.32 | | 47.3 | 127.0 | 49.55 | 25.7 | | |
| IRENE | | 0.324 | 0.25 | | 57.66 | 49.6 | | 57.66 | 23.0 | 1.18 |
| JANET | | | 0.51 | | 64.0 | 258. | 104.5 | 50.0 | 57.2 | 1.28 |
| LUCY | | | | | 108.6 | 199. | 8.78 | 38.5 | | |
| MARY | | 0.567 | | | 53.6 | 2.51 | 14.2 | 59.9 | | |
| OLIVE | | | | 0.31 | 57.2 | 332.4 | 92.8 | 46.4 | | |
| YVONNE | 0.51 | 0.37 | 0.23 | | 64.4 | 385.6 | 22.6 | 63.5 | 56.8<br>54.5 | 1.10 |
| Common noddy (*Anous stolidus*) | | | | | | | | | | |
| VAN | | 0.195 | 0.29 | | 50.5 | 279. | 99.55 | 40.3 | 63.5 | 1.68 |
| REX | | | | | 50.0 | 117.6 | 43.5 | 44.8 | 51.4 | 0.73 |
| HENRY | | | | | | | | | 54.1 | 8.56 |
| IRWIN | | 0.63 | | | 45.95 | 423. | 169. | 49.1 | 5.14 | |
| KEITH | | 0.69 | 0.452 | 0.312 | 80.18 | | | 68.5 | | |
| White-capped noddy (*Anous tenuirostris*) | | | | | | | | | | |
| SALLY | | | | 0.34 | 64.4 | | 36.6 | 61.3 | | |
| BRUCE | | | 0.392 | | 73.9 | 327. | 41.3 | 44.2 | | |
| LEROY | 1.01 | 2.38 | 2.07 | 0.94 | 71.6 | 810.8 | 64.4 | 109.5 | | |
| Sooty tern (*Sterna fuscata*) | | | | | | | | | | |
| SALLY | | | | | 22.4 | 155.0 | | 35.7 | 37.6 | |
| CLYDE | | | | | 49.1 | 146.4 | 20.4 | 36.0 | | |
| DAVID | | | | | 63.5 | 153. | 59.0 | 37.4 | | |
| Pooled sample (Terns, noddys, etc.) | | | | | | | | | | |
| JANET | | | 0.16 | | 52.2 | 171.6 | 59.5 | 40.0 | | |
| PEARL | 0.435 | 0.647 | 0.659 | | 61.7 | | | 46.9 | | |
| Other species: | | | | | | | | | | |
| Red-tailed tropic bird (*Phaethon rubricauda*) | | | | | | | | | | |
| KATE | | | | | | | | | | |
| Reef heron (*Demigretta sacra*) | | | | | | | | | | |
| DAVID | | | | 0.41 | | | | | | |

Table 75. Distribution of $^{137}Cs$ and $^{40}K$ in birds collected at Enewetak Atoll, 1972-1973.

| | Activity, pCi/g, dry wt | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $^{40}K$ | | | | | | $^{137}Cs$ | | |
| | Viscera | Liver | Muscle | Bone | Egg | Eggshell | Bone | Egg | Viscera |
| Common noddy (*Anous stolidus*) | | | | | | | | | |
| ALICE | | 10.2 | 9.66 | 5.3 | | | 1.16 | | |
| IRENE | | 7.88 | 9.42 | | 6.37 | | 0.17 | | |
| JANET | 10.68 | 7.83 | 9.19 | 3.04 | 6.21 | | 0.73 | | |
| LUCY | 13.08 | | 12.23 | | | | 7.45 | | |
| MARY | 11.41 | 6.63 | | 5.74 | | | | | |
| OLIVE | 8.81 | | | 4.07 | | | | | |
| YVONNE | 8.34 | | 7.39 | | 4.53 | | 5.51 | 0.079 | |
| | | | | | 4.13 | | | | |
| | | | | | 7.22 | | | | |
| VAN | | | 10.48 | 6.96 | 6.31 | | 0.74 | 0.136 | |
| REX | | 4.89 | 10.81 | | 7.69 | | | | |
| HENRY | | | | | 3.39 | | | | |
| IRWIN | | 15.84 | 9.28 | | 7.49 | | | | |
| KEITH | 8.97 | | 12.96 | 3.80 | | | | | |
| White-capped noddy (*Anous tenuirostris*) | | | | | | | | | |
| SALLY | 5.89 | | 6.31 | | | | 0.137 | | |
| BRUCE | | 8.37 | 7.09 | | | | | | |
| LEROY | 7.82 | | 10.95 | | | | | | |
| Sooty tern (*Sterna fuscata*) | | | | | | | | | |
| SALLY | 4.79 | | | | 4.57 | | | | |
| CLYDE | 7.94 | | 7.37 | 2.36 | 5.41 | 1.4 | | | |
| DAVID | 8.90 | 20.36 | 7.46 | | | | 0.745 | | |
| Pooled sample (terns, noddys, etc.) | | | | | | | | | |
| JANET | 9.62 | | 8.77 | 3.32 | | | | | 0.18 |
| PEARL | | | 8.67 | | | | 0.793 | | |
| ALVIN | | 20.37 | 10.44 | 10.32 | | | 5.71 | | |
| Other species: | | | | | | | | | |
| Red-tailed tropic bird (*Phaethon rubricauda*) | | | | | | | | | |
| KATE | 7.81 | | 8.79 | | | | 0.10 | | |
| Reef heron (*Demigretta sacra*) | | | | | | | | | |
| DAVID | | | 4.65 | 8.76 | | | 1.34 | 1.59 | |
| Sandpiper (*Erolia acuminata*) | | | | | | | | | |
| DAVID | | 17.57 | | 28.16 | | | 0.789 | | |

Table 76. Distribution of radionuclides in terrestrial biota and soils on ALICE, Enewetak Atoll, 1972-1973.

| Ecosystem level | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ |
|---|---|---|---|---|---|---|
| | Activity, pCi/g, dry wt | | | | | |
| Soil Island range | ---- | 5.6-141 | 14-430 | 1.4-33 | 3.9-68 | ---- |
| Mean | ---- | 36 | 80 | 5.9 | 12 | ---- |
| Soil survey Sample 15 | ---- | 13.00 | 32.00 | 2.7 | 5.80 | ---- |
| Biota soil sample | ---- | 69.05 | 580.20 | 100.90 | 83.78 | ---- |
| Plants | | | | | | |
| *Scaevola frutescens* | 12.82 | 66.53 | 32.7 | ---- | ---- | ---- |
| *Messerschmidia argentea* | 13.38 | 222.80 | 138.30 | ---- | 0.025 | ---- |
| *Guettarda speciosa* | 11.03 | 7.40 | ---- | ---- | ---- | ---- |
| Animals | | | | | | |
| *Anous stolidus* Common noddy | | | | | | |
| Liver | 10.20 | ---- | ---- | ---- | 0.062 | 127.0 |
| Viscera | ---- | ---- | ---- | ---- | ---- | 47.20 |
| Muscle | 9.66 | ---- | 0.01 | 0.32 | ---- | 49.55 |
| Bone | 5.30 | 1.16 | 20.59 | ---- | ---- | 25.68 |

Table 77. Distribution of radionuclides in terrestrial biota and soil on BELLE, Enewetak Atoll, 1972-1973.

| Ecosystem level | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ | $^{3}H$ |
|---|---|---|---|---|---|---|---|
| | Activity, pCi/g, dry wt | | | | | | |
| Soil - Dense | | | | | | | |
| Island range | ---- | 14-170 | 14-670 | 3.1-30 | 7.2-130 | ---- | ---- |
| Mean | ---- | 48 | 123 | 10 | 26 | ---- | ---- |
| Sparse | | | | | | | |
| Island range | ---- | 3.3-44 | 35-130 | 2.4-9.6 | 5.8-26 | ---- | ---- |
| Mean | ---- | 8.6 | 44 | 4.6 | 11 | ---- | ---- |
| Soil survey Sample 32 | ---- | 0.67 | 16.0 | 0.38 | 6.50 | ---- | ---- |
| Sample 33 | ---- | 0.84 | 15.0 | 0.57 | 6.00 | ---- | ---- |
| Mean | ---- | 0.76 | 15.5 | 0.48 | 6.25 | ---- | ---- |
| Plants | | | | | | | |
| Messerschmidia argentea | 15.86 | 5.83 | 25.2 | ---- | 0.036 | ---- | ---- |
| Scaevola frutescens | 12.45 | 1.42 | 2.27 | ---- | 0.072 | ---- | ---- |
| Guettarda speciosa | 12.48 | 109.10 | 152.7 | ---- | ---- | ---- | ---- |
| Pandanus tectorius (fruit) | 14.38 | 923.00 | 206.30 | ---- | ---- | ---- | 0.86 |
| Pandanus tectorius (leaves) | 6.70 | 679.30 | 391.0 | ---- | ---- | 0.44 | ---- |

Table 78. Distribution of radionuclides in terrestrial biota and soil on CLARA, Enewetak Atoll, 1972-1973.

| | Activity, pCi/g, dry wt | | | | | |
|---|---|---|---|---|---|---|
| Ecosystem level | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ |
| Soil - Island range | ---- | 5.6-110 | 13-310 | 0.91-20 | 3.5-88 | ---- |
| Mean | ---- | 26 | 65 | 6.4 | 22 | ---- |
| Soil survey Sample 7 | ---- | 48.0 | 95.0 | 11.0 | 33.0 | ---- |
| Sample 9 | ---- | 110.0 | 173.0 | 20.0 | 55.0 | ---- |
| Biota soil sample | ---- | 5.7 | 61.7 | 6.8 | ---- | ---- |
| Plants | | | | | | |
| *Messerschmidia argentea* | 13.33 | 149.10 | 127.50 | ---- | ---- | ---- |
| *Scaevola frutescens* | 12.37 | 51.00 | 51.8 | ---- | 0.048 | 3.37 |

Table 79. Distribution of radionuclides in terrestrial biota and soil on DAISY, Enewetak Atoll, 1972-1973.

| Ecosystem level | Activity, pCi/g, dry wt | | | | | | |
|---|---|---|---|---|---|---|---|
| | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{3}H$ | $^{238}Pu$ |
| Soil - Dense | | | | | | | |
| Island range | ---- | 3.4-33 | 100-380 | 6.4-26 | 22-98 | ---- | ---- |
| Mean | ---- | 11 | 190 | 11 | 41 | | |
| Sparse | | | | | | | |
| Island range | ---- | 0.86-9.0 | 16-120 | 0.37-7.4 | 3.8-33 | ---- | ---- |
| Mean | ---- | 3.8 | 32 | 0.85 | 15 | | |
| Soil survey Sample 13 | ---- | 4.50 | 28.0 | 1.20 | 20.0 | ---- | ---- |
| Sample 14 | ---- | 7.70 | 45.0 | 0.99 | 26.0 | ---- | ---- |
| Sample 19 | ---- | 7.50 | 120.0 | 1.30 | 33.0 | ---- | ---- |
| Mean | ---- | 6.60 | 62.00 | 1.20 | 26.0 | ---- | ---- |
| Biota soil sample | ---- | 65.86 | 554.1 | 21.34 | 148.00 | ---- | ---- |
| Plants | | | | | | | |
| *Messerschmidia argentea* | 11.10 | 5.90 | 12.21 | 1.45 | 0.055 | ---- | ---- |
| *Scaevola frutescens* | 20.26 | 38.80 | 50.90 | 0.48 | 0.046 | ---- | 0.0085 |
| *Cocos nucifera* | | | | | | | |
| Meat | 6.65 | 7.17 | 0.20 | ---- | ---- | 0.41 | ---- |
| Milk | 45.50 | ---- | 1.40 | ---- | ---- | ---- | ---- |

Table 81 (Continued).

| Sector C<br>Ecosystem level | Activity, pCi/g, dry wt<br>$^{40}K$ | $^{137}Cs$ | $^{60}Co$ | $^{90}Sr$ | $^{55}Fe$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|
| Soil | | | | | | | |
| No. 12 | ---- | 0.43 | 0.43 | 9.10 | ---- | 3.700 | |
| No. 13 | ---- | 0.55 | 0.12 | 9.50 | ---- | 2.800 | |
| No. 32 | ---- | 3.60 | 0.81 | 29.00 | ---- | 3.500 | |
| Mean soil data | ---- | 1.50 | 0.45 | 16.00 | ---- | 3.300 | |
| Biota-C soil | ---- | 0.47 | ---- | 10.27 | ---- | 3.020 | |
| Plants | | | | | | | |
| Messerschmidia argentea | 18.16 | 2.20 | 0.14 | ---- | ---- | 0.0045 | |
| Scaevola frutescens | 14.08 | 1.67 | ---- | 1.14 | ---- | 0.031 | |
| Lepturus repens | 1.95 | 2.57 | 0.26 | 1.15 | ---- | 0.0112 | |
| Cocos nucifera | | | | | | | |
| Milk | 99.90 | 5.11 | ---- | 1.61 | 86.49 | ---- | |
| **Sector D** | | | | | | | |
| Soil | | | | | | | |
| No. 48 | ---- | 8.20 | 21.00 | 50.00 | ---- | 29.000 | |
| Plants | | | | | | | |
| Cocos nucifera | | | | | | | |
| Meat | 7.05 | 1.77 | ---- | 0.07 | ---- | 0.036 | |
| Animals | | | | | | | |
| Coenobita perlatus (hermit crabs) | | | | | | | |
| Hepatopancreas | 7.04 | 124.30 | 82.80 | 29.60 | 12.80 | 0.196 | $^{3}H$ 0.58 |
| Muscle | 7.36 | 130.70 | 62.40 | 22.6 | 3.32 | 0.069 | $^{3}H$ 0.89 |
| Exoskeleton | 1.94 | 27.20 | 1.66 | 491.00 | 0.32 | 0.017 | |
| **Sector E** | | | | | | | |
| Soil | | | | | | | |
| No. 25 | ---- | 3.50 | 7.40 | 100.00 | ---- | 7.700 | |
| No. 51 | ---- | 19.00 | 11.00 | 59.00 | ---- | 12.000 | |
| No. 62 | ---- | 41.00 | 14.00 | 25.00 | ---- | 11.000 | |
| No. 63 | ---- | 3.00 | 8.90 | 25.00 | ---- | 9.200 | |
| Average soil data | ---- | 16.6 | 10.30 | 52.00 | ---- | 10.000 | |

Table 81 (Continued).

| Sector E<br>Ecosystem level | Activity, pCi/g, dry wt $^{40}K$ | $^{137}Cs$ | $^{60}Co$ | $^{90}Sr$ | $^{55}Fe$ | $^{239,240}Pu$ | Other |
|---|---|---|---|---|---|---|---|
| Plants | | | | | | | |
| Messerschmidia argentea[a] | 12.74 | 407.30 | 3.39 | 159.00 | ---- | 0.0019 | |
| Messerschmidia argentea (wood) | 1.94 | 13.02 | 1.59 | 16.98 | ---- | 0.0062 | |
| Scaevola frutescens[a] | 10.41 | 205.20 | 21.14 | 57.21 | ---- | 0.0029 | |
| Scaevola frutescens (wood) | 1.82 | 2.22 | 0.91 | 4.60 | ---- | 0.0029 | |
| Guettarda speciosa | 8.14 | 27.33 | 9.18 | 53.60 | ---- | ---- | |

[a]Integrated samples, 20-25 trees sampled.

Table 82. Location of biota samples collected on JANET (Engebi), Enewetak Atoll, 1972-1973.

| Sector | Site description |
|---|---|
| A | South end of island in Scaevola-Messerschmidia regrowth. |
| B | On south side of the east end of the airstrip, in scattered Messerschmidia-ground cover species. |
| C | Mid-island on seaward side, near small clump of young coconut palms, dense Scaevola-Messerschmidia scrub. |
| D | On south side of the west end of the airstrip, open scrub growth. |
| E | In middle of airstrip, on south side, open meadow-like area with scattered Messerschmidia. |
| F | Near hot spot on island, north of airstrip, 300 yd from shoreline in open Messerschmidia scrub. |
| G | In center of island, near large blockhouse complex, dense regrowth of Messerschmidia-Scaevola. |
| H | Western tip of island, at west end of airstrip near small blockhouse, scattered regrowth of Messerschmidia-Scaevola. |
| I | Near docking area, mid-island on the lagoon side, dense regrowth of Scaevola-Messerschmidia. |

Table 83. Distribution of radionuclides in terrestrial biota and soil on JANET (Engebi), Enewetak Atoll, 1972-1973.

| | Activity, pCi/g, dry wt | | | | | | |
|---|---|---|---|---|---|---|---|
| Sector A<br>Ecosystem level | $^{40}K$ | $^{137}Cs$ | $^{60}Co$ | $^{90}Sr$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
| Soil | | | | | | | |
| No. 121 | ---- | 0.60 | 0.10 | 6.30 | 0.99 | ---- | |
| No. 127 | ---- | 26.00 | 1.00 | 16.00 | 4.10 | ---- | |
| Average | ---- | 13.30 | 0.55 | 11.20 | 2.50 | ---- | |
| Plants | | | | | | | |
| Messerschmidia argentea | 9.95 | 124.80 | ---- | 43.51 | 0.0055 | ---- | |
| Scaevola frutescens | 12.96 | 54.95 | 0.02 | 32.66 | 0.0068 | ---- | $^{238}Pu$ 0.0068<br>$^{152}Eu$ 0.20 |
| Sector B | | | | | | | |
| Soil | | | | | | | |
| No. 21 | ---- | 29.00 | 2.50 | 52.00 | 7.100 | ---- | |
| Plants | | | | | | | |
| Messerschmidia argentea | 18.32 | 555.90 | 0.25 | 40.36 | 0.0103 | ---- | |
| Scaevola frutescens | 16.73 | 294.60 | ---- | 31.53 | 0.0103 | ---- | |
| Pandanus tectorius (leaves) | 8.12 | 0.62 | ---- | 4.41 | ---- | ---- | $^{207}Bi$ 0.11 |
| Sector C | | | | | | | |
| Soil | | | | | | | |
| Soil survey | | | | | | | |
| No. 63 | ---- | 10.00 | 1.40 | 27.0 | 3.70 | ---- | |
| No. 65 | ---- | 11.00 | 0.93 | 20.0 | 2.20 | ---- | |
| No. 71 | ---- | 36.00 | 2.90 | 71.0 | 14.00 | ---- | |
| Mean | ---- | 19.00 | 1.74 | 39.3 | 6.63 | ---- | |
| Plants | | | | | | | |
| Messerschmidia argentea | 10.50 | 385.80 | ---- | 44.60 | 0.0034 | ---- | |
| Scaevola frutescens | 18.28 | 134.10 | ---- | 16.71 | 0.0049 | ---- | |
| Cocos nucifera | | | | | | | |
| Meat | 8.04 | 84.68 | ---- | 0.21 | ---- | ---- | $^{3}H$ 0.34 |
| Milk | 60.05 | 210.70 | ---- | 1.57 | ---- | ---- | |

Table 83 (Continued).

| Sector D<br>Ecosystem level | Activity, pCi/g, dry wt<br>$^{40}K$ | $^{137}Cs$ | $^{60}Co$ | $^{90}Sr$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
|---|---|---|---|---|---|---|---|
| Soil | | | | | | | |
| Soil survey No. 131 | ---- | 42.00 | 4.52 | 95.00 | 2.50 | ---- | |
| Plants | | | | | | | |
| Messerschmidia argentea | 15.30 | 158.30 | ---- | 121.20 | 0.0029 | ---- | |
| Pluchea odorata | 10.80 | 1553.00 | 1.26 | 46.85 | ---- | ---- | |
| Sector E | | | | | | | |
| Soil | | | | | | | |
| Soil survey | | | | | | | |
| No. 58 | ---- | 78.00 | 1.50 | 140.00 | 23.00 | ---- | |
| No. 61 | ---- | 47.00 | 2.30 | 45.00 | 8.90 | ---- | |
| No. 62 | ---- | 56.00 | 1.20 | 120.00 | 28.00 | ---- | |
| Mean | ---- | 60.00 | 1.60 | 101.60 | 19.90 | ---- | |
| Plants | | | | | | | |
| Messerschmidia argentea | 12.17 | 298.70 | ---- | 83.80 | 0.005 | ---- | |
| Scaevola frutescens | 13.65 | 223.40 | 0.45 | 35.70 | 0.003 | ---- | |
| Sector F | | | | | | | |
| Soil | | | | | | | |
| Soil survey No. 12 | ---- | 25.00 | 9.30 | 120.00 | 23.00 | ---- | |
| Plants | | | | | | | |
| Messerschmidia argentea | 10.43 | 526.10 | ---- | 100.90 | ---- | ---- | |
| Scaevola frutescens | 20.57 | 405.90 | 0.24 | 83.30 | 0.0043 | ---- | |
| Animals | | | | | | | |
| Rattus rattus (roof rat) | | | | | | | |
| Viscera | 16.23 | 955.00 | 4.96 | 55.90 | 0.730 | 24.30 | |
| Kidney | ---- | 822.00 | 5.78 | ---- | ---- | ---- | |
| Liver | 33.00 | 742.00 | 2.56 | 0.01 | ---- | 105.40 | |
| Lung | ---- | 1069.00 | ---- | 2.93 | ---- | ---- | |

Table 83 (Continued).

| Sector F<br>Ecosystem level | Activity, pCi/g, dry wt $^{40}K$ | $^{137}Cs$ | $^{60}Co$ | $^{90}Sr$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
|---|---|---|---|---|---|---|---|
| Animals | | | | | | | |
| Rattus rattus (roof rat) | | | | | | | |
| Muscle | ---- | 887.00 | ---- | 3.13 | 0.013 | 26.20 | |
| Bone | 10.32 | 546.00 | 0.45 | 324.30 | 0.168 | ---- | |
| Skin | ---- | 353.00 | ---- | ---- | ---- | ---- | |
| Sector G | | | | | | | |
| Soil | | | | | | | |
| Soil survey | | | | | | | |
| No. 55 | ---- | 52.00 | 6.70 | 180.00 | 52.00 | ---- | |
| No. 59 | ---- | 36.00 | 1.30 | 42.00 | 7.10 | ---- | |
| No. 69 | ---- | 34.00 | 3.50 | 88.00 | 20.00 | ---- | |
| No. 86 | ---- | 53.00 | 2.00 | 58.00 | 6.10 | ---- | |
| Average | ---- | 43.80 | 3.37 | 92.00 | 21.30 | ---- | |
| Plants | | | | | | | |
| Messerschmidia argentea | 14.25 | 299.40 | ---- | 48.20 | ---- | ---- | |
| Scaevola frutescens | 18.12 | 258.60 | ---- | 37.25 | ---- | ---- | |
| Animals | | | | | | | |
| Rattus rattus (roof rat) | | | | | | | |
| Viscera[a] | 12.63 | 881.00 | 2.35 | 14.14 | 0.460 | ---- | |
| Viscera[b] | 11.38 | 768.00 | 1.97 | 6.85 | 0.362 | ---- | |
| Kidney[a] | 26.14 | 656.00 | 2.60 | ---- | ---- | ---- | |
| Kidney[b] | ---- | 467.00 | 4.94 | ---- | ---- | ---- | |
| Liver[a] | 13.42 | 633.00 | 3.23 | .004 | ---- | 77.93 | |
| Liver[b] | 18.17 | 604.00 | 3.97 | ---- | ---- | 30.86 | |
| Muscle[a] | 8.74 | 764.00 | 0.29 | 1.28 | ---- | 30.86 | $^{3}H$ 6.70 |
| Muscle[b] | ---- | 697.00 | 0.41 | 3.44 | 0.007 | 8.69 | |
| Lung[a] | 21.54 | 587.00 | 0.45 | ---- | 0.509 | ---- | |
| Lung[b] | 76.60 | 1272.00 | 4.11 | ---- | ---- | 98.7 | |

[a]Collections made by Enewetak Marine Biological Laboratory personnel in February 1973.
[b]Collections made by AEC Enewetak Terrestrial Biota Survey in January 1973.

Table 83 (Continued).

| Sector G<br>Ecosystem level | Activity, pCi/g, dry wt<br>$^{40}K$ | <br>$^{137}Cs$ | <br>$^{60}Co$ | <br>$^{90}Sr$ | <br>$^{239,240}Pu$ | <br>$^{55}Fe$ | <br>Other |
|---|---|---|---|---|---|---|---|
| Animals | | | | | | | |
| Rattus rattus (roof rat) | | | | | | | |
| Bone[a] | 8.69 | 661.00 | 0.30 | 115.80 | 0.26 | ---- | |
| Bone[b] | 5.97 | 358.00 | ---- | 133.80 | 0.167 | ---- | |
| Skin[a] | 4.94 | 406.00 | ---- | ---- | ---- | ---- | |
| Skin[b] | 6.05 | 390.00 | ---- | ---- | ---- | ---- | |
| Sector H | | | | | | | |
| Soil | | | | | | | |
| Soil survey | | | | | | | |
| No. 113 | ---- | 1.10 | 0.56 | 9.70 | 6.30 | ---- | |
| No. 122 | ---- | 1.40 | 0.63 | 13.00 | 6.50 | ---- | |
| No. 123 | ---- | 2.30 | 1.10 | 13.00 | 4.00 | ---- | |
| No. 143 | ---- | 5.90 | 1.80 | 31.00 | 11.00 | ---- | |
| Mean | ---- | 2.69 | 1.27 | 16.67 | 6.95 | ---- | |
| Plants | | | | | | | |
| Messerschmidia argentea | 13.29 | 322.70 | ---- | 45.95 | ---- | ---- | |
| Scaevola frutescens | 14.31 | 63.30 | ---- | 17.34 | ---- | ---- | |
| Animals | | | | | | | |
| Rattus rattus (roof rat) | | | | | | | |
| Viscera | ---- | 273.20 | 1.72 | 17.30 | 1.40 | ---- | |
| Kidney | ---- | 275.00 | 2.63 | ---- | ---- | ---- | |
| Liver | ---- | 211.50 | 2.21 | 0.01 | 0.0016 | 24.40 | |
| Lung | 48.30 | 308.00 | ---- | 0.55 | 1.320 | ---- | |
| Muscle | ---- | 286.50 | 0.23 | 2.29 | 0.0097 | 10.54 | |
| Bone | 9.06 | 129.00 | 0.22 | 68.90 | 0.0302 | ---- | |
| Skin | 7.81 | 181.00 | ---- | ---- | ---- | ---- | |

[a]Collections made by Enewetak Marine Biological Laboratory personnel in February 1973.
[b]Collections made by AEC Enewetak Terrestrial Biota Survey in January 1973.

Table 83 (Continued).

| Sector H Ecosystem level | Activity, pCi/g, dry wt $^{40}K$ | $^{137}Cs$ | $^{60}Co$ | $^{90}Sr$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
|---|---|---|---|---|---|---|---|
| Birds | | | | | | | |
| Anous stolidus (Common noddy) | | | | | | | |
| Viscera | 9.62 | ---- | ---- | ---- | ---- | 52.25 | |
| Liver | ---- | 171.60 | ---- | 0.005 | 0.0015 | ---- | |
| Muscle | 9.19 | ---- | 0.51 | 0.008 | 0.002 | 104.50 | |
| Eggshell | ---- | ---- | ---- | 16.04 | ---- | 1.28 | |
| Egg | 6.21 | ---- | ---- | 0.20 | 0.0148 | 57.21 | |
| Bone | 3.04 | 0.73 | ---- | 0.39 | ---- | 50.0 | |
| Sector I | | | | | | | |
| Soil | | | | | | | |
| Soil survey | | | | | | | |
| No. 118 | ---- | 6.50 | 0.43 | 18.00 | 3.50 | ---- | |
| No. 125 | ---- | 9.70 | 0.19 | 25.00 | 2.10 | ---- | |
| Mean | ---- | 8.10 | 0.31 | 22.00 | 2.80 | ---- | |
| Plants | | | | | | | |
| Messerschmidia argentea | 12.72 | 36.43 | ---- | 18.38 | 0.0152 | ---- | |
| Scaevola frutescens | 17.44 | 30.50 | ---- | 12.16 | 0.0163 | ---- | |
| Animals | | | | | | | |
| Rattus rattus (roof rat) | | | | | | | |
| Viscera | 18.54 | 999.50 | 2.93 | 8.74 | 0.416 | ---- | |
| Kidney | 62.34 | 838.30 | 5.99 | ---- | ---- | ---- | |
| Liver | ---- | 897.70 | 6.32 | 0.01 | 0.018 | 86.94 | $^{151}Sm$ 34.30 |
| Muscle | 13.87 | 765.80 | 0.64 | 3.14 | 0.023 | 16.31 | |
| Bone | ---- | 627.50 | 0.51 | 121.20 | 3.248 | ---- | |
| Skin | 10.70 | 515.30 | 0.92 | ---- | ---- | ---- | |
| Lung | 29.70 | 830.00 | 2.17 | 1.80 | 0.865 | ---- | |

Table 84. Distribution of radionuclides in terrestrial biota and soil on KATE, Enewetak Atoll, 1972-1973.

| Ecosystem level | Activity, pCi/g, dry wt | | | | | |
|---|---|---|---|---|---|---|
| | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | Other |
| Soil - Dense | | | | | | |
| Island range | ---- | 0.08-37 | 1.6-200 | 0.03-5.8 | 0.17-50 | |
| Mean | ---- | 13.1 | 43.5 | 1.90 | 11.02 | |
| Soil - Sparse | | | | | | |
| Island range | | 1.8-16 | 1.6-49 | 0.03-3.5 | 0.17-14 | |
| Mean | | 4.8 | 11 | 0.46 | 2.3 | |
| Soil survey No. 17 | ---- | 3.90 | 45.0 | 2.3 | 14.0 | |
| Biota soil sample | ---- | 4.30 | 47.0 | 1.1 | 11.0 | |
| Mean | ---- | 4.10 | 46.0 | 1.7 | 12.5 | |
| Plants | | | | | | |
| *Messerschmidia argentea* | 9.62 | 4.26 | 3.75 | ---- | 0.005 | |
| *Scaevola frutescens* | 14.60 | 16.36 | ---- | ---- | ---- | |
| *Pisonia grandis* | 9.59 | 221.10 | 23.60 | 3.85 | 0.0045 | |
| *Morinda citrifolia* | 14.50 | 34.09 | 23.56 | ---- | 0.001 | |
| Animals | | | | | | |
| *Phaethon rubricaudus* (red-tailed tropic bird) | | | | | | |
| Viscera | 7.81 | ---- | ---- | ---- | ---- | |
| Muscle | 8.79 | ---- | ---- | ---- | ---- | |
| Bone | ---- | 0.10 | ---- | ---- | ---- | $^{65}Zn$ 0.64 |

Table 85. Distribution of radionuclides in terrestrial biota and soil on LUCY, Enewetak Atoll, 1972-1973.

| | Activity, pCi/g, dry wt | | | | | | |
|---|---|---|---|---|---|---|---|
| Ecosystem level | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
| Soil | | | | | | | |
| Island range | ---- | 2.2-25 | 10-83 | 0.26-3.8 | 2.4-22 | ---- | |
| Mean | ---- | 11 | 32 | 1.5 | 7.7 | ---- | |
| Soil survey | | | | | | | |
| No. 16 | ---- | 0.10 | 4.40 | 0.05 | 2.10 | ---- | |
| No. 18 | ---- | 0.12 | 4.40 | 0.05 | 1.50 | ---- | |
| Biota soil sample | ---- | 2.24 | 22.40 | 0.90 | 4.90 | ---- | |
| Plants | | | | | | | |
| *Messerschmidia argentea* | 10.73 | 6.36 | ---- | ---- | ---- | ---- | $^{155}Eu$ 0.05 |
| *Scaevola frutescens* | 13.01 | 12.73 | ---- | ---- | ---- | ---- | |
| Animals | | | | | | | |
| *Coenobita perlatus* (hermit crab) | | | | | | | |
| Hepatopancreas/ gonad | 10.42 | 125.70 | ---- | 2.95 | ---- | ---- | |
| Exoskeleton | ---- | 39.15 | ---- | 0.97 | ---- | ---- | |
| *Anous stolidus* (common noddy) | | | | | | | |
| Viscera | 13.08 | ---- | ---- | ---- | ---- | 108.60 | |
| Liver | ---- | ---- | 0.19 | ---- | ---- | ---- | |
| Muscle | 12.23 | ---- | ---- | ---- | 0.022 | 8.78 | |
| Bone | ---- | 7.45 | 0.71 | ---- | ---- | 38.50 | |

Table 86. Distribution of radionuclides in terrestrial biota and soil on PEARL, Enewetak Atoll, 1972-1973.

| | Activity, pCi/g, dry wt | | | | | |
|---|---|---|---|---|---|---|
| Ecosystem level | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ |
| <u>Soil</u> | | | | | | |
| Hot spot | | | | | | |
| Range | ---- | 7.4-55 | 35-140 | 3.6-70 | 15-530 | ---- |
| Mean | ---- | 19 | 62 | 12 | 51 | ---- |
| Remainder | | | | | | |
| Range | ---- | 1.2-34 | 3.2-61 | 0.49-49 | 0.85-100 | ---- |
| Mean | ---- | 7.6 | 17 | 4.1 | 11 | ---- |
| Soil survey | | | | | | |
| No. 41 | ---- | 12.0 | 33.0 | 2.2 | 12.0 | ---- |
| No. 42 | ---- | 9.1 | 19.0 | 1.1 | 7.6 | ---- |
| No. 43 | ---- | 0.24 | 32.0 | 0.05 | 1.1 | ---- |
| No. 44 | ---- | 1.80 | 5.90 | 1.90 | 2.4 | ---- |
| Mean | ---- | 5.78 | 15.30 | 1.30 | 5.8 | ---- |
| Biota soil sample | ---- | 7.90 | 17.04 | 1.90 | 6.68 | ---- |
| <u>Plants</u> | | | | | | |
| <u>Messerschmidia argentea</u> | 14.66 | 0.29 | 0.47 | ---- | ---- | ---- |
| <u>Scaevola frutescens</u> | 16.50 | 0.34 | 0.35 | ---- | 0.0023 | ---- |
| <u>Scaevola frutescens</u>[a] | 12.52 | 30.82 | 20.99 | 0.16 | 0.0031 | ---- |
| <u>Animals</u> | | | | | | |
| <u>Sterna fuscata</u> (sooty tern) | | | | | | |
| Liver | ---- | ---- | ---- | 0.65 | ---- | 317.00 |
| <u>Rattus exulans</u> (rice rat) | | | | | | |
| Liver | 32.33 | 33.30 | 164.90 | 5.07 | 0.0119 | 82.00 |
| Viscera | 61.49 | 30.80 | 1.79 | 7.45 | 1.77 | ---- |
| Muscle | 11.60 | 37.07 | 0.04 | 0.89 | 0.117 | 23.20 |
| Bone | 9.57 | 53.60 | 36.10 | 2.59 | ---- | ---- |
| Skin | 8.40 | 15.00 | ---- | 1.58 | ---- | ---- |
| Kidney | 51.50 | 27.90 | ---- | 5.40 | ---- | ---- |
| Lungs | ---- | 51.22 | 0.84 | ---- | 8.15 | ---- |

[a]From an area of higher environmental radioactivity in center of island.

Table 87. Distribution of radionuclides in terrestrial biota and soil on URSULA, Enewetak Atoll, 1972-1973.

| Ecosystem level | Activity, pCi/g, dry wt | | | | | | |
|---|---|---|---|---|---|---|---|
| | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
| Soil | | | | | | | |
| Island range | ---- | 0.13-7.8 | 2.0-19 | 0.05-1.7 | 0.26-7.3 | ---- | |
| Mean | ---- | 1.7 | 6.8 | 0.31 | 1.3 | ---- | |
| Soil survey | | | | | | | |
| No. 14 | ---- | 2.90 | 10.00 | 0.74 | 3.00 | ---- | |
| No. 17 | ---- | 5.30 | 13.00 | 1.20 | 4.20 | ---- | |
| Biota soil sample | ---- | 1.40 | 9.70 | 0.69 | 0.54 | ---- | |
| Mean | ---- | 3.20 | 11.50 | 0.87 | 3.60 | ---- | |
| Plants | | | | | | | |
| *Messerschmidia argentea* | 10.09 | 104.90 | 13.60 | ---- | ---- | ---- | |
| *Scaevola frutescens* | 5.45 | 91.49 | 6.13 | ---- | ---- | ---- | |
| *Guettarda speciosa* | 14.23 | 13.27 | 7.30 | ---- | ---- | ---- | |
| Animals | | | | | | | |
| *Rattus exulans* (rice rat) | | | | | | | |
| Viscera | 10.87 | 43.14 | 2.17 | 1.13 | ---- | ---- | |
| Liver | 6.72 | 39.41 | ---- | 3.59 | 0.041 | 42.20 | $^{207}Bi$ 0.375 |
| Muscle | 9.22 | 37.86 | ---- | ---- | ---- | ---- | |
| Bone | 7.26 | 61.58 | 19.60 | ---- | 0.146 | ---- | |
| Skin | 7.58 | 18.50 | ---- | 0.41 | ---- | ---- | |
| Kidney | ---- | 38.40 | ---- | ---- | ---- | ---- | |
| Lungs | ---- | 45.00 | ---- | ---- | ---- | ---- | |

Table 88. Distribution of radionuclides in terrestrial biota and soil on SALLY, Enewetak Atoll, 1972-1973.

| | Activity, pCi/g, dry wt | | | | | | |
|---|---|---|---|---|---|---|---|
| Ecosystem level | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
| Soil | | | | | | | |
| Island range | ---- | 0.03-30 | 0.87-140 | 0.05-69 | 0.21-130 | ---- | |
| Mean | ---- | 3.0 | 8.4 | 0.54 | 4.3 | ---- | |
| Soil survey | | | | | | | |
| No. 4 | ---- | 3.20 | 15.0 | 0.81 | 1.90 | ---- | |
| No. 7 | ---- | 1.50 | 8.3 | 0.70 | 0.39 | ---- | |
| Biota soil sample | ---- | 10.30 | 24.55 | 1.26 | 1.89 | ---- | |
| Plants | | | | | | | |
| Messerschmidia argentea | 8.28 | 12.63 | 4.86 | 0.10 | 0.059 | ---- | |
| Scaevola frutescens | 10.78 | 13.38 | 6.67 | ---- | 0.096 | ---- | $^{238}Pu$ 0.0027 |
| Pandanus tectorius | 14.02 | 14.98 | 1.97 | ---- | 0.015 | 0.703 | |
| Lepturus repens (grass) | 3.74 | 83.20 | 1.98 | ---- | 0.0227 | ---- | |
| Animals | | | | | | | |
| Rattus exulans (rice rat) | | | | | | | |
| Viscera | 9.63 | 92.97 | 14.60 | 1.48 | 1.300 | ---- | |
| Liver | 10.73 | 63.83 | 0.002 | 2.54 | 0.008 | 35.50 | |
| Lung | 13.20 | 73.90 | 0.22 | 0.67 | 0.198 | ---- | |
| Muscle | 5.82 | 60.86 | ---- | ---- | ---- | ---- | $^{3}H$ 18.7 |
| Bone | 7.01 | 65.77 | 25.90 | 0.81 | 0.039 | ---- | |
| Skin | 4.52 | 49.10 | ---- | 0.49 | ---- | ---- | |
| Kidney | ---- | 73.30 | ---- | 2.28 | ---- | ---- | |
| Sterna fuscata (sooty tern) | | | | | | | |
| Viscera | 4.79 | ---- | ---- | ---- | ---- | 22.43 | |
| Liver | ---- | ---- | ---- | ---- | ---- | 155.00 | |
| Muscle | 7.63 | ---- | 0.014 | ---- | 0.020 | 109.50 | |
| Egg | 4.57 | ---- | 0.004 | ---- | 0.015 | 37.57 | |
| Eggshell | ---- | ---- | 0.265 | ---- | 0.005 | ---- | |
| Bone | ---- | ---- | ---- | ---- | ---- | 35.70 | |
| Anous tenuirostris (white-capped tern) | | | | | | | |
| Viscera | 5.89 | ---- | ---- | ---- | ---- | 64.40 | |
| Liver | ---- | ---- | ---- | ---- | 0.011 | ---- | |
| Muscle | 6.31 | ---- | ---- | ---- | 0.005 | 36.60 | |
| Bone | ---- | 0.14 | 1.68 | 0.34 | ---- | 61.3 | |

Table 89. Distribution of radionuclides in terrestrial biota and soil on TILDA, Enewetak Atoll, 1972-1973.

| Ecosystem level | Activity, pCi/g, dry wt $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ |
|---|---|---|---|---|---|---|
| Soil | | | | | | |
| Dense | | | | | | |
| Range | ---- | 3.5-20 | 17.54 | 0.61-1.9 | 1.4-17 | ---- |
| Mean | ---- | 8.4 | 27 | 1.2 | 7.6 | ---- |
| Sparse | | | | | | |
| Range | ---- | 0.04-5.3 | 2.2-47 | 0.21-1.7 | 1.1-34 | ---- |
| Mean | ---- | 1.0 | 8.7 | 0.37 | 2.5 | ---- |
| Soil survey No. 4 | ---- | 3.20 | 10.14 | 2.58 | 1.11 | ---- |
| Biota soil sample | ---- | 4.90 | 98.65 | 3.75 | 29.32 | ---- |
| Plants | | | | | | |
| Messerschmidia argentea | 10.13 | 58.78 | 10.27 | ---- | ---- | ---- |
| Scaevola frutescens | 11.39 | 24.94 | 9.05 | ---- | 0.0042 | ---- |
| Morinda citrifolia | 13.94 | 13.90 | 12.48 | ---- | ---- | ---- |
| Pandanus tectorius | 13.29 | 152.20 | 15.50 | ---- | 0.0069 | ---- |
| Guettarda speciosa | 10.10 | 5.90 | 12.57 | ---- | 0.0091 | ---- |

Table 90. Distribution of radionuclides in terrestrial biota and soil on VERA, Enewetak Atoll, 1972-1973.

| Ecosystem level | Activity, pCi/g, dry wt $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ |
|---|---|---|---|---|---|---|
| Soil | | | | | | |
| Range | ---- | 0.03-12 | 1.1-68 | .04-2.2 | 0.60-25 | ---- |
| Mean | ---- | 2.0 | 6.3 | 0.56 | 2.5 | ---- |
| Soil survey No. 10 | ---- | 2.10 | 1.40 | 0.2 | 0.75 | ---- |
| Biota soil sample | ---- | 2.80 | 8.90 | 0.3 | 2.98 | ---- |
| Plants | | | | | | |
| Messerschmidia argentea | 7.07 | 10.77 | 12.79 | ---- | 0.0024 | ---- |
| Scaevola frutescens | 8.18 | 1.69 | 4.49 | ---- | ---- | ---- |
| Morinda citrifolia | 10.46 | 12.12 | 11.85 | ---- | ---- | ---- |
| Pandanus tectorius | 9.17 | 17.58 | 4.24 | ---- | 0.0076 | ---- |
| Cocos nucifera | 5.64 | 9.30 | 0.13 | ---- | ---- | ---- |
| Pisonia grandis | 28.58 | 56.94 | 23.11 | ---- | ---- | ---- |

Table 91. Distribution of radionuclides in terrestrial biota and soil on WILMA, Enewetak Atoll, 1972-1973.

| | Activity, pCi/g, dry wt | | | | |
|---|---|---|---|---|---|
| Ecosystem level | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ |
| Soil | | | | | |
| Range | ---- | 0.31-7.2 | 0.26-13 | 0.01-0.70 | 0.1-5.3 |
| Mean | ---- | 1.3 | 3.3 | 0.12 | 1.1 |
| Soil survey | | | | | |
| No. 21 | ---- | 1.10 | 4.2 | 0.18 | 1.30 |
| No. 22 | ---- | 1.80 | 2.5 | 0.14 | 0.70 |
| Mean | ---- | 1.45 | 3.4 | 0.16 | 1.00 |
| Plants | | | | | |
| *Messerschmidia argentea* | 5.00 | 6.19 | ---- | ---- | ---- |
| *Scaevola frutescens* | 10.31 | 1.24 | ---- | ---- | ---- |
| *Guettarda speciosa* | 10.60 | 3.14 | ---- | ---- | ---- |

Table 92. Locations of biota samples collected on YVONNE (Runit), Enewetak Atoll, 1972-1973.

| Sector | Description |
|---|---|
| A | At north end of island, near Cactus crater in scattered *Messerschmidia-Scaevola* regrowth. |
| B | At north end of island, on lagoon side of road, 150 yd south of Cactus crater. |
| C | Mid-island, on peninsula which extends into seaward reef, along old airstrip. |
| D | Old camp area at south end of island. |

Table 93. Distribution of radionuclides in terrestrial biota and soil on YVONNE, Enewetak Atoll, 1972-1973.

| Sector A<br>Ecosystem level | Activity, pCi/g, dry wt<br>$^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
|---|---|---|---|---|---|---|---|
| Soil | | | | | | | |
| Soil survey | | | | | | | |
| No. 139 | ---- | 7.30 | ---- | 16.00 | 23.00 | ---- | |
| No. 140 | ---- | 6.50 | 10.00 | 4.10 | 5.60 | ---- | |
| No. 141 | ---- | 47.00 | 190.00 | 54.00 | 55.00 | ---- | |
| Mean | ---- | 20.26 | 100.00 | 24.70 | 27.87 | ---- | |
| Plants | | | | | | | |
| *Messerschmidia argentea* | 9.93 | 5644.00 | 257.20 | 1.16 | 0.253 | ---- | |
| *Scaevola frutescens* | 18.77 | 658.00 | 80.63 | 6.26 | 0.195 | ---- | |
| *Scaevola frutescens* | 10.68 | 609.00 | 159.00 | 20.26 | 0.322 | ---- | |
| *Guettarda speciosa* | 11.15 | 794.00 | 64.41 | 4.52 | 0.002 | ---- | |
| Animals | | | | | | | |
| *Rattus rattus* (roof rat) | | | | | | | |
| Muscle | 12.35 | 4240.00 | 5.09 | 12.35 | 0.052 | 32.80 | $^{3}H$ 1.8 |
| Bone | ---- | 1833.00 | 146.40 | 5.92 | 0.057 | ---- | |
| Viscera | 7.61 | 2928.00 | ---- | 112.60 | 1.05 | ---- | |
| Skin | 6.69 | 2088.00 | ---- | 14.00 | ---- | ---- | |
| Liver | ---- | 2559.00 | ---- | 7.03 | 0.027 | 126.10 | $^{151}Sm$ 18.70 |
| Kidney | ---- | 3427.00 | ---- | 257.70 | ---- | ---- | |
| Lung | 14.26 | 3306.00 | 0.24 | 10.53 | 0.107 | ---- | $^{134}Cs$ 1.5 |
| Muscle | 13.07 | 3824.00 | 37.79 | 8.51 | 0.003 | 78.83 | |
| Bone | 7.93 | 2199.00 | 135.10 | 10.57 | 0.029 | ---- | $^{134}Cs$ 1.36 |
| Viscera | 13.33 | 3531.00 | 4.09 | 230.00 | 0.581 | ---- | |
| Skin | 6.92 | 1875.00 | ---- | 7.43 | ---- | ---- | |
| Liver | 14.15 | 2215.00 | 0.005 | 86.13 | 0.013 | 135.60 | |
| Kidney | 33.10 | 3286.00 | ---- | 261.80 | ---- | 252.30 | |
| Lung | 33.12 | 2760.00 | 16.17 | 11.08 | ---- | ---- | |

Table 93 (Continued).

| Sector B Ecosystem level | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
|---|---|---|---|---|---|---|---|
| | Activity, pCi/g, dry wt | | | | | | |
| Soil | | | | | | | |
| Soil survey | | | | | | | |
| No. 135 | 0.31 | 0.52 | 2.50 | 0.29 | 3.400 | ---- | |
| No. 136 | ---- | 1.70 | 3.50 | 0.84 | 7.000 | ---- | |
| No. 137 | 1.60 | 1.60 | 2.50 | 0.28 | 9.400 | ---- | |
| Biota soil sample | 1.26 | 4.33 | 6.13 | 0.69 | ---- | ---- | |
| Mean | ---- | 2.04 | 3.65 | 0.52 | 6.60 | ---- | |
| Plants | | | | | | | |
| Messerschmidia argentea | 10.91 | 95.32 | 8.60 | ---- | 0.013 | ---- | |
| Scaevola frutescens | 15.93 | 28.25 | 1.94 | ---- | 0.190 | ---- | |
| Cocos nucifera | | | | | | | $^{3}H$ |
| Meat | 8.24 | 3.96 | 0.01 | ---- | ---- | ---- | 0.66 |
| Animals | | | | | | | |
| Rattus rattus (roof rat) | | | | | | | |
| Muscle | 16.82 | 86.04 | ---- | ---- | ---- | ---- | |
| Bone | 9.74 | 48.78 | 16.67 | ---- | 0.304 | ---- | |
| Viscera | 9.67 | 76.71 | 0.57 | 1.99 | 0.393 | ---- | |
| Skin | 4.74 | 42.64 | ---- | ---- | ---- | ---- | |
| Liver | ---- | 56.22 | ---- | 2.90 | 0.008 | 25.01 | $^{151}Sm$ 23.00 |
| Kidney | ---- | 59.64 | ---- | 4.96 | ---- | ---- | |
| Lung | ---- | 39.72 | ---- | ---- | 0.023 | ---- | |
| Anous stolidus (common noddy) | | | | | | | |
| Egg | 7.22 | ---- | 0.07 | ---- | ---- | 54.50 | |
| Eggshell | ---- | ---- | ---- | ---- | 0.009 | ---- | |
| Viscera | 8.34 | ---- | ---- | ---- | ---- | 64.41 | |
| Liver | ---- | ---- | ---- | 0.37 | ---- | 385.60 | |
| Muscle | 7.39 | ---- | 0.007 | 0.23 | 0.02 | 22.61 | |
| Bone | ---- | 5.51 | ---- | ---- | 0.021 | 63.50 | |

Table 93 (Continued)

| Sector C<br>Ecosystem level | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
|---|---|---|---|---|---|---|---|
| | Activity, pCi/g, dry wt | | | | | | |
| Soil | | | | | | | |
| Soil survey | | | | | | | |
| No. 26 | ---- | 3.40 | 3.40 | 2.80 | 6.300 | ---- | |
| No. 28 | ---- | 2.30 | 9.40 | 9.50 | 21.000 | ---- | |
| No. 29 | ---- | 0.55 | 1.50 | 4.60 | 3.300 | ---- | |
| No. 55 | ---- | 2.30 | 4.30 | 2.20 | 5.300 | ---- | |
| Mean | ---- | 2.13 | 4.65 | 4.70 | 8.970 | ---- | |
| Plants | | | | | | | |
| *Messerschmidia argentea* | 14.19 | 2.28 | 0.064 | ---- | 0.008 | ---- | |
| *Messerschmidia argentea* | 14.46 | 3.81 | 1.43 | ---- | 0.011 | ---- | |
| *Messerschmidia argentea* | 10.91 | 95.32 | 8.60 | ---- | 0.129 | ---- | |
| *Scaevola frutescens* | 13.21 | 11.88 | 1.76 | 0.51 | 0.026 | ---- | $^{238}Pu$ 0.0068 |
| *Scaevola frutescens* | 14.16 | 1.57 | 0.44 | ---- | 0.004 | ---- | |
| *Scaevola frutescens* | 15.00 | 8.06 | 0.66 | 0.25 | 1.293 | ---- | $^{238}Pu$ 0.061<br>$^{241}Am$ 0.146 |
| *Scaevola frutescens* | 10.68 | 609.90 | 159.00 | 20.26 | 0.322 | ---- | |
| *Scaevola frutescens* | 15.93 | 28.25 | 1.94 | ---- | 0.190 | ---- | $^{238}Pu$ 0.076 |
| Animals | | | | | | | |
| *Rattus rattus* (roof rat) | | | | | | | |
| Skin | ---- | 28.40 | ---- | 0.69 | ---- | ---- | |
| Lung | ---- | 53.33 | ---- | ---- | 0.568 | ---- | |
| Viscera | ---- | 55.81 | ---- | ---- | 0.211 | 3.46 | $^{238}Pu$ 0.096 |
| Liver | ---- | 38.68 | 0.002 | 5.63 | 0.011 | 13.83 | |
| Kidney | 30.64 | 29.00 | ---- | 8.03 | ---- | ---- | |
| Muscle | 5.77 | 49.19 | 6.76 | 0.55 | ---- | 4.12 | $^{3}H$ 1.10 |
| Bone | ---- | 38.78 | 6.40 | 0.51 | 0.059 | ---- | |

Table 93 (Continued).

| Sector D Ecosystem level | Activity, pCi/g, dry wt $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
|---|---|---|---|---|---|---|---|
| Soil | | | | | | | |
| Soil survey | | | | | | | |
| No. 43 | ---- | 0.25 | 43.00 | 0.05 | 210.00 | ---- | |
| No. 2 | ---- | 0.21 | 1.20 | 0.12 | 0.37 | ---- | |
| Biota soil sample | ---- | 0.82 | ---- | 8.00 | ---- | ---- | |
| Plants | | | | | | | |
| *Messerschmidia argentea* | 14.19 | 2.28 | 0.64 | ---- | 0.004 | ---- | |
| *Scaevola frutescens* | 14.16 | 1.57 | 0.44 | ---- | 0.004 | ---- | |
| *Cocos nucifera* | | | | | | | |
| Meat | 6.39 | 1.99 | ---- | ---- | ---- | ---- | |
| Animals | | | | | | | |
| *Rattus rattus* (roof rat) | | | | | | | |
| Muscle | 15.87 | 3.74 | 0.63 | ---- | 0.008 | 1.23 | |
| Bone | 23.95 | 23.80 | 1.32 | 1.31 | 0.058 | ---- | |
| Lung | ---- | 11.55 | ---- | ---- | 0.201 | ---- | |
| Viscera | 17.77 | 5.69 | ---- | 0.20 | 0.020 | ---- | |
| Liver | ---- | 4.62 | 10.54 | ---- | 0.398 | 17.30 | |
| Skin | 10.70 | 3.94 | ---- | ---- | ---- | ---- | |
| Kidney[a] | 16.72 | 6.19 | ---- | ---- | ---- | ---- | |
| *Anous stolidus* (common noddy) | | | | | | | |
| Eggshell | ---- | ---- | 0.22 | ---- | ---- | 1.10 | |
| Egg | 4.13 | ---- | ---- | ---- | 0.023 | 56.76 | |

[a]Analysis showed 167.20 pCi/g $^{40}K$.

Table 94. Distribution of radionuclides in terrestrial biota and soil on BRUCE, Enewetak Atoll, 1972-1973.

| Ecosystem level | Activity, pCi/g, dry wt | | | | | | |
|---|---|---|---|---|---|---|---|
| | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
| Soil | | | | | | | |
| Range | ---- | 0.02-111 | 0.03-1.8 | 0.03-0.74 | 0.02-0.22 | ---- | |
| Mean | ---- | 0.40 | 0.59 | 0.12 | 0.08 | ---- | |
| Soil survey | | | | | | | |
| No. 4 | ---- | 0.59 | 0.30 | 0.08 | 0.02 | ---- | |
| No. 5 | ---- | 0.37 | 0.32 | 0.04 | 0.03 | ---- | |
| No. 6 | ---- | 0.20 | 0.03 | 0.04 | 0.04 | ---- | |
| Mean | ---- | 0.327 | 0.22 | 0.05 | 0.03 | ---- | |
| Biota soil sample | 0.64 | 2.60 | 1.53 | 1.25 | 0.26 | ---- | |
| Plants | | | | | | | |
| *Cocos nucifera* | 5.93 | 0.58 | ---- | ---- | ---- | ---- | |
| *Pisonia grandis* | 17.76 | 1.46 | 0.50 | ---- | ---- | ---- | |
| *Messerschmidia argentea* | 8.03 | 1.16 | 0.33 | ---- | ---- | ---- | |
| *Scaevola frutescens* | 9.32 | 0.75 | 0.88 | ---- | ---- | ---- | |
| Animals | | | | | | | |
| *Rattus rattus* (roof rat) | | | | | | | |
| Liver | 30.20 | 1.07 | ---- | 1.62 | 0.013 | 46.4 | |
| Viscera | ---- | 1.09 | ---- | ---- | 0.035 | ---- | |
| Muscle | 5.21 | 1.47 | 0.07 | ---- | 0.009 | 2.21 | |
| Kidney | ---- | 1.20 | ---- | 3.19 | ---- | ---- | |
| Lungs | 35.88 | 1.55 | ---- | ---- | ---- | ---- | |
| Skin | 8.07 | 0.61 | ---- | ---- | ---- | ---- | |
| Bone | 18.81 | 13.25 | 1.69 | ---- | 3.28 | ---- | |
| *Anous tenuirostris* (white-capped noddy) | | | | | | | |
| Liver | 8.37 | ---- | 0.03 | ---- | 0.022 | 326.6 | |
| Viscera | ---- | ---- | ---- | ---- | ---- | 73.9 | |
| Muscle | 7.10 | ---- | ---- | 0.39 | 0.006 | 41.3 | |
| Bone | ---- | ---- | 0.66 | ---- | ---- | 44.2 | |
| *Birgus latro* (coconut crab) | | | | | | | |
| Muscle | 11.28 | 1.98 | 0.18 | 0.20 | ---- | 0.98 | $^{3}H$ 0.42 |
| Hepatopancreas | 3.02 | 0.42 | 0.13 | 0.20 | ---- | 5.70 | $^{3}H$ 0.16 |
| Exoskeleton | 2.59 | 0.29 | 6.08 | ---- | 0.001 | 0.07 | |

Table 95. Distribution of radionuclides in terrestrial biota and soil on DAVID, Enewetak Atoll, 1972-1973.

| | Activity, pCi/g, dry wt | | | | | | |
|---|---|---|---|---|---|---|---|
| Ecosystem level | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
| **Soil** | | | | | | | |
| Range | ---- | 0.03-1.0 | 0.08-2.6 | 0.01-0.14 | 0.01-0.23 | ---- | |
| Mean | ---- | 0.39 | 0.55 | 0.034 | 0.054 | ---- | |
| Soil survey | | | | | | | |
| No. 2 | 0.38 | 0.56 | 2.60 | 0.02 | 0.05 | ---- | |
| No. 3 | ---- | 0.45 | 0.32 | 0.03 | 0.01 | ---- | |
| Biota soil sample | ---- | 0.36 | 0.41 | 0.03 | 0.02 | ---- | |
| **Plants** | | | | | | | |
| *Messerschmidia argentea* | 13.55 | 1.09 | 0.46 | ---- | 0.0061 | ---- | |
| *Messerschmidia argentea* | 11.02 | 7.24 | 0.76 | ---- | ---- | ---- | |
| *Messerschmidia argentea* | 13.22 | 2.58 | 1.06 | ---- | ---- | ---- | |
| *Messerschmidia argentea* | 3.88 | 15.84 | 0.75 | ---- | ---- | ---- | |
| *Scaevola frutescens* | 17.59 | 1.11 | 0.34 | ---- | 0.0005 | ---- | |
| *Scaevola frutescens* | 10.69 | 4.82 | 0.37 | ---- | ---- | ---- | |
| *Scaevola frutescens* | 13.02 | 5.18 | 0.31 | ---- | ---- | ---- | |
| *Scaevola frutescens* | 16.33 | 2.01 | 0.56 | ---- | ---- | ---- | |
| *Morinda citrifolia* | 12.26 | 3.51 | 0.02 | ---- | 0.013 | ---- | |
| *Pandanus tectorius* | 9.74 | 15.90 | 3.56 | ---- | ---- | 0.13 | |
| *Tacca leontopetaloides* | 6.63 | 1.09 | 0.46 | ---- | 0.0061 | ---- | $^{3}H$ 0.52 |
| *Fimbristylis atollensis* | 3.83 | 7.39 | ---- | ---- | ---- | ---- | |
| *Pisonia grandis* | 19.02 | 3.12 | 0.77 | ---- | 0.0013 | ---- | |
| *Pisonia grandis* | 10.2 | 1.8 | 0.56 | ---- | 0.0002 | ---- | |
| *Guettarda speciosa* | 4.00 | 3.16 | 0.32 | ---- | ---- | ---- | |
| *Cocos nucifera* | 6.44 | 2.59 | 0.01 | ---- | ---- | ---- | $^{3}H$ 0.31 |
| *Cocos nucifera* | 3.76 | 1.67 | 0.18 | ---- | ---- | ---- | $^{102}Rh$ 0.123 |
| *Cocos nucifera* | 4.69 | 0.40 | 0.03 | ---- | 0.0034 | ---- | |
| *Cocos nucifera* Milk | 30.93 | 23.32 | ---- | ---- | ---- | ---- | |

95 (Continued).

| stem level | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
|---|---|---|---|---|---|---|---|
| | Activity, pCi/g, dry wt | | | | | | |
| ıls | | | | | | | |
| bita perlatus (hermit crab) | | | | | | | |
| ɔpancreas | 7.61 | 1.95 | 0.19 | 0.23 | 4.82 | 0.57 | $^{3}H$ 0.95 |
| e | 7.52 | 2.06 | 0.31 | 0.28 | 0.0031 | ---- | $^{3}H$ 0.58 |
| ɔleton | 1.76 | 0.60 | 4.05 | ---- | 0.010 | 0.04 | |
| ı fuscata (sooty tern) | | | | | | | |
| e | 7.46 | ---- | ---- | ---- | 0.119 | 59.0 | |
| | ---- | 0.74 | ---- | ---- | ---- | 37.4 | $^{134}Cs$ 0.413 |
| | 20.36 | ---- | ---- | ---- | ---- | 153.20 | |
| ra | 8.9 | ---- | ---- | ---- | ---- | 63.5 | |
| ı acuminata (sandpiper) | | | | | | | |
| | 17.57 | ---- | ---- | ---- | ---- | ---- | |
| | 28.16 | 0.79 | ---- | ---- | ---- | ---- | |
| ɡretta sacra (reef heron) | | | | | | | |
| | 8.76 | 1.34 | ---- | 0.41 | ---- | ---- | |
| .e | 4.65 | 1.59 | ---- | ---- | ---- | ---- | |
| s exulans (rice rat) | | | | | | | |
| ra | 12.24 | 21.97 | 0.24 | ---- | 0.0087 | ---- | |
| | ---- | 16.36 | ---- | ---- | 0.0042 | 3.67 | |
| .e | 7.80 | 18.78 | 0.60 | ---- | 0.044 | 0.98 | |
| | 11.46 | 28.37 | 1.37 | ---- | 0.065 | ---- | |
| | 6.49 | 9.13 | ---- | ---- | ---- | ---- | |
| y | ---- | 17.0 | ---- | ---- | ---- | ---- | |
| | ---- | 18.5 | ---- | ---- | 0.031 | ---- | |

Table 96. Distribution of radionuclides in terrestrial biota and soil on REX, Enewetak Atoll, 1972-1973.

| Ecosystem level | Activity, pCi/g, dry wt | | | | | |
|---|---|---|---|---|---|---|
| | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ |
| Soil | | | | | | |
| Soil survey | | | | | | |
| No. 3 | ---- | 0.92 | 0.70 | 0.04 | 0.050 | ---- |
| No. 4 | ---- | 1.10 | 1.60 | 0.05 | 0.060 | ---- |
| No. 6 | ---- | 0.23 | 0.37 | 0.08 | 0.020 | ---- |
| Mean | ---- | 0.75 | 0.89 | 0.06 | 0.040 | ---- |
| Plants | | | | | | |
| *Scaevola frutescens* | 6.36 | 0.49 | ---- | ---- | ---- | ---- |
| *Messerschmidia argentea* | 8.90 | 2.45 | ---- | ---- | ---- | ---- |
| *Pisonia grandis* | 16.00 | 2.64 | ---- | 0.091 | ---- | ---- |
| Animals | | | | | | |
| *Anous stolidus* (common noddy) | | | | | | |
| Eggshell | ---- | ---- | ---- | ---- | ---- | 0.73 |
| Egg | 7.69 | ---- | ---- | ---- | 0.0077 | 51.4 |
| Liver | 4.39 | ---- | ---- | ---- | ---- | 117.6 |
| Muscle | 10.81 | ---- | 0.006 | ---- | 0.0056 | 43.5 |
| Bone | ---- | ---- | ---- | ---- | ---- | 44.77 |
| Viscera | ---- | ---- | ---- | ---- | ---- | 50.0 |
| *Coenobita perlatus* (hermit crab) | | | | | | |
| Hepatopancreas | 5.83 | 0.78 | 0.30 | 0.57 | 0.0035 | 1.82 |
| Muscle | 6.63 | 1.05 | 0.32 | 1.44 | 0.0026 | 1.47 |
| Exoskeleton | 1.84 | 0.25 | 3.62 | ---- | 0.001 | 0.085 |

Table 97. Distribution of radionuclides in terrestrial biota and soil on ELMER, Enewetak Atoll, 1972-1973.

| Ecosystem level | Activity, pCi/g, dry wt | | | | | | |
|---|---|---|---|---|---|---|---|
| | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
| Soil | | | | | | | |
| Soil survey | | | | | | | |
| No. 19 | ---- | 0.50 | 0.44 | ---- | 0.100 | ---- | |
| No. 67 | ---- | 0.22 | 0.31 | ---- | 0.060 | ---- | |
| No. 68 | ---- | 0.51 | 0.24 | ---- | 0.020 | ---- | |
| Biota soil sample | ---- | 2.44 | 2.26 | ---- | 0.19 | ---- | |
| Biota soil sample | 0.40 | 0.40 | 0.71 | ---- | 0.03 | ---- | |
| Plants | | | | | | | |
| Messerschmidia argentea | ---- | 2.39 | 0.98 | ---- | ---- | ---- | |
| Scaevola frutescens | 13.60 | 2.40 | 0.27 | ---- | ---- | ---- | |
| Cocos nucifera | 9.73 | 2.14 | 0.03 | ---- | ---- | ---- | $^{3}H$ 0.31 |
| Messerschmidia argentea | 9.04 | 1.66 | 0.63 | ---- | ---- | ---- | |
| Scaevola frutescens | 11.83 | 1.47 | 0.62 | ---- | ---- | ---- | |
| Cocos nucifera | 5.50 | 3.45 | ---- | ---- | ---- | ---- | |
| Pandanus tectorius | 8.86 | 3.09 | 25.14 | ---- | 0.002 | 0.41 | |
| Animals | | | | | | | |
| Rattus rattus (roof rat) | | | | | | | |
| Viscera | 11.19 | 19.00 | 0.16 | 1.39 | 0.0074 | ---- | |
| Liver | 11.12 | 15.60 | 0.018 | ---- | ---- | 0.93 | |
| Bone | 9.04 | 9.96 | 1.42 | ---- | 0.23 | ---- | |
| Muscle | 10.3 | 18.4 | 0.06 | ---- | 0.016 | 0.10 | $^{3}H$ 11.3 |
| Skin | 6.5 | 7.6 | ---- | ---- | ---- | ---- | |
| Lung | 14.7 | 16.9 | 1.0 | ---- | 0.14 | ---- | |
| Kidney | 21.8 | 15.0 | ---- | 1.74 | ---- | ---- | |

Table 98. Distribution of radionuclides in terrestrial biota and soil on FRED, Enewetak Atoll, 1972-1973.

| | Activity, pCi/g, dry wt | | | | | |
|---|---|---|---|---|---|---|
| Ecosystem level | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | Other |
| Soil | | | | | | |
| Soil survey | | | | | | |
| No. 18 | ---- | 0.16 | 0.85 | ---- | ---- | |
| No. 52 | ---- | 0.48 | 1.50 | 0.15 | 0.17 | |
| Plants | | | | | | |
| Messerschmidia argentea | 11.23 | 0.56 | 0.43 | ---- | ---- | |
| Messerschmidia argentea | 8.83 | 1.78 | 0.49 | ---- | ---- | |
| Scaevola frutescens | 10.36 | 0.65 | 0.23 | ---- | 0.0006 | |
| Scaevola frutescens | 7.14 | 3.80 | 0.81 | ---- | ---- | |
| Cocos nucifera | 6.39 | 2.39 | 0.03 | ---- | ---- | $^{3}H$ 0.39 |
| Cocos nucifera | 5.59 | 0.53 | 0.37 | ---- | ---- | |
| Pandanus tectorius | 3.38 | 4.29 | 0.42 | ---- | 0.0077 | $^{55}Fe$ 0.85 |

Table 99. Distribution of radionuclides in terrestrial biota and soil on GLENN, Enewetak Atoll, 1972-1973.

| Ecosystem level | Activity, pCi/g, dry wt | | | | | | |
|---|---|---|---|---|---|---|---|
| | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
| **Soil** | | | | | | | |
| Range | ---- | 0.01-0.25 | 0.09-3.9 | 0.01-0.25 | 0.005-0.26 | ---- | |
| Mean | ---- | 0.60 | 1.37 | 0.069 | 0.105 | ---- | |
| Soil survey | | | | | | | |
| No. 15 | ---- | 1.20 | 0.24 | 0.12 | 0.13 | ---- | |
| No. 16 | ---- | 0.53 | 0.95 | 0.03 | 0.04 | ---- | |
| No. 17 | ---- | 0.58 | 0.71 | 0.02 | 0.04 | ---- | |
| Mean | ---- | 0.77 | 0.63 | 0.06 | 0.07 | ---- | |
| Biota soil sample | ---- | 1.67 | ---- | 0.13 | 0.30 | ---- | |
| **Plants** | | | | | | | |
| *Scaevola frutescens* | 12.84 | 0.64 | 1.54 | ---- | ---- | ---- | |
| *Scaevola frutescens* | 13.74 | 0.53 | 1.34 | ---- | ---- | ---- | |
| *Messerschmidia argentea* | 21.81 | 1.24 | 2.05 | ---- | ---- | ---- | |
| *Messerschmidia argentea* | 9.75 | 1.27 | 2.51 | ---- | ---- | ---- | |
| *Pisonia grandis* | 25.79 | 1.86 | 2.88 | ---- | ---- | 0.81 | $^{102}Rh$ 0.17 |
| *Pisonia grandis* | 30.28 | 3.91 | 1.74 | ---- | ---- | ---- | |
| *Morinda citrifolia* | 22.29 | 0.64 | 1.58 | ---- | ---- | ---- | |
| *Morinda citrifolia* | 14.16 | 0.76 | 0.40 | ---- | ---- | ---- | |
| *Cocos nucifera* (meat) | 9.10 | 1.65 | 0.33 | ---- | ---- | ---- | |
| *Cocos nucifera* (meat) | 8.28 | 1.30 | ---- | ---- | ---- | ---- | |
| **Animals** | | | | | | | |
| *Birgus latro* (coconut crab) | | | | | | | |
| Hepatopancreas | 15.0 | 0.54 | 0.27 | 0.28 | ---- | ---- | $^{3}H$ 0.27 |
| Muscle | 10.45 | 1.88 | ---- | ---- | ---- | 0.68 | $^{3}H$ 0.69 |
| Exoskeleton | 1.06 | 0.31 | 10.40 | ---- | 0.0035 | ---- | |
| *Coenobita perlatus* (hermit crab) | | | | | | | |
| Hepatopancreas | 8.68 | 1.51 | 0.43 | 1.12 | 0.006 | 1.55 | |
| Exoskeleton | 1.52 | 0.25 | 9.14 | ---- | 0.0011 | ---- | |
| Muscle | 7.86 | 1.51 | 0.91 | 1.97 | 0.011 | 1.32 | |

Table 99 (Continued).

| Ecosystem level | Activity, pCi/g, dry wt $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
|---|---|---|---|---|---|---|---|
| Animals | | | | | | | |
| Rattus rattus (roof rat) | | | | | | | |
| Viscera | 11.75 | 1.88 | 0.28 | 2.06 | 0.036 | ---- | |
| Liver | 12.79 | 1.45 | ---- | 1.18 | 0.035 | ---- | |
| Bone | 10.61 | 6.02 | 2.67 | 0.71 | 0.87 | ---- | |
| Muscle | 8.18 | 1.76 | 1.03 | 0.48 | 0.017 | 4.49 | |
| Skin | 2.3 | 0.33 | ---- | ---- | ---- | ---- | |
| Kidney | ---- | 1.46 | ---- | 2.40 | ---- | ---- | |
| Lung | 20.7 | 1.74 | ---- | ---- | 0.30 | ---- | |

Table 100. Distribution of radionuclides in terrestrial biota and soil on HENRY, Enewetak Atoll, 1972-1973.

| Ecosystem level | Activity, pCi/g, dry wt $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
|---|---|---|---|---|---|---|---|
| Soil | | | | | | | |
| Soil survey | | | | | | | |
| No. 7 | ---- | 0.01 | 0.24 | 0.01 | 0.21 | ---- | |
| No. 8 | ---- | 0.19 | 0.28 | 0.05 | 0.11 | ---- | |
| Biota soil sample | 1.40 | 0.98 | ---- | ---- | ---- | ---- | |
| Plants | | | | | | | |
| Messerschmidia argentea | 12.77 | 0.52 | 1.98 | ---- | ---- | ---- | |
| Scaevola frutescens | 12.64 | 0.19 | ---- | ---- | ---- | ---- | |
| Morinda citrifolia | 17.01 | 1.19 | 0.32 | ---- | ---- | ---- | |
| Cocos nucifera | 3.66 | 0.70 | ---- | ---- | ---- | ---- | |
| Animals | | | | | | | |
| Coenobita perlatus (hermit crab) | | | | | | | |
| Hepatopancreas | 5.72 | 1.17 | 0.50 | 0.98 | ---- | ---- | |
| Muscle | 7.69 | 1.08 | 0.64 | 2.00 | 0.0066 | 0.98 | |
| Exoskeleton | 2.34 | 0.24 | 9.64 | ---- | 0.0009 | 0.08 | |
| Anous stolidus (common noddy) | | | | | | | |
| Egg | 3.38 | ---- | ---- | ---- | ---- | 54.1 | $^{65}Zn$ 0.79 |
| Eggshell | ---- | ---- | ---- | ---- | ---- | 8.6 | |

able 101. Distribution of radionuclides in terrestrial biota and soil on JAMES, Enewetak Atoll, 1972-1973.

| cosystem level | Activity, pCi/g, dry wt | | | | | |
|---|---|---|---|---|---|---|
| | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ |
| *oil* | | | | | | |
| oil survey | | | | | | |
| o. 6 | ---- | 0.08 | 0.57 | 0.06 | 0.03 | ---- |
| o. 8 | ---- | 0.02 | 0.39 | 0.12 | 0.11 | ---- |
| lean | ---- | 0.05 | 0.48 | 0.09 | 0.07 | ---- |
| iota soil sample | ---- | ---- | 1.81 | 9.04 | 0.16 | ---- |
| *lants* | | | | | | |
| *lesserschmidia argentea* | 17.71 | 1.76 | ---- | 0.25 | ---- | ---- |
| *caevola frutescens* | | 9.42 | 0.52 | ---- | ---- | ---- |
| *isonia grandis* | 12.66 | 1.55 | ---- | ---- | ---- | ---- |
| *uettarda speciosa* | 13.74 | 0.68 | ---- | ---- | ---- | ---- |
| *lorinda citrifolia* | 16.99 | 2.23 | 1.85 | ---- | ---- | ---- |
| *nimals* | | | | | | |
| *irgus latro* (coconut crab) | | | | | | |
| luscle | 9.62 | 1.25 | 0.079 | 1.05 | ---- | 1.84 |
| epatopancreas | 4.00 | 0.32 | ---- | 1.56 | ---- | 12.80 |
| xoskeleton | 1.44 | 0.22 | 5.90 | 0.11 | 0.002 | 0.30 |

Table 102. Distribution of radionuclides in terrestrial biota and soil on KEITH, Enewetak Atoll, 1972-1973.

| | Activity, pCi/g, dry wt | | | | | | |
|---|---|---|---|---|---|---|---|
| Ecosystem level | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
| Soil | | | | | | | |
| Soil survey | | | | | | | |
| No. 7 | ---- | 1.40 | 3.40 | 0.28 | 0.430 | ---- | |
| No. 9 | ---- | 0.81 | 1.60 | 0.11 | 0.100 | ---- | |
| No. 11 | ---- | 0.05 | 0.06 | 0.07 | 0.130 | ---- | |
| Biota soil sample (coconut) | ---- | 0.18 | 1.38 | 0.14 | 0.080 | ---- | |
| Biota soil sample (*Pisonia*) | ---- | 0.19 | 1.57 | 5.21 | 0.070 | ---- | |
| Plants | | | | | | | |
| *Messerschmidia argentea* | 12.45 | 0.25 | 0.32 | 0.20 | 0.0044 | ---- | |
| *Scaevola frutescens* | 15.52 | 0.43 | 0.64 | ---- | ---- | ---- | |
| *Pisonia grandis* | 30.81 | 3.65 | 3.00 | ---- | ---- | ---- | |
| *Cocos nucifera* | 7.69 | 0.95 | ---- | ---- | ---- | ---- | |
| *Guettarda speciosa* | 12.87 | 0.47 | 1.74 | ---- | ---- | ---- | |
| *Pandanus tectorius* (leaves) | 12.70 | 0.86 | 13.11 | ---- | ---- | 12.20 | $^{3}H$ 2.0 |
| *Pandanus tectorius* (flower) | 8.18 | 0.57 | ---- | ---- | ---- | 0.36 | |
| Animals | | | | | | | |
| *Birgus latro* (coconut crab) | | | | | | | |
| Muscle | 10.11 | 1.92 | 1.19 | 0.42 | ---- | 1.46 | |
| Exoskeleton | 3.35 | 0.51 | 9.96 | ---- | 0.0007 | 0.18 | |
| Hepatopancreas | 3.20 | 0.50 | 0.40 | 1.03 | 0.0098 | 6.17 | |
| *Anous stolidus* (common noddy) | | | | | | | |
| Viscera | 8.97 | ---- | ---- | ---- | ---- | 8.02 | |
| Muscle | 12.96 | ---- | ---- | 0.45 | 0.001 | ---- | |
| Bone | 3.80 | ---- | ---- | 0.31 | ---- | 68.5 | |
| Liver | ---- | ---- | ---- | 0.69 | ---- | ---- | |

Table 103. Distribution of radionuclides in terrestrial biota and soil on LEROY, Enewetak Atoll, 1972-1973.

| | Activity, pCi/g, dry wt | | | | | | |
|---|---|---|---|---|---|---|---|
| Ecosystem level | $^{40}K$ | $^{137}Cs$ | $^{90}Sr$ | $^{60}Co$ | $^{239,240}Pu$ | $^{55}Fe$ | Other |
| <u>Soil</u> | | | | | | | |
| Range | ---- | 0.5-10 | 1.6-34 | 0.04-5.0 | 0.02-2.0 | ---- | |
| Mean | ---- | 3.2 | 11 | 0.58 | 0.63 | ---- | |
| Soil survey | | | | | | | |
| No. 2 | ---- | 2.4 | 15.0 | 1.60 | 0.88 | ---- | |
| No. 4 | ---- | 2.6 | 9.2 | 2.2 | 0.89 | ---- | |
| Mean | ---- | 2.5 | 12.0 | 1.9 | 0.88 | | |
| Biota soil sample | ---- | 7.3 | 11.8 | 3.6 | 2.23 | ---- | |
| <u>Plants</u> | | | | | | | |
| <u>Cocos nucifera</u> | 4.10 | 3.54 | 0.19 | ---- | ---- | ---- | $^{102}Rh$ 0.13 |
| <u>Scaevola frutescens</u> | 13.29 | 1.80 | 3.74 | ---- | ---- | ---- | |
| <u>Messerschmidia argentea</u> | 15.09 | 4.71 | 14.37 | 0.21 | ---- | ---- | |
| <u>Pisonia grandis</u> | 34.27 | 10.17 | 14.86 | ---- | ---- | ---- | |
| <u>Pandanus tectorius</u> | 7.99 | 9.14 | 1.69 | ---- | 0.0022 | 0.21 | |
| <u>Pandanus tectorius</u> | 30.2 | 26.2 | 16.26 | ---- | ---- | ---- | |
| <u>Animals</u> | | | | | | | |
| <u>Birgus latro</u> (coconut crab) | | | | | | | |
| Muscle | 8.80 | 12.60 | 1.58 | 1.23 | 0.003 | 1.59 | $^{3}H$ 0.88 |
| Exoskeleton | 1.58 | 2.52 | 8.96 | 0.71 | 0.025 | 0.17 | |
| Hepatopancreas | 2.54 | 3.83 | 2.58 | 0.84 | 0.004 | 5.05 | $^{3}H$ 0.21 |
| <u>Anous tenuirostris</u> (white-capped noddy) | | | | | | | |
| Muscle | 10.95 | ---- | ---- | 2.06 | 0.003 | 64.4 | |
| Liver | ---- | ---- | 0.40 | 2.83 | 0.007 | 810.8 | |
| Viscera | 7.82 | ---- | ---- | 1.01 | ---- | 71.6 | |
| Bone | ---- | ---- | ---- | 0.94 | ---- | 109.5 | |

Discussion of Survey Data

The data on terrestrial biota samples collected in the Enewetak Atoll survey are shown in Table 59. It should be emphasized that an attempt was made to obtain samples of the range of edible species important to the evaluation of potential dosages. If an organism was not collected on an island, it is most likely that it did not occur there in significant numbers or in sufficient density to be encountered by the survey crews in several hours of collecting effort. We sampled judiciously so as not to alter the ecological state by our presence or removal of specimens. Because of the construction and test activities on the northern islands, the biota on many islands were in early stages of recovery or ecological succession, and therefore characterized by a limited number of species from a rather small flora (St. John, 1960). On some islands, only two ubiquitous woody species, Messerschmidia argentea and Scaevola frutescens, were found with a few widespread indigenous or introduced herb, grass, and vine species.

A wide range of plant species was sampled in order to obtain information on the transfer of radionuclides from soil to plants; while not eaten by man, several species were collected to provide a broad background on soil-plant relationships. It is apparent in the survey data that considerable variation occurs in the uptake of radionuclides from the stratum by plants, and the inclusion of non food plant species in the collections provides greater perspective on this subject.

Because most of the animals collected in the Enewetak survey were physically small, pooling of samples and organs from a single large sample of animals from a given island or area was necessary to obtain an adequate sample size for analysis. Therefore, the radionuclide data on mammals, birds, and land crustacea represent integrated or population values rather than single animal analyses.

In Table 59, the basic survey data are listed according to the island from which the samples were obtained. This information is essentially the biological data bank for evaluation of dose to man through the terrestrial food chain.

In Tables 60 to 75, the survey data are ordered on the species of organism and permit the range of radionuclide concentration in a single species throughout the Atoll to be observed in a single table. In Tables 76 to 103, the basic survey data are arranged by island and include the soil, plant, and animal data obtained from the site.

Data presented in Tables 60 to 75 will be discussed here to provide a detailed ecological description of the Enewetak terrestrial biota survey. In Table 60, the radionuclide concentrations in Messerschmidia argentea, a broad-leaved evergreen tree which was collected throughout the Atoll, are listed. $^{137}$Cs was found in M. argentea on every island. Highest concentrations were observed at the northern end of YVONNE (Runit), on JANET (Engebi), and on IRENE (Bogon). Elevated concentrations of $^{137}$Cs were found in Messerschmidia in islands from ALICE, across the northern arc of islands and south along the eastern rim of the Atoll to YVONNE. One value on DAVID (Japtan) of 15.84 pCi/g $^{137}Cs$ is approximately 2-3 times the other values from that island. This sample had an unusually low potassium content.

Correlation between $^{137}Cs$ and $^{90}Sr$ radioactivity in Messerschmidia and other plant species was not generally high. The differential uptake of these two radionuclides is undoubtedly influenced by the character of the Atoll substratum or soil. Most soils develop in place from the chemical and physical erosional products derived from the geological parent materials, which on Enewetak Atoll is composed entirely of coralline or algal limestone, or calcium and magnesium carbonate. The low potassium content of the Atoll substratum, the lack of clay-size particles (usually responsible for potassium and cesium complexing in soils), and the alcareous nature of the Atoll substratum suggest differential movement of cesium and strontium.

Highest $^{137}Cs$ concentration occurred in the Messerschmidia collected at the northern end of YVONNE (Runit), and the highest $^{90}Sr$ in Messerschmidia was on IRENE. The southern chain of islands from GLENN (Igurin) to KEITH (Giriinian) have Messerschmidia trees (leaves) with concentrations of $^{137}Cs$ from 0.25 to 1.76 pCi/g. Scaevola frutescens leaf concentrations also fall in this range. Vegetation growing in the San Francisco Bay area (approximately 38° N latitude) in 1972 had a mean concentration of 0.25 pCi/g dry wt $^{137}Cs$*, which is at the lower limit of concentrations observed in the southern arc of islands at Enewetak Atoll. Soil in the San Francisco area ranged from 0.01 to 0.10 pCi $^{137}Cs$/g dry wt in 1972.

The levels of $^{137}Cs$ observed on the southern and eastern islands south of BRUCE are higher than expected from world background for the southwest Pacific area. In 1964, a radiobiological survey of Enewetak and Bikini Atolls was conducted by the University of Washington Laboratory of Radiation Biology, and levels of $^{137}Cs$ in Messerschmidia and Scaevola on GLENN (Igurin) ranged from 2.4 to 5.0 pCi/g dry wt.† These southern islands received fallout from the peripheries of clouds which typically exited the Atoll toward the southwest. This is suggested by the elevated concentrations of $^{137}Cs$ in Messerschmidia, Scaevola, Pisonia, and Pandanus on LEROY (Rigili).

The radionuclide concentrations in Scaevola frutescens (Table 61) show patterns similar to those seen in Messerschmidia, but generally lower in value. Highest concentrations were again found on the northern end of YVONNE (Runit), where the maximum

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*P. H. Gudiksen, C. L. Lindeken, J. W. Meadows, and K. O. Hamby, Environmental Levels of Radioactivity in the Vicinity of the Lawrence Livermore Laboratory, 1972 Annual Report, Lawrence Livermore Laboratory, Rept. UCRL-51333 (1973).

†A. D. Welander, K. Bonham, L. R. Donaldson, R. F. Palumbo, S. P. Gessel, F. G. Lowman, and W. B. Jackson, Bikini-Enewetak Studies 1964 Part I, Ecological Observations. University of Washington Laboratory of Radiation Biology, Seattle, Rept. UWFL-93, Part I (1966).

$^{137}Cs$ concentrations in both species occurred. Maximum concentrations of $^{60}Co$ in both Messerschmidia and Scaevola were found on IRENE (Bogon) adjacent to Seminole crater. Highest $^{239,240}Pu$ concentrations were observed on the north end of YVONNE (Runit) in both Messerschmidia (0.766 pCi/g) and Scaevola (1.293 pCi/g). The highest $^{90}Sr$ value in Scaevola also occurred on YVONNE (Runit). There are 12 islands on which Messerschmidia or Scaevola had over 25 pCi/g of either $^{137}Cs$ or $^{90}Sr$. These are:

| | |
|---|---|
| ALICE | NANCY |
| CLARA | PEARL |
| IRENE | RUBY |
| JANET | TILDA |
| MARY | URSULA |
| MARY/NANCY* | YVONNE |

The arc of islands bounded by ALICE (Bogallua) on the west and YVONNE (Runit) on the east embraces the portion of the Atoll with the highest levels of environmental radioactivity. This is reflected by the radionuclide concentrations in the dominant vegetation of those sites. Within this sector of the Atoll, the highest levels of environmental radioactivity in the biota were found on IRENE (Bogon), JANET (Engebi), and YVONNE (Runit). In Table 62, the $^{137}Cs$ and $^{90}Sr$ concentrations in Messerschmidia and Scaevola on the three most radioactive islands are compared. From this table it is apparent that both $^{90}Sr$ and $^{137}Cs$ are higher in Messerschmidia than in Scaevola. No explanation for this species difference can be made from these data. Scaevola is thought to be slightly more halophytic or salt-tolerant than Messerschmidia. The $^{40}K$ concentrations, and hence the stable potassium levels, were found to be somewhat higher in Scaevola.

*Small islet or bar between MARY and NANCY.

The concentrations of radionuclides on Cocos nucifera, the coconut palm, on the islands of Enewetak Atoll are shown in Table 63. On the northern and eastern arc of islands, from DAISY to YVONNE, the coconut palms were young and most of the trees were just beginning to bear nuts at the time of the survey. On JANET (Engebi) fruit-bearing coconut palms were found along the eastern, or seaward, side of the island. These collections on JANET, and two others on MARY and NANCY, had the highest concentrations of $^{137}Cs$. Almost every high concentration of $^{137}Cs$ in coconut milk was correlated with high $^{40}K$. Two high concentrations of $^{55}Fe$ were found in coconuts from IRENE and MARY. The only $^{239,240}Pu$ detected in coconuts was found on IRENE (Bogon), in a radioactive area on the eastern side of the island.

The small tree, Morinda citrifolia, bears a soft, edible fruit. The leaves of this tree, and the fruit when available, were collected on 11 islands. Radionuclide concentrations in Morinda are given in Table 64. High $^{137}Cs$ concentrations were found in Morinda on the northeastern arc of the islands from KATE to VERA. The highest $^{137}Cs$ and $^{90}Sr$ values are observed on MARY.

A second small tree species, Guettarda speciosa, was collected on 13 islands (Table 65). It is apparently an early invader of bare or denuded habitats, or perhaps regenerates readily from root stocks left in the ground.* Elevated $^{137}Cs$ and $^{90}Sr$ concentrations were seen in Guettarda on BELLE, MARY, IRENE, and YVONNE.

The large tree, Pisonia grandis, which was not found on the Atoll north of KATE, was collected on 12 islands (Table 68). North of DAVID, Pisonia was found on five islands, two of which had been disturbed (KATE and NANCY) during the test period. On the southern islands from GLENN to LEROY, and on DAVID and BRUCE on the eastern side of the Atoll, Pisonia grandis forms almost mono-specific stands with essentially closed canopies. On the northern two islands (KATE and NANCY), scattered trees of Pisonia are reinvading the disturbed habitats which are typically dominated by Messerschmidia and Scaevola at this time. Pisonia collected on KATE, NANCY, and VERA had the highest $^{137}Cs$ and $^{90}Sr$ concentrations in the species on the Atoll. The plant species Pisonia appears to have a high potassium content from its $^{40}K$ concentration; some plants have more than 3% potassium in their leaves. The mean $^{40}K$ concentration in Pisonia is 21.0 pCi/g, which is higher than any plant sampled except coconut milk. The Pisonia forest soon creates an organic layer or mull in the soil of the island, and the potassium cycle of the site becomes enriched. The elevated levels of $^{137}Cs$ and $^{90}Sr$ in Pisonia on LEROY again suggest that this island received fallout from tests conducted to the northeast across the lagoon.

*R. F. Palumbo, "Recovery of the Land Plants at Enewetak Atoll Following a Nuclear Detonation," Radiation Botany 1, 182 (1962).

The Pandanus tree, Pandanus tectorius, was found on 11 islands at Enewetak Atoll (Table 67). Two trees bore fruit at the time of the survey, one on BELLE in the northern part of the Atoll and the other on KEITH in the southern islands. The fruit of this plant had 1.35 times the $^{137}Cs$ concentration that leaves from the same plant had. Pandanus on LEROY had elevated $^{137}Cs$ levels which were seen in other trees on that island. A high uptake of $^{90}Sr$ is indicated by elevated levels of that radionuclide in Pandanus leaves on ELMER and KEITH, where soil concentrations are low.

In Table 68, radionuclide concentrations in miscellaneous plant species are given. Lepturus repens is an indigenous grass which invades disturbed sites on the islands, and may be locally abundant around bird rookeries. A sedge counterpart, Fimbristylis atollensis, is also found in meadow-like areas in open stands or savannahs of Messerschmidia, such as on the north end of JANET. Suriana maritima is a halophytic shrub species which was collected on the southern margin of Seminole crater on IRENE. Pluchea odorata is a low succulent shrub typically found on the edges of natural openings in the trees and was collected at the western end of the airstrip on JANET. Tacca leontopetaloides, or arrowroot, is a coarse herb which has a large edible corm or storage organ that is eaten after rigorous processing. It was found in abundance in deep organic soil on DAVID, and in small patches on some of the southern islands. Terminalia samoensis is a low shrub which was observed and collected on one of the southern islands (IRWIN).

Lepturus had elevated concentrations of $^{137}Cs$ on MARY and SALLY, but concentrations were low on HELEN and IRENE, probably because collections were made on the beach where radioactivity levels are low. Fimbristylis, the sedge, collected from the margin of Seminole crater on IRENE had high $^{137}Cs$, $^{90}Sr$, $^{60}Co$, and $^{239, 240}Pu$ concentrations. Suriana growing in the same area also showed an accumulation of the same radionuclides, especially $^{60}Co$, which is prominent in most of the collections from IRENE.

Pluchea odorata, another shrubby species, was collected on JANET and had high concentrations of $^{137}Cs$ and $^{90}Sr$. This plant had the highest concentration of $^{137}Cs$ of any plant on JANET.

Tacca leontopetaloides, or arrowroot, had low concentrations of radionuclides on DAVID, but no specimens were found on islands with higher levels of radioactivity. Hence, any tendency for accumulation of radionuclides in the underground storage organs cannot be evaluated. This is a commonly used food plant which can be cultivated on islands with deep organic soils.

The radionuclide concentrations in land crustacea (Tables 69 and 70), in both species of rats (Tables 71 and 72), and in birds (Tables 73, 74, and 75) will be discussed in the next section, where these organisms will be placed in the context of the location in which they were collected. They are compiled here to facilitate reference to a specific organism and its occurrence on the islands of the Atoll, and to summarize radionuclide data for the animal species. These animals are significant in the Atoll ecology because they are food organisms, or they play a role similar to that of man in the island ecosystem.

The data on radionuclide concentrations in terrestrial biota have been combined with soil-survey data to produce an analysis of the island ecosystem at the time of the survey. Because of the highly variable distributions of soil radionuclide concentrations, it is probably not appropriate to use mean values of a radionuclide concentration in the soil, since they they may be high because of a few high values. To make this comparison as realistic as possible, data from the soil-survey location closest to the vegetation and animal collection site have been used. In most cases, a terrestrial biota soil sample was taken in the area in which the plant species were collected, and these data are also used in the ecosystem analysis. The terrestrial biota soil sample usually was taken to a depth of 5.0 cm and from an area of 30 $cm^2$. These soil samples often contained higher concentrations of radioactivity than the soil-survey samples, which were taken to 15-cm depths, because of the surficial nature of radioactivity in many areas. The mean value and range of soil radionuclide concentrations will also be given in this analysis.

In Table 76, the analysis of ALICE is presented. Three plant species constituted the bulk of the vegetative biomass and no mammals were known to be present. The common noddy, Anous stolidus, was nesting on the island at the time of the survey.

*Messerschmidia argentea* had $^{137}$Cs concentrations that were about 1.6 times the maximum values for that radionuclide in soil on the island. The soil $^{137}$Cs concentrations in the closest survey point for the 15-cm depth were 13 pCi/g, while the sample taken in the biota survey contained 69.05 pCi/g. Radioactivity depth profiles on the island showed both isotropic depth distribution of $^{137}$Cs and logarithmic depth decreases in radioactivity. The biota soil sample is probably biased toward high concentrations because of the possibility of sampling a highly active surface layer of soil which would have had as much as 100 pCi/g $^{137}$Cs. Calculated concentration factors for $^{137}$Cs in *Messerschmidia* therefore range from 3.2 to 17, depending upon which soil sample is considered appropriate.

Samples of the common noddy, *Anous stolidus*, were obtained on ALICE and, although the animals were collected on the land, their food base is derived from the lagoon or the sea. Radioactivity in birds exhibited a qualitative correlation with radioactivity levels found in the lagoon adjacent to their nesting site. Some species may be pelagic feeders, and their body burdens reflect radionuclide concentrations in the open sea.

Data obtained on BELLE are summarized in Table 77. Vegetation recovery on this island was studied by Palumbo (1962), and Welander* presented data on BELLE obtained in a 1964 survey of Enewetak Atoll. Three plant species were collected on BELLE, including a *Pandanus* which was bearing fruit at the time. Both *Pandanus* leaves and fruit showed a strong tendency to accumulate $^{137}$Cs from the soil. Three soil samples collected in the vicinity of the *Pandanus* plant had a mean $^{137}$Cs concentration of 44.3 pCi/g (Nos. 39, 42, and 52), which is close to the dense vegetative cover mean soil value of 48 pCi/g, indicating a concentration factor of about 20 for fruit and 15 for leaves. Soil samples (Nos. 32 and 33) collected by the soil-survey crews were adjacent to the *Messerschmidia* and *Scaevola* trees sampled, and their low radioactivity is reflected in the low concentrations of $^{137}$Cs in those two species. *Guettarda* occurred closer to the center of the island, where higher soil radioactivity occurred. These results agree with those presented by Welander, except that higher concentration factors are evident in the 1973 data. Concentration effects for $^{90}$Sr are seen in plants in BELLE but, in general, they are small. However, *Pandanus* leaves have slightly more than three times the soil concentration.

CLARA radioecological relationships are analyzed in Table 78. Two plant species were collected on the island. Two soil samples (Nos. 7 and 9) were collected in the vicinity of the plant samples, both of which were higher in radionuclides than the biota sample collected with the plants. Soil sample No. 7 appeared to be closest to the area sampled, and the radionuclide concentrations in it were used for comparison with the vegetation data. *Messerschmidia* showed a small concentration factor of

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* A. D. Welander, "Distribution of Radionuclides in the Environment and Bikini Atolls," in *Proc. of Second National Symposium on Radioecology*, Ann Arbor, Mich. 1967 (1969), p. 346.

about three, while no large factors were observed for $^{90}Sr$ or for Scaevola.

Table 79 contains summary data of terrestrial biota and soil radioactivity on DAISY. Young, nut-bearing coconut palms were found on the island, but only a low level of $^{137}Cs$ and $^{60}Co$ was detected in the meat of the nut. Low levels of $^{239,240}Pu$ were detected in both Messerschmidia and Scaevola in the presence of rather high levels in the soil. The biota soil sample collected at the plant collection site was higher than three soil-survey samples collected in the same general area.

Radionuclide concentrations in biota on IRENE are summarized in Tables 80 and 81. Five areas were sampled on this island, which has a crater at its western end. The area around the crater is generally more radioactive than the eastern part of the island. The five sample areas are listed and described in Table 80. In area E, along the eastern edge of the crater, integrated vegetation samples of Messerschmidia and Scaevola were collected. These samples were obtained by collecting 10 to 20 leaves from each of 25 trees in a transect along the eastern end of the crater; a small stand of young coconut palms was found in the dense growth on the eastern end of the island.

Three biota-survey soil samples were collected on IRENE, and the ecosystem analysis uses soil-survey data obtained in areas being sampled. An attempt was made to obtain a sample of rats on the island, but large numbers of hermit crabs and birds prevented this by tripping the traps and taking the bait.

Plant samples from IRENE are characterized by higher levels of $^{60}Co$ than are found in plants on other islands.

Relatively low concentrations of all radionuclides except $^{55}Fe$ are found in coconuts on IRENE. High concentrations of $^{40}K$ in coconuts, especially in coconut milk, have been found several times in the analyses made on Enewetak samples. Plant samples collected in the B area generally have higher $^{137}Cs$ concentrations than the A or C areas. Both Messerschmidia and Scaevola had high levels of $^{90}Sr$, with a concentration factor of 13 occurring in Messerschmidia. Biota soil sample B had a slightly higher $^{137}Cs$ concentration, while $^{60}Co$ was higher in the A-area soil sample. Suriana maritima, a large shrub growing on the eastern edge of the crater throw-out, had the highest $^{60}Co$ concentration found on the island, with a concentration factor for $^{60}Co$ of about 22. This $^{60}Co$ concentration was the highest found in plants on Enewetak Atoll.

Hermit crabs living on vegetal debris on IRENE had correspondingly high $^{137}Cs$ and $^{60}Co$ concentrations in hepatopancreas and muscle tissues. The hepatopancreas of these land crustacea typically contains elevated levels of $^{60}Co$ and $^{239,240}Pu$, as well as $^{137}Cs$. The exoskeleton of hermit crabs had high concentrations of $^{90}Sr$, an observation also made by Welander at Enewetak and Bikini.

Common noddys nesting on a grassy spit at the southern edge, or lagoon side, of the island had low levels of $^{90}Sr$, $^{60}Co$, $^{55}Fe$, and $^{239,240}Pu$ in their tissues. The highest concentrations of radionuclides in the IRENE noddys was $^{55}Fe$ in the liver.

The large island of JANET (Engebi) was sampled in nine areas. These sample areas or sectors are listed in Table 82 with a brief description of their location on the island. The eco-system analysis of JANET is shown in Table 83.

High concentration factors for $^{137}Cs$ and $^{90}Sr$ are apparent for Messerschmidia and Scaevola in Sector A. In Sector B a strong concentration mechanism is seen in both Messerschmidia and Scaevola (10 to 20 times). A high $^{239,240}Pu$ level in the soil resulted in an increase of this radionuclide in plant leaves.

In Sector C, $^{137}Cs$ and $^{90}Sr$ were the prominent radionuclides in the soil samples collected adjacent to the biota collection site, and both radionuclides were detected in the three plant species in the area. A high $^{40}K$ and $^{137}Cs$ level was found in coconut milk, but the level in coconut meat was lower. The concentration of $^{137}Cs$ in Messerschmidia was 20 times the mean soil concentration.

In Sector D, the shrub Pluchea odorata had a concentration factor for $^{137}Cs$ of approximately 31, while Messerschmidia had a concentration factor of only three. In Sector E, Messerschmidia and Scaevola had concentration factors for $^{137}Cs$ of about 3 to 5 times the soil levels of $^{137}Cs$, but exhibited on concentration effect for $^{90}Sr$.

Near the most radioactive area on the island, Sector F supported a population of roof rats, Rattus rattus, which were trapped during the night. Concentration factors in plants for $^{137}Cs$ at this site ranged from 16 to 21, and in animals another factor of two is apparent over the plant concentrations. In a 1964 survey, Welander[*] observed lower concentration factors on the same island. The variation that is seen from sector to sector in our data may account for these relatively small differences. Viscera and lung $^{137}Cs$ concentrations and $^{239,240}Pu$ in the bones of the rats was also observed. Rat body burdens of radioactivity may be related directly to radionuclide concentrations in Scaevola and Messerschmidia, according to Jackson and Carpenter[†], because these plants constitute more than 70% of the diet of the rats.

A similar relationship was seen in Sector G area, near a large blockhouse complex in the center of the island. A large population of roof rats was evident in this area, feeding even in the daylight. Soil radioactivity was composed of $^{137}Cs$, $^{60}Co$, $^{90}Sr$, and $^{239,240}Pu$, with approximately twice as much $^{90}Sr$ as $^{137}Cs$. Both $^{60}Co$ and $^{239,240}Pu$ appeared in the animal samples but not in the plant samples. Concentration factors for $^{137}Cs$ are about six for Messerschmidia and seven for Scaevola, while $^{90}Sr$ has factors of less than one for both types. Lung and viscera again have the highest values in rat organs. Localization of $^{60}Co$ and $^{55}Fe$ in the liver, and $^{90}Sr$ and $^{239,240}Pu$ in the bone is evident in this series of animal samples.

In Sector H, $^{137}Cs$, $^{60}Co$, $^{90}Sr$, and $^{239,240}Pu$ are apparent in four soil

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[*] Welander, op. cit.

[†] W. B. Jackson and M. L. Carpenter, "Radioisotope Cycling in Terrestrial Communities at Enewetak Atoll," in Proc. of Second National Symposium on Radioecology, Ann Arbor, Mich. (1969), p. 644.

samples collected in the area. The soil again contains higher $^{90}Sr$ than $^{137}Cs$ concentrations. Concentration factors for both $^{90}Sr$ and $^{137}Cs$ are seen in Messerschmidia (3 and 120), and lower factors are found in Scaevola (1 and 24). Roof rats trapped in Sector H show the high concentration factors observed in Sectors F and G for $^{137}Cs$. High concentrations of $^{239,240}Pu$ were detected in viscera and lungs, suggesting ingestion and inhalation of plutonium particles from the surface soil stratum. Rodents preen their pelage frequently, and undoubtedly ingestion occurs in this manner.* The highest concentration of $^{90}Sr$ in rats occurred in the bones.

Common noddys nesting in the area had an unusually high concentration of $^{137}Cs$ in their livers. It is possible that they were eating some terrestrial materials which are high in $^{137}Cs$. Fish in the vicinity of JANET are not highly contaminated with $^{137}Cs$. Fish samples collected in the lagoon near JANET had maximum concentrations of 6.7 pCi $^{137}Cs$/g, but most were lower.

In Sector I, a sample of roof rats was obtained, and a three-level analysis of the area is possible. Soil-survey samples indicate a low level of $^{137}Cs$, $^{239,240}Pu$, and $^{60}Co$, with higher concentrations of $^{90}Sr$ in the surface 15 cm of soil. Vegetation in this area showed small concentration factors of 3 to 4 over soil $^{137}Cs$ concentrations. Rat $^{137}Cs$ body burdens were about 30 times the plant concentrations, and therefore over 100 times for soil-to-animal transfer.

Concentration factors of 10 to 20 for $^{60}Co$ were apparent for visceral organs over that which occurred in the soil of the area. Bone contained high concentrations of $^{239,240}Pu$ and $^{90}Sr$. Liver and muscle contained $^{55}Fe$, and viscera (mainly gastrointestinal tract) contained $^{90}Sr$ and $^{239,240}Pu$, as well as a high level of $^{137}Cs$. The soil-to-bone concentration factor for $^{90}Sr$ was approximately five. Concentration factors for $^{90}Sr$ in plants at Enewetak Atoll, however, are usually low.

Table 84 contains the radionuclide concentrations in biota collected on KATE. The biota-survey soil sample and the nearest soil-survey samples agree quite well in this analysis. The red-tailed tropicbird, Phaethon rubricaudus, was found nesting on this island and was collected for analysis. This is a valuable measurement because this bird is mainly a pelagic sea feeder and provides a southwest Pacific oceanic background value for biota radionuclide concentrations.

Pisonia grandis was collected on KATE and was not found north of this site. It contained a level of $^{137}Cs$ approximately 55 times the soil $^{137}Cs$ concentration in the area. It is interesting that the $^{40}K$ value in Pisonia on KATE is in the same range as other tree species (~10 pCi/g), while on southern islands, in mature Pisonia forests, $^{40}K$ values are in the range of 16 to 30 pCi/g. The KATE Pisonia $^{40}K$ value is the lowest concentration found in the species on the Atoll. A small concentration factor of about two for $^{60}Co$ was found in Pisonia.

The red-tailed tropic bird had almost no radioactivity in its body, except for a

* N. R. French, P. Hayden, and T. Tagami, "The Source of Ingested Radioactivity in Desert Rodents," Health Physics 11, 637 (1965).

small amount of $^{137}Cs$ in the bone.

A summary of radionuclide concentrations in biota collected on LUCY is made in Table 85. The biota-survey sample is higher than the two soil-survey samples obtained in the same locality, which agreed quite closely with each other. A low level of $^{137}Cs$ occurred in the two plant species, Messerschmidia and Scaevola. In the hermit crabs, which feed primarily on vegetal debris, there were higher levels of $^{137}Cs$ and a relatively high concentration of $^{60}Co$ in the hepatopancreas. If the soil-survey data are used, concentration factors from soil to crab are more than 100 for $^{137}Cs$ and for $^{60}Co$. In this ecosystem, the hermit crab may be considered a "grazing" arthropod, and the soil-plant-animal economy is closely coupled.

The ecosystem analysis of PEARL is given in Table 86. The soil-survey data for the PEARL collection sites agreed well with the biota-survey soil sample, and the average of the two values may be used. No concentration effect for $^{137}Cs$ was seen in Messerschmidia and Scaevola at the collection site. Scaevola collected in an area indicated as radioactive by the aerial survey had higher concentrations of $^{137}Cs$ and $^{90}Sr$.

Rice rats collected on PEARL in the sampled area exhibit concentration factors of approximately 100 from plant to animal, but only five from soil to animal.

The ecosystem analysis of URSULA is given in Table 87. Good agreement is seen in the soil-survey data and the biota-survey soil data. Low levels of the four prominent radionuclides occurred in the soils on URSULA. Concentration factors are seen for $^{137}Cs$ in Messerschmidia and Scaevola in the range of 30 to 35. The rice rat population had lower levels of radionuclides in their organs than most of the vegetation sampled. The usual pattern of $^{239,240}Pu$ and $^{90}Sr$ in the bone and $^{60}Co$ in the liver is again manifested in this sample series. $^{55}Fe$ typically is concentrated in the livers of both mammals and birds.

Data on radionuclide concentrations in biota collected on SALLY is made in Table 88. This small island has experienced a considerable amount of recent disturbance, and the remnants of a partially recovered vegetation were sampled. Two soil-survey samples were obtained in the biota collection site. A biota soil sample was also collected, and it contained higher concentrations of all radionuclides found in the soil. The two soil-survey samples agreed relatively well, and the mean concentrations of these two samples will be used in this analysis. Held* has described radionuclide accumulation at the interface between the organic soil or surface litter and the mineral horizon or stratum below. Most of the northern and northeastern islands do not have deep accumulations of organic litter on the surface, and this phenomenon may only be present on relatively undisturbed islands.

Low levels of $^{60}Co$ and $^{239,240}Pu$ are present in the soils on SALLY, with slightly more than two times as much $^{90}Sr$ in the soil as $^{137}Cs$. The grass

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*E. F. Held, S. P. Gessel, and R. B. Walker, Atoll Soil Types in Relation to the Distribution of Fallout Radionuclides, University of Washington Laboratory of Radiation Biology, Seattle, Rept. UWFL-92 (1965).

*Lepturus repens* shows a concentration factor of about 35 for $^{137}Cs$ and less than one for $^{90}Sr$. *Messerschmidia*, *Scaevola*, and *Pandanus* exhibited only modest accumulation levels of $^{137}Cs$ (5 to 6). This *Pandanus* plant did not show the high concentration factor for $^{137}Cs$ in leaves that the specimen collected on BELLE did.

Table 89 contains a summary of radionuclide data obtained on TILDA. A soil-survey sample was collected in the area where biota were sampled, and a biota soil sample was also collected. The biota soil sample again has higher concentrations of radionuclides than the soil-survey sample. $^{90}Sr$ concentrations in the biota soil sample are almost 10 times those in the soil-survey sample. Both the $^{60}Co$ and the $^{90}Sr$ concentrations in the biota soil sample are higher than the maximum concentrations for these radionuclides found by the soil survey.

The $^{137}Cs$ activity in plants shows some concentration effects, especially in *Pandanus*, which had a concentration factor of about 18, using the dense vegetative cover mean soil value. *Scaevola* had three times and *Messerschmidia* had seven times the concentration of $^{137}Cs$ in soil.

Radionuclide concentrations in biota collected on VERA are shown in Table 90. This heavily vegetated island has one of the northernmost examples of mature Atoll forest vegetation characterized by *Pisonia* stands. A soil-survey sample was collected close to the biota sample area, and a biota soil sample was collected in the same area. The $^{90}Sr$ and $^{239,240}Pu$ concentrations in the biota soil sample were 6.3 and 3.9 times the levels in the soil-survey sample. $^{137}Cs$ and $^{60}Co$ concentrations in the two soil samples agreed quite well.

Six plant species were collected on VERA. The presence of *Pisonia* and *Pandanus* as large plants is a good indicator of successional maturity of Atoll vegetation. The highest $^{137}Cs$ concentration in plants was in *Pisonia*, which had a concentration factor of about 24. *Pandanus* leaves showed a concentration factor for $^{137}Cs$ of seven. *Pandanus* exhibited a concentration factor of nine for $^{90}Sr$, which is a comparatively high value in plants. On BELLE a *Pandanus* plant had a $^{90}Sr$ concentration factor of three. The higher concentrations of radionuclides in the shallower biota soil sample on an island such as VERA, with a well-developed organic matter horizon on the soil surface, was observed on Rongelap.* Most of the mineral cycling must take place in this organic layer, and it is a logical site for soluble radionuclides to be complexed to organic colloids.

Table 91 shows radionuclide concentrations in biota collected on WILMA. Two soil-survey samples were collected close to the biota sample site. These two samples were comparable in radionuclide concentrations, and the mean value will be used. Low levels of four radionuclides were present in the soil of WILMA, with slightly more than two times as much $^{90}Sr$ as $^{137}Cs$.

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*D. W. Cole, S. P. Gessel, and E. E. Held, "Tension Lysimeter Studies of Ion and Moisture Movement in Glacial Till and Coral Atoll Soils," Soil Sci. Soc. Amer. Proc. 25, 321 (1961).

Three plant species were collected on WILMA, and they all had low levels of $^{137}Cs$, with more $^{40}K$ than fission products in the plants.

Tables 92 and 93 contain radionuclide concentrations in biota collected on YVONNE. This long, narrow island was sampled at four sites to obtain a representative series of biota samples where the physiography was somewhat diverse, and where there was considerable variation in the radioactivity levels of the island. The locations of the five sample sites are described in Table 92.

The data obtained in Sector A of YVONNE are shown in Table 93. This area was at the north end of the island – the most radioactive site of those sampled. Three soil-survey samples which were collected near the biota sample site exhibit some variation; one sample is considerably more radioactive than the other two. Mean soil radionuclide concentrations may be elevated because of this high value. $^{90}Sr$ was approximately five times higher in the soil of this area than $^{137}Cs$. Concentration factors for $^{137}Cs$ in Messerschmidia and Scaevola are quite high when the mean soil concentration is used to calculate the factor. With such a high concentration of $^{137}Cs$ in Messerschmidia and Scaevola, it is probable that the plants were growing on soil with high $^{137}Cs$ concentration, and the use of the highest soil value is justified. Concentration factors when using the value for soil survey No. 141 (47 pCi $^{137}Cs$/g of soil) become 120 for Messerschmidia and 14 for Scaevola. Only a small concentration mechanism is seen for $^{90}Sr$ in Messerschmidia (1.4).

Two large samples of roof rats were obtained in the area and, when pooled, provided two population samples of the mammals living in Sector A. Typical patterns of radionuclide localization in the mammalian body are apparent in these data. $^{137}Cs$ concentrations are highest in the muscle, bone, and viscera. Bone $^{137}Cs$ concentrations have been quite high in many of these animal samples, and similar bone levels were reported by Yamagata and Yamagata* in humans. High concentrations of $^{239,240}Pu$ in viscera and lung are produced by ingestion of particles, either in preening by the rats or in the process of eating plant materials. $^{55}Fe$ is detected in the highly vascularized tissues of liver and muscle. Concentrations of $^{60}Co$ in the kidneys were five times the high soil concentration. The highest concentrations of $^{90}Sr$ were found in the bone.

The second site sampled on YVONNE, Sector B, was on the north end of the island, 150 yd south of Cactus crater. The vegetation and general topography were similar to those in the Sector A site.

Three soil-survey samples were obtained in the area, and one biota soil sample was collected. The larger surface area of the biota sample resulted in higher concentration of most radionuclides detected at the site. An average was taken of all four samples for comparison with the biota.

The concentration factor for $^{137}Cs$ apparent in Messerschmidia is about 47 and in Scaevola about 14. A concentra-

*N. Yamagata and T. Yamagata, "The Concentration of $^{137}Cs$ in Human Tissues and Organs," Bull. Inst. Public Health (Tokyo) 9(2), 72 (1960).

tion factor of about two was found in the meat of the coconut for $^{137}$Cs. A small concentration factor of 2.4 for $^{90}$Sr was seen in Messerschmidia. Of the two common tree species, Messerschmidia showed the highest concentration factor for both $^{137}$Cs and $^{90}$Sr.

A small collection of roof rats, Rattus rattus, was obtained in the area, but the radionuclide concentrations were elevated much above the level observed in plants. Concentration factors from soil to animal were in the range 19 to 43 for $^{137}$Cs, and in the bone $^{90}$Sr was 4.75 times the concentration in the soil. High $^{239,240}$Pu concentrations were seen in the bone and viscera.

The common noddy, Anous stolidus, was nesting on the island in Sector B, and a sample was obtained with a shotgun. Eggs showed little radioactivity, except for $^{55}$Fe and a small amount of $^{90}$Sr. The viscera of the bird, mainly the gastrointestinal tract, which would contain the food eaten recently, showed detectable levels of only $^{55}$Fe. The livers of the noddys contained $^{60}$Co and $^{55}$Fe in rather high concentration.

Table 93 contains a summary of radionuclide concentrations in biota collected in Sector C on YVONNE. This area was mid-island along the short airstrip that extends east to west. Four soil-survey samples were obtained in the area, three of which showed general agreement; the fourth was somewhat higher. The mean concentrations of radionuclides in the soil from these samples will be used in this analysis. Soil radionuclide concentrations are in general low, except for $^{239,240}$Pu. $^{90}$Sr is present in 2.2 times the concentration of $^{137}$Cs.

Plants in Sector C were sampled several times, and the data show some rather wide variations, both between and within species. Of the three Messerschmidia samples, one contained 25 to 42 times the $^{137}$Cs concentration of the other two. The same variation was seen in the concentrations of $^{137}$Cs in Scaevola. Comparatively high concentrations of $^{239,240}$Pu were seen in the plants collected in this area, with one value as high as 1.29 pCi/g. One Scaevola collection had rather high concentration factors for the species, 286 for $^{137}$Cs and 34 for $^{90}$Sr. With the soil radionuclide concentions exhibiting the variations shown in these data, it is possible that the high activity seen in a single collection in a series is due to a small, localized "hot" spot.

A sample of roof rats was easily obtained in this area, since they are quite numerous at the north end of YVONNE. The highest concentrations of radionuclides in these animals was due to $^{137}$Cs and occurred in the lungs and viscera. High concentrations of $^{239,240}$Pu were also present in the lungs and viscera of these animals. Concentration factors are difficult to assess in this area because of the variation in plant radionuclide concentrations. Concentrations of $^{137}$Cs in the muscle of rats were about 23 times the concentration in the soil. The mean $^{137}$Cs concentration of the plants in the area, exclusive of the high Messerschmidia (95.32 pCi/g) and Scaevola (609.90 pCi/g), is 7.33 pCi/g. Rat muscle exhibits a 6.7 concentration factor over $^{137}$Cs concentrations in plants.

A summary of radionuclide concentrations in biota collected in Sector D on YVONNE is made in Table 93. Two soil-survey samples were obtained in the area, and a biota soil sample was also obtained. The biota soil sample again is higher than the soil-survey samples in $^{137}Cs$ and $^{60}Co$. One soil-survey sample is very high in $^{239,240}Pu$ and also has a high $^{90}Sr$ concentration. $^{137}Cs$ concentrations on this part of the island are not much higher than the southern arc of islands from GLENN to KEITH. Radionuclides in general are low in plants in this area.

Sector D area is at the south end of YVONNE. A small sample of roof rats was trapped in the area, and a collection of common noddy eggs was made. The rat organs and tissue had low levels of $^{60}Co$, $^{90}Sr$, $^{55}Fe$, and $^{137}Cs$. Lung and bone had the highest $^{137}Cs$ burdens, with lower values occurring in the muscle, viscera, and liver. The livers had the highest $^{55}Fe$, $^{90}Sr$, and $^{239,240}Pu$ concentrations. It appears that there were plutonium-contaminated areas at the southern end of the island, with only modest fission-product levels occurring in the area.

The eggs of the common noddy contained $^{55}Fe$ and a small amount of $^{239,240}Pu$.

Data on radionuclide concentrations in biota collected on BRUCE are given in Table 94. This completely vegetated island has a mature Pisonia forest on it which was apparently modified only slightly by test activities. The island is far enough from test areas to not have been affected by physical effects of weapons tests. Three soil-survey samples were collected in the area where biological samples were obtained. A biota soil sample was also collected in the area, and had radionuclide concentrations that were higher than any of the soil-survey samples used in this analysis. Slightly more $^{137}Cs$ than $^{90}Sr$ was present in the soil on BRUCE.

Scaevola frutescens had the highest $^{137}Cs$ concentrations in plants, and the coconut palm nut meat had the lowest — less than 1 pCi/g. A low level of $^{90}Sr$ was present in Pisonia, Messerschmidia, and Scaevola.

Coconut crabs, Birgus latro, were abundant on the island, and a sample of five was collected. $^{137}Cs$, $^{60}Co$, and $^{90}Sr$ were present in coconut crabs in low levels. $^{137}Cs$ was present in the highest concentration in the muscle of the crabs. Less than 1 pCi/g of $^{137}Cs$, $^{60}Co$, and $^{90}Sr$ occurred in the hepatopancreas. As observed in other land crustacea, $^{90}Sr$ was relatively high in the exoskeleton.

A sample of roof rats, Rattus rattus, was trapped on BRUCE. Low concentrations of $^{137}Cs$, $^{60}Co$, $^{90}Sr$, and $^{239,240}Pu$ were detected in the rat organs. The highest radionuclide concentration in rat livers was $^{55}Fe$, with a low level of $^{60}Co$. $^{137}Cs$ concentrations were higher in bone than in any other tissue.

White-capped noddys, Anous tenuirostris, were collected on BRUCE; the analysis of liver, muscle, and viscera showed low levels of all radionuclides.

In Table 95, radionuclide concentrations in biota collected on DAVID are shown. This large island is covered by dense Pisonia and Ochrosia on the eastern portions, with a scrub vegetation of *Messerschmidia* and *Scaevola* occupying areas disturbed by test activities on the island. Mature coconut palms occur on the western, or lagoon, side of the island and in the central portion. Five soil-survey samples and two biota soil samples were obtained in the areas where biological samples were collected. Low concentrations, less than 1 pCi/g, of $^{137}$Cs, $^{90}$Sr, $^{60}$Co, and $^{239,240}$Pu were present in the soil on DAVID, and biota- and soil-survey samples exhibited good agreement.

Replicate samples of the major plant species were collected on DAVID to evaluate the island variations in vegetation radionuclide content. Four *Messerschmidia* and *Scaevola* samples were collected on the island and, except for one sample of *Messerschmidia*, exhibit general agreement within the species for the most prominent fission product, $^{137}$Cs. A single sample of *Messerschmidia* had 15.84 pCi/g $^{137}$Cs, while the other three samples were in the range of 1 to 8 pCi/g. This *Messerschmidia* sample had an unusually low $^{40}$K concentration, approximately 25% of the value observed in the other three samples. The mean *Messerschmidia* $^{137}$Cs concentration, including the high value, was 6.69 pCi/g, which would be a concentration factor of about 17, using a mean biota- and soil-survey value of 0.40 pCi/g. The mean *Scaevola* $^{137}$Cs concentration of 3.3 pCi/g indicated a concentration factor of about eight for the species.

A large *Pandanus* located in the central part of the island had the highest $^{137}$Cs concentration in plants, except for coconut milk. The *Pandanus* concentration factor for $^{137}$Cs on DAVID was about 40.

The herb, *Tacca leontopetaloides*, was collected on DAVID. A large sample of the corms of this plant was collected in a meadow-like area on the western half of the island. The radionuclide concentrations are low, with $^{137}$Cs and $^{90}$Sr occurring in levels at or less than 1 pCi/g. The sedge, *Fimbristylis atollensis*, was very abundant on bare ground on DAVID and contained a low level of $^{137}$Cs.

*Pisonia grandis*, which forms continuous stands of tall trees on the eastern half of DAVID, had low levels of $^{137}$Cs and $^{90}$Sr. High $^{40}$K concentrations are seen on DAVID in this species and on most of the southern islands.

*Cocos nucifera*, the coconut, was collected from three sites on DAVID and had a mean concentration of $^{137}$Cs of 2.66 pCi/g in the meat. The analysis of coconut milk, however, indicated that in the milk solids 23.32 pCi/g of $^{137}$Cs was present, and the high value of $^{40}$K indicated a potassium content in excess of 3.5%. This high concentration of $^{137}$Cs in coconut milk may be partially an analytical artifact. The whole coconut milk from DAVID coconuts contained 4.7% solids, and the coconut milk therefore would have a wet concentration of 1.09 pCi/g $^{137}$Cs. This value is in the same range as the coconut meat, which is 34.1% solids and has a $^{137}$Cs concentration of 1.30 pCi/g wet weight.

The hermit crab, *Coenobita perlatus*, was collected on DAVID, and three tissues were analyzed for radioactivity.

The hepatopancreas and muscle of these small land crabs contained small amounts of $^{137}$Cs, $^{60}$Co, $^{90}$Sr, and $^{239,240}$Pu.

The sooty tern was collected on DAVID but was not particularly abundant there, probably nesting farther northward on the Atoll, where sandy spits and beaches such as those on CLYDE provided sites. Very low concentrations of radionuclides were found in the terns, although $^{55}$Fe was present in the livers at a concentration of 153.2 pCi/g. A small amount of $^{137}$Cs was present in the bone, and $^{239,240}$Pu was detected in the muscle.

Two other birds were collected on DAVID – the sandpiper, which is probably a migratory species at Enewetak Atoll, and the reef heron, which is indigenous. The sandpiper contained only a small amount of $^{137}$Cs. The reef heron had slightly higher concentrations of $^{137}$Cs in the bone and muscle, and a small amount of $^{60}$Co in the bone.

A sample of rice rats, Rattus exulans, was obtained on the western side of DAVID in the vicinity of the site where Tacca and Morinda were collected. $^{137}$Cs was the radionuclide in the highest concentration in the rice rats; the highest value was found in the bone. This localization of $^{137}$Cs in the bone was also noted by Takizawa and Sugai* in a study of human tissues in Japan. Highest values in the period 1962-1966 were found in the bones of people living in northern Japan. High bone concentrations of $^{137}$Cs have been consistently noted in these analyses for mammals living in areas of high environmental radioactivity. A low concentration of $^{90}$Sr and $^{239,240}$Pu was found in the rice rats on DAVID.

Table 96 contains a summary of radionuclide concentrations in biota of the small island, REX. This island, although small in area, has mature Atoll vegetation on it. Three soil-survey samples were collected in the area in which biota samples were obtained. Low concentrations of the four radionuclides typically found on the islands occurred on REX, where slightly more $^{90}$Sr than $^{137}$Cs was present in the soil.

Three plant species were collected on REX, and the most prominent radionuclides were $^{40}$K and $^{137}$Cs. Pisonia and Messerschmidia had concentrations of $^{137}$Cs of about 2.5 pCi/g and Scaevola contained less than 1 pCi/g. Concentration factors were about three.

Hermit crabs, Coenobita perlatus, were abundant on the island, and a large collection was made. $^{137}$Cs concentrations in hermit crabs did not exceed those observed in the soil or the vegetation. $^{90}$Sr and $^{60}$Co were detected in the muscle and hepatopancreas of hermit crabs in low concentrations. Low levels of $^{239,240}$Pu were also found in these tissues.

Common noddys were nesting on the island, and their tissues contained low concentrations of $^{90}$Sr and $^{239,240}$Pu. The concentration of $^{55}$Fe in the liver of the common noddy was the highest radionuclide concentration found on this island.

An ecosystem analysis of ELMER is given in Table 97. Three soil-survey samples were obtained in the area of biota sampling, and two biota group soil

* Y. Takizawa and R. Sugai, "Plutonium-239, Strontium-90, and Cesium-137 Concentrations in Human Organs of the Japanese," Arch. Environ. Health 23, 446 (1971).

samples were also obtained. Three radionuclides were detected in the soil on ELMER, and a low level of $^{40}K$ was found in one of the biota soil samples. One biota soil sample contained higher concentrations of $^{137}Cs$, $^{90}Sr$, and $^{239,240}Pu$ than the other three samples by factors of 2 to 11.

Four plant species were sampled on ELMER. Pandanus had the highest concentrations of $^{137}Cs$ and $^{90}Sr$, which was concentrated 79 times over the soil concentration (mean soil-survey sample = 0.33 pCi/g $^{90}Sr$). Concentration factors for $^{137}Cs$ are much lower, about 3 to 6.

A sample of roof rats, Rattus rattus, was obtained on ELMER by trapping at night. $^{137}Cs$ and $^{90}Sr$ were the only man-made radionuclides detected in rat tissues and organs. $^{137}Cs$ in viscera, liver, and bone showed concentrations 25 to 46 times mean soil concentrations, and 5 to 7 times the plant concentrations.

Table 98 contains an analysis of the soil radioactivity and vegetation on FRED. A large number of soil samples were collected on FRED by the soil-survey group. Two soil-survey samples were collected in the general area in which vegetation samples were obtained. Low concentrations of four radionuclides were detected in FRED soil materials. Two samples did not agree very closely in the concentrations, differing by factors of 1.5 to 3 for $^{90}Sr$ and $^{137}Cs$. $^{60}Co$ and $^{239,240}Pu$ were detected in only one sample of the pair.

Four species of plants were sampled on FRED. Pandanus was again the highest in $^{137}Cs$ concentration but did not have the high concentration of $^{90}Sr$ that was observed in the same species on ELMER. Low levels of $^{239,240}Pu$ were detected in Scaevola and Pandanus.

A summary of radionuclide concentrations in biota collected on GLENN is given in Table 99. Three soil-survey samples were collected in the biota sample area, and one large-surface-area biota soil sample was obtained. The concentrations of $^{137}Cs$ in the biota soil sample were slightly higher than in the soil-survey sample, but in general, radionuclide concentrations in the two types of samples were comparable. All four samples will be averaged in this analysis. $^{137}Cs$ is the most abundant radionuclide in the soil.

Plants growing on GLENN have two fission-product radionuclides and one naturally occurring radioisotope in all of the species sampled. $^{137}Cs$ was present in Pisonia and Messerschmidia in concentrations of 1.2 to 3.9 pCi/g, with fractional picocurie/gram concentrations occurring in Morinda, Scaevola, and Cocos. $^{90}Sr$ concentrations were slightly higher than $^{137}Cs$ concentrations in all species except Cocos. The high levels of $^{40}K$ and stable potassium in Pisonia seem to indicate a positive correlation between $^{137}Cs$ concentration and stable potassium content. The Pisonia leaves contained 3.0 and 3.5% potassium on the basis of their $^{40}K$ concentrations. Only slight concentration effects are seen in the vegetation on GLENN for the typical radionuclide that is concentrated in the biota, $^{137}Cs$.

A sample of rice rats (Rattus exulans) was collected in the central portion of the island where they subsist on coconuts and other plant materials. $^{137}Cs$ and $^{90}Sr$ were the most prominent radionuclides in the rat tissues, with the highest concentration occurring in the bone. The highest concentrations of $^{60}Co$ occurred in the kidney, viscera, and liver.

Two land crustaceans were collected on GLENN. The hermit crab, Coenobita perlatus, and the coconut crab, Birgus latro, were quite abundant in the Pisonia and coconut forest of the island. Small amounts of $^{137}Cs$ were present in the hepatopancreas of the hermit crab, which also contained $^{60}Co$. $^{90}Sr$ and $^{239,240}Pu$ also occurred in hermit crab hepatopancreas in sub-picocurie/gram levels.

The coconut crabs on GLENN had small amounts of $^{137}Cs$ in the muscle and hepatopancreas. Traces of $^{60}Co$ and $^{90}Sr$ were also detected in the hepatopancreas.

There was essentially no concentration effect for $^{137}Cs$ from plant to animal in the crustacea on GLENN. A factor of approximately six times the soil $^{137}Cs$ concentration was seen in the bones of rice rats. A mean $^{137}Cs$ concentration for all plants on GLENN is 1.32 pCi/g dry wt, and most of the animal tissues are within a factor of two of this value, except for rat bone.

Data on radionuclide concentrations in biota collected on HENRY are summarized in Table 100. This island is in the southeastern arc of islands characterized by mature atoll forest vegetation with small, local disturbances on them. Comparatively deep, organic soils are found in the Pisonia forests, and the effects of bird guano deposits may be quite evident as cemented strata beneath the organic horizons. Two soil-survey samples and a biota soil sample were obtained in the area sampled on HENRY. The biota sample contained a measurable concentration of $^{40}K$, probably due to the high organic content. The highest soil concentration of $^{137}Cs$ was found in the biota soil sample. $^{90}Sr$ was approximately twice the $^{137}Cs$ concentration in the soil-survey samples.

Four species of plants were sampled on HENRY, and only two man-made radionuclides were detected. Low concentrations are seen for $^{137}Cs$ in plants; however, Messerschmidia exhibited almost an eightfold concentration factor for $^{90}Sr$.

Hermit crabs, Coenobita perlatus, showed a small concentration effect for $^{137}Cs$ and $^{90}Sr$, but a concentration factor of 66 for $^{60}Co$ in the muscle. $^{60}Co$ was not detected in the plants sampled.

Table 101 contains a summary of radionuclide concentrations in biota collected on JAMES. Two soil-survey samples and a biota soil sample were collected in the area studied. Low levels of $^{137}Cs$ and $^{60}Co$ were found on JAMES with higher concentrations of $^{90}Sr$ and $^{239,240}Pu$. The biota soil sample contained higher concentrations of radionuclides than either of the two soil-survey samples. The mean soil-survey data will be used in analyzing the JAMES terrestrial ecosystem.

Five plant species were collected on the island, and the prominent radionuclide in their leaves was $^{137}Cs$. Morinda had $^{137}Cs$ concentrations 44 times those in soils, while Scaevola continued approximately 10 times as much. $^{90}Sr$ appeared only in Morinda, at a level 3.8 times the soil concentration.

Coconut crabs, Birgus latro, occurred in modest numbers in the areas around coconut palms in the Pisonia forest, where a sample of these crustacea was collected. Only small concentration factors were seen for $^{137}$Cs and $^{90}$Sr in the coconut crab. Again a concentration effect for $^{60}$Co is apparent in the muscle and hepatopancreas of the crab where concentration factors of 12 and 17 occur. No $^{60}$Co was detected in plants.

Data on radionuclide concentrations in biota collected on KEITH are summarized in Table 102. This island is the westernmost island in the southern arc of islands, and from its higher levels of environmental radioactivity it apparently received more fallout than islands to the east, such as GLENN and HENRY.

Three soil-survey samples and two biota soil samples were collected on KEITH. One biota soil sample was collected under Pisonia trees and another under coconut palms. Biota soil samples had less radioactivity than the 15-cm-deep soil-survey samples. Mean soil radionuclide concentrations on KEITH are several times the concentrations found on JAMES, but not quite as high as those found on LEROY to the west.

Six plant species were collected on KEITH. Two samples of large Pandanus plant were obtained, one of leaves and the other a mature fruit. Pandanus again showed a concentration effect (a factor of eight) for $^{90}$Sr. A comparatively high $^{137}$Cs concentration was measured in Pisonia, which had a concentration factor of about five.

Coconut crabs, Birgus latro, on KEITH contained four man-made radionuclides and $^{40}$K in their tissues. No concentration effects were seen for $^{137}$Cs and $^{90}$Sr in the coconut crabs. $^{60}$Co was found in the hepatopancreas and muscle but was not detected in plants on the island.

Common noddys nesting on KEITH had two radionuclides in their tissues, $^{60}$Co and $^{239,240}$Pu in low concentration.

Table 103 contains a summary of radionuclide data in biota collected on LEROY. This island is in the southwestern quadrant of the Atoll and received fallout from tests conducted in the northeastern portion of the Atoll. Two soil-survey samples were obtained in the areas sampled by the terrestrial biota group, and a biota soil sample was also collected in this area. The biota soil sample contained higher concentrations of all four radionuclides present on the island, except $^{90}$Sr.

Five plant species were collected on LEROY, all of which contained $^{137}$Cs and $^{90}$Sr. Only the Pandanus contained a trace of $^{239,240}$Pu. $^{137}$Cs was present in highest concentration in the flowering stalk of Pandanus. Pisonia grandis had the highest $^{40}$K concentration of the plants collected. $^{90}$Sr was also the highest in Pandanus. If the mean soil-survey concentration is used, concentration factors for $^{137}$Cs are 3.6 for Pandanus, 4 for Pisonia, 1.8 for Messerschmidia, and 1.4 for the coconut palm, Cocos nucifera.

Coconut crabs, Birgus latro, were collected on LEROY, and their tissues contained low concentrations of the four radionuclides detected in the soil. Muscle of the coconut crab exhibited a 3.5 concentration factor for $^{137}$Cs in coconuts. No concentration effects were observed for $^{90}$Sr, $^{60}$Co, or $^{239,240}$Pu in the coconut crab.

White-capped noddys were nesting on

the island, and a sample was obtained for radionuclide analysis. The birds appeared to be feeding in the lagoon adjacent to the island. The most abundant radionuclide in the birds was $^{55}Fe$, which was highest in the liver and muscle.

## Conclusions

The distribution of radionuclides in the terrestrial biota throughout the islands of Enewetak Atoll generally conforms to the results of the environmental radiation survey. On islands with elevated levels of radiation, the biota contained elevated concentrations of radionuclides. The most prominent radionuclides are $^{137}Cs$, $^{90}Sr$, $^{55}Fe$, $^{60}Co$, and $^{239,240}Pu$.

Concentration factors are observed in many species, especially for $^{137}Cs$. Low concentration factors are observed for $^{90}Sr$ in plants, with the exception of Pandanus. Uptake coefficients are generally very low (about $10^{-3}$) for $^{239,240}Pu$ in plants, and only occasional concentration effects are seen for $^{60}Co$, typically in the livers of animals.

The most effectively transferred radionuclide within the terrestrial ecosystems of Enewetak Atoll appears to be $^{137}Cs$. This occurs for at least two reasons. $^{137}Cs$ remains soluble in the Atoll soil or substratum, where it is taken up by plants and incorporated into organic matter. It then apparently enters the potassium pool of the ecosystem, and follows the kinetics of that element, at least in a superficial sense.

The chemical form of a radionuclide in the unusual substratum of the islands of Enewetak Atoll will affect its transfer within the ecosystem and the biota, especially on to man. $^{90}Sr$, for example, which is present in higher concentrations in the substratum on many islands, is not as prominent in the biota because it is probably tied up as insoluble carbonates in the Atoll soil.

Radionuclides are apparently transferred from plants, where initial concentration effects take place, to terrestrial animals, either warm- or cold-blooded, where additional concentration effects occur. The efficiency of this transfer is somewhat difficult to describe from survey data whose main purpose was not functional research, but strong indications of the trophic relationships in atoll ecology are inherent in the data.

Radionuclides such as $^{60}Co$ and $^{55}Fe$ enter the elemental pools for those elements and are typically found wherever those elements accumulate or sequester in animal tissues. Livers, kidneys, and hepatopancreases are such sites in mammals, birds, and crustacea.

Most radionuclide distributions in elements of the terrestrial biota sampled in this survey conform to the classical patterns that have evolved in the development of radiobiological science; e.g., $^{90}Sr$, $^{137}Cs$, and $^{239,240}Pu$ have an affinity for bone, $^{137}Cs$ is also found in physiologically active tissues such as muscle, and $^{55}Fe$ and $^{60}Co$ typically are retained in the liver and kidney.

One difficult aspect in the analysis of these data has been the variation in the basic ecological conditions present on the islands surveyed throughout the Atoll. One might attempt to compare radionuclide concentrations within a single species, such as Messerschmidia argentea, or more appropriately Cocos nucifera, throughout the Atoll, but islands in the northern part of the Atoll are recovering from severe physical disturbance. The physiology of plants under such conditions is undoubtedly different from those growing and reproducing under stable or quasi-stable successional conditions in undisturbed habitats in the southern part of the Atoll. Therefore, attempts to develop generalizations from the spectrum of ecological conditions which were encountered in the Enewetak survey must be made cautiously. Thus, a concentration factor determined for a species which is colonizing a catastrophically disturbed habitat may be quite different for the same species growing in a stable environment in climatic and edaphic equilibrium.

## AIR-SAMPLING PROGRAM

B. Clegg and D. Wilson
Lawrence Livermore Laboratory
Livermore, California

### Introduction

An air-sampling program was carried out on Enewetak to evaluate potential population dosages from inhalation of resuspended soil radioactivity, and to develop information on this pathway for guidance in cleanup and rehabilitation activities. The air-sampling program sought first to ascertain the level of any inter-island atmospheric transport of radioactivity which was reflected in elevated air levels in the Atoll in general, and second, to evaluate air levels in the vicinity of known elevated soil burdens of radioactivity.

To meet these objectives, sampling was carried out on FRED and DAVID, representing low soil radioactivity areas, and on JANET, SALLY, and YVONNE, representing areas with more significant soil contamination.

### Air-Sampling Equipment

#### Ultra High-Volume Air Samplers (UHVS)

Two portable UHVS's (see Figs. 80 and 81, and Wells et al.*) were obtained from Lawrence Livermore Laboratory (LLL) resuspension studies in progress on the Nevada Test Site and adapted to

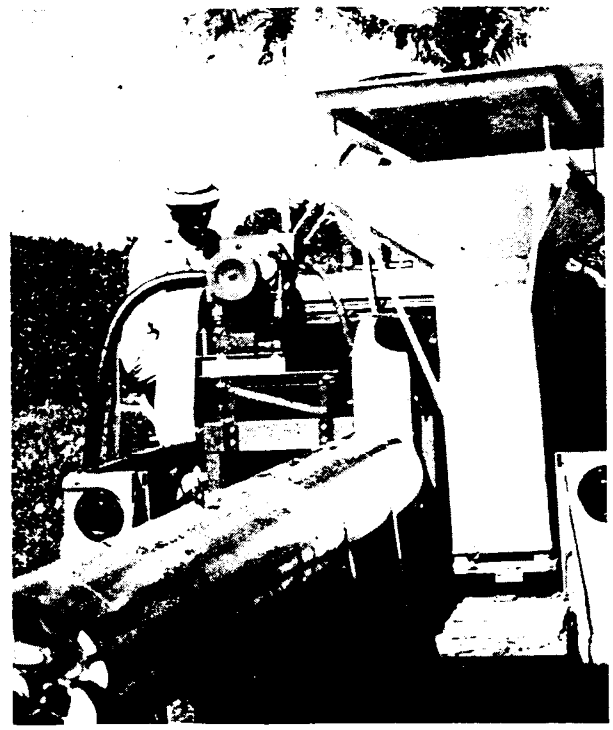

Fig. 80. Truck-mounted portable ultra high-volume air sampler.

the special field conditions of the survey. These samplers were designed and built at LLL to provide the very high-volume flow rate needed to sample large volumes of air in short time intervals. The flow rate through the sampler was approximately 2000 $m^3$/hr, or about 20-50 times the flow rate of more conventional high-volume samplers. A special low-ash polystyrene filter, Delbag Microsorban, is used with this sampler. The filter medium is over 99% efficient for particles of 0.3 $\mu$m diameter, and has a filter collecting area of 1.25 $m^2$. Samplers were powered on Enewetak by 15-hp gasoline engines and fueled for 40 hr of operation by 55-gal gasoline drums. The UHVS's were calibrated at Livermore for flow rate and total integrated volume by standard flowmeter measurements. Field air volumes were measured by an

*W. Wells, B. R. Clegg, and J. C. Taylor, An Ultra-High Volume Air Sampler for the Collection of Airborne Particulates in Low Concentrations, Lawrence Livermore Laboratory report in preparation (1973).

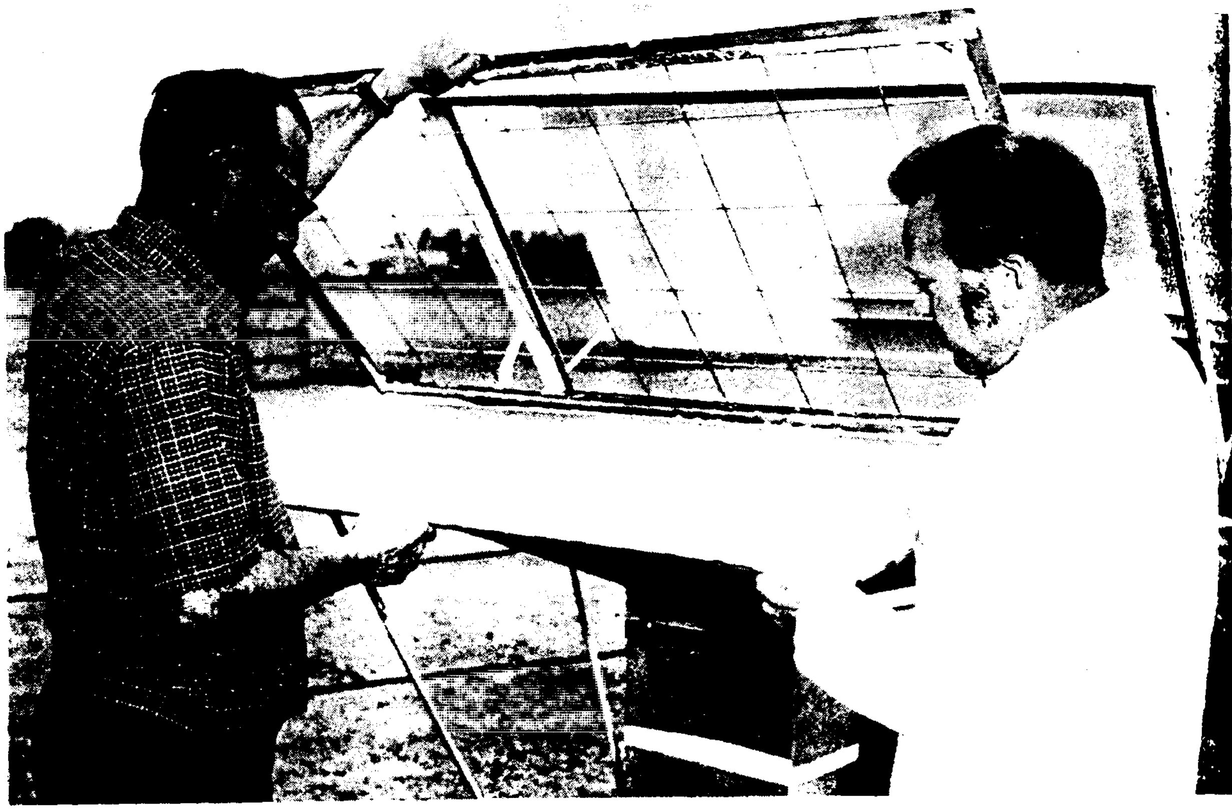

Fig. 81. Portable ultra high-volume air sampler.

integrating flowmeter which was verified by a pitot-tube, instantaneous-flow-rate indicator. One UHVS unit was mounted on a 1/2-ton truck for off-island use on an LCM (Landing Craft Mechanized) and was limited in deployment to islands accessible by this craft. The second UHVS unit remained on FRED for continuous measurements.

Low-Volume Air Samplers (VCS)

Specially instrumented hand-held vacuum cleaners were used to collect week-long air samples on FRED and YVONNE. These samplers filtered at a rate between 8 and 20 $m^3$/hr. Approximate flow-rate-over-time-of-sampling was obtained by averaging the initial and final flow rates determined by direct measurement. The VCS units were powered by base electricity on FRED and by small gasoline generators on YVONNE. These generators were connected redundantly so as to improve power reliability of these inherently poor sources.

Andersen Cascade Impactors (ACI)

Two five-stage particle spectrometers (Fig. 82) were used to obtain data on the particle-size distribution of airborne radioactivity. These Andersen Cascade Impactors sampled at 34 $m^3$/hr and separated five particle fractions on Fiberglas filter paper in the following increments: 0.1-1.1 μm, 1.1-2.0 μm, 2.0-3.3 μm, 3.3-7.0 μm, and >7 μm.

Sampling Operations

Daily observations were made of rainfall, wind velocity, and relative humidity. Weather information was

Fig. 82. Five-stage particle spectrometer.

available every 6 hr from the Enewetak Coast Guard Station. On YVONNE, a battery-powered station was used to measure wind velocity over the duration of the air-sampling operation.

Table 104 provides a summary of all samples collected, time of sampling, volume of air filtered, wind velocities, and the precipitation record. Figures 83 through 88 show the locations of sampling stations. Soil data appropriate to each air-sampling location may be found in the figures of Appendix II.

FRED

UHVS, VCS, and ACI samples (Table 104) were obtained from October 21 to 23, 1972, and from November 28 until December 19. The sampler location (Fig. 83) was such as to measure regional ocean background or air which crosses YVONNE, depending on the wind direction. East winds prevailed 80% of the time; however, for two periods, October 22-23 and December 11-14, moderately high winds from the NNE prevailed which would be expected to reflect any pickup and transport of radioactivity from YVONNE to the southern part of the Atoll.

DAVID

Sampling was carried out on DAVID with the portable UHVS from October 19 to 22, resulting in two separate day-long samples. The sampling station was in the central part of the island (Fig. 84), with the winds from the east and northeast.

The FRED sampling location served to measure regional ocean background levels and, at other times, depending on wind direction, to measure inter-island transport. Ocean background was measured 80% of the sampling time during the typical east tradewinds. Samples UH5 and UH10 (128, 000 $m^3$) were taken during a 010-050° northeast wind which sampled air along populated areas of FRED, as well as inter-island air from YVONNE. Neither sample exhibited radionuclide levels above ocean values.

Blank samples of 1.25 $m^2$ of the Delbag Micrasorban filter paper used in the UHVS samplers, when analyzed in the same way as the samples for which data are shown in Table 105, show $^{239,240}Pu$ levels as high as 0.6 pCi/total paper, or about 0.01 $fCi/m^3$ if a sample volume of 40,000 $m^3$ is assumed. These "background" levels have not been subtracted from the data in Table 105 since they appear to be quite variable; therefore, tabulated values for $^{239,240}Pu$ in the range of 0.01 $fCi/m^3$ or less should be used with the understanding that they may represent upper limits.

The JANET and SALLY sampling positions were downwind from the highest gamma levels observed in the aerial

Table 104. Air samples collected on Enewetak Atoll.

| | Sample No. | Sampling period (1972) | Particle-size range, μm | Volume $m^3$ | Wind direction | Wind speed, knots | Precipitation, in. |
|---|---|---|---|---|---|---|---|
| FRED | UH3 | Oct 21-22 | | 60,000 | E, ENE | 9-10 | < 0.01 |
| | UH5 | Oct 22-23 | | 30,900 | NE, NNE | 10-15 | 0.0-0.01 |
| | UH6 | Nov 28-30 | | 58,700 | E | 18-20 | 0.01 |
| | UH7 | Nov 30-Dec 1 | | 61,000 | E, ENE | 15-21 | 0.01 |
| | UH8 | Dec 1-2 | | 16,400 | E | 15-18 | 0.0-0.01 |
| | UH9 | Dec 7-11 | | 101,000 | NE | 15-20 | 0.40 |
| | UH10 | Dec 11-14 | | 97,400 | NNE | 11-17 | 0.25 |
| | UH11 | Dec 14-17 | | 97,500 | NE | 15-22 | 0.04 |
| | UH12 | Dec 17-19 | | 74,000 | NE | 23-24 | 0.01 |
| | UH13 | Blank | | (40,000 $m^3$ assumed) | | | |
| | VC11 | Nov 28-Dec 7 | | 1,640 | | | |
| | VC21 | Nov 28-Dec 7 | | 1,640 | | | |
| | VC12 | Dec 7-18 | | 2,300 | | | |
| | VC22 | Dec 7-18 | | 2,300 | | | |
| | A11A | Nov 28-Dec 7 | (0.01-1.1) | 7,300 | | | |
| | A11B | Nov 28-Dec 7 | (1.1-2.0) | 7,300 | | | |
| | A11C | Nov 28-Dec 7 | (2.0-3.3) | 7,300 | | | |
| | A11D | Nov 28-Dec 7 | (3.3-7.0) | 7,300 | | | |
| | A11E | Nov 28-Dec 7 | (>7.0) | 7,300 | | | |
| | A12A | Dec 7-18 | (0.01-1.1) | 9,900 | | | |
| | A12B | Dec 7-18 | (1.1-2.0) | 9,900 | | | |
| | A12C | Dec 7-18 | (2.0-3.3) | 9,900 | | | |
| | A12D | Dec 7-18 | (3.3-7.0) | 9,900 | | | |
| | A12E | Dec 7-18 | (>7.0) | 9,900 | | | |
| DAVID | UH1 | Oct 19-20 | | 56,000 | E, ENE, NE | 6-10 | 0.01 |
| | UH4 | Oct 21-22 | | 36,400 | NE, NNE | 10-15 | 0.0-0.01 |
| JANET | UH21 | Dec 4-5 | | 36,000 | NE, E | 13-18 | 0.37 |
| | UH22 | Dec 5-6 | | 22,800 | E | 15-20 | 0.40 |
| | UH23 | Dec 8-9 | | 19,800 | NE, ESE | 9-15 | 0.14 |
| SALLY | UH24 | Dec 13-14 | | 34,400 | NE, ENE | 8-18 | 0.0-0.01 |
| | UH25 | Dec 14-15 | | 39,000 | NNE, NE | 15-22 | 0.01 |
| YVONNE | UH26 (Pu area) | Dec 15-16 | | 27,000 | NE | 15-25 | 0.03 |
| | UH27 (Pu area) | Dec 16-17 | | 34,000 | NNE, NE | 20-25 | 0.03 |
| | UH28 (Cactus) | Dec 17-19 | | 21,400 | NE | 22-24 | 0.01 |
| | VC31 (Pu area) | Dec 2-9 | | 1,800 | | | |
| | VC41 (Pu area) | Dec 2-9 | | 1,800 | | | |
| | A21A (Pu area) | Dec 2-9 | (0.01-1.1) | 5,700 | | | |
| | A21B (Pu area) | Dec 2-9 | (1.1-2.0) | 5,700 | | | |

Table 104 (continued).

| | Sample No. | Sampling period (1972) | Particle-size range, µm | Volume $m^3$ | Wind direction | Wind speed, knots | Precipitation, in. |
|---|---|---|---|---|---|---|---|
| YVONNE | A21C (Pu area) | Dec 2-9 | (2.0-3.3) | 5,700 | | | |
| | A21D (Pu area) | Dec 2-9 | (3.3-7.0) | 5,700 | | | |
| | A21E (Pu area) | Dec 2-9 | (>7.0) | 5,700 | | | |
| | VC32 (Pu area) | Dec 9-19 | | 2,100 | | | |
| | VC42 (Pu area) | Dec 9-19 | | 2,100 | | | |
| | VC43 (Pu area) (blind sample) | | | | | | |
| | A22A | Dec 9-19 | (0.01-1.1) | 7,750 | | | |
| | A22B | Dec 9-19 | (1.1-1.1) | 7,750 | | | |
| | A22C | Dec 9-19 | (2.0-3.3) | 7,750 | | | |
| | A22D | Dec 9-19 | (3.3-7.0) | 7,750 | | | |
| | A22E | Dec 9-19 | (>7.0) | 7,750 | | | |

survey. All of these samples, however, exhibited the type of results observed on the FRED samples.

As an extreme test of resuspension, the UHVS was located in an area of highest plutonium surface contamination on YVONNE (Fig. 88). Both UHVS samples at that location exhibited measurable plutonium levels (1.8 and 2.6 fCi/$m^3$). The UH27 sample returned a detectable $^{241}$Am value of 0.30 fCi/$m^3$ ± 32%. Only one ACI sample measured a high $^{239,240}$Pu value (0.18-fCi/$m^3$), but that was in the respirable range of particle sizes (<1.1 µm). In addition, one VCS sample taken during the same period (Dec. 2-9, 1972) exhibited a high value of $^{239,240}$Pu (0.41 fCi/$m^3$). Other low-volume and cascade-impactor samples yielded plutonium air concentrations similar to those observed on FRED.

A resuspension factor can be inferred at the high plutonium site on YVONNE if one assumes that an average 200 pCi/g plutonium soil concentration in the top centimeter is available for suspension on the surface layer. The 2.6 fCi/$m^3$ air concentration (UH27), for example, indicates an approximate resuspension factor of $10^{-9}$/m.

Two days of sampling near the CACTUS crater measured a $^{239-240}$Pu air concentration equal to 1.1 fCi/$m^3$ and a $^{238}$Pu concentration equal to 0.13 fCi/$m^3$. No detectable $^{241}$Am was found. Such a high air concentration is somewhat anomalous because the surface plutonium concentrations in this area are not known to be nearly so high as at the central YVONNE site. Ocean spray is a possible source, because the CACTUS crater water contains a surface concentration of 200

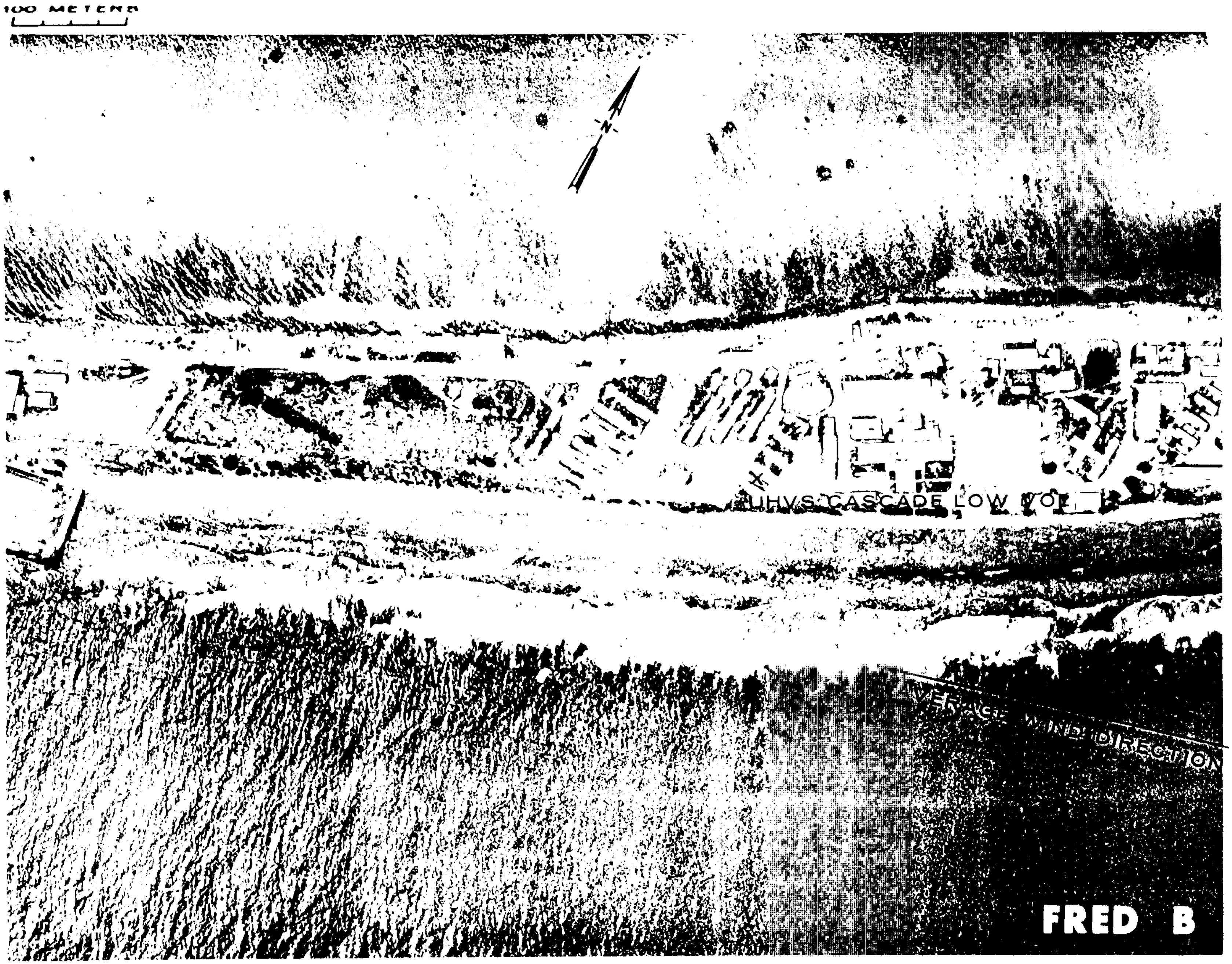


Fig. 83. Air-sample station location, Fred B.

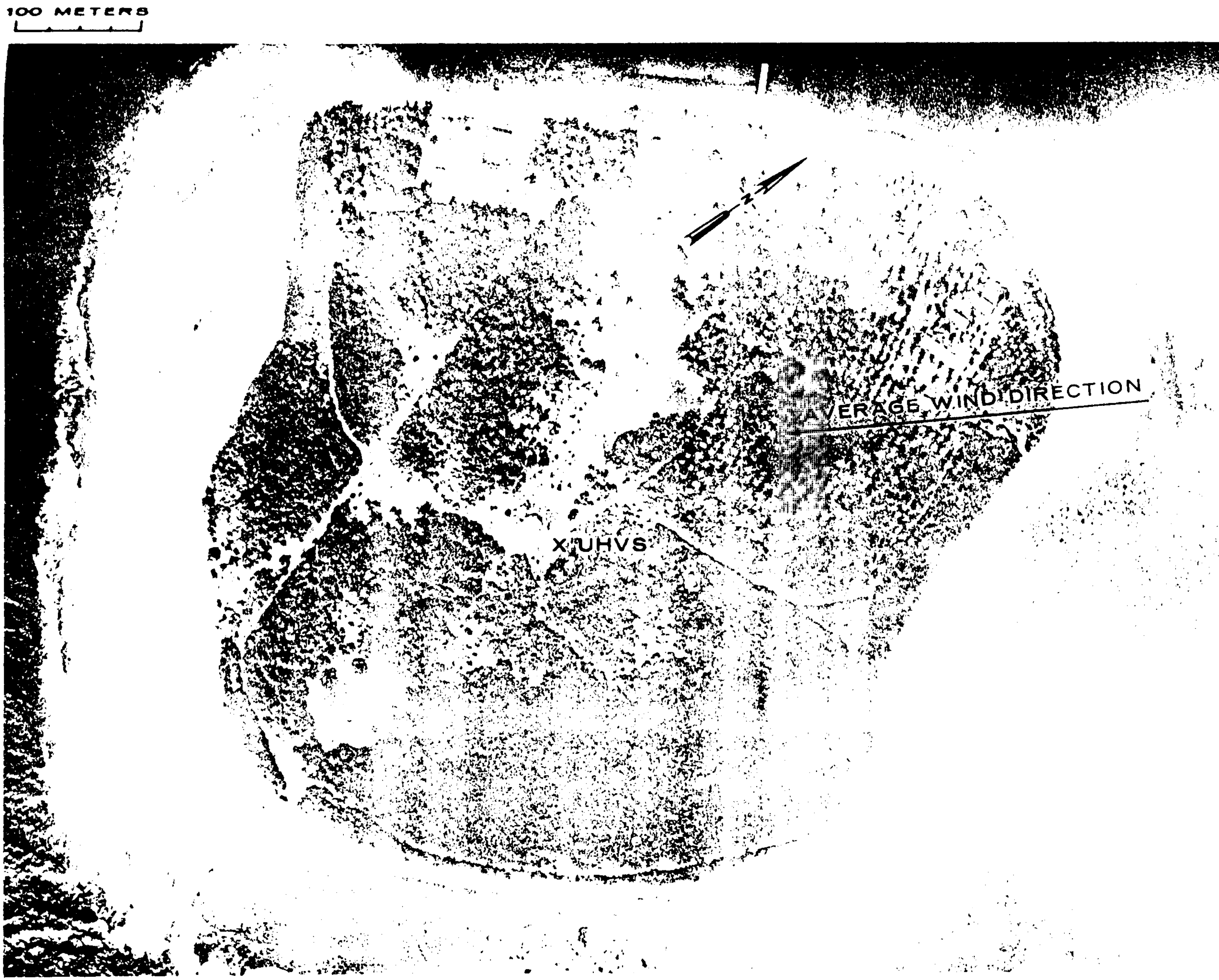


Fig. 84. Air-sample station location, David.

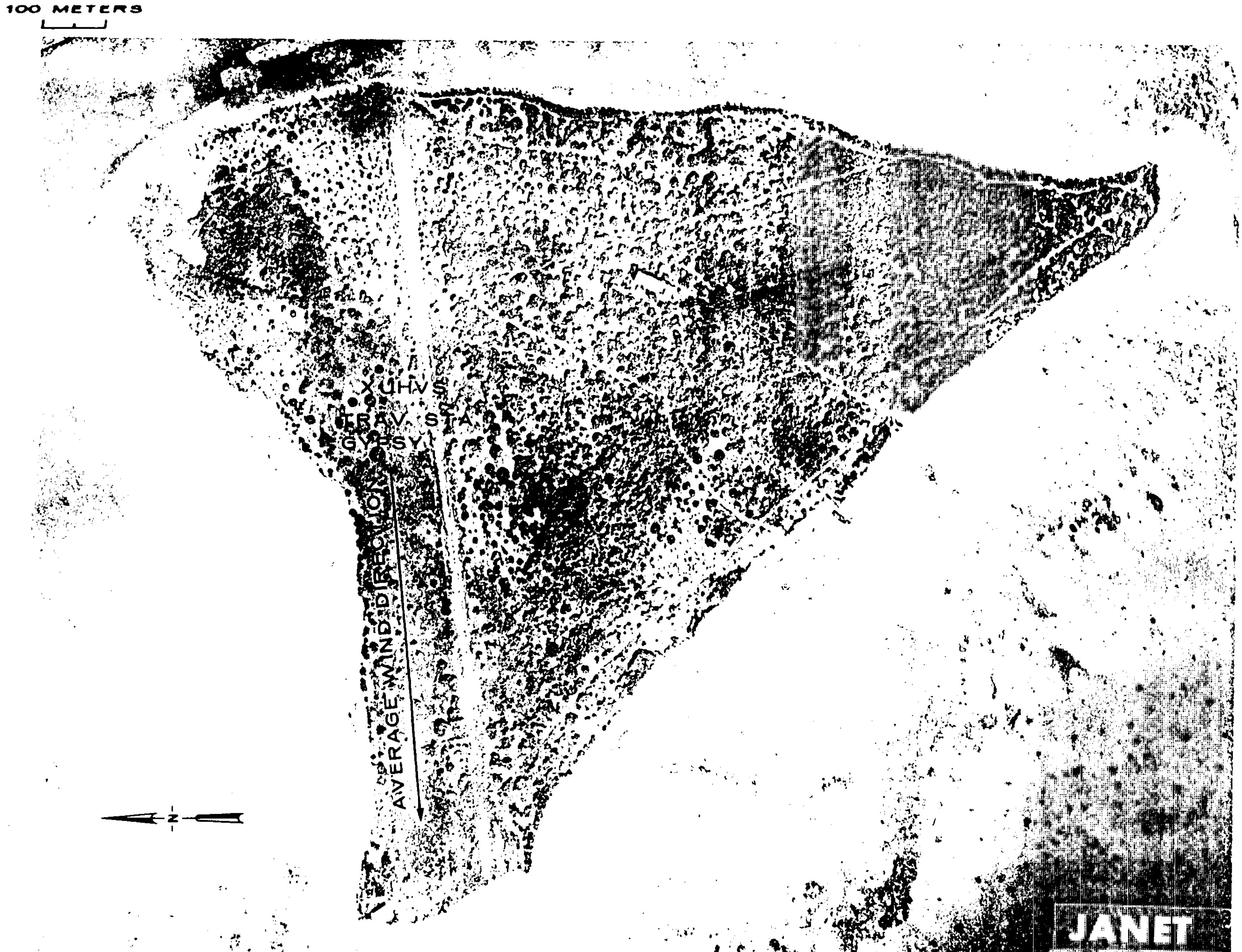


Fig. 85. Air-sample station location, Janet.


Fig. 86. Air-sample station location, Sally.


Fig. 87. Air-sample station location, Yvonne B.