UNITED STATES
ATOMIC ENERGY COMMISSION
NEW YORK OPERATIONS OFFICE
70 COLUMBUS AVENUE
NEW YORK 23, NEW YORK

400197

TELEPHONE NO.:
PLaza 7-3600

Health and Safety Laboratory
HSA:IBW

November 16, 1956

Dr. Forrest Western
U. S. Atomic Energy Commission
Division of Biology and Medicine
1901 Constitution Avenue, N. W.
Washington 25, D. C.

Dear Forrest:

I am enclosing a copy of the recent Marshall Island Survey data for your information. Since the table was prepared we have received the information which was incomplete and also several corrections with some of the original data. Of most importance is the correction of sample 3815 which was originally recorded to be too high by a factor of 100.

Sincerely yours,

Ira

Ira B. Whitney
Assistant Chief
Analytical Branch

NMPB 3 D/L Navy Dept
Medical Library
00296

5002034

UWAFL - POST BRAVO MARSHALL ISLAND SURVEY SAMPLES

	HASL Number	UWAFL Number	Organism	Tissue	Sampling Location Island	Collection Date	No. Spec.	Lab	Total Activity (β) C-Date	Total Activity (β) d/m/g wet	Sr^{90} d/m/g - wet	Ca gm/g - wet	S.U.
Invertebrates	4042	I- 9	Holothurai atra	gonad	Rongelap	7-23-56		I,Inc.	10-10-56	46	2.7 ± 0.14	0.00566	210 ± 11
	4043	I-10	Holothurai atra	gut & content	Rongelap	7-23-56		I,Inc.	10-10-56	31	incomplete	0.155	incomplete
	4044	I-11	Holothurai atra	integument	Rongelap	7-23-56		I,Inc.	10-10-56	10	incomplete	<0.00101	incomplete
	4045	I-12	Tridacna gigas	mantle	Kabelle	7-24-56		I,Inc.	10-10-56	2.6	0.090 ± 0.016	<0.00239	≥6
	4046	I-13	Tridacna gigas	muscle	Kabelle	7-24-56		I,Inc.	10-10-56	1.5	incomplete	0.00400	incomplete
	4047	I-49a	Cenobita	muscle	Kabelle	7-24-56		MSE		lbs	Wet - Weight -	Data	4600 ± 300
	4048	I-49b	Cenobita	skeleton	Kabelle	7-24-56		MSE		"	" " "	"	3960 ± 170
	4049	I-49c	Cenobita	liver	Kabelle	7-24-56		MSE		"	" " "	"	4600 ± 300
	4050	I-50a	Cenobita	skeleton	Kabelle	7-24-56		MSE		"	" " "	"	2190 ± 80
	4051	I-50b	Cenobita	liver	Kabelle	7-24-56		MSE		"	" " "	"	2620 ± 130
	4052	I-50c	Cenobita	muscle	Kabelle	7-24-56		MSE		"	" " "	"	2860 ± 170
	4053	I-52	Cenobita	skeleton	Rongelap	7-23-56		MSE		"	" " "	"	2200 ± 120
	4054	I-51	Cenobita	skeleton	Kabelle	7-24-56		MSE		"	" " "	"	3600 ± 150
Fish	4035	F-266a	Reef fish	muscle	Rongelap	7-23-56	19	MSE		12	0.036 ± 0.003	0.000608	20 ± 1.9
	4036	F-266b	Reef fish	bone	Rongelap	7-23-56	19	MSE		31	1.9 ± 0.082	0.0711	12 ± 0.5
	4037	F-266c	Reef fish	liver	Rongelap	7-23-56	19	MSE		230	recheck	0.000990	recheck
	4038	F-311a	Reef fish	muscle	Kabelle	7-24-56	15	I,Inc.	10-10-56	2.9	0.027 ± 0.004	0.00125	9.8 ± 1.6
	4039	F-311b	Reef fish	muscle	Kabelle	7-24-56	15	I,Inc.	10-10-56	0.39	0.401 ± 0.007	0.00104	175 ± 3
	4040	F-311c	Reef fish	bone	Kabelle	7-24-56	15	I,Inc.	10-10-56	0.66	0.106 ± 0.014	0.0744	0.65± 0.09
	4041	F-311d	Reef fish	liver	Kabelle	7-24-56	15	I,Inc.	10-10-56	7.2	0.061 ± 0.041	<0.00485	≥6
Land Plants	4024	RO- 1	Breadfruit	meat	Rongelap	7-23-56		MSE		31	0.26 ± 0.008	0.000447	260 ± 10
	4025	RO- 2	Papaya	seeds	Rongelap	7-23-56		I,Inc.	10-11-56	0.86	0.38 ± 0.01	<0.00208	≥ 86
	4026	RO- 2	Papaya	seeds	Rongelap	7-23-56		MSE		28	0.38 ± 0.002	0.00237	74 ± 4
	4027	RO- 6	Coconut	meat	Rongelap	7-23-56		I,Inc.	10-10-56	0.36	0.033 ± 0.003	<0.000376	≥ 41
	4028	RO- 7	Coconut	milk	Rongelap	7-23-56		MSE		666(d/m/l)	0.034 ± 0.004(d/l)	0.000277(gm/ml)	58 ± 7
	4034	RO- 8	Morinda	pulp & seeds	Rongelap	7-23-56		MSE		46	1.4 ± 0.08	0.000659	1000 ± 50
	4029	RO-12	Arrowroot	corm	Rongelap	7-23-56		I,Inc.	10-10-56	0.16	0.27 ± 0.004	0.000642	190 ± 3
	4030	RO-16	Pandanus	fruit	Rongelap	7-23-56		MSE		63	1.2 ± 0.04	0.00106	530 ± 20
	4031	RO-20	Coconut	meat	Kabelle	7-24-56		I,Inc.	10-10-56	0.56	0.15 ± 0.003	<0.000250	≥ 272
	4032	RO-21	Coconut	milk	Kabelle	7-24-56		MSE		145	1.9 ± 0.076	0.000474	1720 ± 110
	4033	RO-22	Papaya	fruit	Rongelap	7-23-56		I,Inc.	10-10-56	0.40	0.37 ± 0.006	0.000636	265 ± 4

	HASL Number	UWAFL Number	Type	Island Location	S-Date	Area	Lab	Total Activity (β) C-Date	Total Activity (β) d/m/l	Sr^{90} d/m/l
Water	3814		Cistern	Rongelap	7-27-56	Village	I,Inc.	8-7-56	31,000 (after filtering twice)	7700 ± 300
	3815		Well	Rongelap	7-23-56	Village	I,Inc.	8-7-56	22,000 (after filtering twice)	

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	HASL Number	UWAFL Number	Sampling Location	Collection Date	Depth	Area	Lab	Total Activity (β) C-Date	Total Activity (β) d/m/gm-wet	Sr^{90} d/m/gm-wet	Sr^{90} d/m/ft²	Sr^{89}/Sr^{90}	Total Ca gm/gm-wet	Minimum S.U.
Soil	3802		Kabelle	7-24-56	0-2"	(first set)	HASL	8- 4-56	1980 ± 80	150 ± 3.7		0.07	0.29	
							I,Inc.	8-29-56	1820	155 ± 4.1			0.31	220 ± 6
	3803		Kabelle	7-24-56	2-4"	(first set)	HASL	8- 4-56	406 ± 45					
							I,Inc.	8-29-56	471	40 ± 0.41			0.32	55 ± 0.6
	3804		Kabelle	7-24-56	4-6"	(first set)	HASL	8- 4-56	≤40					
							I,Inc.	8-29-56	106	1.5 ± 0.07			0.35	8.0 ± 0.9
	3807		Kabelle	7-24-56	0-2"	(second set)	HASL	8- 4-56	6210 ± 110	250 ± 4.9		0.16	0.37	
							I,Inc.	8-30-56	5940	265 ± 1.2			0.36	330 ± 2
	3806		Kabelle	7-24-56	2-4"	(second set)	HASL	8- 4-56	3500 ± 102	58 ± 2.9		0.07	0.35	
							I,Inc.	8-30-56	1785	96 ± 1.7			0.35	125 ± 2
	3805		Kabelle	7-24-56	4-6"	(second set)	HASL	8- 4-56	1160 ± 62	54 ± 2.8		0.08	0.56	
							I,Inc.	8-30-56	651	30 ± 0.57			0.34	40 ± 1.3
	3808		Rongelap	7-23-56	0-2"	100' fr. lagoon village area	HASL	8- 4-56	266 ± 52					
							I,Inc.	8-30-56	152	10 ± 0.40			0.36	13 ± 1.1
	3809		Rongelap	7-23-56	2-4"	100' fr.lagoon village area	HASL	8- 4-56	≤39					
							I,Inc.	8-30-56	79.2	4.5 ± 0.1			0.35	5.8 ± 0.4
	3810		Rongelap	7-23-56	4-6"	100' fr.lagoon village area	HASL	8- 4-56	≤45					
							I,Inc.	8-30-56	54.9	0.98± 0.03			0.32	1.4 ± 0.04
	3813		Rongelap	7-23-56	0-2"	mid island	HASL	8- 4-56	1220 ± 58	68 ± 2.8		0.06	0.20	
							I,Inc.	8-30-56	663	31 ± 0.21			0.32	44 ± 0.5
	3812		Rongelap	7-23-56	2-4"	mid island	HASL	8- 4-56	134 ± 51					
							I,Inc.	8-30-56	106	4.0 ± 0.2			0.35	5.2 ± 0.3
	3811		Rongelap	7-23-56	4-6"	mid island	HASL	8- 4-56	≤37					
							I,Inc.	8-30-56	54.9	0.98 ± 0.03			0.32	1.4 ± 0.1
	3818		Parry	7-25-56	surface	shore	HASL	8- 4-56	17900 ± 203	7.6 ± 2.0		8.7	0.30	
	3819		Parry	7-25-56	sub-surface	shore	HASL	8- 4-56	103 ± 39					

* As of 9-20-56

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Invertebrates and Fish

HASL #	Sr^{90} d/m/g--wet	S. U.
4043	1.15 ± 0.029	3.39 ± 0.08
4044	0.27 ± 0.0074	
4046	0.046	---
4037	0.058 ± 0.029	27 ± 13

Water

HASL #	Sr^{90} d/m/g--wet
3814	147 ± 4.32
3815	77 ± 2.84

Soil

HASL #	d/m/gr-wet	S. U.
3810	1.39 ± 0.06	1.90 ± 0.08

Corrections in Table - UAWFL-Post Redwing Marshall Islands Survey Samples
November 16, 1956

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Invertebrates and Fish

HASL #	Sr^{90} d/m/g--wet	S. U.
4043	1.15 ± 0.029	3.39 ± 0.08
4044	0.27 ± 0.0074	
4046	0.046	---
4037	0.058 ±	27 ± 13

Water

HASL #	Sr^{90} d/m/g--wet
3814	
3815	147 ± 4.32 77 ± 2.84

Soil

HASL #	Sr^{90} d/m/gr-wet	S. U.
3810	1.39 ± 0.06	1.90 ± 0.08

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Water

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3814	
3815	147 ± 4.32
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HASL #	Sr^{90} d/m/g—wet	S. U.
4043	1.15 ± 0.029	3.39 ± 0.08
4044	0.27 ± 0.0074	
4046	0.046	
4037	0.058 ±	27 ± 13

Water

HASL #	Sr^{90} d/m/g—wet
3814	
3815	147 ± 4.32
	77 ± 2.84

Soil

HASL #	Sr^{90} d/m/gr-wet	S. U.
3810	1.39 ± 0.06	1.90 ± 0.08

USAFL - FORT SHAFTER HONOLULU, HAWAII FISSION SAMPLES

	HASL Number	USAFL Number	Organism	Tissue	Sampling Location Island	Collection Date	No. Days	Lab	Total Activity (β) C-Date	Total Activity (β) d/m/g ash	Sr^{90} d/m/g - wet	Ca gm/g - wet	S.U.
Invertebrates	b042	I- 9	Heliotheuri etra	gonad	Rongelap	7-23-56		I,Inc.	10-10-56	46	2.7 ± 0.14	0.00566	210 ± 11
	b043	I-10	Heliotheuri etra	gut & content	Rongelap	7-23-56		I,Inc.	10-10-56	31	incomplete	0.155	incomplete
	b044	I-11	Heliotheuri etra	integument	Rongelap	7-23-56		I,Inc.	10-10-56	10	incomplete	<0.00101	incomplete
	b045	I-12	Tridacna gigas	muscle	Kabelle	7-24-56		I,Inc.	10-10-56	2.6	0.030 ± 0.016	<0.00839	8.4
	b046	I-13	Tridacna gigas	muscle	Kabelle	7-24-56		I,Inc.	10-10-56	1.5	incomplete	0.00400	incomplete
	b047	I-49a	Conchita	muscle	Kabelle	7-24-56		HASL			Re - Wet - Weight - Data		4600 ± 300
	b048	I-49b	Conchita	skeleton	Kabelle	7-24-56		HASL			" " " "		3840 ± 170
	b049	I-49c	Conchita	liver	Kabelle	7-24-56		HASL			" " " "		4500 ± 300
	b050	I-50a	Conchita	skeleton	Kabelle	7-24-56		HASL			" " " "		2190 ± 80
	b051	I-50b	Conchita	liver	Kabelle	7-24-56		HASL			" " " "		2620 ± 130
	b052	I-50c	Conchita	muscle	Kabelle	7-24-56		HASL			" " " "		2860 ± 170
	b053	I-52	Conchita	skeleton	Rongelap	7-23-56		HASL			" " " "		2200 ± 120
	b054	I-51	Conchita	skeleton	Kabelle	7-24-56		HASL			" " " "		3600 ± 150
Fish	b035	F-266a	Reef fish	muscle	Rongelap	7-23-56	15	HASL		12	0.036 ± 0.003	0.000808	20 ± 1.9
	b036	F-266b	Reef fish	bone	Rongelap	7-23-56	15	HASL		31	1.9 ± 0.082	0.0711	12 ± 0.5
	b037	F-266c	Reef fish	liver	Rongelap	7-23-56	15	HASL		230	recheck	0.000990	recheck
	b038	F-311a	Reef fish	muscle	Kabelle	7-24-56	15	I,Inc.	10-10-56	2.9	0.027 ± 0.004	0.00125	9.8 ± 1.6
	b039	F-311b	Reef fish	muscle	Kabelle	7-24-56	15	I,Inc.	10-10-56	0.39	0.401 ± 0.007	0.00104	175 ± 3
	b040	F-311c	Reef fish	bone	Kabelle	7-24-56	15	I,Inc.	10-10-56	0.66	0.106 ± 0.014	0.0744	0.65± 0.09
	b041	F-311d	Reef fish	liver	Kabelle	7-24-56	15	I,Inc.	10-10-56	7.2	0.061 ± 0.041	<0.00485	26
Land Plants	b024	RO- 1	Breadfruit	meat	Rongelap	7-23-56		HASL		31	0.26 ± 0.008	0.000447	260 ± 10
	b025	RO- 2	Papaya	seeds	Rongelap	7-23-56		I,Inc.	10-11-56	0.86	0.38 ± 0.01	<0.00208	186
	b026	RO- 2	Papaya	seeds	Rongelap	7-23-56		HASL		28	0.36 ± 0.002	0.00237	74 ± 4
	b027	RO- 6	Coconut	meat	Rongelap	7-23-56		I,Inc.	10-10-56	0.36	0.033 ± 0.003	<0.000376	141
	b028	RO- 7	Coconut	milk	Rongelap	7-23-56		HASL		6646/640	0.034 ± 0.004 (40	0.000277 (gm/ml)	58 ± 7
	b034	RO- 8	Morinda	pulp & seeds	Rongelap	7-23-56		HASL		46	1.4 ± 0.08	0.000659	1000 ± 50
	b029	RO-12	Arrowroot	corm	Rongelap	7-23-56		I,Inc.	10-10-56	0.16	0.27 ± 0.004	0.000642	190 ± 3
	b030	RO-16	Pandanus	fruit	Rongelap	7-23-56		HASL		63	1.2 ± 0.041	0.00106	530 ± 20
	b031	RO-20	Coconut	meat	Kabelle	7-24-56		I,Inc.	10-10-56	0.56	0.15 ± 0.003	<0.000250	272
	b032	RO-21	Coconut	milk	Kabelle	7-24-56		HASL		145	1.9 ± 0.076	0.000474	1720 ± 110
	b033	RO-22	Papaya	fruit	Rongelap	7-23-56		I,Inc.	10-10-56	0.40	0.37 ± 0.006	0.000636	265 ± 4

	HASL Number	USAFL Number	Type	Island Location	S-Date	Area	Lab	Total Activity (β) C-Date	Total Activity (β) d/m/l	Sr^{90} d/m/l
Water	3814		Cistern	Rongelap	7-27-56	Village	I,Inc.	8-7-56	31,000 (after filtering twice)	
	3815		Well	Rongelap	7-23-56	Village	I,Inc.	8-7-56	22,000 (after filtering twice)	7700 ± 300

	HASL Number	USAFL Number	Sampling Location	Collection Date	Depth	Area	Lab	Total Activity (β) C-Date	Total Activity (β) d/m/gm-wet	Sr^{90} d/m/gm-wet	Sr^{90} d/m/ft^2	Sr^{89}/Sr^{90}	Total Ca gm/gm-wet	Minimum S.U.
Soil	3802		Kabelle	7-24-56	0-2"	(first set)	HASL	8- 4-56	1980 ± 80	150 ± 3.7		0.07	0.29	
							I,Inc.	8-29-56	1820	155 ± 4.1			0.31	220 ± 6
	3803		Kabelle	7-24-56	2-4"	(first set)	HASL	8- 4-56	406 ± 45					
							I,Inc.	8-29-56	471	40 ± 0.41			0.32	55 ± 0.6
	3804		Kabelle	7-24-56	4-6"	(first set)	HASL	8- 4-56	± 40					
							I,Inc.	8-29-56	106	1.5 ± 0.07			0.35	8.0 ± 0.9
	3807		Kabelle	7-24-56	0-2"	(second set)	HASL	8- 4-56	6210 ± 110	250 ± 4.9		0.16	0.37	
							I,Inc.	8-30-56	5940	265 ± 1.2			0.36	330 ± 2
	3806		Kabelle	7-24-56	2-4"	(second set)	HASL	8- 4-56	3300 ± 102	58 ± 2.9		0.07	0.35	
							I,Inc.	8-30-56	1795	96 ± 1.7			0.35	125 ± 2
	3805		Kabelle	7-24-56	4-6"	(second set)	HASL	8- 4-56	1160 ± 62	54 ± 2.8		0.08	0.56	
							I,Inc.	8-30-56	651	30 ± 0.57			0.34	40 ± 1.3
	3808		Rongelap	7-23-56	0-2"	100' fr. lagoon village area	HASL	8- 4-56	266 ± 52					
							I,Inc.	8-30-56	152	10 ± 0.60			0.36	13 ± 1.1
	3809		Rongelap	7-23-56	2-4"	100' fr. lagoon village area	HASL	8- 4-56	± 39					
							I,Inc.	8-30-56	79.2	4.5 ± 0.1			0.35	5.8 ± 0.4
	3810		Rongelap	7-23-56	4-6"	100' fr. lagoon village area	HASL	8- 4-56	± 45					
							I,Inc.	8-30-56	54.9	0.98± 0.03			0.32	1.4 ± 0.04
	3813		Rongelap	7-23-56	0-2"	mid island	HASL	8- 4-56	1220 ± 58	68 ± 2.8		0.06	0.20	
							I,Inc.	8-30-56	663	31 ± 0.21			0.32	44 ± 0.5
	3812		Rongelap	7-23-56	2-4"	mid island	HASL	8- 4-56	134 ± 51					
							I,Inc.	8-30-56	106	4.0 ± 0.2			0.35	5.2 ± 0.3
	3811		Rongelap	7-23-56	4-6"	mid island	HASL	8- 4-56	± 37					
							I,Inc.	8-30-56	54.9	0.98 ± 0.03			0.32	1.4 ± 0.1
	3818		Parry	7-25-56	surface	shore	HASL	8- 4-56	17900 ± 203	7.6 ± 2.0		8.7	0.30	
	3819		Parry	7-25-56	sub-surface	shore	HASL	8- 4-56	103 ± 39					

* As of 9-20-56

Note corrections attached

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Invertebrates and Fish

HASL #	Sr^{90} d/m/g—wet	S. U.
4043	1.15 ± 0.029	3.39 ± 0.08
4044	0.27 ± 0.0074	
4046	0.046	—
4037	0.058 ±	27 ± 13

Water

HASL #	Sr^{90} d/m/g—wet
3814	
3815	147 ± 4.32
	77 ± 2.84

Soil

HASL #	Sr^{90} d/m/gr-wet	S. U.
3810	1.39 ± 0.06	1.90 ± 0.08

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D R A F T
@Dunning:vm
12-11-56

ATOMIC ENERGY COMMISSION

RETURN OF RONGELAPESE TO THEIR HOME ISLAND

Report to the General Manager by the
Director of Biology and Medicine

THE PROBLEM

1. To determine if it is advisable to return the Rongelapese to their home island in the Marshalls.

SUMMARY

2. After the relatively heavy fallout on the Marshall Islands March 1, 1954, 82 inhabitants were evacuated first to Kwajalein and to Ejit, where they are now living. There have been public statements, concurred in by the Atomic Energy Commission, Department of Interior and the Department of State to the effect that these people will be returned to their home island of Rongelap as soon as it is possible from health considerations. Such a statement was submitted to the 17th Session of the U. N. Trustee Council, Subcommittee of Petitions, March 27, 1956 by Mr. D. Vernon McKay, Special Representative of the Administering Authorities for the Trust Territory of the Pacific Islands.

3. Since the Rongelapese are now subsidized by the United States Government with little need nor opportunity to actively engage in normal livelihood, there is the risk of an onset of indulence, to the detriment of the best interest of the Rongelapese.

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4. Several biological surveys of the Marshall Islands especially Rongelap Atoll, have been made during the past two and one-half years. The latest survey (July 23-24, 1956) indicates a presence of a residual contamination on the Island of Rongelap, but at a level that is acceptable from a health point of view, both for the potential external gamma radiation exposure and the strontium-90 content in the food supply, with the possible exception of land crabs.

5. Therefore, it is recommended that the position of the Atomic Energy Commission should be ~~to permit the return of~~ that the Rongelapese could be returned to their home island as soon as rehabilitation procedures on the Island of Rongelap are completed, with the advise that land crabs not be eaten at this time.

STAFF JUDGMENTS

6. The Divisions of Military Application, Information Services, and Classification, Office of Special Projects, Office of the General Counsel concur in the recommendation of this paper.

RECOMMENDATION

7. The General Manager recommends that the Atomic Energy Commission:

a. Approve the ~~return of~~ position of the Atomic Energy Commission that the Rongelapese ~~be permitted to return~~ could be returned to their island as soon as rehabilitation procedures have been completed on the Island ~~according to~~ as described in Appendix "B".

b. Note that ~~an appropriate public announcement will be made by the Commission.~~ Appendix "A" is a draft announcement which will be proposed to the Department of Interior for issuance when the Department determines that the natives can return.

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c. Note that the Joint Committee on Atomic Energy, the GAC, and the MLC will be advised of this action by letter such as Appendix "C".

LIST OF ENCLOSURES

APPENDIX "A"

BACKGROUND AND DISCUSSION

BACKGROUND

1. On March 1, 1954, a relatively heavy fallout occurred on some of the Marshall Islands as a result of a nuclear weapons test at the Eniwetok Proving Ground. Between the 36th and 50th hour after detonation 82 inhabitants were evacuated to Rongelap where they were under the surveillance of a team of medical experts from the United States. On June 9, 1954, they were moved to the Island of Kwajalein (majuro Atoll) where they are now living.

2. There have been public statements, concurred in by the Atomic Energy Commission, Department of Interior and the Department of State to the effect that these people will be returned to their home Island of Rongelap as soon as it is possible from health considerations. Such a statement was submitted to the 17th Session of the U. N. Trustee Council, Subcommittee of Petitions, March 27, 1956 by Mr. D. Vernon McKay, Special Representative of the Administering Authorities for the Trust Territory of the Pacific Islands.

3. Several radiological surveys have been made of the Marshall Islands, especially Rongelap Atoll, since March 1, 1954. The results of these surveys are contained in the several reports by the cognizant laboratories and are being summarized in one report by the Division of Biology and Medicine (in preparation).

4. The Rongelapese have received complete medical investigations at six months, one year and two year post-detonation, by a team headed by Dr. Robert Conard of Brookhaven National Laboratory, as well as several routine examinations.

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DISCUSSION

A. Status of Rongelapese Health

5. Pertinent to any discussion of the return of the Rongelapese to their home island is the body insult suffered from the fallout on March 1, 1954. One group of 64 people received about 175 roentgens whole body gamma radiation, and a second group of 18 received 69 roentgens. The most highly exposed group might have received an additional 100 - 150 reps to the thyroid from internally deposited isotopes of iodine. The deposition of bone seeking isotopes was very small and at two years the body burden of strontium-90, as estimated by urinalysis was little greater than for controls in the United States. Of the 82 individuals exposed, 45 experienced superficial skin lesions and 13 deep lesions while 35 showed some degree of epilation.

6. The present condition of the Rongelap people is best described by the results of the two year medical examination:*

> "The medical survey of the Rongelap people two years after exposure to fallout radiation shows that the people appear to have been in generally good state of health and nutrition and are making satisfactory recovery from their radiation exposure. Serious illness has occurred in two individuals but neither these illnesses nor clinical findings in other individuals can be attributed to radiation effects. One death in May 1956, that of a 46-year-old Rongelap man, was due to hypertensive heart disease. Previous examinations had shown that the disease was undoubtedly present at the time of exposure to fallout radiation.
>
> "There is evidence of continued improvement of hemopoiesis. The mean lymphocyte count is slightly increased over the one-year levels, but is still slightly below the mean control count. The mean platelet level is about the same as founded one year after exposure and is still slightly below the control level. The delay in complete recovery of lymphocytes and platelets is similar to that reported in the two-year follow-up studies of the Japanese casualties of the atomic bombings (7,8). Evidence from the Marshallese experience indicates that the lowered levels of these blood elements have not lowered the resistance of the people to

* Medical Survey of Marshallese Two Years After Exposure to Fallout Radiation. Conard, R. A. et al. Brookhaven National Laboratory, March, 1956.

disease, and the present levels are not considered to represent a serious condition.

"Residual changes in the skin from the beta irradiation continue to show improvement. Pigment aberrations are still evident in 15 cases and in four of these/is also scarring with some adherence of the skin to the subcutaneous tissue. However, there is no gross evidence of tissue breakdown or malignant change in any of these lesions, and surgical repair is not considered necessary at this time. Histological examination of skin biopsies at sites of radiation lesions shows residual effects of radiation damage, but no evidence of premalignant or malignant changes.

"Ophthalmological survey reveals that there are no radiation-induced lens opacities, and the incidence of ocular lesions is similar in exposed and control populations.

"The radiochemical analysis of the urine of the Rongelap people shows measurable activity which is largely due to cerium-144-praseodymium-144 with only slight activity due to strontium-90. The body burden of these isotopes is estimated to be well below the permissible levels. Examination of bone specimens in the case of the one man who died shows no radiation that can be definitely associated with fallout deposition in the bones. Studies of radiographs of the femurs of the exposed children show no evidence of any bone defects from possible deposits of radionuclides."

B. External Gamma Dose Rates on Rongelap Atoll.

7. The external gamma dose rates at three feet above the ground on the Island of Rongelap are shown in Graph One. It might be expected that this curve will flatten out with time due to the dominance of the 33 year half-life cesium-137. The latest survey of Rongelap Island at the end of July 1956 showed a range of values from 0.2 - 0.5 milliroentgens per hour, with an average of 0.4 mr/hr. Graph One suggests an anticipated dose rate at the time of the survey to be about 0.1 mr/hr. The higher value found is undoubtedly due to the small additional fallout that occurred during Operation Redwing. Since this is relatively fresh

radioactive material, the decay will be more rapid so that the doserates on Rongelap Islands at the time of repatriation should be less than 30 milliroentgens/week.

The maximum permissible external gamma exposure to adult workers recommended by the National Committee on Radiation Protection is 0.3 roentgens/week with an added restriction that will probably be added, that the maximum yearly exposure shall be 5.0 roentgens. The permissible exposure to general populace would then be 0.5 roentgens per year. It is difficult to extrapolate precisely far into the future, but the data suggest that the gamma doses on Rongelap Island would not greatly exceed (if at all) the 0.5 roentgens for the first year of reoccupancy, with lesser doses in subsequent years.

8. The gamma dose rates on other islands of Rongelap Atoll have not been followed as closely as on Rongelap but the data suggest the relative dose rates now are the same as measured in the first part of March 1954, i.e. the highest activity on any island is about a factor of 10 higher than Rongelap.

9. The Rongelapese go on fishing expeditions to other islands including those showing both higher and lower activity. However, these Rongelapese spend an appreciable part of their time in boats over water where the external gamma activity is near background values. Thus, the yearly average for these probably would not differ greatly from those on Rongelap Island.

C. Food Supply

10. The basic data on the normal food supply of the Rongelapese are contained in Table One. There are wide variances in the data so that

estimated average values are used. This is not an unreasonable approach since it would be expected that the food actually consumed would be about as variable as the individual samples collected for analyses.

11. The isotope of principal concern in the food chain is strontium-90. For an adult worker the maintained maximum permissible body burden is 1000 Sunshine Units (1000 micromicrocuries of Sr^{90} per gram of calcium). Values for maximum permissible exposures to the general population are 1/10 that for adult workers, or 100 Sunshine Units, maintained level in the body. The National Academy of Sciences report stated "---There seems no reason to hesitate to allow a universal human strontium---burden of 1/10 of the permissible---" for adult workers. This corresponds to the 100 Sunshine Units.

12. Table One indicates that the average concentration of strontium-90 in the total food supply might be less than 360 Sunshine Units. (The data on land crabs shown in Table One are from the Island of Kabelle which is more heavily contaminated than the Island of Rongelap). However, if crabs were eliminated from the diet, the intake might be about 107 Sunshine Units. Further, elimination or restriction of the consumption of pandanus would reduce the strontium-90 intake to well under 100 Sunshine Units.

13. There is some doubt concerning the correct strontium-90 activity in the land crabs since they are higher than for previous surveys which is contrary to all other data. Additional surveys should clarify this point. In any event these land crabs are from the Island

of Kabelle (There were no collections of land crabs made on Rongelap Island during the last survey). The general contamination on Rongelap is about one-fifth that of Kabelle. The difference in strontium-90 content may not be as great as this, but since these are land crabs it would be expected those on Rongelap Island to be lower than on Kabelle Island.

D. Estimated Future Body Burden of Strontium-90.

14. Although precise values have not been established, there is a discriminatory factor between Sr/Ca ratio in the food supply (except possibly cow's milk which is not a part of the Rongelapese diet) and that found in the bones. Animal experiments and limited human data suggest values of at least a factor of two or three.

15. If the Rongelapese are returned to their home island, their diet would be supplemented by imported (relatively uncontaminated) foods, especially rice. Also, the cisterns would be cleaned out and refilled with fresh water.

16. Despite the wide variances in the data, analysis of the results from all of the surveys on the Pacific Islands show a general decline of Sr^{90} with time in the food chain (except the land crabs).

17. The above data and estimates clearly indicate that if land crabs are eliminated from their diet, the estimated future body burden of the Rongelapese would be substantially less than 100 μμc/ of Sr^{90} per gram of calcium. Limiting the intake of pandanus would further reduce the estimated Sr^{90} intake. By means of the continuing medical examinations described below it would be possible to note any tendency of untoward accumulation of strontium-90 with time, and appropriate

action could be taken before excessive levels were reached.

E. Medical Surveillance

18. If the Rongelapese were returned to their home island, a program would be inaugurated of continuing medical inspections. The Rongelapese would be examined once a month and a complete medical examination performed once a year by an American doctor. A radio would be provided on Rongelap for communication with the Trust Territories Office on Ebey (Kwajalein Atoll) where a plane would be available at all times for any emergency. A fully equipped dispensary would be provided on Rongelap and an experienced health aide (a Marshallese) would be present at all times. Before their return, the Marshallese would be given a complete medical examination, and immunized against Smallpox, Typhoid and Tetanus.

F. Animals Living on Rongelap

19. Of considerable interest are the results obtained from animals (swine, chickens, ducks, rats) living on the island of Rongelap at the time of the fallout on March 1, 1954. These were collected and sacrificed serially in time. The last group of animals was collected and sacrificed about two years after the initial fallout. Like all of the other previous examinations there were no gross nor pathological changes in the animals that could be definitely ascribed to radiation. The estimated external gamma dose was near 500 roentgens for the two years.

20. Of equal interest is the body burden of strontium-90 in these animals. The analyses have not been completed but Table Two

summarized the data to date. These animals have continued to live (with their normal eating habits) in the environment during the time when the fission product intake by way of direct contamination was optimum and the strontium-90 was highest in the soil-plant-animal cycle. Also, due to their relatively short life span, it would be expected that they had approached equilibrium values. These data support the conclusion above that the estimated future body burden of the Rongelapese (under the conditions stated) would be substantially less than 100 μμc of Sr^{90} per gram of calcium.

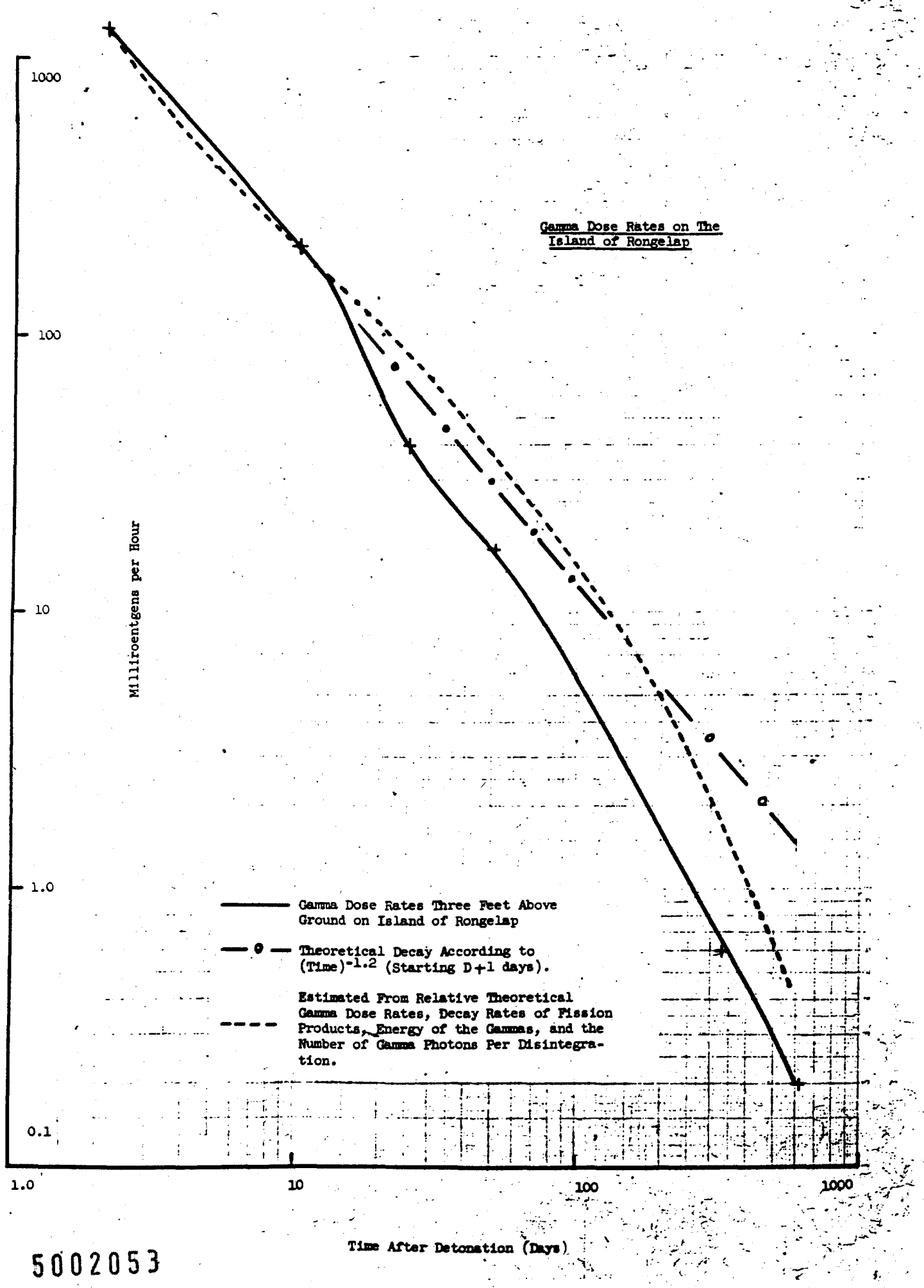
Gamma Dose Rates on The Island of Rongelap
1000
100
10
1.0
0.1
Milliroentgens per Hour
1.0
10
100
1000
Time After Detonation (Days)
Gamma Dose Rates Three Feet Above Ground on Island of Rongelap
Theoretical Decay According to (Time)$^{-1.2}$ (Starting D+1 days).
Estimated From Relative Theoretical Gamma Dose Rates, Decay Rates of Fission Products, Energy of the Gammas, and the Number of Gamma Photons Per Disintegration.

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TABLE ONE

ESTIMATES OF CONTAMINATION OF THE NORMAL FOOD SUPPLY OF RONGELAPESE

	A Daily Intake Pounds/day/ Person	B Calcium Content (gms Ca/gm wet weight)	C Daily Intake of Ca (gms)	D Fraction of Total Ca Intake	E Strontium-90 Content (S. U.) [a]	F Contribution To Total Sr^{90}. Intake (S. U.) (Column D x E)
Fish	1.22	0.001	0.56	0.645	12	7.73
Pandanus	0.36	0.001	0.16	0.184	500	92.0
Clams	0.1	0.004	0.018	0.021	5 [b]	0.11 [b]
Arrowroot	0.09	0.0006	0.025	0.029	250	7.26
Wild Birds (muscle)	0.09	0.0001 [d]	0.004	0.0046	300	1.38
Land Crabs [e]	0.03	0.004	0.055	0.063	(4000) [b, c]	(252.0) [b, c]
Coconut Meat Milk	0.02	0.0004	0.004	0.0046	40	0.02
Bread Fruit	0.01	0.0006	0.003	0.0034	260	0.88
Imported:						
Rice						
Flour						
Canned Beef						
Milk	0.1	~ 0.0001	~ 0.045	~ 0.046	few	small
Sardines						
Shoyu						
Coffee						
Tea						

a. Average values
b. These data are from island of Kabelle (no date from island of Rongelap for July 1956 survey). General contamination of island of Rongelap is about one-fifth that of Kabelle. lagoon waters around these islands do not show as great a difference in activity.
c. These are land crabs from island of Kabelle. The strontium-90 concentration is higher than from earlier surveys, which is contrary to the plant activity as well as to the soil, and marine life data.
d. Estimated.
e. An unknown part of this intake may be sea crabs, (which contain considerably less Sr^{90}) but is assumed here to be all land crabs.

TABLE TWO

ANALYSIS OF A ROOSTER COLLECTED ON ISLAND OF RONGERLAP FEBRUARY 1956

Rats	Wet Wt.	d/m Sr^{90}/sample	Ca/sample (gm)	S. U.
1510 Femur	26.0*	1210 ± 39	5.19	105 ± 3
1510 Tibia	41.0	5702 ± 119	9.50	272 ± 5

* Dry weight of 2 femur halves.

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APPENDIX "B"

REHABILITATION PLANS

1. The Division of Military Application has had plans prepared for the reconstruction and rehabilitation of homes and facilities on Rongelap. These plans have been incorporated into a comprehensive program for the return of the Rongelap people to their home atoll which will be implemented if the decision is made to return them at this time. The High Commissioner of the Trust Territories of the Pacific Islands, the Commander in Chief, U. S. Pacific Fleet (to whom the Chief of Naval Operations and the Commander in Chief Pacific delegated responsibility for this matter), the Commander JTF SEVEN, and the Division of Military Application have approved this program. The cost of the program is estimated at approximately $575,000. Of this amount the Department of Defense is contributing about $295,000 in the form of rental of an LST to support the operation for the duration of the project and for subsistence support of the Rongelap people for one year after their return to Rongelap. The remaining $280,000 for reconstruction of the village at Rongelap, rehabilitation of facilities there, and emergency radio equipment, will be provided by AEC.

2. In 1954 CINCPAC requested that he be assigned primary responsibility for the rehabilitation of the Rongelap people with AEC assistance. Although it was never made clear what the extent of this assistance was to be, the viewpoint within AEC was that we might furnish a portion of the necessary funds, radsafe and health support, and reconstruction assistance. However, it was originally thought that the construction

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effort involved would be minor, and JTF SEVEN included $24,400 for this purpose in their FY 55 and FY 56 budgets. Because of this budgeting by JTF SEVEN, AEC has never included funds for this work in its budget. However, with the passage of time the buildings on Rongelap have deteriorated to the point where they can no longer be repaired and the entire village must be reconstructed. The cost of this reconstruction and other rehabilitation measures is $200,000. In an effort to resolve this problem and in consonance with CINCPAC'S statement, we requested CNO (The Executive Agent of the Joint Chiefs of Staff) to provide funds for the construction on Rongelap. The CNO reply (copy of which is attached) states that at no time has the cost of repatriation of the Rongelapese been considered a Navy responsibility. In view of this situation AEC will accept the responsibility for funding for the reconstruction and other rehabilitation measures on Rongelap and DMA will make the $200,000 available out of the ALOO operating budget.

CNO Letter to Come.

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APPENDIX "E"

DRAFT LETTER TO JCAE, NLC AND GAC

1. After the relatively heavy fallout on the Marshall Island March 1, 1954, 82 inhabitants were evacuated first to Kwajalein and to Ejit where they are now living. There have been public statements, concurred in by the Atomic Energy Commission, Department of Interior and the Department of State to the effect that these people will be returned to their home Island of Rongelap as soon as it is possible from health considerations. Such a statement was submitted to the 17th Session of the U. N. Trustee Council, Subcommittee of Petitions, March 27, 1956 by Mr. D. Vernon McKay, Special Representative of the Administering Authorities for the Trust Territory of the Pacific Islands.

2. Several radiological surveys of the Marshall Islands especially Rongelap Atoll, have been made during the past two and one-half years. The latest survey (July 23-24, 1956) indicates a presence of a residual contamination on the Island of Rongelap, but at a level that is acceptable from a health point of view, both for the potential external gamma radiation exposure and the strontium-90 content in the food supply, with the possible exception of land crabs.

3. Therefore, the position of the Atomic Energy Commission is that the could be permitted to return to permit the return of the Rongelapese to their home Island as soon as rehabilitation procedures on the Island of Rongelap are completed, with the advise that land crabs not be eaten at this time.

APPENDIX "D" TO COME

Dr. L. R. Donaldson, Director
Applied Fisheries Laboratory
Uni ·sity of Washington
Seat·le 5, Washington
December 11, 1956

Comments on Sr^{90} in Land Crabs re.: Dr. Seymour's letter of December 4, 1956:

The Sr^{90} levels in land crabs can be expected to remain constant (excepting physical decay) over a period of years. This statement is based on the data resulting from repeated collections at Belle Island, Eniwetok, during a period of two years following Nectar test.

The radioactivity in the carapace (exoskeleton) due to long lived isotopes remained approximately constant at a level of approximately 10,000 d/m/g wet throughout a period of 23 months during which collections were made.

Radiochemical analysis of 15 samples taken at various times during the collecting period, and three samples taken 35 days before Nectar test demonstrated that virtually 100% of the long lived isotopes was Sr^{90} and its Y^{90} daughter.

The land crabs being omnivorous can probably be considered an index of biologically available strontium. However, the ratio of the strontium to that in food items is not known. Judging from the meager data presently available the radio-strontium content of the crab skeleton is more than ten times that in land plants on a wet weight basis and is more than three times that in soil on a dry weight basis.

The data from the Belle Island collections indicates that turnover of strontium in the land crab skeleton is rapid. The

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comparatively high levels of Sr^{90} in the carapace probably represent a condition of equilibrium with the available strontium rather than an accumulation over a long period of time.

In muscle of land crabs collected at Belle Island in February and November 1955, and analyzed in January and March of 1956, Cs^{137}, $Sr^{90}+Y^{90}$, and $Ce^{144}+Pr^{144}$ accounted for 84%, 10%, and 1%, respectively, of the total activity. In contrast to the exoskeleton, muscle had a variable, though generally decreasing level of long lived isotopes throughout the post Nectar collecting period at Belle Island. Whether or not Sr^{90} levels in the muscle were decreasing during this period is not known. Although there was a decrease from 90 d/m/g wet in a single specimen collected in February 1955 to 60 d/m/g wet in a specimen collected in November 1955, experience has shown that individual variation may account for such differences. Values of determinations of Sr^{90} in muscle of land crabs from Kabelle Island, Rongelap Atoll, indicate that the Sr^{90} level is remaining constant. But here again individual variation is great; the value for duplicate determinations of muscle from a single coconut crab collected in January 1955 was 59 ± 1.5 d/m/g wet and the average of three samples of hermit crab muscle taken in July 1956 was 59 ± 37 d/m/g wet.

It should be clearly understood that the above discussion applies only to the land crabs and not to marine crabs. Marine crabs have lower levels of total activity than do the land crabs and contain little, if any, Sr^{90} (see for example NRDL-455 Table A.3).

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File = Rongelap

NRDL MARSHALL ISLAND RESURVEY - 1956

RESULTS OF ANALYSES PERFORMED AT HASL

Laboratory Report 56-7

by

E. P. Hardy

W. R. Collins

NMB-3

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NRDL MARSHALL ISLAND RESURVEY - 1956

RESULTS OF ANALYSES PERFORMED AT HASL

During February of 1956 a survey team from the U. S. Naval Radiological Defense Laboratory collected samples of marine life, land plants, water and soil, and lagoon and ocean water on or near selected islands in the Marshall group. Some of the collected samples were sent to HASL for fission product analysis. In some cases portions of specimens were retained at NRDL for inter-laboratory cross-checking purposes. A complete listing of samples received including those selected for analysis is given in Table 1.

The marine, water, and urine samples were received in good condition but many of the vegetation specimens were in a severe state of decay upon arrival at HASL. Furthermore, some samples were received unsealed so that the contents had leaked out and were on the outside of their own and other containers. It was felt that this could be a source of cross contamination in addition to the loss of the leaking samples.(1) For this reason and because of limited time and manpower, only selected samples were subjected to analysis. However, all of the marine and vegetation samples received (with the exception of coconut shell) were wet-ashed using nitric acid, diluted to known volumes, and stored

in polyethylene containers. Concentrations are based on the weight of the material at the time it was received at HASL. Consequently, all radiochemical and analytical results are reported here in terms of d/m or grams, per gram of material as received at HASL. Dr. H. Weiss has stated via letter(2) that the wet weights of the plant specimens were not recorded at the time of collection. He has proposed that the results be expressed in terms of d/m/kg of material as received at NRDL.

For determination of total beta activity an aliquot of the solution of wet-ashed material was transferred to a glass planchet, evaporated and dried under an infra-red lamp. Counts were converted to disintegrations by applying a geometry factor based on K^{40} as a standard. A self-absorption correction was also applied in each case.* Under the wet ashing and plating conditions used at HASL possible loss of volatile fission products such as Ru^{106} - Rh^{106} is avoided.(3) For practical reasons, the coconut outer and inner shells were dry ashed at 500°C prior to dissolution.

* For the particular specimen type under consideration, several values of activity vs. dry weight of the plated aliquot were plotted and a smooth curve fitted for the points. Another curve (based on extrapolation to zero mass) of activity ratio (A/A_o) was drawn and used for determining the self-absorption correction. See Figures 2 through 8.

The procedure outlined in NYO-4617 was followed for the radiochemical analysis of Sr^{90}. The Cs^{137} analyses were performed by S. Tarras using a method which to date has not been documented. It involves the coprecipitation of cesium with ammonium alum to eliminate mixed fission products as well as potassium, then a final precipitation as the chloroplatinate. Radiochemical and gravimetric yields of 95% are attainable. The samples were analyzed for calcium by C. Baxter employing the oxalate-permanganate titration method(4).

As a check on radiochemical purity, beta absorption analyses were carried out by N. Hallden(5) on the Cs^{137} fractions of two pooled urine samples (specimens collected at Utirik and Likiep), one water sample (HASL #3457), and one soil (HASL #3462). In each case Cs^{137} was positively identified and there was no evidence of other interfering isotopes. The radioactive decay of the Y^{90} fractions of the urine samples was followed over a period of one hundred hours. Within statistical limits concurrence with the theoretical half-life was observed.

Analytical results are shown in Tables 2 through 6. The error term accompanying each absolute result represents one standard deviation due to the error in counting. The only available interlaboratory cross-check data are given in Table 7. These

results were obtained from Dr. S. Cohn by phone on April 24, 1956. A follow-up letter from Dr. Cohn[6] expressed his idea that the discrepancy in the beta count probably lies in the conversion from c/m to d/m. NRDL used Sr^{90} - Y^{90} as a standard in this case and for purposes of comparison, the HASL results were also standardized against Sr^{90} - Y^{90}. It is felt that the use of K^{40} as a standard allows the best approximation of the energy for mixed fission products among the available long-lived isotopes[7].

As an aid in evaluating these data, Figure 1 and Table 8 are included.

REFERENCES

1. Memorandum from Dr. J. H. Harley to Mr. M. Eisenbud, "Rongelap Resurvey Samples from NRDL", April 17, 1956.

2. Letter of May 9, 1956 from Dr. H. Weiss to Edward Hardy.

3. Memorandum from G. Hamada to Dr. J. H. Harley, "The Effect of the Wet Ashing Technique Used at HASL on Ruthenium Volatilization", March 29, 1956.

4. Private communication, Mr. I. B. Whitney.

5. "Analyzing Beta Absorption Graphically to Identify Emitters", J. H. Harley and N. Hallden, Nucleonics, 13, 1, January 55, pp 32-35.

6. Letter of May 2, 1956 from Dr. S. Cohn to Mr. I. B. Whitney.

7. HASL Laboratory Report 56-1, "Standardization and Operation of Fallout Counters", N. A. Hallden and J. H. Harley.

TABLE 1

NRDL MARSHALL ISLAND RESURVEY - 1956

Samples Received at HASL

(samples analyzed at HASL shown in parenthesis)

MARINE ORGANISMS - 65 (23), received 3/6/56

	Rongelap	Gejen	Eniaetok	Eniwetak	Sifo	Utirik	Likiep	Kabelle
Fish - 37 (13)								
Unicorn	1			1				
Mullet	1							
Surgeon	1 (1)	1 (1)		1 (1)		2 (2)		
Damsel	1 (1)			1 (1)		2 (2)	1 (1)	1 (1)
Sea Cucumber	1							
Bl. Tip Shark								1
Trigger								1
Siganus					1		1	1
Butterfly					1 (1)		1 (1)	1 (1)
Snapper		1		1	1			
Squirrel		1			1	1		
Parrot			1		1	1		
Angel			1		1			
Goat			1					
Sergeus					1			
Sea Bass							1	
Crab - 11	3	1	1		3	3		
Clam - 2	2							
Snail 9 (4)	2	4 (4)*				2		1
Coral 6 (6)	1 (1)	1 (1)	1 (1)			2 (2)	1 (1)	
LAND PLANTS - 77 (14), received 4/3/56								
Coconuts - 26 (5)	3 (3)	3	4	4	4	4 (1)*	4 (1)*	
Portulaca 6	1	1	1	1		1	1	
Pandanus - 18 (2)	3 (2)*	2	3	2	2	3	3	
Papaya - 9	3					3	3	
Arrowroot 14 (7)	2 (1)*	2 (1)*	2 (1)*	2 (1)*	2 (1)*	2 (1)*	2 (1)*	
Banana - 2							2	
Taro - 2							2	
SOIL - 21 (13), received 4/3/56	3	3 (2)*	3 (3)*	3 (2)*	3 (2)*	3 (2)*	3 (2)*	
LAND WATER - 7 (6), received 4/3/56								
Well - 4 (4)						2 (2)	2 (2)	
Cistern - 2 (1)	1 (1)					1 (1)*		
Lens - 1 (1)			1 (1)					
SEA WATER - 14 (14), received 4/3/56								
Ocean - 7 (7)	1 (1)*	1 (1)*	1 (1)*	1 (1)*	1 (1)*	1 (1)*	1 (1)*	
Lagoon - 7 (7)	1 (1)*	1 (1)*	1 (1)*	1 (1)*	1 (1)*	1 (1)*	1 (1)*	
URINE - 24 (24), received 3/29/56	5 (5) (Majuro)					10 (10)	9 (9)	

* Interlaboratory cross-check samples.

TABLE 2

NRDL - MARSHALL ISLAND - RESURVEY - 1956

Results of Analyses Performed at HASL

MARINE ORGANISMS

HASL #	NRDL #	Sampling Location	Organism	Tissue	C-Date Total Activity	Total Activity d/m/gram*	Sr^{90} d/m/gram*	Cs^{137} d/m/gram*	Ca grams/gram*	S. U.	% Sr^{90}
3336	1519	Rongelap	Surgeon	Entire	4- 9-56	52± 6.4	≤0.10				
3337	1512	Rongelap	Damsel	Entire	4- 9-56	37± 6.0					
3350	1541	Kabelle	Butterfly	Entire	4- 9-56	lost	lost				
3351	1542	Kabelle	Damsel	Entire	4- 9-56	125± 8.0	2.8 ±0.55		0.031	41 ± 8.1	2.3
3354	1622	Gegen	Surgeon	Entire	4- 9-56	235± 8.9					
3369	1555	Sifo	Butterfly	Entire	4- 9-56	95± 5.7	≤0.81		0.024	≤15	
3374	1564	Eniwetak	Damsel	Entire	4- 9-56	20± 6.2	≤0.15		0.033	≤ 2.1	
3376	1559	Eniwetak	Surgeon	Entire	4- 9-56	34± 6.9			0.033		
3379	1606	Likiep	Butterfly	Entire	4- 9-56	51± 6.2			0.023		
3380	1615	Likiep	Damsel	Entire	4- 9-56	11± 6.5	0.37±0.23		0.037	4.5± 2.8	3.4
3383	1593	Utirik	Surgeon	Entire	4- 9-56	22± 5.4			0.015		
3384	1574	Utirik	Damsel	Entire	4- 9-56	14±11			0.039		
3385	1577	Utirik	Damsel	Entire	4- 9-56	22± 6.7			0.038		
3387	1572	Utirik	Surgeon	Entire	4- 9-56	18± 6.0			0.022		
3346	1522	Rongelap	Coral		4-10-56	35±17					
3357	1635	Gejen	Coral		4-10-56	310±22	≤0.62		0.31	≤0.91	
3363	1534	Eniaetok	Coral		4-10-56	205±20	3.1 ±0.42		0.35	4.1± 0.55	1.5
3381	1617	Likiep	Coral		4-10-56	≤15	≤0.45		0.30	≤0.68	
3393	1601	Utirik	Coral		4-10-56	≤18	≤0.27		0.26	≤0.47	
3394	1589	Utirik	Coral		4-10-56	21±15	0.48±0.14		0.24	0.91±0.27	2.3
3326	1636	Gejen	Spider Snail	Entire	4-23-56	520±10	4.4 ±0.39	13 ±0.48	0.018	110 ± 9.8	0.85
3327	1637	Gejen	Spider Snail	Entire	4-23-56	2180±29	1.3 ±0.34	4.0±0.48	0.0072	82 ±21	0.061
3328	1638	Gejen	Scorpion Snail	Entire	4-23-56	23310±290	1.1 ±0.44	3.4±1.5	0.0085	57 ±24	0.0046
3329	1639	Gejen	Scorpion Snail	Entire	4-23-56	9800±120	1.5 ±0.58	7.1±1.1	0.0125	55 ±21	0.015

* Weight as received at HASL

TABLE 3

NRDL - MARSHALL ISLAND RESURVEY - 1956

Results of Analyses Performed at HASL

LAND PLANTS

HASL #	NRDL #	Sampling Location	Organism	Tissue	Total Activity C-Date	Total Activity d/m/gram*	Sr^{90} d/m/gram*	Cs^{137} d/m/gram*	Ca grams/gram*	S. U.	% Sr^{90}	% Cs^{137}
3437	521	Rongelap	Coconut	Outer & Inner Shell	4-17-56	26±0.7	0.22 ±0.01		0.00022	450± 21	0.85	
				Milk	4-17-56	43±1.7	0.11 ±0.10	19 ±2.7	0.00020	260±230	0.26	44
3438	523	Rongelap	Coconut	Outer Husk	4-17-56	71±1.7			0.00038			
				Inner Shell	4-17-56	26±0.7	0.14 ±0.06		0.00013	480±210	0.52	
				Meat and Milk	4-17-56	98±2.2	0.047±0.039		0.00001	2140±1800	0.048	
3439	525	Rongelap	Coconut	Outer Husk	4-17-56	66±1.7	0.70 ±0.04		0.00085	375± 21	1.1	
				Inner Shell	4-17-56	35±0.7	0.081±0.071		0.00015	245±215	0.23	
				Meat and Milk	4-17-56	87±2.1	0.080±0.043		0.00020	186± 98	0.094	
3513	752	Utirik	Coconut	Entire	4-17-56	51±2.0	2.7 ±0.1		0.0096	104± 4.7	5.3	
3534	803	Likiep	Coconut	Entire	4-17-56	10±0.7	0.046±0.02		0.00031	67± 29	0.45	
3441	535	Rongelap	Pandanus	Entire	4-14-56	42±1.9	0.26 ±0.11	16 ±3.7	0.00010	1180±500	0.62	38
3442	536	Rongelap	Pandanus	Entire	4-14-56	30±1.5	≤0.16		0.00010	≤730		
3447	558	Rongelap	Arrowroot	Entire	4-14-56	lost	lost					
3456	856	Gegen	Arrowroot	Entire	4-14-56	300±4.1	3.6 ±0.15	250 ±5.4	0.0012	1370± 57	1.2	83
3476	580	Eniaetok	Arrowroot	Entire	4-14-56	180±3.8	1.4 ±0.82	54 ±1.6	0.00060	1050±620	0.77	30
3492	726	Eniwetak	Arrowroot	Entire	4-14-56	67±2.1	0.20 ±0.06	17 ±0.6	0.00060	155± 45	0.30	25
3505	674	Sifo	Arrowroot	Entire	4-14-56	59±2.2	0.19 ±0.03	36 ±1.0	0.0026	32± 5.2	0.31	61
3519	756	Utirik	Arrowroot	Entire	4-14-56	26±1.6	0.22 ±0.06	17 ±2.8	0.00003	3300±910	0.84	65
3541	807	Likiep	Arrowroot	Entire	4-14-56	7.3±1.1	≤0.13	3.8±2.1	0.00070	≤85		52

* Weight as received at HASL

TABLE 4

NRDL - MARSHALL ISLAND RESURVEY - 1956

Results of Analyses Performed at HASL

HASL #	SOIL NRDL #	Sampling Location	Depth	C-Date Total Activity	Total Activity d/m/gram*	Sr^{90} d/m/gram*	Cs^{137} d/m/gram*	Ca grams/gram*	S. U.	% Sr^{90}	% Cs^{137}
3482	605	Eniaetok		4-21-56	65± 45	≤0.42		0.318	≤0.60		
3483	608	Eniaetok		4-21-56	≤41	1.6±0.42		0.286	2.6±0.67		
3431	600	Eniaetok		4-14-56	290± 40	20 ±0.8		0.314	29 ±1.2	6.9	
3549	819	Likiep		4-21-56	≤53	≤0.47		0.335	≤0.64		
3548	814	Likiep		4-21-56	≤65	1.2±0.71		0.275	2.0±1.2		
3494	734	Eniwetak		4-21-56	≤61	≤0.58		0.369	≤0.71		
3493	728	Eniwetak		4-14-56	3000± 93	80 ±1.4		0.347	104 ±1.8	2.7	
3463	847	Gegen		4-21-56	120± 69	1.0±0.48		0.348	1.3±0.63	0.84	
3462	842	Gegen		4-14-56	69400±470	1640 ±2.4	1535±60	0.305	2440 ±3.6	2.4	2.2
3530	768	Utirik		4-21-56	≤73	3.4±0.72		0.342	4.6±0.96		
3529	762	Utirik		4-14-56	1600± 92	49 ±1.3		0.281	79 ±0.21	3.1	
3507	682	Sifo		4-21-56	≤57	≤0.55		0.355	≤70		
3506	676	Sifo		4-14-56	620± 79	28 ±1.0		0.353	36 ±1.3	4.5	

* Weight as received at HASL.

TABLE 5

NRDL - MARSHALL ISLAND RESURVEY - 1956

Results of Analyses Performed at HASL

HASL #	WATER NRDL #	Sampling Location	Type	C-Date Total Activity	d/m/l Total Activity *	d/m/l Total Activity **	Sr^{90} d/m/l	Cs^{137} d/m/l	% Sr^{90}	% Cs^{137}
3457	543	Rongelap	Well or Cistern	5-8-56	2500±32	1530±32	590±21	310±20	24	12
3480	599	Eniaetok	Lens	5-8-56		560±23		130±12		
3526	785	Utirik	Well	5-8-56	37±15	≤20		44± 5.2		
3527	787	Utirik	Well	5-8-56	34±15	≤19		35±16		
3528	788	Utirik	Cistern	5-8-56		43±20		49±18		
3520	757	Utirik	Well	5-8-56		28±20		27± 4.6		
3547	830	Likiep	Well	5-8-56	18±16	≤20		34±13		
3458	1003	Rongelap	Lagoon	5-11-56		≤26		35± 5.4		
3459	1036	Gejen	Lagoon	5-11-56		≤21				
3478	1007	Eniaetok	Lagoon	5-11-56		≤20		22±16		
3497	1028	Eniwetak	Lagoon	5-11-56		≤19		32± 5.4		
3509	1023	Sifo	Lagoon	5-11-56		≤20		24±10		
3525	1030	Utirik	Lagoon	5-11-56		≤19				
3546	1032	Likiep	Lagoon	5-11-56		≤20		31±10		
3460	1002	Rongelap	Ocean	5-11-56		49±18		34± 2.2		
3461	1034	Gejen	Ocean	5-11-56		≤18				
3479	1008	Eniaetok	Ocean	5-11-56		≤23		39± 2.2		
3496	1027	Eniwetak	Ocean	5-11-56		25±19				
3510	1024	Sifo	Ocean	5-11-56		≤19				
3524	1029	Utirik	Ocean	5-11-56		≤21		41± 2.2		
3545	1031	Likiep	Ocean	5-11-56		45±19		43± 3.0		

* Sample directly plated

** Sample scavenged with $Fe(OH)_3$

TABLE 6

NRDL MARSHALL ISLAND RESURVEY - 1956

Results of Analyses Performed at HASL

HUMAN URINE

HASL #	NRDL #	Sampling Location	Collection Date	Name	Age	Total Volume Received (ml)	C-Date Total Activity	Total Activity d/m/l *	Total Activity d/m/l **	Sr^{90} d/m/l	Cs^{137} d/m/l
3399	6	Utirik	2-11-56	Tonika	4	190	3-25-56	4800±240			
3400	1	Utirik	2-11-56	Milton	2	250	3-25-56	3600±280			
3401	4	Utirik	2-11-56	Isao	12	570	3-25-56	3360±320			
3402	9	Utirik	2-11-56	Kramer	27	440	3-25-56	3320±300			
3403	10	Utirik	2-11-56	Elas	22	135	3-25-56	7600±240		3.4±0.3	720±15
3404	7	Utirik	2-11-56	Deodor	5	180	3-25-56	4400±280			
3405	2	Utirik	2-11-56	Allick	16	285	3-25-56	8200±360	170±100		
3406	3	Utirik	2-11-56	Kai	6	310	3-25-56	2200±320			
3407	8	Utirik	2-11-56	Jamul	16	340	3-25-56	3480±240			
3408	11	Utirik	2-11-56	POOLED		620	3-25-56	7600±320	≤100	6.8±1.4	2540±63
3409	4	Likiep	2-11-56	Likimento		260	3-25-56	4400±320			
3410	1	Likiep	2-11-56	Matilna	3	360	3-25-56	4400±320			
3411	8	Likiep	2-11-56	Alma	8	160	3-25-56	4800±320			
3412	9	Likiep	2-11-56	Nels	1	225	3-25-56	4000±240			
3413	5	Likiep	2-11-56	Neork	26	235	3-25-56	4800±320		5.3±0.3	1487±23
3414	3	Likiep	2-11-56	Joden	13	410	3-25-56	9800±360	600±100		
3415	2	Likiep	2-11-56	Klara	35	600	3-25-56	2920±280	≤100		
3416	7	Likiep	2-11-56	Wine	45	190	3-25-56	8800±320			
3417	10	Likiep	2-11-56	POOLED		990	3-25-56	9200±360	≤100	4.7±0.7	2862±45
3418	9	Majuro***	2-29-56	Billiet	24	980	3-25-56	2600±240			
3419	40	Majuro	2-29-56	John	31	990	3-25-56	2400±240			
3420	36	Majuro	2-29-56	Jekras	8	1000	3-25-56	1160±200		2.4±0.2	33±8
3421	26	Majuro	2-29-56	Iroji	13	930	3-25-56	2200±240			
3422	76	Majuro	2-29-56	Morrio	11	990	3-25-56	1360±280			
		CONTROL	3-26-56	(pooled sample collected at HASL)		1000		4250±250	≤100	1.6±0.4	29±8
		Control	June 1956	(pooled sample collected at HASL)		5000				1.4±0.2	
		Control	June 1956	(pooled sample collected at HASL)		5000				1.9±0.2	
		Control	June 1956	(pooled sample collected at HASL)		5000				1.0±0.2	
		Control	June 1956	(pooled sample collected at HASL)		2000					30±8

* Direct plating
** Carbonate precipitation
*** Rongelap natives

TABLE 7

NRDL MARSHALL ISLAND RESURVEY - 1956

INTERLABORATORY COMPARISON

(Snail Solutions Prepared at NRDL from Specimens Collected on Gejen Island)

HASL #	NRDL #	Type	Total β Activity (d/m/gram-wet) HASL*	Total β Activity (d/m/gram-wet) HASL†	Total β Activity (d/m/gram-wet) NRDL°	Total γ Activity (d/m/gram-wet) NRDL	Sr^{90} (d/m/gram-wet) HASL	Sr^{90} (d/m/gram-wet) NRDL
3326	1636	Spider	520± 10	570± 11	877	378	4.4±0.39	
3327	1637	Spider	2180± 29	2400± 32	2965	1605	1.3±0.34	
3328	1638	Scorpion	23310±290	25600±300	29700	9150	1.1±0.44	
3329	1639	Scorpion	9800±120	10800±125	11250	4640	1.5±0.58	

* Standardized against K^{40}

† Standardized against Sr^{90}- Y^{90}

o Standardized against Sr^{90}- Y^{90}

NOTE: Wet weights furnished by NRDL
NRDL results forwarded by phone to I. B. Whitney from S. Cohn on April 24, 1956.

TABLE 8

NRDL MARSHALL ISLAND RESURVEY - 1956

TOTAL β ACTIVITY - d/m/gram*

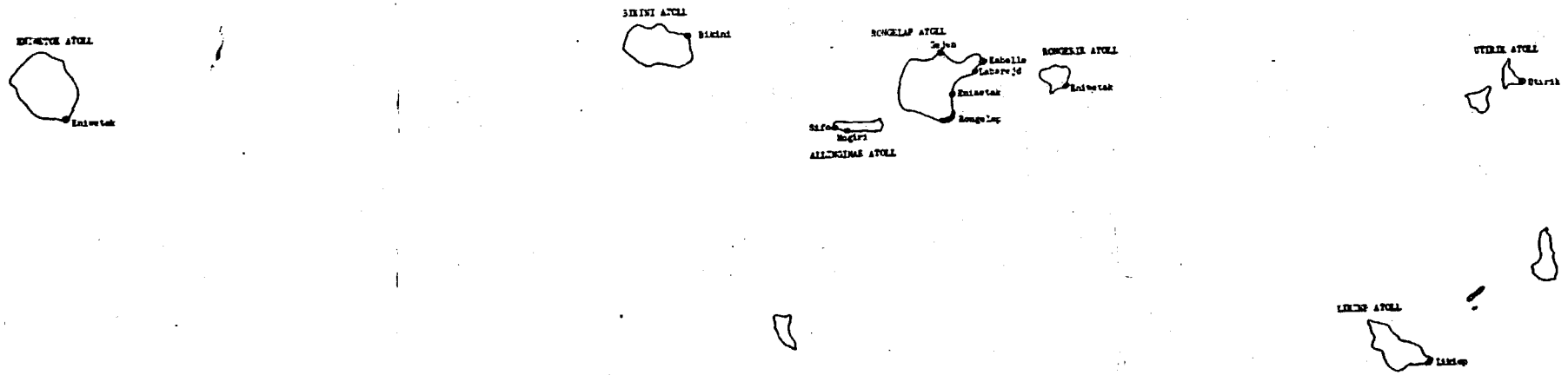
	Rongelap	Eniaetok	Kabelle	Gejen	Eniwetak	Sifo	Utirik	Likiep
FISH								
Surgeon	52				34		22; 18	
Damsel	37		120	230	20		14; 22	11
Butterfly						95		51
CORAL	35	200		310			≤18; 21	≤15
SNAILS								
Spider				520; 2200				
Scorpion				23,000; 9800				
LAND PLANTS								
Coconuts								
Outer Husk	71;66 } 26						} 51	} 10
Inner Shell	26;35 }							
Meat and Milk	98;87							
Milk	43							
Pandanus	42; 30							
Arrowroot	lost	180		300	67	59	26	7.3
SOIL		290; 65; ≤41		69,000; 120	3000; ≤61	620; ≤57	1600; ≤73	≤53; ≤65
LAND WATER**								
Well							≤20; ≤19; 28	≤20
Cistern	1500						43	
Lens		560						
SEA WATER**								
Ocean	49	≤23		≤18	25	≤19	≤21	45
Lagoon	≤26	≤20		≤21	≤19	≤20	≤19	≤20

* Weight of material as received at HASL

** Samples scavenged with $Fe(OH)_3$

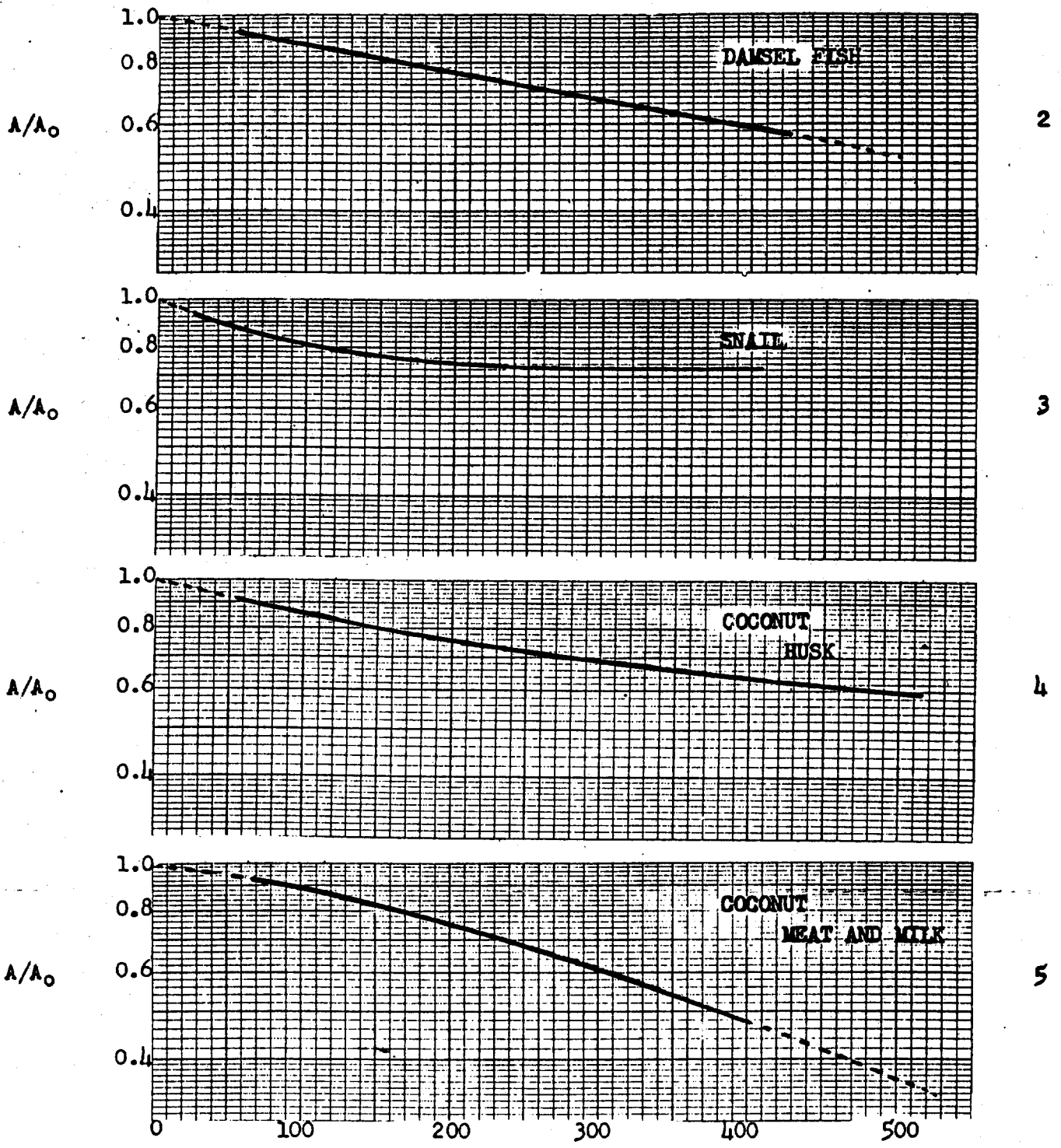
FIGURE 1

LAYOUT SKETCH OF PORTION OF MARSHALL ISLAND AREA



SELF-ABSORPTION CURVES

FIGURE

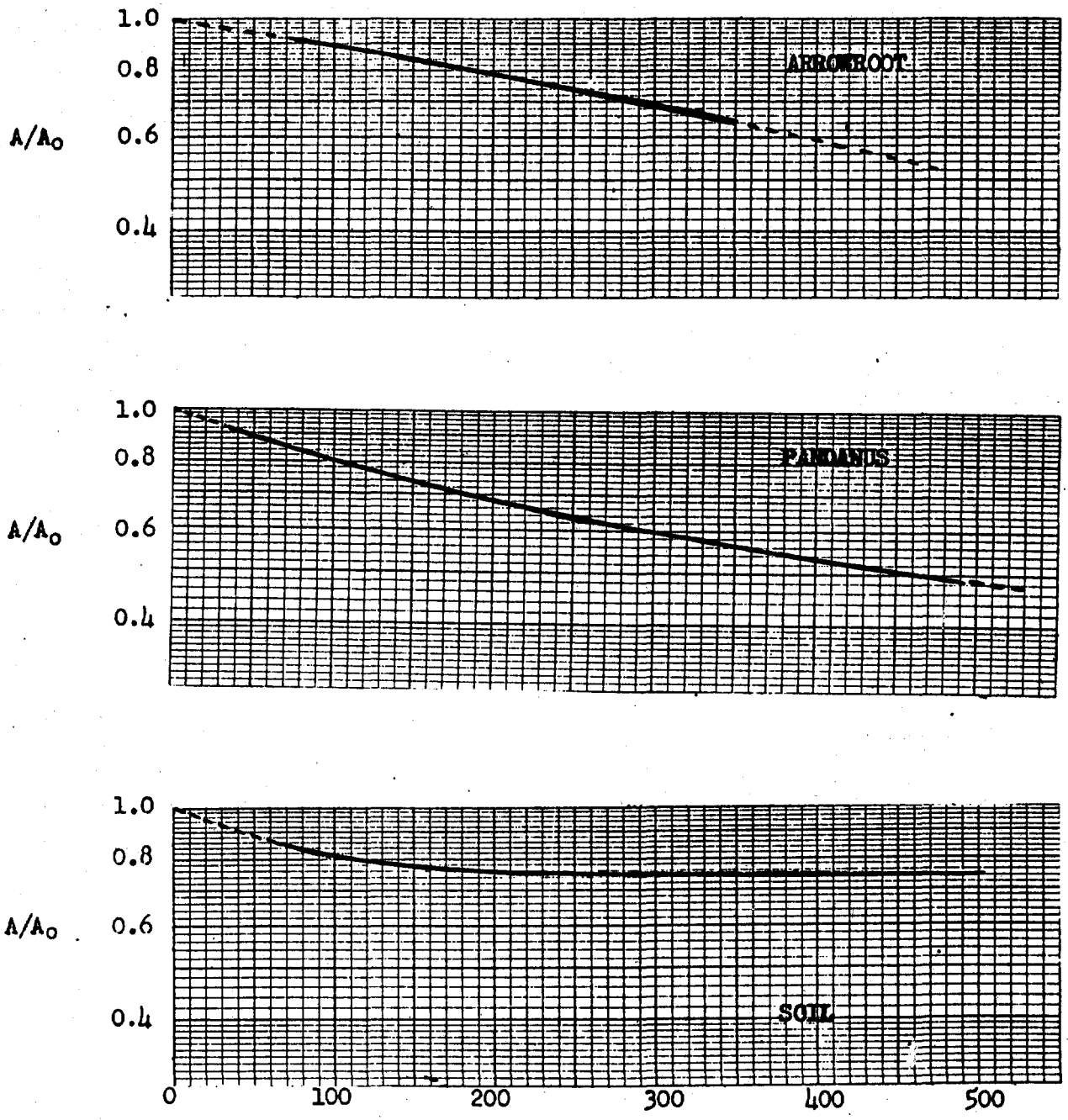


Residue Weights in Milligrams

NRDL MARSHALL ISLAND RESURVEY - 1956

SELF-ABSORPTION CURVES

FIGURE



Residue Weights in Milligrams

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REVIEW OF DATA
RADIOACTIVE CONTAMINATION OF PACIFIC AREAS
FROM NUCLEAR TESTS

Gordon M. Dunning
Division of Biology and Medicine
United States Atomic Energy Commission
Washington, D. C.

November 1956

OFFICIAL USE ONLY

NMB 3

I. EXTERNAL GAMMA RADIATION

II. GROSS ACTIVITY

A. Land Plants

B. Marine Organisms and Birds

C. Soils

D. Water

III. RADIOCHEMICAL ANALYSIS

IV. INTERNAL CONTAMINATION OF ANIMALS

V. RESIDUAL ACTIVITY IN PACIFIC OCEAN - Operation Troll

VI. RETURN OF RONGELAPESE

A. Physical Status of Rongelapese

B. External Gamma Dose Rates on Rongelapese Atoll

C. Food Supply

D. Additional Considerations

INTRODUCTION

On March 1, 1954, fallout occurred on some of the Marshall Islands as a result of a nuclear detonation at the Eniwetok Proving Ground. At that time 82 people were evacuated from Rongelap and Ailiginae Atolls and 154 from Utirik Island. In June of 1954, the 154 were returned to Utirik. Since March 1954 periodic surveys have been made of these Islands to investigate the degree of contamination.

Soils and biological collections were made on and around the Marshall Islands by the Applied Fisheries Laboratory (AFL) of the University of Washington on March 26, 1954, December 18, 1954, January 29, 1955, October 21-23, 1955, and July 1956; by the Naval Radiological Defense Laboratory (NRDL) on February 1955 and February 1956. Analyses of the samples were performed by AFL, NRDL and by the Health and Safety Laboratory (HASL) of the Atomic Energy Commission. Surveys were also made of residual activity in the Pacific Ocean by Health and Safety Laboratory of the AEC and Office of Naval Research in February-May 1955; by the Applied Fisheries Laboratory in June and September 1956. In addition, teams of medical experts from the United States examined and cared for the Marshallese following their exposure in March 1954, and returned to reexamine the Rongelapese at about six months, one year, and two years after exposure.

The purpose of this report is to abstract the highlights of the findings from these investigations. In doing so there is the risk of unintentionally quoting the original reports out of context. It should be understood that the original authors are not responsible for any

such violations and if there be any question it is recommended that reference be made to the basic documents (See references).

It should be noted that direct comparison of the data between laboratories is very difficult due to differences in times and places of collection, and in counting. Further, the samples usually were not identical but rather of the same type (soil, coconut, water, etc.) and wide variances have been noted even when samples came from the same location. Added difficulties were encountered in transportation such as possible cross contamination and loss of water from biological specimen.

I. EXTERNAL GAMMA RADIATION

Gamma dose rates were taken periodically on several islands in the Pacific over a time ranging from about two days to over two years. The attached map is an estimate of the gamma dose rates at three feet above the ground at D + 1 (one day after the detonation). A very rough approximation of the degree of contamination may be made by dividing these readings by four to arrive at units of gamma megacuries per square mile. (The beta to gamma ratio varies with time but at one day may be near unity, so these values may also be thought of beta activities.) However, the gamma dose rates do indicate the relative degrees of contamination on the islands and therefore are useful in this respect when evaluating the data in subsequent sections of this report.

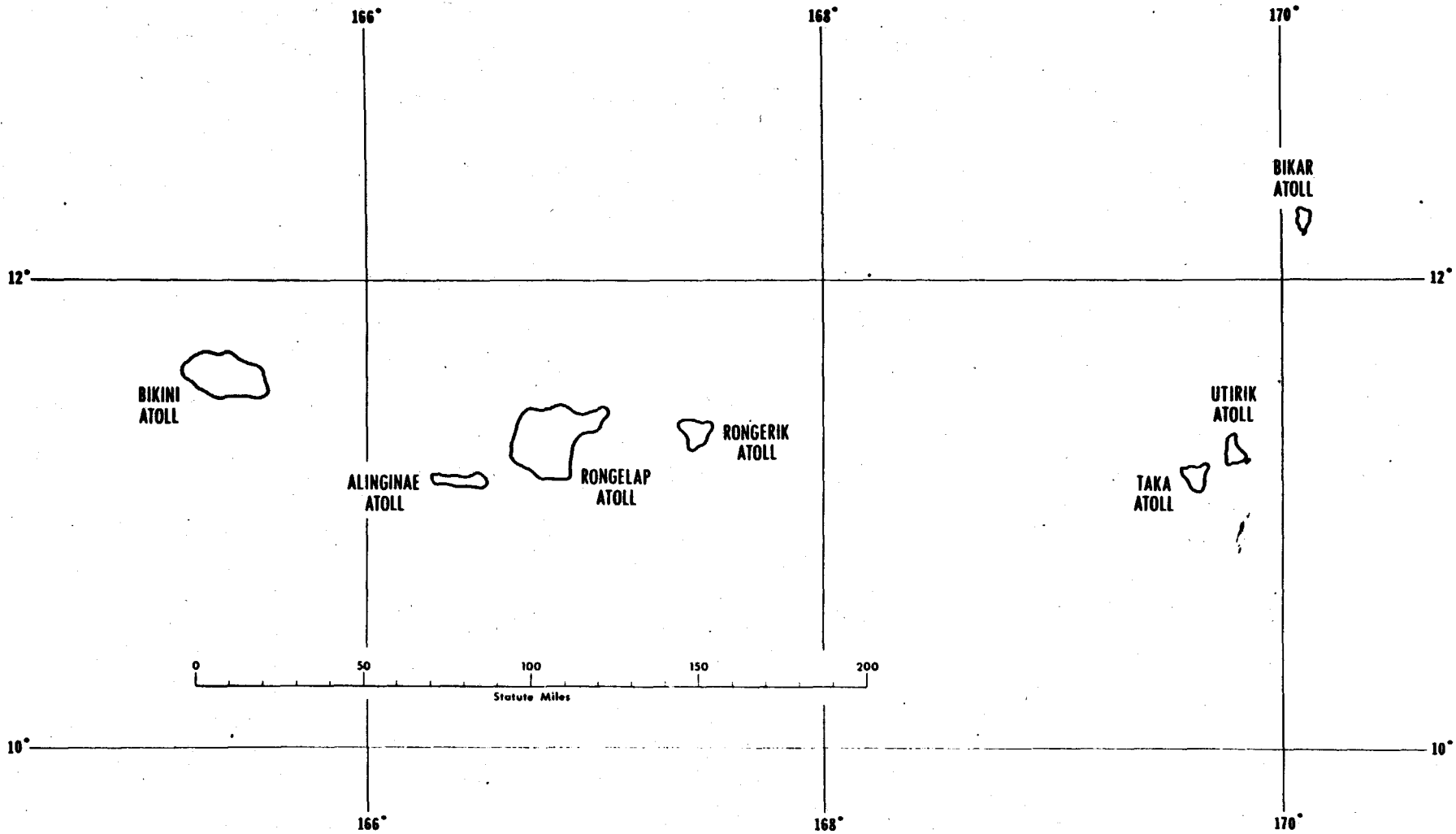
Graph One shows the decay with time of gamma dose rates on the Island of Rongelap. Similar decay curves were found on other islands in the Atoll and in nearby Atolls (Ailinginae and Rongerik). The decay of activity of mixed fission products is assumed to follow $(\text{time})^{-1.2}$ principle. This is intended to apply to disintegrations of atoms. However, in estimating the reduction of gamma dose rates above a plane with time there must be considered the changing numbers and energy spectra of gamma photons released per disintegration, and the effects of weathering. When computing the infinity radiation doses from fallout that occurs within a few hours after detonation, integration of the $(\text{time})^{-1.2}$ curve gives a fair approximation since most of this total dose is accumulated during the early periods when this curve lies near the theoretical gamma decay curve. However, in extrapolating by $(\text{time})^{-1.2}$

there may be a significant difference in estimating dose rates a year or more after detonation and in estimating doses that might occur at these later periods. This is because $(\text{time})^{-1.2}$ is intended to apply to disintegrations of atoms. However, in estimating the reduction of gamma dose rates above a plane with time there must be considered the changing numbers and energy spectra of gamma photons released per disintegration, and the effects of weathering.

During the first two weeks after fallout there was no rainfall and the winds were light. About the end of the second week a tropical storm occurred. For these reasons, a straight line was drawn for the first two weeks followed by a break in the curve. The readings are not to be considered precise, due to the nature of such measurements, but the curves suggest that a much greater reduction in contamination was produced by the first weathering events than for later ones.

The theoretical curve of Graph One would flatten out with time due to the dominance of Cesium-137 with its 33 year half-life. The last survey of Rongelap Island in late July 1956 indicates a range of gamma dose rates at three feet above the ground of 0.2 - 0.5 milli-roentgens per hour with an average of 0.4 mr/hr. The continued drop in actual dose rates versus theoretical might be explained on the basis of the effects of weathering.

PACIFIC MARSHALL ISLANDS



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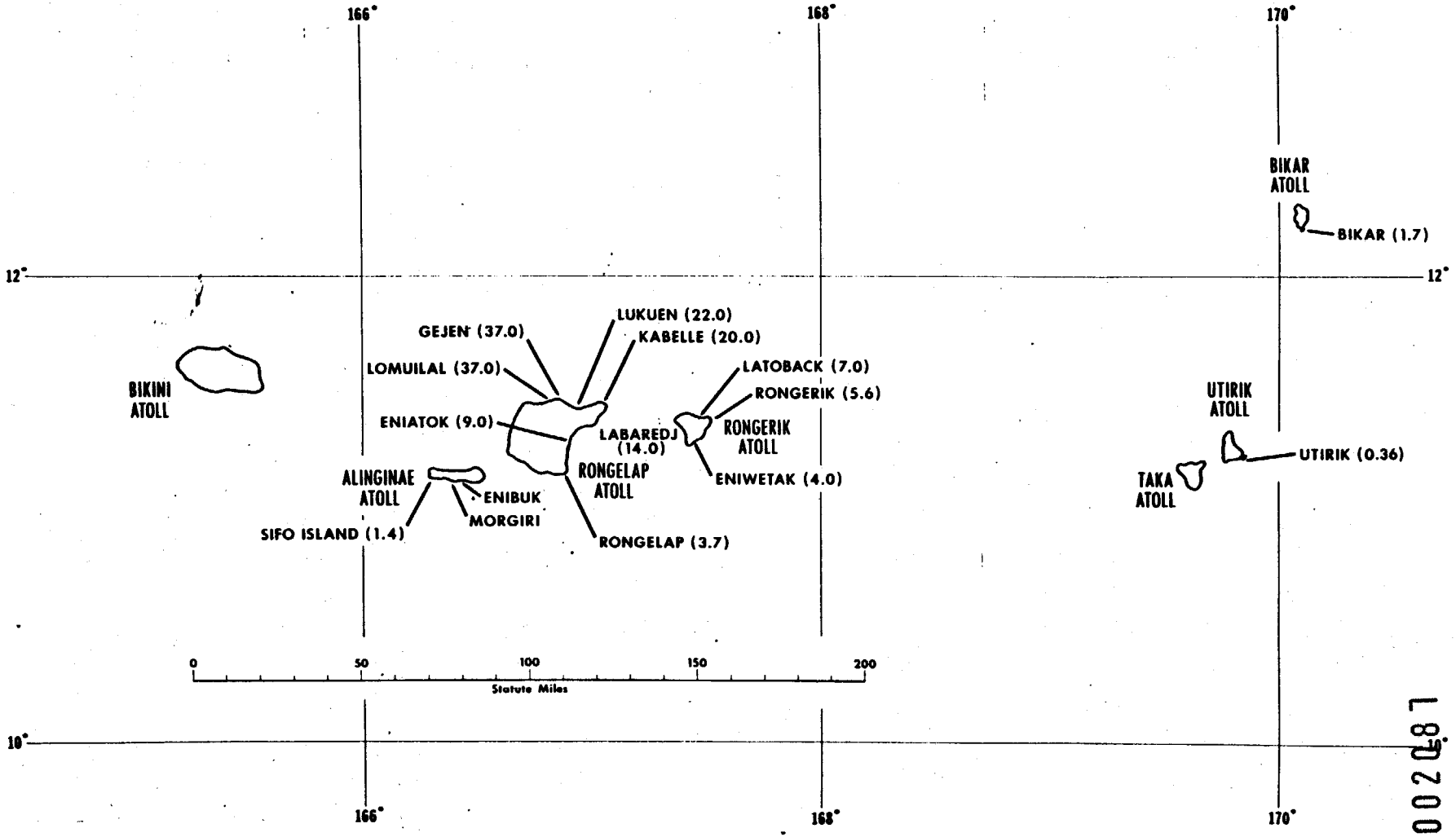
APPROXIMATE GAMMA DOSE RATES AT THREE FEET ABOVE THE GROUND ON D + 1 (One Day after Detonation)
(Roentgens Per Hour)



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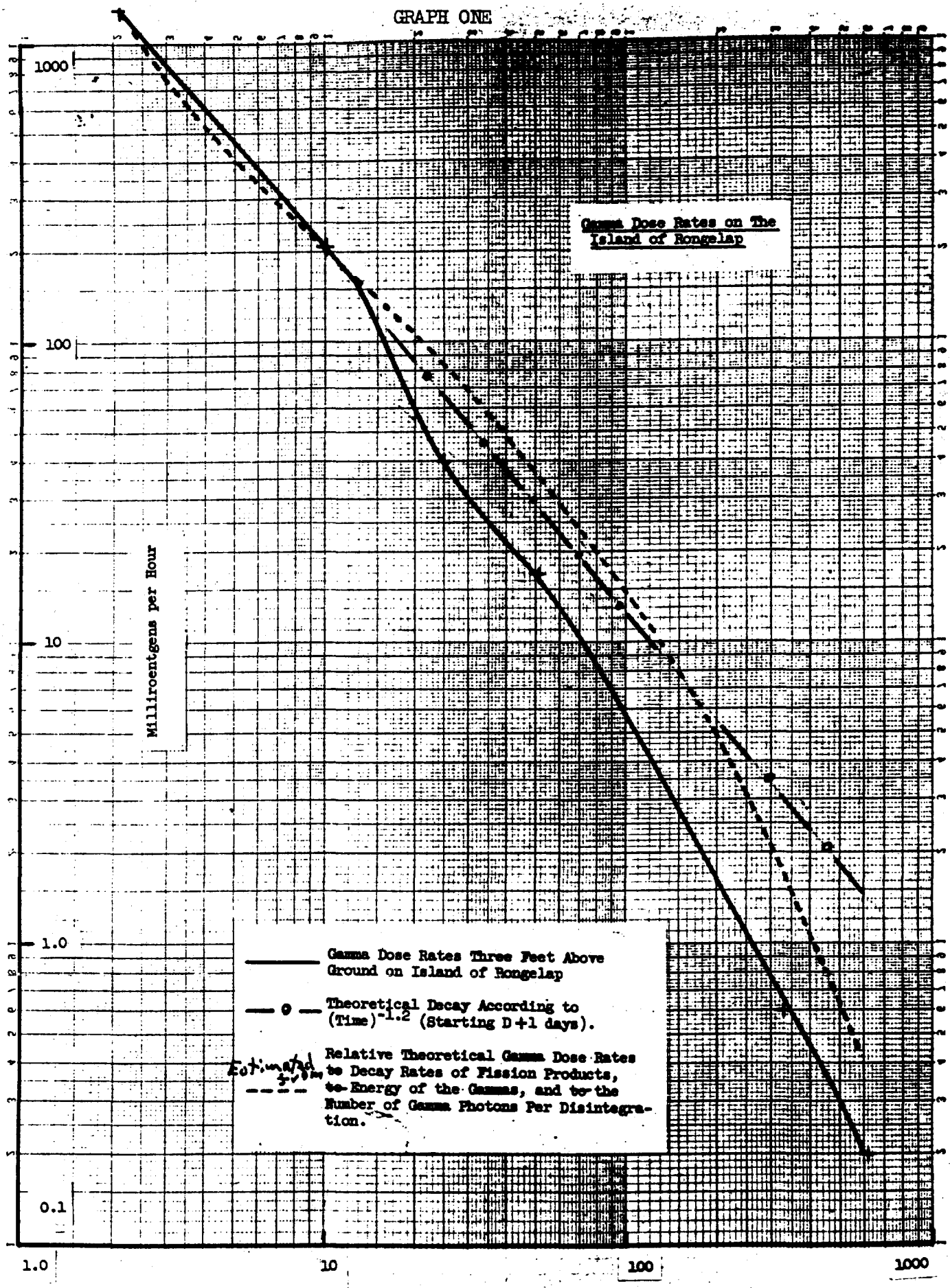
GRAPH ONE



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II. GROSS ACTIVITY

A. Land Plants

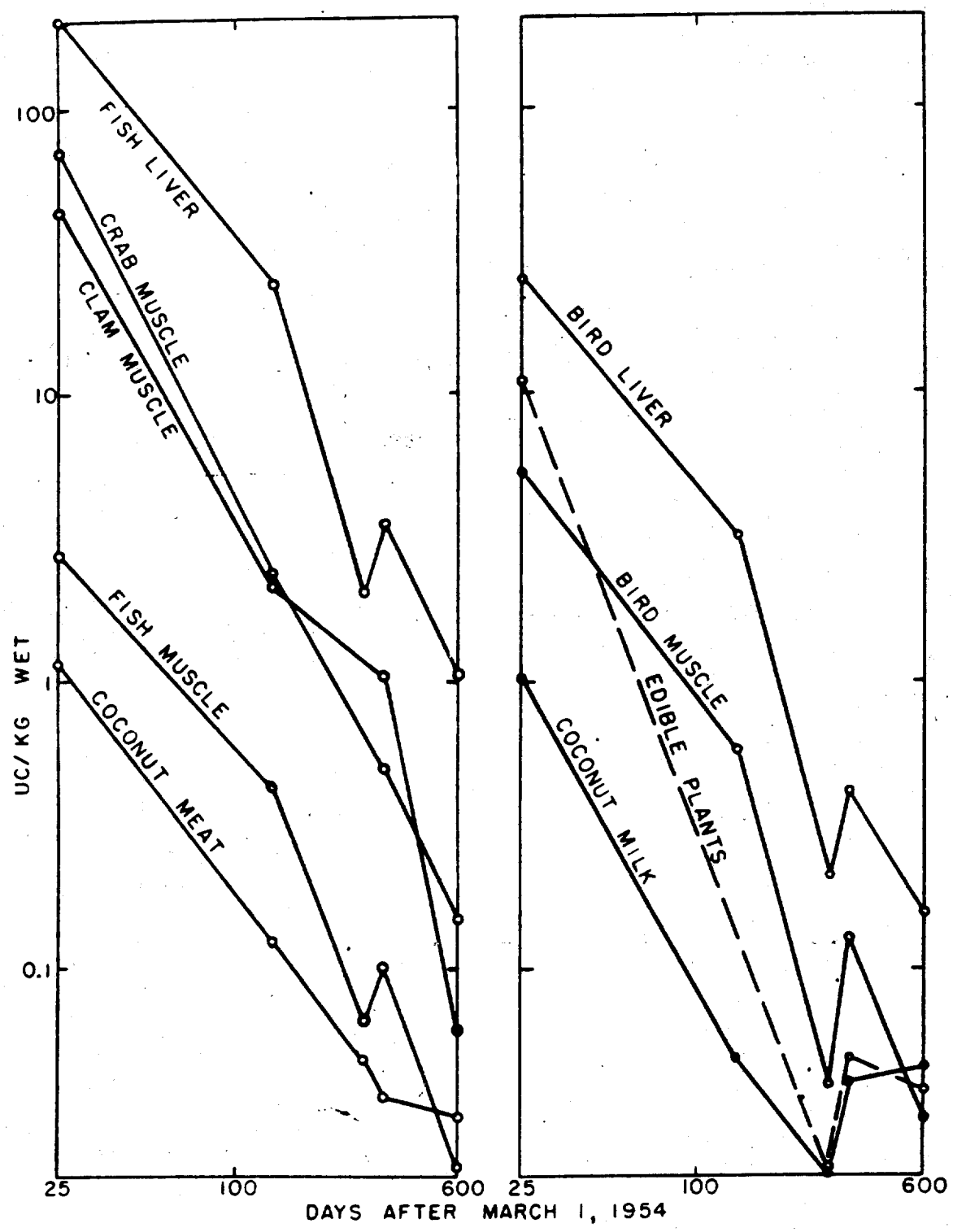
Graph Two indicates the general levels of activity of edible plants (pandanus, papaya, breadfruit, arrowroot), and coconut meat and milk at Rongelap Atoll together with their decline of activity with time.[1,2]

Tables One and Two show the analyses made by NRDL for the first survey in February 1955.[3] Table Three is based on the February 1956 survey.[4]

Tables Four, Five and Six show the analyses by HASL.[5, 6]

The high initial activity of the "edible plants" (Graph Two) was probably due to surface contamination caused by the direct fallout. The rise in activity after a year after the fallout occurred may be due in part to sampling and counting variances but probably results from the ability of some plants to concentrate Cs^{137} (See Section Radiochemical Analysis), or may represent a condition of increased availability of the radioactive fallout material to the plants. Initially the activity in the coconut milk and meat was less than other edible plants but the rate of decline of activity has been less than for other edible land plants probably due to the higher percentage uptake of this longer-lived Cs^{137}.

GRAPH TWO



Rate of decline of radioactivity in food items from collections at Rongelap Atoll between March 26, 1954 and October 22-23, 1955. (AFL)

TABLE ONE

Summary of Gross Beta Activity in Miscellaneous Plant Samples

Plant Material	Average Activity (μc/g x 10^6) (a)											
	Island											
	Likiep	Utirik	Rongelap	Busch	Eniaetok	Labaredj	Kabelle	Lukuen	Gejen	Lomuilal	Bikar	Eniwetak
Grass	20	400	3000	420	2800	5300	1900	2100	68,000	5600	180	400
Coconut leaf		1100				750	1800	670				
Coconut frond stem								140				
Coconut shell							17		150			
Coconut husk	1.7	1.5	53				73		110		8.4	
Coconut sprout			28				110					
Sprouted coconut roots			72				740					
Scaevola leaf							120		100	290	6.7	60
Scaevola Trunk Section											23	
Arrowroot stem			19									
Arrowroot leaf			61									
Pumpkin	2.0		35									
Limes	2.0											
Taro	1.1											
Banana	4.6											
Vines									490			340

(a) Wet weight

*Collections made about February 1, 1955.
Data reported as of March 1, 1955.

TABLE TWO

Summary of Gross Beta Activity in Major Plant Foods (NRDL)*

Source		Average Activity (μc/g x 10^6[a] or μc/cc x 10^6)					
Atoll	Island	Arrowroot	Breadfruit	Pandanus	Papaya	Coconut Meat	Coconut Milk
Likiep	Likiep	4.0	9.1	5.7	3.6	2.5	3.0
Utirik	Utirik	16	3.4	5.0	9.0	2.3	2.6
Rongelap	Rongelap	15		28	27	9.8	9.6
Rongelap	Busch	68		13		8.0	11
Rongelap	Eniaetok	80		34		12	12
Rongelap	Labaredj	36				13	13
Rongelap	Kabelle	40		130		16	12
Rongelap	Lukuen					18	16
Rongelap	Gejen	130				72	25
Rongelap	Lomuilal	180				19	30
Bikar	Bikar					5.9	5.0
Rongerik	Eniwetak					7.8	9.4

(a) Wet weight

*Collections made about February 1, 1955.
Data reported as of March 1, 1955.

TABLE THREE

Gross Beta Activity in Plant, [redacted] Samples[a] (NRDL)

Plant	Part	Gejen	Eniwetak	Eniaetok	Rongelap	Sifo	Utirik	Likiep
		PLANTS[b] (c/m/kg x 10^{-5})						
Portulaca	Whole Plant	87.4	19.2	3.05	1.26	-	1.71	1.33
Arrowroot	Stems, Leaves	11.0	4.5	0.32	0.25	0.21	-	0.03
	Tubers	2.32	0.57	0.69	0.55	0.08	0.14	0.03
Pandanus	Air Root	2.87	0.17	1.05	0.32	0.96	0.08	0.02
	Leaves	2.64	1.02	5.26	0.38	0.15	0.21	0.03
	Green Keys	1.27	0.37	0.70	0.22	0.10	0.09	0.03
	Ripe Keys	-	-	0.53	0.17	-	0.07	0.02
Papaya	Ripe	-	-	-	0.12	-	0.11	-
	Green	-	-	-	0.25	-	0.09	0.04
	Leaves, Trunk	-	-	-	0.09	-	0.16	0.06
Ripe Coconut	Milk	2.87	-	-	0.54	0.63	0.12	0.57
	Meat	1.90	0.36	1.97	0.24	0.17	0.08	0.06
	Shell	4.98	0.38	0.72	0.44	0.28	0.06	0.02
	Husk	1.83	0.65	1.57	1.31	0.77	0.21	0.09
Green Coconut	Whole	3.1	-	-	-	-	-	-
	Milk	-	0.29	0.11	0.05	0.13	-	0.05
	Meat	-	0.33	0.25	-	0.08	0.07	0.02
	Shell	-	-	0.80	-	0.37	0.08	0.09
	Husk	-	-	0.48	0.12	0.11	0.11	0.02
	Shell, Husk	-	0.11	-	-	-	-	-
Sprouting Coconut	Milk	-	1.61	0.76	0.79	0.71	0.11	0.09
	Meat	-	0.38	0.40	0.12	0.30	0.07	0.06
	Shell	-	0.29	0.41	0.35	0.18	0.04	0.02
	Husk	-	0.73	1.57	0.88	0.68	0.26	0.07
Coconut	Leaves	-	15.4	0.86	-	0.84	4.7	1.66
	Frond	-	0.94	0.51	-	0.23	0.09	0.11
	Leaves, Frond	1.48	-	-	-	-	-	-
Banana	Fruit	-	-	-	-	-	-	0.06
	Bark	-	-	-	-	-	-	0.07
	Leaves	-	-	-	-	-	-	0.18
Taro	Leaves, Staiks	-	-	-	-	-	-	0.06
	Tuber, Roots with Soil	-	-	-	-	-	-	0.19

(a) All counts were corrected for the counting efficiency of Sr^{90}-Y^{90}.

(b) Gross beta activity of plant samples was determined in April 1956 and that of soil and water in May 1956.

TABLE FOUR

HASL Analysis
(AFL Surplus)

VEGETATION

H.S.L. No.	Specimen No.	Organism	Tissue	Area Collected	Collection Date	Remarks	Total Activity * d/m/gram Wet	Total Activity * d/m/gram Dry	Sr-90 d/m/gram Wet	Sr-90 d/m/gram Dry	Ca Based on Wet Weight	Sr-90 Ca
3175	A 35-39	Papaya	pulp	Rongelap Island	10-22-55	5 fruits - village area, skin and seeds removed: dried at 95°C	98.2±0.6	415± 4.3	0.43±0.02	3.07±0.14	0.022	838 ± 41
3172	A 40-42	Papaya	pulp and seed	Rongelap Island	10-22-55	Halves from 3 fruits, village area: seeds removed: dried at 95°C	105 ±1.0	740± 7.0	1.23±0.06	8.64±0.39	0.037	1511 ± 74
3170	A 35-39	Papaya	skin	Rongelap Island	10-22-55	Peeled from 5 fruits, village area: dried at 95°C	21.0±0.5	146± 1.5	0.86±0.07	5.96±0.48	0.070	559 ± 45
3173	A 35-42	Papaya	seeds	Rongelap Island	10-22-55	8 fruits, village area: dried at 95°C	63.9±1.0	345± 5.4	0.32±0.04	1.75±0.25	0.169	65.9± 11
3177	A 62-64	Morinda	entire	Rongelap Island	10-22-55	3 fruits, village area: dried at 95°C	33.8±1.9	278± 7.5	1.12±0.08	9.22±0.67	0.065	783 ± 56
3171	A 67-71	Arrowroot	corm	Rongelap Island	10-22-55	Peeled tubers, skin removed, village area: ashed at 550°C	102 ±1.1		3.61±0.32		0.030	5469 ±485
3176	A 43	Squash	leaves and flowers	Rongelap Island	10-22-55	Village area, plant in blossom but no fruit: dried at 95°C	24 ±1.0	307±13	5.72±0.43	71.5 ±4.27		
3213 - 3217	A 75-79	Pandanus	entire	Rongelap Island	10-22-55	Part of 5 fruits from 5 trees, village area	64.4±0.6		2.57±0.07		0.136	959 ± 23

ALGAE

3154	A 109			Rongelap Island	10-22-55	From cistern in village, species undefined: dried at 95°C	9411±60	48440±425	9.73±9.35	70.0±7.3		
3155	A 110			Rongelap Island	10-22-55	From well in village (taken from sides below water level) species undefined: dried at 95°C	683±13	2140± 72	6.90±2.14	37.7±11.7		

*Date of counting February 27, 1956.

TABLE FIVE

HASL Analysis
(AFL Surplus)

COCONUTS

HASL No.	Specimen No.	Area Collected	Collection Date	Remarks	d/m/gram - wet Total Activity * Outer Husk	Inner Shell	Meat and Milk	d/m/gram - wet Sr-90 Outer Husk	Inner Shell	Meat and Milk	% Ca Based on Wet Weight Outer Husk	Inner Shell	Meat and Milk
3196	A 30	Kabelle Is.	10-21-55	ONE COCONUT FROM EACH OF FIVE (5) TREES - - - VARIOUS AREAS OF THE ISLAND	84.0± 3.3	15.6±0.7	54.5±2.3	1.2 ±0.14	0.60±0.19	0.06±0.33			
3199	A 31	Kabelle Is.	10-21-55		56.6± 2.7	39.5±1.6	60.3±2.6	0.11±0.31	0.07±0.04	(-0.24)±0.18			
3200	A 32	Kabelle Is.	10-21-55		66.3± 2.9	12.7±1.1	37.1±1.6	0.09±0.06	(-0.05)±0.08	0.03±0.14	0.038	0.058	0.013
3201	A 33	Kabelle Is.	10-21-55		69.6± 3.1	20.4± .95	45.5±1.9	0.12±0.05	0.03±0.06	(-0.07)±0.14			
3202	A 34	Kabelle Is.	10-21-55		127 ± 5.5	32.0±1.5	55.2±2.4	0.66±0.25	0.14±0.08	0.28±0.23			
3203	A 35	Labaredj Is.	10-21-55	NORTHERN END OF ISLAND	141 ± 6.0	20.9±0.9	59.2±2.5	1.3 ±0.14	0.28±0.11	(0.38)±0.32			
3204	A 36	Labaredj Is.	10-21-55		318 ±13	26.1±1.1	177 ±7.1	4.8 ±0.30	0.89±0.16	0.10±0.34			
3205	A 37	Labaredj Is.	10-21-55		182 ± 7.6	31.1±1.3	61.3±2.6	1.3 ±0.16	0.17±0.07	0.10±0.18	0.062	0.019	0.011
3206	A 38	Labaredj Is.	10-21-55		220 ± 9.2	41.2±1.7	63.1±2.7	1.0 ±0.29	0.19±0.12	0.56±0.22			
3207	A 39	Labaredj Is.	10-21-55		143 ± 6.2	23.4±1.1	54.0±2.3	1.5 ±0.14	0.33±0.11	0.32±0.30			
3208	A 40	Rongelap Is.	10-22-55	VILLAGE AREA	254 ±11	46.3±1.9	81.2±3.3	3.5 ±0.24	0.51±0.13	0.22±0.20			
3209	A 41	Rongelap Is.	10-22-55		49.4± 2.2	4.0±0.2	55.2±2.2	0.39±0.10	0.09±0.07	(0.09)±0.10			
3210	A 42	Rongelap Is.	10-22-55		87.4± 3.9	34.6±1.4	24.0±1.0	(0.19)±0.20	0.21±0.09	0.44±0.21	0.053	0.078	0.007
3211	A 43	Rongelap Is.	10-22-55		73.2± 3.3	9.5±0.5	33.3±1.5	0.70±0.21	0.31±0.13	0.57±0.42			
3212	A 44	Rongelap Is.	10-22-55		84.3± 3.5	5.3±0.3	20.3±1.0	0.75±0.17	0.07±0.10	0.09±0.23			

COMMERCIAL COCONUTS

3311		Puerto Rico	February 1956			1.2±0.2	5.1±1.0						
3312		Puerto Rico	February 1956			8.0±0.2	5.3±1.0						
3313		Puerto Rico	February 1956			1.9±0.2	5.8±1.0						

*Date of counting February 27, 1956.

TABLE SIX

Results of Analyses Performed at HASL *

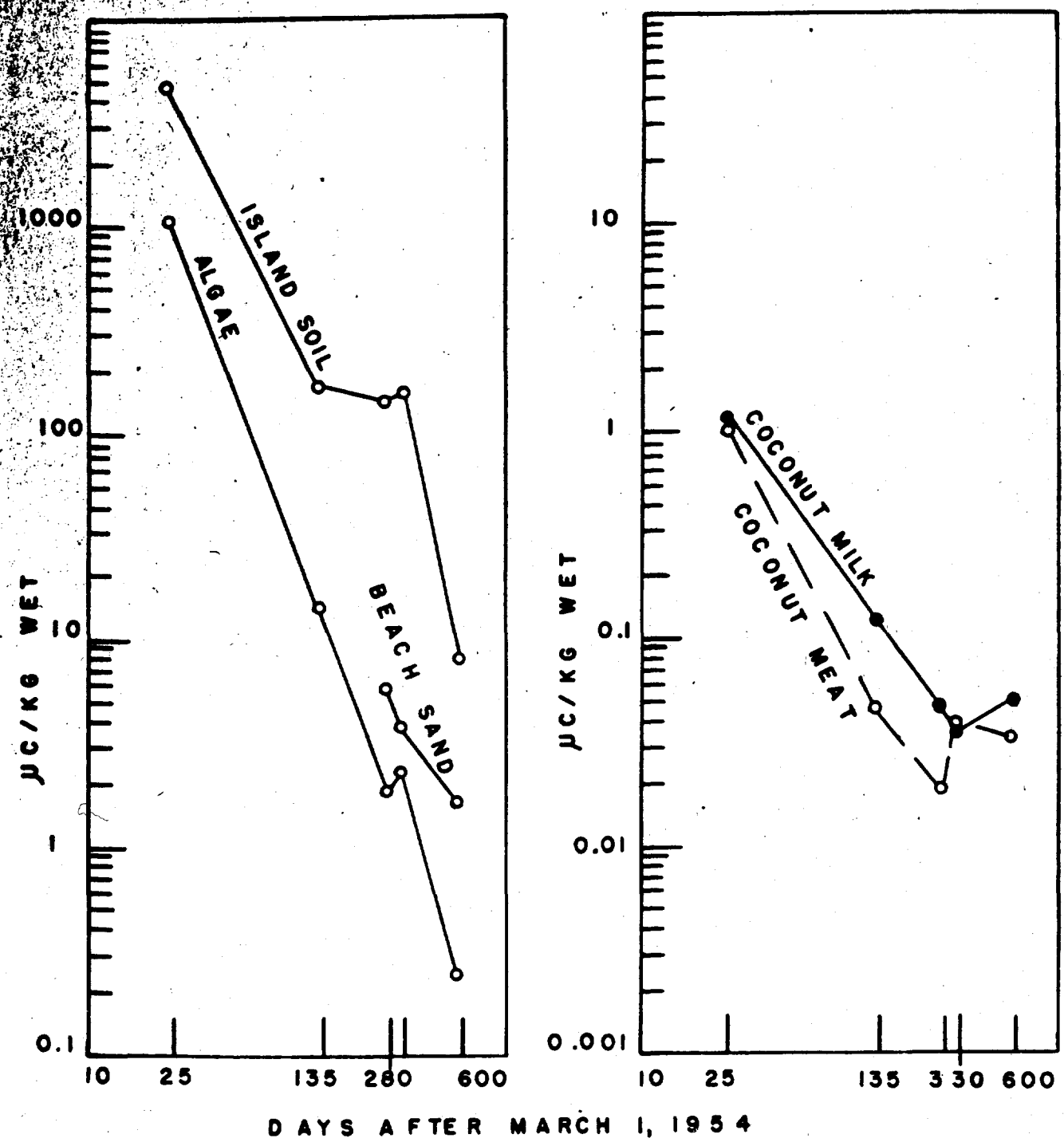
LAND PLANTS

HASL #	NRDL #	Sampling Location	Organism	Tissue	C-Date	Total Activity d/m/gram*	Sr^{90} d/m/gram*	Cs^{137} d/m/gram*	Ca grams/gram*	S. U.	g Sr^{90}	% Cs^{137}
3437	521	Rongelap	Coconut	Outer & Inner Shell	4-17-56	26±0.7	0.22 ±0.01		0.00022	450± 21	1.75	
				Milk	4-17-56	43±1.7	0.11 ±0.10	19 ±2.7	0.00020	2400±230	1.2	...
3438	523	Rongelap	Coconut	Outer Husk	4-17-56	71±1.7			0.00033			
				Inner Shell	4-17-56	26±0.7	0.14 ±0.06		0.00013	1100±210	1.54	
				Meat and Milk	4-17-56	88±2.2	0.047±0.039		0.00001	4700±1300	0.54	
3439	525	Rongelap	Coconut	Outer Husk	4-17-56	66±1.7	0.70 ±0.04		0.00035	975± 31	1.1	
				Inner Shell	4-17-56	35±0.7	0.081±0.071		0.00025	1425±215	1.03	
				Meat and Milk	4-17-56	87±2.1	0.080±0.043		0.00020	1360± 98	0.954	
3513	752	Utirik	Coconut	Entire	4-17-56	51±2.0	2.7 ±0.1		0.0096	1134± 44	1.3	
3534	803	Likiep	Coconut	Entire	4-17-56	10±0.7	0.046±0.02		0.00031	478± 29	1.45	
3441	535	Rongelap	Pancanus	Entire	4-14-56	42±1.9	0.26 ±0.11	16 ±3.7	0.00010	1180±500	1.62	38
3442	536	Rongelap	Pandanus	Entire	4-14-56	30±1.5	≤0.16		0.00010	≤730		
3447	558	Rongelap	Arrowroot	Entire	4-14-56	lost	lost					
3456	856	Jegen	Arrowroot	Entire	4-14-56	300±4.1	3.6 ±0.15	250 ±5.4	0.0012	1370± 57	1.2	83
3476	580	Eniaetok	Arrowroot	Entire	4-14-56	180±3.8	1.4 ±0.82	54 ±1.6	0.00060	1050±620	0.77	30
3492	726	Eniwetak	Arrowroot	Entire	4-14-56	67±2.1	0.20 ±0.06	17 ±0.6	0.00060	155± 45	0.30	25
3505	674	Sifo	Arrowroot	Entire	4-14-56	59±2.2	0.19 ±0.03	36 ±1.0	0.0026	32± 5.2	0.31	61
3519	756	Utirik	Arrowroot	Entire	4-14-56	26±1.6	0.22 ±0.06	17 ±2.8	0.00003	3300±910	0.84	65
3541	807	Likiep	Arrowroot	Entire	4-14-56	7.3±1.1	≤0.13	3.8±2.1	0.00070	≤85		52

* Weight as received at HASL

*Date of counting February 27, 1956

GRAPH THREE



Rate of decline of radioactivity in algae and soils and coconut meat and milk at Rongelap Atoll from March 26, 1954 to October 23, 1955.

5002097

II. GROSS ACTIVITY

B. Marine Organisms and Birds

Graph Three indicates the general level of activity in fish at Rongelap Atoll and the decline of activity with time.[2]

Tables Seven and Eight report the results of NRDL analysis for the February 1955 survey.[3] Tables Nine and Ten are for the February 1956 survey.[4] Tables Eleven and Twelve show the analyses by HASL.[5, 6]

The data show a significant higher concentration of gross activity in the livers of fish and in the crustacean muscles.

Tables Eight (a) and Ten (a) show the gross activity in birds and fowls.[3, 4]

TABLE SEVEN

(NRDL)*

Summary of Beta and Gamma Activity Concentration in Fish and Marine Invertebrates

Location	Radioactivity Concentration (μc/kg)[a]											
	Large Fish[b]			Small Fish[c]			Crabs and Clams			Snails		
	No. of Specimens	Activity β	Activity γ	No. of Specimens	Activity β	Activity γ	No. of Specimens	Activity β	Activity γ	No. of Specimens	Activity β	Activity γ
Rongelap Atoll												
North Lagoon	3	0.22	1.2	22	.49	1.58	4	1.54	1.25	2	19.5	5.6
South Lagoon	3	.054	0.33	7	.14	0.94	3	0.49	1.76	-[d]	-	-
Rongerik Atoll												
Eniwetak	2	0.23	0.26	2	.23	.21						
Utirik Atoll												
Utirik				6	.14	.04						
Likiep Atoll												
Likiep	1	0.02	0.01	3	.05	.01	1	0.12	0.35			
Bikar Atoll												
Bikar							2	0.39	0.19			

(a) μc are in terms of Co^{60} equivalent.
(b) >150 g.
(c) <150 g.
(d) No data taken.

*Collections made about February 1, 1955.
Data reported as of March 1, 1955.

TABLE EIGHT

Distribution of Gross Beta and Gamma Activity in Tissues of Large Fish[a] (UCRL)*

Island	Fish	Wet Weight (g)	Radioactivity (μc x 10^3/Tissue)[b] Total β	Total γ	Skin β	Skin γ	Muscle β	Muscle γ	Bone β	Bone γ	Gills β	Gills γ	Viscera β	Viscera γ
Rongelap Atoll, North														
Gejen	Flat Fish with Orange Spots[c]	597	196	714	25	24	18	96	120	310	7	16	26	268
North	2 Pelargic	503	84	500	6	69	9	78	29	271	3	16	37	66
Lagoon	Snappers	391	53	550	4	68	9	94	35	313	3	17	8	60
	Average	497	113	588	12	54	12	89	61	298	4	16	24	131
Percentage of Total Activity					10.6	9.2	10.6	15.1	54.0	50.7	3.5	2.7	21.0	22.3
Rongelap Atoll, South														
Southeast Lagoon	Grouper	1490	112	590	19	16	14	93	41	308	4	33	34	140
	Lutinius	2170	69	513	25	69	19	119	18	111	6	51	1	163
	Red Snapper	1980	106	339	12	36	14	104	59	122	8	27	13	50
	Average	1880	96	481	19	40	16	105	39	180	6	37	16	118
Percentage of Total Activity					19.8	8.3	16.7	21.9	40.7	37.5	6.3	7.7	16.7	24.6
Rongerik Atoll														
Eniwetak	Parrot	1450	272	339	1	39	48	44	8	106	8	10	207	140
	Mullet	230	64	68	8	13	3	15	7	18	1	3	45	19
	Average	840	168	204	5	26	26	30	8	62	5	7	126	80
Percentage of Total Activity					3.0	12.7	15.5	14.7	5.2	30.4	3.2	3.4	82.0	39.2

(a) >150 g.
(b) μc are in terms of Co^{60} equivalent.
(c) Name unknown.

*Collections made about February 1, 1955.
Data reported as of March 1, 1955.

TABLE 8a

Summary of the Gross Beta and Gamma Activity in Birds and Fowl

Island and Specimen	No. of Specimens	Wet Weight (g)	Activity(μc x 10^4/Tissue)[a] β	γ
Rongelap Atoll				
Gejen - Terns	2	163		
Gut			46	115
Tibia			10	10
Carcass			197	290
			253	415
Kabelle - Terns	2	184		
Gut			13	9
Tibia			23	NDA[b]
Muscle			22	6
Carcass			242	133
			300	148
Larbaredj - Terns	2	146		
Gut			114	37
Tibia			29	4
			143	41
Rongelap - Rooster	1	1140		
Skeleton		268	6800	8270
Muscle		434	260	120
Viscera		64	166	51
Liver		144	29	6
Heart		15	8	2
Skin		157	16	18
Lung			2	2
			7281	8479
Rongerik Atoll				
Eniwe ak - Terns	2	[c]		
Gut			10	9
Tibia			6	NDA
Muscle			33	14
Carcass			126	294
			175	317
Bikar Atoll				
Bikar - Terns	2	126		
Gut			9	3
Tibia			6	1
Muscle			40	14
Carcass			14	14
			69	32

(a) μc are in terms of Co^{60} equivalent.
(b) No detectable activity.
(c) No data taken.

Collections made about February 1, 1955.
Data reported as of March 1, 1955.

TABLE NINE

Distribution of Gross Beta and Gamma Activity in Tissues of Fish (NRDL

Island	Fish	Wet wt (g)	Radioactivity (d/m/tissue x 10^{-4}) Total β	Total γ	Skin β	Skin γ	Head β	Head γ	Muscle β	Muscle γ	Bone β	Bone γ	Gill β	Gill γ	Viscera β	Viscera γ
Rongelap Atoll, South																
Rongelap	Goat	218	8.8	15.5	0.2	2.4	0.45	3.3	1.1	2.1	1.5	2.7	0.6	2.2	4.9	2.8
Rongelap	Grouper	452	5.2	5.7	0.4	0.3	0.8	0.7	0.4	0.5	1.4	2.6	0.3	0.3	1.9	1.4
	Average		7.0	10.6	0.3	1.3	.63	2.0	0.8	1.3	1.5	2.7	0.5	1.3	3.4	2.1
	Per cent of total activity		100	100	4.2	12.1	8.8	18.7	11.2	12.1	21.0	25.2	7.0	12.1	47.7	19.6
Rongelap Atoll, North																
Gejen	Snapper	1154	26.3	87.0	1.0	11.8	6.6	24.7	5.4	16.8	5.5	15.7	1.7	2.1	6.1	15.9
Kabelle	Snapper	735	12.3	18.5	1.0	11.2	4.5	1.9	1.0	0.7	2.4	4.4	0.5	1.1	2.9	6.3
Kabelle	Parrot	1957	24.8	71.3	1.1	8.9	8.5	20.9	2.4	6.6	7.0	23.4	0.8	2.7	5.0	8.8
	Average		21.1	58.9	1.0	10.6	6.5	15.8	2.9	8.0	5.0	14.5	1.0	2.0	4.7	10.3
	Per cent of total activity		100	100	4.8	17.3	30.8	25.9	13.7	13.1	23.7	23.7	4.8	3.3	22.3	16.9
Ailingnae Atoll																
Sifo	Snapper	640	3.2	38.9	0.3	5.9	0.7	9.9	0.6	6.2	0.5	10.6	0.1	2.7	0.9	3.6
	Per cent of total activity		100	100	9.7	15.2	22.5	25.4	19.3	15.9	16.1	27.2	3.2	7.0	29.0	9.4
Rongerik Atoll																
Eniwetak	Squirrel	387	0.41	2.0	.02	.35	.23	.55	.04	.27	.06	.39	.02	.08	.04	0.4
	Per cent of total activity		100	100	4.9	17.3	55	27.2	9.8	13.4	14.6	19.3	4.9	4.0	9.8	18.8
Utirik Atoll																
Utirik	Parrot	425	0.66	0.87	0	.24	0	.09	.15	.22	.13	.13	0	.04	.38	0.2
	Per cent of total activity		100	100	0	27.6	0	10.3	22.7	25.3	19.7	15.0	0	4.6	57.5	17.2
Likiep Atoll																
Likiep	Snapper	453	1.1	2.2	0	0	0	.02	0.1	0.2	0	0	0	0	1	2
	Per cent of total activity		100	100	0	0	0	0.9	9	9	0	0	0	0	91	90

TABLE TEN

Summary of Beta and Gamma Activity in Fish and Marine Invertebrates NRDL

Island	Fish			Crabs			Clams			Snails		
	No. of Samples	Activity (d/m/kg x 10^{-4})		No. of Samples	Activity (d/m/kg x 10^{-4})		No. of Samples	Activity (d/m/kg x 10^{-4})		No. of Samples	Activity (d/m/kg x 10^{-4})	
		β	γ		β	γ		β	γ		β	γ
Rongelap Atoll												
North: Gejen	8	24.5	78.8	2	28	87				4	648	513
Kabelle	10	14.9	55.4							1	17.7	43.9
Central: Eniaetok	5	19.3	45.1	1	4.5	14.1	1	4.5	8.8			
South: Rongelap	5	17.7	32	6	25.4	24.5	2	23	56	2	31	51
Rongerik Atoll												
Eniwetak	8	2.2	7.8	1	2.8	18.3						
Ailingnae Atoll												
Sifo	6	4.5	22.7	3	21.9	14.5	1	6.4	15.0			
Utirik Atoll												
Utirik	8	1.6	2.1							3	.006	2.8
Likiep Atoll												
Likiep	8	2.6	1.3									

TABLE 10a

Summary of Gross Beta and Gamma Activity in Birds and Eggs

Island	Sample	No. of Samples	Average Weight (g)	Radioactivity			
				Beta		Gamma	
				(d/m/sample x 10^{-4})	(d/m/kg x 10^{-4})	(d/m/sample x 10^{-4})	(d/m/kg x 10^{-4})
Rongelap Atoll							
Rongelap	Tern						
	Egg shell	1	6	NDA	0	0.62	10.3
	Egg, soft tissue	1	33	0.26	7.9	0.11	3.3
Gejen	Tern	1	92	0.93	10.1	0.32	3.5
	Viscera	1	101	0.38	3.8	0.025	0.25
	Muscle	1	141	NDA	0	0.019	0.14
	Tibia	1		NDA	0	NDA	0
Kabelle	Tern	1	145	1.1	7.8	1.7	12
	Muscle	1	16.9	0.1	5.9	0.13	7.7
	Tibia	1	0.9	0.07	79	.027	30
	Egg shell	2	5.3	NDA	0	0.13	26
	Egg, soft tissue	2	22.8	0.15	6.7	.03	1.3
Allingnae Atoll							
Sifo	Tern	7	116	0.38	3.3	1.7	14.7
	Muscle	7	11.7	0.057	4.9	0.43	36.7
	Viscera	7		0.08		0.14	
	Tibia	7	0.31	NDA	0	NDA	0
	Egg shell	1	6	NDA	0	0.06	10
	Egg, soft tissue	1	33	0.26	7.9	0.11	3.3
Rongerik Atoll							
Eniwetak	Tern	2	92	1.9	21.0	0.9	9.8
	Muscle	2	19.7	0.04	2.3	0.03	1.9
	Tibia	2	.23	NDA	0	NDA	0
	Viscera	2		0.05		0.09	

Counted in April-May 1956

TABLE 11

HASL Analysis
(AFL Surplus)

FISH

HASL No.	Specimen No.	Organism	Tissue	Area Collected	Collection Date	Remarks	d/m/gram Total Activity * Wet	Dry	d/m/gram Sr-90 Wet	Dry	% Ca based on wet weight
3176	A 165	Dog-tooth Tuna	bone	Kabelle-Labaredj	10-21-55	Caught half-way between Kabelle and Labaredj Islands in Rongelap Lagoon. Total weight: 44 lbs. Bone includes some connective tissue. Not possible to remove all tissue.	31 ±35	85 ±95	0.17 ±0.07	0.42 ±0.20	11.3
3179	A 165	Dog-tooth Tuna	muscle	Kabelle-Labaredj	10-21-55	Dried at 95°C - shared with U of W: HTOO samples placed into 5 bags.	24.4± 1.0	111 ± 4.5	(0.01)±0.04	(-0.05)±0.18	0.0017
3167	A 165	Dog-tooth Tuna	liver	Kabelle-Labaredj	10-21-55	Dried at 95°C - shared with U of W.	186 ± 2.5	1483 ±20	0.104±0.41	0.83 ±3.3	0.0048
3174	A 64	Bonito	muscle	Labaredj Island	10-21-55	1 fish dried at 95°C.	56.3± 1.0	269 ± 4.8	0.019±0.11	0.089±0.53	0.043
3165	A 64	Bonito	bone	Labaredj Island	10-21-55	Backbone boiled to remove meat. Wet weight given is that after boiling.	227 ±78	269 ±87	(0.28)±0.90	(0.33)±1.06	18.0
3169	A 112-116	Goatfish	muscle	Rongelap Island	10-22-55	Part sample of 5 fish: dried at 95°C.	21.1± 1.8	89.6± 7.7	0.082±0.12	0.35 ±0.51	

PLANKTON

3170	A 2 - 5			Kabelle-Rongelap	10-21,22-55	A 2-5 pooled after removing samples for U. of W. - AFL - Sample A 2 and A 3 off Kabelle Island, 10-21-55: and A 4 and A 5 off Rongelap Island, 10-24-55. ~ 20 gms wet weight in pooled sample, of which ~ 80% is from samples A 4 and A 5.	43.1± 1.0	663 ±17	0.19 ±0.89	2.97 ±13.7	

*Date of counting February 27, 1956.

TABLE 12

Results of Analyses Performed at HASL*

MARINE ORGANISMS

HASL #	NRDL #	Sampling Location	Organism	Tissue	C-Date Total Activity	Total Activity d/m/gram*	Sr^{90} d/m/gram*	Cs^{137} d/m/gram*	Ca grams/gram*	S. U.	% Sr^{90}
3336	1519	Rongelap	Surgeon	Entire	4- 9-56	52± 6.4	≤0.10				
3337	1512	Rongelap	Damsel	Entire	4- 9-56	37± 6.0					
3350	1541	Kabelle	Butterfly	Entire	4- 9-56	lost	lost				
3351	1542	Kabelle	Damsel	Entire	4- 9-56	125± 3.0	2.8 ±0.55		0.031	41 ± 3.1	2.3
3354	1622	Gegen	Surgeon	Entire	4- 9-56	235± 8.9					
3369	1555	Sifo	Butterfly	Entire	4- 9-56	95± 5.7	≤0.81		0.024	≤15	
3374	1564	Eniwetak	Damsel	Entire	4- 9-56	20± 6.2	≤0.15		0.033	≤ 2.1	
3376	1559	Eniwetak	Surgeon	Entire	4- 9-56	34± 6.9			0.033		
3378	1606	Likiep	Butterfly	Entire	4- 9-56	51± 6.2			0.023		
3380	1615	Likiep	Damsel	Entire	4- 9-56	11± 6.5	0.37±0.23		0.037	4.5± 2.8	3.4
3383	1593	Utirik	Surgeon	Entire	4- 9-56	22± 5.4			0.015		
3384	1574	Utirik	Damsel	Entire	4- 9-56	14±11			0.039		
3385	1577	Utirik	Damsel	Entire	4- 9-56	22± 6.7			0.038		
3387	1572	Utirik	Surgeon	Entire	4- 9-56	18± 6.0			0.022		
3346	1522	Rongelap	Coral		4-10-56	35±17					
3357	1635	Gejen	Coral		4-10-56	310±22	≤0.62		0.31	≤0.91	
3363	1534	Eniaetok	Coral		4-10-56	205±20	3.1 ±0.42		0.35	4.1± 0.55	1.5
3381	1617	Likiep	Coral		4-10-56	≤15	≤0.45		0.30	≤0.68	
3393	1601	Utirik	Coral		4-10-56	≤19	≤0.27		0.26	≤0.47	
3394	1589	Utirik	Coral		4-10-56	21±15	0.48±0.14		0.24	0.91±0.27	2.3
3326	1636	Gejen	Spider Snail	Entire	4-23-56	520±10	4.4 ±0.39	13 ±0.48	0.018	110 ± 9.8	0.85
3327	1637	Gejen	Spider Snail	Entire	4-23-56	2180±29	1.3 ±0.34	4.0±0.48	0.0072	82 ±21	0.061
3328	1638	Gejen	Scorpion Snail	Entire	4-23-56	23310±290	1.1 ±0.44	3.4±1.5	0.0085	57 ±24	0.0046
3329	1639	Gejen	Scorpion Snail	Entire	4-23-56	9800±120	1.5 ±0.58	7.1±1.1	0.0125	55 ±21	0.015

* Weight as received at HASL

*Date of counting February 27, 1956.

II. GROSS ACTIVITY

C. Soils

Graph Three shows the general levels of activity in the soils of Kabelle and Labarejd Islands of Rongelap Atolls, as reported by AFL.[2]

Tables 13, 13a and 14 report the activity in different soils at different depths for the February 1955 survey,[3] Table 15 for the February 1956 survey.

Tables 16 and 17 show the analyses by HASL.[6]

The data clearly indicates the major portion of the activity is to be found in the top three inches of the soil. As suggested in Section III, Ce^{144} - Pr^{144} and Ru^{106} - Rh^{106} make up much of the fixed contamination in the soils at periods of one year and more after the fallout occurred.

TABLE 13

(NRDL)*

Beta Activity in Core Samples of Soil

Island	No. of Cores	Beta Activity (β^-/min/g) 1-in. Increment of Soil Coring								
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Likiep	1	140	40	40	NDA[a]	NDA				
Utirik	3	1,250	480	240	130	100	160	60	25	
Rongelap	4	6,600	2,100	570	420	230	160	200	150	50
Busch	1	10,800	7,100	7,200	6,400	6,800				
Eniaetok	1	57,000	24,000	4,300	18,000	26,000	12,000	11,000		
Labaredj	1	42,000	33,000	29,000	23,000	19,000				
Kabelle	3	43,000	30,000	10,000	3,600	2,000	2,300	180		
Lomuilal	3	53,000	48,000	26,000	20,000	14,000	1,000			
Gejen	1	37,000	37,000	8,000	4,000	4,400	3,400			
Lukuen	2	35,000	40,000	13,000	10,500	10,000	10,000	4,700		
Bikar	3	4,000	740	250	170	120	100	27		
Eniwetak	2	16,000	7,500	3,000	2,000	1,800	1,100	160	100	

(a) No detectable activity

* Collections made about February 1, 1955.
Data reported as of March 1, 1955.

TABLE 13a

(NRDL)*

Summary of Beta Activity in Gross Samples of Soil

Island	Number of Samples	Beta Activity (β^-/min/g) Depth of Soil	
		0 to 1 in.	1 to 5 in.
Likiep	1	90	
Utirik	4	960	550
Rongelap	5	8,900	800
Eniaetok	2	48,000	640
Labaredj	3	85,000	1,300
Kabelle	6	96,000	3,100
Gejen	1	348,000	12,400
Bikar	1	8,400	90
Eniwetak	1	12,000	240

*Collections made about February 1, 1955.
Data reported as of March 1, 1955.

TABLE 14

Beta Activity in Soil Samples Taken From Exposed Soil Profiles (NRDL)*

Depth (in.)	Beta Activity (β⁻/min/g)				
	Island				
	Rongelap	Labaredj	Kabelle	Kabelle	Kabelle
0 to 1	12,400	130,000	72,000	93,000	97,000
3	1,500	380	6,800	2,900	440
6	110	950	1,700	400	130
9	140	770	130	2,300	240
12	NDA (a)	160	40	580	140
18	70	120	70	70	90
24		40	100	70	NDA
30				NDA	
36				60	
40				40	

(a) No detectable activity

*Collections made about February 1, 1955.
Data reported as of March 1, 1955.

TABLE 52

Gross Beta Activity in Water and Soil Samples[a] (NRDL)

	Gejen	Eniwetak	Eniaetok	Rongelap	Sifo	Utirik	Likiep
Source	**WATER[b] (c/m/liter x 10^{-5})**						
Cistern	-	-	-	0.008	-	NDA[c]	-
Well	-	-	NDA	-	-	0.1, 0.03, NDA	NDA
Ocean	NDA	NDA	0.06	0.06	0.09	NDA	0.08
Lagoon	NDA	NDA	NDA	NDA	0.08	0.09	NDA
Depth (in.)	**SOIL[b] (c/m/kg x 10^{-5})**						
0-1	3470	34.8	6.43	7.00	4.97	4.43	NDA
12	-	-	-	0.70	-	-	-
18	0.80	-	NDA	-	-	-	NDA
24	-	NDA	-	-	0.04	0.51	-
33	1.33	-	-	NDA	-	-	-
36	-	-	-	-	-	-	NDA
44-45	-	-	0.07	-	-	-	-
48	-	NDA	-	-	NDA	-	-
55-56	-	-	-	-	-	0.70	-

(a) All counts were corrected for the counting efficiency of Sr^{90}-Y^{90}.

(b) Gross beta activity of plant samples was determined in April 1956 and that of soil and water in May 1956.

(c) NDA indicates no detectable activity.

TABLE 16

HASL Analysis *

SOIL

(AFL Surplus)

HASL No.	Spec. No.	Collection Date	Area Collected	Description	Depth	Beckman MX-5 Reading Surface	3" below	6" below	Total Activity d/m/gram Wet	Dry	Sr-90 d/m/gram Wet	Dry	I Cs Based on Wet Weight	I Cs
3122	A 1	10-21-55	Kabelle Island	Open area - 200 yards from lagoon near mid - island	0 - 3"	3.5/12		0.2 /0.9	15000±225	16300±244	906 ±4.7	548 ±5.1	27	552 ±7.7
3123	A 2	10-21-55	Kabelle Island	Open area - 200 yards from lagoon near mid - island	3 - 6"	3.5/12		0.2 /0.9	617± 90	658± 96	22.7±2.6	24.2±2.8		
3124	A 3	10-21-55	Kabelle Island	Grass area - 20 feet from A 1 and A 2	0 - 3"	2/8		0.2 /0.5	6620±152	7990±182	200 ±3.3	240 ±4.0	29	231
3125	A 4	10-21-55	Kabelle Island	Grass area - 20 feet from A 1 and A 2	3 - 6"	2/8		0.2 /0.5	302±104	329±113	4.7±0.67	5.1±0.73		
3126	A 5	10-21-55	Labaredj Island	Open area - 100 yards from lagoon (high tide mark in SW part of island)	0 - 3"	2/8		0.08/0.5	5470±147	9990±161	188 ±3.4	205 ±3.7		
3127	A 6	10-21-55	Labaredj Island	Open area - 100 yards from lagoon (high tide mark in SW part of island)	3 - 6"	2/8		0.08/0.5	622± 88	678± 97	6.7±0.99	7.3±1.1	31	
3128	A 7	10-21-55	Labaredj Island	Under a tree 15 feet from A 5 and A 6	0 - 3"	0.6/7.0	0.3/1.0	0.07/0.5	7480±129	9490±164	263 ±4.5	334 ±5.7	28	
3129	A 8	10-21-55	Labaredj Island	Under a tree 15 feet from A 5 and A 6	3 - 6"	0.6/7.0	0.3/1.0	0.07/0.5	356± 70	399± 78	4.9±0.97	5.4±0.52		
3130	A 9	10-21-55	Rongelap Island	Grass near well (10 feet W of well)	0 - 3"	0.3/0.9	0.09/0.3	0.05/0.2	3000± 74	4290±104	127 ±2.6	264 ±3.7		
3131	A 10	10-22-55	Rongelap Island	Grass near well (10 feet W of well)	3 - 6"	0.3/0.9	0.09/0.3	0.05/0.2	406± 54	543± 72	11.8±0.68	15.8±0.91	31	17.3±1.1
3132	A 11	10-22-55	Rongelap Island	Papaya cluster (near school house) rocky soil	0 - 3"	0.3/1.0	0.1/0.5	0.1 /0.4	5700± 69	12300±149	212 ±3.3	457 ±7.1	24	471 ±4.3
3133	A 12	10-22-55	Rongelap Island	Papaya cluster (near school house) rocky soil	3 - 6"	0.3/1.0	0.1/0.5	0.1 /0.4	1040± 75	1410±101	32.3±1.0	43.6±1.4	29	30.4±1.5

*Date of counting February 27, 1956.

TABLE 17

Results of Analyses Performed at HASL*

HASL #	SCIL NRDL #	Sampling Location	Depth	C-Date Total Activity	Total Activity d/m/gram*	Sr^{90} d/m/gram*	Cs^{137} d/m/gram*	Ca grams/gram*	S. U.	% Sr^{90}	% Cs^{137}
3482	605	Eniaetok		4-21-56	65± 45	≤0.42		0.318	≤0.60		
3483	606	Eniaetok		4-21-56	≤41	1.6±0.42		0.286	2.6±0.67		
3481	600	Eniaetok		4-14-56	290± 40	20 ±0.8		0.314	29 ±1.2	6.9	
3545	319	Likiep		4-21-56	≤53	≤0.47		0.335	≤0.64		
3547	324	Likiep		4-21-56	≤65	1.2±0.71		0.275	2.0±1.2		
3494	734	Eniwetak		4-21-56	≤61	≤0.58		0.369	≤0.71		
3493	728	Eniwetak		4-14-56	3000± 93	80 ±1.4		0.347	104 ±1.8	2.7	
3463	547	Jegen		4-21-56	120± 69	1.0±0.48		0.348	1.3±0.63	0.8	
3462	842	Jegen		4-14-56	69400±470	1640 ±2.4	1535±60	0.305	2440 ±3.6	2.4	2.2
3530	768	Utirik		4-21-56	≤73	3.4±0.72		0.342	4.6±0.96		
3529	762	Utirik		4-14-56	1600± 92	49 ±1.3		0.281	79 ±0.21	3.1	
3527	532	Sifo		4-21-56	≤57	≤0.55		0.355	≤70		
3526	676	Sifo		4-14-56	620± 79	28 ±1.0		0.353	36 ±1.3	4.5	

* Weight as received at HASL.

*Date of counting February 27, 1956.

II. GROSS ACTIVITY

D. Water

Table Eighteen suggests a relatively high ratio of activity associated with the filtrate which is perhaps not unexpected since the fallout material consisted principally of calcium oxide and calcium carbonate.

Tables Fifteen[4], Eighteen[2] and Nineteen[2] show the gross activity found in water sources. Table Twenty the analyses by HASL.[6]

TABLE 18

Radioactivity of Water Samples, July 1954-October 1955 (AFL)

Values expressed in d/m/liter ±0.95 counting error

Date and Island	Lagoon Water		Island Water		
	Untreated	Treated	Unfiltered	Filtered Filtrate	Filtered Residue
Rongelap Atoll					
7/16/54					
Kabelle	3800±3200				
12/18/54					
Rongelap			3000± 190*	1800±180#	
1/26-30/55					
Eniaetok			17000±2200##		
Kabelle	3300±2700		48000±3200**		
Labaredj	6800±3000		25000±2200##		
Lomuilal	5600±3000				
Rongelap	5600±3000		4200±1800*		
10/21-22/55					
Kabelle	3500±1600	410±150			
Labaredj	600±1500	450±160			
Rongelap	1900±1600	60±120	540±120	310±190	75±17#
			5300±140	4300±200	1200±34*
			1300± 86	850±140	75±19***
Ailinginae Atoll					
10/23/55					
Enibuk	1600±1400	80±130	1400± 91	820±140	820±56##

* from cistern near schoolhouse; # from well back of schoolhouse; ** ground water; ## standing water from can, drum, etc.; *** from cistern with collapsed roof.
Date of analysis: November 18-20, 1955.

TABLE 19

Summary of Gross Beta Activity in Water (NRDL)*

Island	Beta Activity (β^-/min/liter)							
	Sources of Water							
	Ocean		Cistern					
	Lagoon Side	Ocean Side	Top	Bottom	Well	Barrel	Tree Bole	Exposed Soil Profile
Likiep	NDA(a)	NDA	12		NDA			
Utirik	50	NDA	290	1,350	28			
Rongelap	80	330	6,300	16,000	430	44,000		
Busch	36	NDA					14,000	
Eniaetok	460	260	23,000					
Labaredj	7,700	56					8,100	
Kabelle	2,300	60						15,000
Lomuilal	380	170						
Bikar	37	28						
Eniwetak	100	170						

(a) No detectable activity

*Collections made about February 1, 1955.
Data reported as of March 1, 1955.

TABLE 20

Results of Analyses Performed at HASL *

HASL #	WATER NRDL #	Sampling Location	Type	C-Date Total Activity	d/m/l Total Activity *	d/m/l Total Activity **	Sr^{90} d/m/l	Cs^{137} d/m/l	% Sr^{90}	% Cs^{137}
3457	543	Rongelap	Well or Cistern	5-8-56	2500±32	1530±32	590±21	310±20	24	12
3480	599	Eniaetok	Lens	5-8-56		560±23		130±12		
3526	785	Utirik	Well	5-8-56	37±15	≤20		44± 5.2		
3527	787	Utirik	Well	5-8-56	34±15	≤19		35±16		
3528	788	Utirik	Cistern	5-8-56		43±20		49±18		
3520	757	Utirik	Well	5-8-56		28±20		27± 4.6		
3547	330	Likiep	Well	5-8-56	18±16	≤20		34±13		
3458	1003	Rongelap	Lagoon	5-11-56		≤26		35± 5.4		
3459	1036	Gejen	Lagoon	5-11-56		≤21				
3478	1007	Eniaetok	Lagoon	5-11-56		≤20		22±16		
3497	1028	Eniwetak	Lagoon	5-11-56		≤19		32± 5.4		
3509	1023	Sifo	Lagoon	5-11-56		≤20		24±10		
3525	1030	Utirik	Lagoon	5-11-56		≤19				
3546	1032	Likiep	Lagoon	5-11-56		≤20		31±10		
3460	1002	Rongelap	Ocean	5-11-56		49±18		34± 2.2		
3461	1034	Gejen	Ocean	5-11-56		≤18				
3479	1008	Eniaetok	Ocean	5-11-56		≤23		39± 2.2		
3496	1027	Eniwetak	Ocean	5-11-56		25±19				
3510	1024	Sifo	Ocean	5-11-56		≤19				
3524	1029	Utirik	Ocean	5-11-56		≤21		41± 2.2		
3545	1031	Likiep	Ocean	5-11-56		45±19		43± 3.0		

* Sample directly plated

** Sample scavenged with $Fe(OH)_3$.

*Date of counting Februar 27, 1956.

III. RADIOCHEMICAL ANALYSIS

Tables Twenty-one and Twenty-two show the radiochemical analysis made by AFL for the 1954-1955 surveys,[2] and Tables Twenty-three, Twenty-four and Twenty-five for the July 1956 survey.[7] In two pools of 19 and 15 feet fish muscle samples collected in late July 1956 and analyzed by AFL, no radiostrontium was found.

Tables Twenty-six and Twenty-seven show the radiochemical analysis made by NRDL for the February 1955 survey,[3] and Tables Twenty-eight and Twenty-nine, Thirty, Thirty-one, and Thirty-two for the February 1956 survey.[4]

Tables Four, Five, Six, Eleven, Twelve, Sixteen, Seventeen, Twenty, Thirty-three, Thirty-four, Thirty-five and Thirty-six show analyses by HASL.

Cs^{137} accounted for an appreciable portion of activity found in most of the plant life. However, in terms of a potential biological hazard the strontium-90 activity is of most interest.

At one year post detonation NRDL reports: "---In muscle and viscera samples of the animals from Rongelap, Utirik, and Rongerik, Sr^{89} contributes approximately 0.5 percent of the total beta activity. Sr^{90} is present in an approximately 1:1 ratio with Sr^{89}. Since the Hunter and Ballou calculations indicate that Sr^{89} and Sr^{90} each contribute about 2 percent of the total beta activity at one year after fission, there does not appear to be any fractionation of radio-strontium into the soft tissues. As expected, most of the internally deposited radioactivity was found in the skeleton.

"Tissues of a few marine specimen were analyzed for Cs^{137} (37-year half-life) since this nuclide was present in high concentrations in water and coconut milk from this area. The tissues of the rooster and of the coconut crab contain significant amounts of Cs^{137}. A very high fraction of Cs^{137} activity was noted in the muscle of the rooster (40 percent of the total beta). * Further radioanalysis of marine specimen indicated that the rare earth group constituted a few percent of the total beta activity. Ru^{106}-Rh^{106} and Zr^{95}-Nb^{95} contributed the largest percentage of the total beta activity."

The AFL reports:

> "---The Sr^{90} values for food plants, except coconuts, collected in October 1955 approximate the theoretical porportion of mixed fission products activity at 1.7 years, 4 percent. Coconuts contained 0.1 percent Sr^{90} with appropriate correction for time of collection.---
>
> "---In contrast to the strictly marine forms, the coconut crab, which feeds principally on land plants, had Sr^{90} levels of 3 percent in the muscle and 12 percent in the hepato-pancreas or liver, where calcium salts are stored.. The radioisotopes in salts leached from the carapace were found to consist entirely of Sr^{90} - Y^{90}.---
>
> "---Radionuclides of Sr, Cs, Ce and their daughters did not account for the total activity in most (fish) samples analyzed. Complete fission product analyses of samples collected at Eniwetok and Bikini Atolls indicate that non-fission-product radionuclides may account for more than half of the total activity in some fish. Zn^{65} contributes one-fourth or more of the total activity in shark muscle as determined by radiochemical analysis and confirmed by following the decay."
>
> (Zn^{65} is not a fission product.)

The two year survey by NRDL continues to indicate the high

---

* See Section IV

percentage of Zn^{65} in fish. Unlike localization in the liver of mammals, Zn^{65} was found distributed fairly uniformly among the tissues. The Co^{60} found in clams accounted for the major portion of the activity. (The ability of clams to concentrate Co^{60} selectively was verified by laboratory experiments.)

The percentage of calcium in the soils that is available to the plants is not known. The Sunshine Units reported are on the basis that all of the calcium is available. This provides a base line until better knowledge is gained but it is recognized that the correct value for Sunshine Units probably are one to two orders of magnitude higher.

TABLE 21

Radiostrontium, Radiocesium and Radiocerium-Pragseodymium in Biological Samples, December 1954-January 1955 (AFL)

Island	Organism	Percentage of Total Activity Sr^{89}	Sr^{90}	Cs^{137}	$Ce^{144}Pr^{144}$
Rongelap Atoll					
Gejen	#31 coconut milk	<0.1	<0.1	81.	0.0
Kabelle	#37 Caulerpa	-	-	0.0	71.
	#30 coconut milk	-	-	72.	0.0
	#38 Halimeda	-	-	0.0	28.
	#39 coconut crab muscle	0.86	4.8	67.	1.0
	#41 mullet muscle	0.0	0.0	0.0	1.5
Labaredj	#29 coconut milk	<0.5	<0.5	76.	0.0
	#42 tern bone	0.0	0.0	0.0	28.
	#43 tern bone	0.0	0.0	0.0	26.
Mellu	#40 dogtooth tuna muscle	0.0	0.0	4.8	0.6
Rongelap	#27 coconut meat	0.0	0.0	26.	<0.4
	#28 coconut milk	0.0	0.0	78.	<0.2
	#32 pandanus fruit	<0.1	1.3	110.	0.7
	#34 papaya meat	<0.1	2.5	68.	3.7
	#33 squash meat	<0.1	1.5	51.	1.0
	Dates of analysis	June-July 1955		Sept. Oct. 1955	July Aug. 1955

TABLE 22

Sr^{90} in Biological and Lagoon Bottom Samples from Rongelap Atoll, October 1955 (AFL)

Island	Sample		Total Activity d/m/g*	Sr^{90}, Percent of Total Activity
Rongelap	coconut meat		110	0
	pandanus fruit		180	2.1
	morinda "		47	4.6
Labaredj	arrowroot corm		40	3.2
Kabelle	coconut crab muscle		440	2.9
	" " "liver"		1,200	12.
	" " salts of carapace			50.
	" " cuticle " "			29.
Labaredj	giant clam mantle and muscle		1,700	0
	" " kidney		5,200	0
Labaredj	bonito muscle		150	0
	" liver		1,700	0
	" bone		390	<0.6
Kabelle	grouper muscle		31	0
	" liver		5,500	0
	goatfish muscle		42	0
Labaredj	tern muscle		61	0
Kabelle	lagoon bottom, depth of water 6', fraction containing particles <0.074 mm diameter.	top inch	40,000	0.73
		7th inch	25,000	0.71

* Wet weight basis except lagoon bottom which is on a dry weight basis.

TABLE 23

Radiostrontium in Plants Collected at Rongelap Atoll July 23-24, 1956

Counted September 4, 1956 (AFL)

Sample No.	Plant	Tissue	Island	Total activity d/m/g wet	Sr^{90} d/m/g wet	Calcium g/g wet	"Sunshine units"	$Sr^{89}:Sr^{90}$
Ro 1	Breadfruit	Pulp	Rongelap	42.0	0.82 ± 0.03	0.000628	591 ± 70	1.77 ± 0.10
Ro 8	Morinda	Pulp & Seed	"	80.4	3.1 ± 0.1	0.00136	694 ± 0	3.68 ± 0.22
Ro 15	Pandanus	Seed	"	79.7	2.2 ± 0.6	0.00450	150 ± 44	0.76 ± 0.06
Ro 12	Arrowroot	Pulp & Skin	"	108	2.5 ± 0.6	0.00333	294 ± 39	1.48 ± 0.05
Ro 7	Coconut	Milk	"	262	0			
Ro 6	"	Meat	"	64.6	0			
Ro 21	"	Milk	Kabelle	36.9	0			
Ro 20	"	Meat	"	148	0			

Note: Specimen numbers will be forwarded later.

TABLE 24

Radiostrontium in Land Hermit Crabs (Cenobita sp.)
Collected at Rongelap Atoll July 23-24, 1956 (AFL)

Radioactivity as of Counting Date, September 10, 1956

Specimen Number	Tissue	Island	Total β activity d/m/g wet	Sr^{90} d/m/g wet	Calcium g/g wet	"Sunshine units"	$Sr^{89}:Sr^{90}$
I-49	Liver	Kabelle	243	42±2	0.00304	6250±231	1.6±0.3
"	Muscle	"	434	62±22	0.00320	8890±3110	0.0
"	Skeleton	"	5410	2400±9	0.206	5310±19	0.24±0.02
I-50	Liver	Kabelle	633	47±14	0.00718	3110±946	3.6±1.6
"	Muscle	"	273	24±6	0.00223	4910±1170	2.4±0.75
"	Skeleton	"	4100	1310±3	0.202	2960±7	0.58±0.16
I-51	Muscle	Kabelle	444	90±6	0.00919	5120±382	0.71±0.05
"	Skeleton	"	5600	2130±130	0.189	4440±158	0.32±0.04
I-52	Skeleton	Rongelap	3900	1310±5	0.177	3360±14	0.48±0.14

TABLE 25

Radioactivity in the Top Two Inches of Soil

Collected at Rongelap Atoll July 23-24, 1956

Counted September 26, 1956 (AFL)

Count Date HASL	Specimen Number	Island	β Total activity d/m/g wet	Sr^{90} (Wet) d/m/g	Calcium g/g dry	"Sunshine units"	$Sr^{89}:Sr^{90}$
9/26	5562	Rongelap	7750	230 ± 12	0.437	364 ± 20	0.30 ± 0.02
9/26	5543	Kabelle	58700	1738 ± 34	0.423	2511 ± 48	0.10 ± 0.01

TABLE 26

Radiochemical Composition of Residual Contamination (NRDL)*

Material	Percentage of Total Activity Observed[a]					
	Radionuclides					
	Sr^{89}	Sr^{90}	Rare Earths	Zr^{95}[b]	Ru^{106}[b]	Cs^{137}
Arrowroot	1.3	5.9	3.0	0.5	7.8	80
Breadfruit	NDA[c]	6.3	50	19	NDA	24
Coconut Frond	1.2	5.0	80	4.2	6.7	1.6
Coconut Meat	NDA	NDA	1.2	NDA	NDA	95
Coconut Milk	NDA	NDA	0.9	NDA	NDA	96
Grass	1.3	4.6	74	6.4	4.8	8.4
Pandanus	0.5	2.4	1.2	0.2	0.6	95
Papaya	1.6	7.3	37	31	12	11
Coral	3.2	14	67	10	4.5	1.1
Soil	0.8	2.2	73	0.1	23.3	1.1
Lagoon Bottom	1.1	5.0	82	0.2	13	NDA
Cistern Water	2.9	8.6	41	24	20	13
Ground Water	0.8	2.5	49	20	16	9.2
Lagoon Water	0.9	4.0	76	9.7	7.0	0.8

(a) Values as of 15 July 1955 (16 mos after the nuclear detonation).
(b) Nb^{95} and Rh^{106} may be calculated from the reported parent values.
(c) No detectable activity.

*Collections made about February 1, 1955.

TABLE 27

Radiochemical Analysis of Fish and Chicken (NRDL)*

Island	Fish	Weight (g)	Tissue	Total Beta Activity ($d/m \times 10^{-3}$)	Percentage of Total Beta Activity					
					Sr^{89}	Sr^{90}	Rare Earths	Cs^{137}	Ru^{106}-Rh^{106}	Zr^{95}
Rongelap Atoll										
Rongelap Lagoon	Pelargic Snapper	503	Viscera	82	1.2	1.0	3.2	0.07		
			Gill	3	0.4	0.3	3.2			
			Muscle	20	0.2	0.2	-(a)			
	Flat Fish	597	Muscle	40	0.6	0.5	5.6			
			Viscera	585	0.1	0.1	18		14.2	61
Gejen	Coconut Crab	1008	Muscle	175	0.2	0.2	1.3			
			Viscera	225	0.7	0.6	1.9	2.1		
	Spider Snail	26	Total Body	1204	0.1	0.1	7.8			
	Spider Snail	11	Total Body	432	0.1	NDA(b)	1.9		5.3	65
	Red Eye Crab	30	Total Body	29	1.1	0.8	1.6	1.0		
Labaredj	Killer Clam	230	Total Body	60	0.2	0.2	2.5			
Rongelap	ROOSTER	1140	Muscle	11	-	-	2	40		
			Viscera	23	0.6	0.5	14			
			Liver	7	2.0	1.6	4			
			Skin	12	1.3	1.0	51			
			Tibia	101	0.2	0.2	1.4	1.0		
Utirik Atoll										
Utirik	Eel	24	Total Body	1	1.1	0.9	11			
	Butterfly Fish	185	Total Body	7	-	-	-			
Rongerik Atoll										
Eniwetak	Mullet	230	Muscle	7	0.8		8.2			
			Viscera	100	0.2	0.2	39	0.04		

(a) No data taken.

(b) No detectable activity.

*Collections made about February 1, 1955.
Data reported as of April 1, 1955.

TABLE 28

Radiochemical Analysis of Biological Specimens from Rongelap Atoll

Sample No.	Sample	Tissue	Wet Wt. (g)	Ca (mg)	Beta Activity (d/m/sample x 10^{-4})	Gamma Activity d/m/sample x 10^{-4})	Nuclide	Nuclide Activity d/m/sample x 10^{-4})	Per Cent of Total Activity	Sunshine Units
1509	Killer Clam	Soft Tissue	1800	743	20	33	R.E.	NDA	0	
							Sr^{90}	2.4 ± 0.69	0.12	146 ± 42
							Co^{60}	2090	63.4	
1513	Killer Clam	Soft Tissue	882	1565	31	83	R.E.	77	2.5	
							Sr^{90}	83.8 ± 0.90	2.7	2436 ± 31
							Co^{60}	7370	89	
1520A	Langousta Crab	Soft Tissue	79	330	1.3	2.1	R.E.	26	20	
							Sr^{90}	NDA	0	0
1520C	Red Eye Crab	Soft Tissue	57	2343	0.75	3.8	R.E.	37	49	
							Sr^{90}	0.13 ± 0.07	0.2	3 ± 1
1520D	Red Spotted Crab	Soft Tissue	73	2900	0.75	0.43	R.E.	15	20	
							Sr^{90}	1.28 ± 0.18	1.7	20 ± 3
1520B	Coconut Crab	Soft Tissue	114		3.5	3.1	Cs^{137}	26	7.4	
							R.E.	0.58	16.5	
Kabelle Island										
1538	Snapper Fish	Muscle	281	85	0.95	0.69	R.E.	4.1	4.2	
							Sr^{90}	NDA	0	0
							Zn^{65}	58	84.2	
		Skin	89	987	1	4.1	R.E.	2.4	2.4	
							Sr^{90}	0.53 ± 0.76	0.5	24 ± 34
							Zn^{65}	380	92.7	

(Continued)

TABLE 28 (Continued)

Radiochemical Analysis of Biological Specimens from Rongelap Atoll

Sample No.	Sample	Tissue	Wet Wt. (g)	Ca (mg)	Beta Activity (d/m/sample x 10^{-4})	Gamma Activity (d/m/sample x 10^{-4})	Nuclide	Nuclide Activity (d/m/sample x 10^{-4})	Per Cent of Total Activity	Sunshine Units[a]
		Gill	28	403	1.7	2.1	R.E.	NDA	0	
							Zn^{65}	210	100	
1630	Grouper Fish	Whole	169	2190	1.8	77.9	R.E.	13.3	7.4	
							Sr^{90}	1.7 ± 0.92	0.1	35 ± 18
							Zn^{65}	6230	80	
1629	Sand Crab	Soft Tissue	46	1090	1.3	2.3	R.E.	0.8	0.6	
							Sr^{90}	4.72 ± 0.59	2.0	196 ± 25
1637	Spider Snail	Soft Tissue	90	713	18.7	18	Ru^{106}	360	19.2	
							R.E.	1210	65	336 ± 30
							Sr^{90}	5.28 ± 0.47	0.3	
1638	Spider Snail	Soft Tissue	56	175	102	68	R.E.	11900	116	
							Sr^{90}	1.95 ± 0.60	0.02	502 ± 331

(a) Sunshine Unit = 0.001 μc Sr^{90}/kg Ca.

(b) R.E. = Rare Earth Group.

(c) NDA = No Detectable Activity.

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TABLE 29

Radiochemical Analysis of Biological Specimens from Rongelap Atoll (NRDL)

Sample No.	Sample	Tissue	Wet Wt. (g)	Ca (mg)	Beta Activity (d/m sample $\times 10^{-4}$)	Gamma Activity (d/m/sample $\times 10^{-4}$)	Nuclide	Nuclide Activity (d/m/sample $\times 10^{-4}$)	Per Cent of Total Activity	Sunshine Units(a)
Rongelap Island										
1502C	Goat Fish	Bone	29	860	1.5	217	R.E.(b)	NDA(c)	0	
							Sr^{90}	11 ± 1.7	7.3	587 ± 90
							Zn^{65}	240	89	
		Viscera	10	37.5	4.9	2.8	R.E.	0.68	0.14	
							Sr^{90}	NDA	0	0
							Zn^{65}	250	89.3	
		Skin	28	337	0.2	2.4	R.E.	2.5	12.5	
							Sr^{90}	0.34 ± 0.26	1.7	45 ± 34
							Zn^{65}	230	95.8	
		Muscle	87	111	1.1	2.1	R.E.	NDA	0	
							Sr^{90}	0.46 ± 0.76	0.4	189 ± 313
							Zn^{65}	190	90.6	

(Continued)

(a) Sunshine Unit = 0.001 μc Sr^{90}/kg Ca.
(b) R.E. = Rare Earth Group
(c) NDA = No Detectable Activity

TABLE 29 (continued)

Radiochemical Analysis of Biological Specimens from Rongelap Atoll

Sample No.	Sample	Tissue	Wet Wt. (g)	Ca (mg)	Beta Activity (d/m/sample x 10^{-4})	Gamma Activity (d/m/sample x 10^{-4})	Nuclide	Nuclide Activity (d/m/sample x 10^{-4})	Per Cent of Total Activity	Sunshine Units[a]
		Viscera	258	11450	5	8.8	R.E.	NDA	0	
							Sr^{90}	2.5 ± 1.38	0.3	10 ± 5
							Zn^{65}	820	93	
737	Helmet Snail	Soft Tissue	271	224	4.8	11.9	R.E.	59	12.3	
							Sr^{90}	1.36 ± 0.34	0.3	276 ± 69
							Zn^{65}	1090	91.6	
Gejen Island										
1621	Snapper Fish	Head	219	3250	6.6	24.7	R.E.	NDA	0	
							Sr^{90}	1.65 ± 2.4	0.2	23 ± 33
		Skin	73	1315	1.0	11.8	R.E.	NDA	0	
							Sr^{90}	0.68 ± 0.48	0.7	24 ± 16
		Bone	173	3270	5.5	15.7	R.E.	NDA	0	
							Sr^{90}	1.5 ± 0.44	0.3	21 ± 6
							Zn^{65}	1540	98	
		Muscle	511	190	5.4	16.8	R.E.	3.5	0.7	
							Sr^{90}	0.22 ± 0.35	0.04	53 ± 88
							Zn^{65}	1600	95	
		Viscera	87		6.1	15.9	R.E.	11	1.8	
							Sr^{90}	1.2 ± 0.29	0.2	
							Zn^{65}	1480	93	

(Continued)

TABLE 29 (continued)

Radiochemical Analysis of Biological Specimens from Rongelap Atoll

Sample No.	Sample	Tissue	Wet Wt. (g)	Ca (mg)	Beta Activity (d/m/sample x 10^{-4})	Gamma Activity (d/m/sample x 10^{-4})	Nuclide	Nuclide Activity (d/m/sample x 10^{-4})	Per Cent of Total Activity	Sunshine Units[3]
		Bone	141	1842	2.4	4.4	R.E.	19	7.9	
							Sr^{90}	3.0 ± 0.36	1.2	73 ± 8
							Zn^{65}	440	100	
		Viscera		2413	2.7	6.3	R.E.	120	44	
							Sr^{90}	7.85 ± 0.94	2.9	147 ± 18
							Zn^{65}	530	84.2	
1540	Grouper Fish	Whole	176	1630	0.75	6	R.E.	NDA	0	
							Sr^{90}	0.79 ± 0.17	1.0	22 ± 4
							Zn^{65}	580	97	
1544	Parrot Fish	Bone	449	1905	7.0	23.4	R.E.	5	0.7	
							Sr^{90}	13.7 ± 1.0	2	326 ± 22
							Zn^{65}	1870	79.8	
		Gill	56	428	0.83	2.7	R.E.	3.9	4.7	
							Sr^{90}	0.55 ± 0.44	0.7	58 ± 46
							Zn^{65}	180	66.8	
		Head	280	7920	8.5	20.9	R.E.	3.7	0.4	
							Sr^{90}	0.97 ± 0.52	0.1	6 ± 3
							Zn^{65}	1670	80	

(Continued

TABLE 30

Average Relative Composition of Nuclides in Plants, Soil, and Water (NRDL)

Source		No. of Samples Averaged	Relative Composition (per cent) Cs^{137}	Total Rare Earths	Sr^{90}	Ru^{106}
Plant	**Part**	**PLANTS**				
Portulaca	Whole	1	48.9	39.2	11.8	-
Papaya	Fruit	1	79.8	17.8	2.5	-
Coconut	Husk	3	98.2	1.1	0.7	-
	Meat	2	98.9	0.05	1.0	-
	Shell	2	99.5	0.4	0.1	-
	Milk	1	99.6	0.2	0.2	-
	Leaves	2	8.3	86.5	0.4	5.1
Pandanus	Keys	2	92.6	2.2	5.5	-
	Leaves	2	72.7	13.3	5.1	8.9
	Air Root	2	88.9	10.3	0.8	-
Arrow Root	Tuber	1	75.4	16.8	1.0	6.8
	Leaves	1	11.7	83.9	3.0	1.4
		SOIL				
Depth, 0-1 in.		2	0.34	83.8	5.6	10.0
Source		**WATER**				
Cistern		2	-	64.4	35.6	-
Well		2	-	100	0	-
Lagoon		2	-	94.5	5.5	-
Ocean		2	-	100	0	-

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TABLE 31

Sunshine Units of Plant, Water and Soil Samples

Sample	Island	PLANTS Sample Weight (g)	Calcium Content (mg)	Sr^{90} (d/m/sample)	Sunshine Units (2.2 d/m Sr^{90}/g Ca)
Portulaca	Eniaetok	223	178	10000 ± 100	2.58×10^4 ± 250
	Gejen	23	398	5380 ± 106	6140 ± 120
Papaya	Rongelap	240	338	240 ± 33	322 ± 44
Coconut Husk	Rongelap	200	162	340 ± 28	950 ± 76
	Eniaetok	23	58	150 ± 24	1200 ± 190
	Gejen	360	47	420 ± 24	4060 ± 240
Coconut Meat	Rongelap	450	28	110 ± 60	1801 ± 960
	Eniaetok	160	40	18 ± 29	200 ± 320
	Gejen	190	20	28 ± 23	635 ± 520
Coconut Shell	Eniaetok	90	16	25 ± 18	706 ± 500
	Eniaetok	120	8	NDA[a]	0
	Gejen	85	23	NDA	0
Coconut Milk	Gejen	140	20	41 ± 21	955 ± 500
Coconut Leaves	Eniwetak	35	69	197 ± 37	1300 ± 250
	Utirik	36	163	NDA	0
Coconut, Whole	Gejen	170	19.5	157 ± 22	3600 ± 520
Arrowroot Tuber	Eniaetok	305	1140	250 ± 26	103 ± 10
	Sifo	280	383	73 ± 16	86 ± 19
	Gejen	103	114	196 ± 35	780 ± 140
Arrowroot Leaves and Stalks	Gejen	15	385	290 ± 44	340 ± 50
Pandanus Keys	Eniaetok	180	86	1060 ± 50	5600 ± 280
	Eniaetok	215	134	420 ± 44	1400 ± 150
Pandanus Leaves	Eniaetok	10	65	460 ± 41	3200 ± 300
	Gejen	32	43	NDA	0
Pandanus Air Root	Eniaetok	46	23	20 ± 33	390 ± 650
	Gejen	30	14	105 ± 27	3360 ± 840

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TABLE 32

Sunshine Units of Plant, Water and Soil Samples

Sample	Island	Calcium in kg of Soil (g)	Sr^{90} (d/m/liter)	Sunshine Units (2.2 d/m Sr^{90}/g Ca)
		SOILS		
Depth, (0-1 in.)	Rongelap	316	$3.3 \times 10^4 \pm 1.3 \times 10^3$	47 ± 2
	Gejen	341	$5.26 \times 10^6 \pm 5.2 \times 10^3$	$7 \times 10^3 \pm 70$
	Eniaetok	352	$2.1 \times 10^4 \pm 2.2 \times 10^3$	28 ± 3
	Sifo	350	$1.3 \times 10^4 \pm 1.0 \times 10^3$	17 ± 1
	Eniwetak	360	$5.8 \times 10^4 \pm 2.3 \times 10^3$	73 ± 3
	Utirik	268	$4.8 \times 10^4 \pm 3.0 \times 10^3$	92 ± 6
		WATER		
		Calcium in Liter (mg)	Sr^{90}(d/m/liter)	
Cistern	Rongelap	48	1180 ± 10	$1.1 \times 10^4 \pm 230$
	Utirik	61	20 ± 14	147 ± 104
Well	Utirik	88	39 ± 10	201 ± 54
	Utirik	80	NDA	0
	Eniaetok	2300	NDA	0
Ocean	Rongelap	352	NDA	0
	Utirik	408	NDA	0
	Eniwetak	402	NDA	0
Lagoon	Rongelap	456	190 ± 68	188 ± 68
	Eniwetak	137	NDA	0
	Utirik	441	204 ± 150	208 ± 150

(a) NDA indicates no detectable activity

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Table 33 - See Table 4

Table 34 - See Table 5

Table 35 - See Table 11

TABLE 36

[illegible] - FORT SHAFTER BIKINI ATOLL ISLAND SURVEY SAMPLES (HASL)

	HASL Number	USAFL Number	Organism	Tissue	Sampling Location Island	Collection Date	No. Days	Lab	Total Activity (β) C-Date	Total Activity (β) d/m/g-wet	Sr^{90} d/m/g-wet	Ca gm/g-wet	S.U.
Invertebrates	5042	I-9	Holothurai atra	gonad	Rongelap	7-23-56		* I,Inc.	10-10-56	46	2.7 ± 0.14	0.00566	210 ± 11
	5043	I-10	Holothurai atra	gut & content	Rongelap	7-23-56		I,Inc.	10-10-56	31	incomplete	0.155	incomplete
	5044	I-11	Holothurai atra	integument	Rongelap	7-23-56		I,Inc.	10-10-56	10	incomplete	<0.00101	incomplete
	5045	I-12	Tridacna gigas	muscle	Kabelle	7-24-56		I,Inc.	10-10-56	2.6	0.030 ± 0.016	<0.00239	Σ6
	5046	I-13	Tridacna gigas	muscle	Kabelle	7-24-56		I,Inc.	10-10-56	1.5	incomplete	0.00400	incomplete
	5047	I-49a	Conchita	muscle	Kabelle	7-24-56		HSE			No - Wet - Weight - Data		4600 ± 300
	5048	I-49b	Conchita	skeleton	Kabelle	7-24-56		HSE			" " " "		3940 ± 170
	5049	I-49c	Conchita	liver	Kabelle	7-24-56		HSE			" " " "		4400 ± 300
	5050	I-50a	Conchita	skeleton	Kabelle	7-24-56		HSE			" " " "		2190 ± 80
	5051	I-50b	Conchita	liver	Kabelle	7-24-56		HSE			" " " "		2020 ± 130
	5052	I-50c	Conchita	muscle	Kabelle	7-24-56		HSE			" " " "		2860 ± 170
	5053	I-52	Conchita	skeleton	Rongelap	7-23-56		HSE			" " " "		2200 ± 120
	5054	I-51	Conchita	skeleton	Kabelle	7-24-56		HSE			" " " "		3600 ± 150
Fish	5036	F-36a	Reef fish	muscle	Rongelap	7-23-56	19	HSE		12	0.036 ± 0.003	0.000808	70 ± 1.9
	5038	F-36b	Reef fish	bone	Rongelap	7-23-56	19	HSE		31	1.9 ± 0.082	0.0711	12 ± 0.5
	5037	F-36c	Reef fish	liver	Rongelap	7-23-56	19	HSE		230 c.o.s	residue ± 0.012	0.000990	[illegible] 27 ± 3
	5039	F-51a	Reef fish	muscle	Kabelle	7-24-56	15	I,Inc.	10-10-56	2.9	0.027 ± 0.004	0.00125	9.8 ± 1.6
	5039	F-51b	Reef fish	muscle	Kabelle	7-24-56	15	I,Inc.	10-10-56	0.39	0.401 ± 0.007	0.00104	175 ± 3
	5040	F-51b	Reef fish	bone	Kabelle	7-24-56	15	I,Inc.	10-10-56	0.66	0.106 ± 0.014	0.0744	0.65± 0.09
	5041	F-51d	Reef fish	liver	Kabelle	7-24-56	15	I,Inc.	10-10-56	7.2	0.061 ± 0.041	<0.00485	Σ6
Land Plants	5081	RP- 1	Breadfruit	meat	Rongelap	7-23-56		HSE		31	0.26 ± 0.008	0.000847	260 ± 10
	5085	RP- 2	Papaya	seeds	Rongelap	7-23-56		I,Inc.	10-11-56	0.86	0.38 ± 0.01	<0.00208	Σ 86
	5086	RP- 2	Papaya	seeds	Rongelap	7-23-56		HSE		28	0.38 ± 0.002	0.00237	74 ± 4
	5087	RP- 6	Coconut	meat	Rongelap	7-23-56		I,Inc.	10-10-56	0.36	0.033 ± 0.003	<0.000376	Σ41
	5088	RP- 7	Coconut	milk	Rongelap	7-23-56		HSE		66(44ml)	0.034 ± 0.004(ml)	0.000277(gm/ml)	58 ± 7
	5034	RP- 8	Marinda	pulp & seeds	Rongelap	7-23-56		HSE		46	1.4 ± 0.048	0.000659	1000 ± 50
	5089	RP-12	Arrowroot	corm	Rongelap	7-23-56		I,Inc.	10-10-56	0.16	0.27 ± 0.004	0.000642	190 ± 3
	5030	RP-16	Pandanus	fruit	Rongelap	7-23-56		HSE		63	1.2 ± 0.041	0.00108	530 ± 20
	5031	RP-20	Coconut	meat	Kabelle	7-24-56		I,Inc.	10-10-56	0.56	0.15 ± 0.003	<0.000250	Σ 272
	5032	RP-21	Coconut	milk	Kabelle	7-24-56		HSE		145	1.9 ± 0.076	0.000474	1790 ± 120
	5033	RP-22	Papaya	fruit	Rongelap	7-23-56		I,Inc.	10-10-56	0.40	0.37 ± 0.006	0.000636	268 ± 4

	HASL Number	USAFL Number	Type	Island Location	C-Date	Area	Lab	Total Activity (β) C-Date	Total Activity (β) d/m/l	Sr^{90} d/m/l
Water	3014		Cistern	Rongelap	7-27-56	Village	I,Inc.	8-7-56	31,000 (after filtering twice)	
	3015		Well	Rongelap	7-23-56	Village	I,Inc.	8-7-56	22,000 (after filtering twice)	7700 ± 300

	HASL Number	USAFL Number	Sampling Location	Collection Date	Depth	Area	Lab	Total Activity (β) C-Date	Total Activity (β) d/m/gm-wet	Sr^{90} d/m/gm-wet	Sr^{90} d/m/ft²	Sr^{89}/Sr^{90}	Total Ca gm/gm-wet	Minimum S.U.
Soil	3002		Kabelle	7-24-56	0-2"	(first cut)	HASL	8- 4-56	1980 ± 80	150 ± 3.7		0.07	0.29	
							I,Inc.	8-29-56	1820	155 ± 4.1			0.31	220 ± 6
	3003		Kabelle	7-24-56	2-4"	(first cut)	HASL	8- 4-56	406 ± 45					
							I,Inc.	8-29-56	471	40 ± 0.41			0.32	55 ± 0.6
	3004		Kabelle	7-24-56	4-6"	(first cut)	HASL	8- 4-56	± 40					
							I,Inc.	8-29-56	106	1.5 ± 0.07			0.35	8.0 ± 0.9
	3007		Kabelle	7-24-56	0-2"	(second cut)	HASL	8- 4-56	4210 ± 110	250 ± 4.9		0.16	0.37	
							I,Inc.	8-30-56	5940	265 ± 1.2			0.36	330 ± 2
	3006		Kabelle	7-24-56	2-4"	(second cut)	HASL	8- 4-56	3500 ± 102	58 ± 2.9		0.07	0.35	
							I,Inc.	8-30-56	1705	96 ± 1.7			0.35	125 ± 2
	3005		Kabelle	7-24-56	4-6"	(second cut)	HASL	8- 4-56	1160 ± 62	54 ± 2.8		0.08	0.56	
							I,Inc.	8-30-56	651	30 ± 0.57			0.34	40 ± 1.3
	3008		Rongelap	7-23-56	0-2"	100' fr. lagoon village area	HASL	8- 4-56	266 ± 52					
							I,Inc.	8-30-56	152	10 ± 0.40			0.36	13 ± 1.1
	3009		Rongelap	7-23-56	2-4"	100' fr. lagoon village area	HASL	8- 4-56	± 39					
							I,Inc.	8-30-56	79.2	4.5 ± 0.1			0.35	5.8 ± 0.4
	3010		Rongelap	7-23-56	4-6"	100' fr. lagoon village area	HASL	8- 4-56	± 45					
							I,Inc.	8-30-56	54.9	0.98± 0.03			0.32	1.4 ± 0.04
	3013		Rongelap	7-23-56	0-2"	mid island	HASL	8- 4-56	1220 ± 58	68 ± 2.8		0.06	0.20	
							I,Inc.	8-30-56	663	31 ± 0.21			0.32	44 ± 0.5
	3012		Rongelap	7-23-56	2-4"	mid island	HASL	8- 4-56	134 ± 51					
							I,Inc.	8-30-56	106	4.0 ± 0.2			0.35	5.2 ± 0.3
	3011		Rongelap	7-23-56	4-6"	mid island	HASL	8- 4-56	± 37					
							I,Inc.	8-30-56	54.9	0.98 ± 0.03			0.32	1.4 ± 0.1
	3018		Parry	7-25-56	surface	shore	HASL	8- 4-56	17900 ± 203	7.6 ± 2.0		8.7	0.30	
	3019		Parry	7-25-56	sub-surface	shore	HASL	8- 4-56	103 ± 39					

* As of 9-20-56

* Isotopes, Incorporated, Westwood, N. J.

** Nuclear Science and Engineering, Pittsburgh, Pa.

Counting Date September - October 1956.

IV. INTERNAL CONTAMINATION OF ANIMALS

At the time of the fallout on Rongelap Island there were a variety of animals present. These were left to live on the Island, and representative numbers were collected on the 8th, 25th, 33rd, and 51st-53rd days and then sacrificed. Tables Thirty-seven, Thirty-eight, and Thirty-nine, show the relevant data concerning external doses to the animals while living on the Island, and an analysis of their internal contamination.[8]

Over 90 percent of the activity in the body of animals was in the skeleton. At 82 days past detonation, 62 percent of the skeletal beta activity of the pigs was due to Sr^{89}, seven percent Ba^{140}, and 10 percent rare earth group. However, it was reported that "---In the six months period post detonation neither significant gross changes nor pathological changes which could be definitely ascribed to radiation were detected in any of the animals."[8]

Table Forty shows the activity of a rooster and rats collected two years post detonation.[6] The gross activity in the rooster was 40 percent of that of a rooster from the same locality at one year post detonation. About 86 percent of the total body activity was in the skeleton.

Since these animals represented interesting cases of living continuously in a heavily contaminated environment, an analyses was made later of some rats and a rooster collected at the two year period (Table Forty-one).[9] These data are obviously not complete nor precise but do indicate the relatively low body burden of strontium-90.

TABLE 37

Mortality and External Radiation Dose of Animals from the Living Areas of Groups I and IV

External dose (**Day of Collection) / Animals	Series A 280 r (Day 8)			Series B 330 r (Day 25)			Series C 340r (Day 33)			Series D 360 r (Day 51-53)			TOTAL		
	Total Rec'd	Dead	Sac'd	Total Rec'd	Dead	Sac'd	Total Rec'd	Dead	Sac'd	Total Rec'd	Dead	Sac'd	Total Rec'd	Dead	Sac'd
Hens	6	1 Day 23	1 Day 23				20	2 Day 42 Day 43	2 Day 44	11	5 Day 67 #36 74 #39 92 #35 99 #7 130 #24		37	8	3
Roosters	1						2	1 Day 49		1			4	1	
Chicks							9	9					9	9	
Ducks							4		1 Day 56				4		1
Pigs	1		1 Day 45	7		4 Day 38 Sow 57 #6 82 #24 82 #25				3*			11		5
Cat	1												1		
													66	18	9

* Animals from Group IV area; all others from Group I area (Group IV area animals rec'd 32 r external dose).

** Day Post Detonation

TABLE 38

Beta and Gamma Activity of Chickens from Group I Area
(uc x 10^4)

	Hen #1		Hen #2		Hen #39		Hen #36	Hen #35		Hen #7		Hen #24	
Day of death**	Day 23		Day 23		Day 74		Day 97	Day 121		Day 138		Day 159	
Day analyzed**	Day 24		Day 24		Day 79		Day 107	Day 122		Day 140		Day 159	
Tissue	Beta	Gamma	Beta	Gamma	Beta	Gamma	Beta Gamma	Beta	Gamma	Beta	Gamma	Beta	Gamma
Tibia	7600	3850	8180	4610	133	695	253	21[illegible].5	59	41.3	31.3	33.2	8.1
Skeleton	11030	55800	11900	66900	1930	8600	3670*	3120	850*	600	454*	437	117.5*
Liver	119	21	352	271	12	72	34	32	33	17.7	13.5	10.7	1.8
Gizzard					4.1	17	7.0	8.5	7.6	10.3	7.9	3.6	0.6
Gizzard (content)					0.93	-	-	1.4	-	7.5	1.2	0	0.3
Crop					0.43	5.0	2.0	7.9	-	12.2	9.3	4.5	0
Intestine (L) and contents					0.63	10.0	3.0	6.3		14.0	10.7	8.9	.29
Intestine (S) and contents					1.6	4.0	3.0		-	8.4	6.4		
Pancreas					0.16	-	-	-	-	-	-	0.75	0
Spleen					-	-	1.0	-	-	-	-	0.26	-
Kidney	198	46			1.17	9.0	9.0	12.2	10.0	14.9	12.4	0.79	0.23
Lungs (Alveoli)	17	28	0	26	0.57	4.0	2.0	1.4	4.5	5.6	4.3	16.8	0.83
Trachea					0.24	2.0	1.0	10.7	3.7	0.9	0.2	-	-
Turbinates					3.87	19	22	15.3	7.6	-	-	-	-

*Calculated using ratio of gamma activity skeleton/tibia
**Day post detonation

TABLE 39

Radiochemical Analysis of Tissues and Urine of Pigs from Group I Area on 82nd Day Post-Detonation

Sample	Beta Activity - d/m/total sample			
	Gross Activity x 10-3	Sr^{89} x 10^{-3}	Ba^{140} x 10^{-3}	Total Rare Earth x 10^{-3}
Pig #24 (25.8 kgm)				
Skeleton (total)	8890	5660	660	1010
Liver	31	0.40	0.33	6.4
Colon & Contents	12	5.0	2.4	3.2
Lung (Alveolar)	1.5	0.22	0.20	0.8
Stomach	1.2	0.22	1.1	1.3
Intestine (Small)	2.3	0.62	0.50	0.51
Kidney	3.3	0.21	0.42	0.74
Remaining Tissues	690	-	-	-
Total	9630	5667	665	1020
Urine Sample, 24 hr	13	8.7	1.2	1.6
Pig #25 (22.7 kgm)				
Skeleton (total)	8600	5100	530	690
Liver	27	0.53	0.20	5.5
Colon & Contents	16	5.0	3.2	4.9
Lung (Alveolar)	1.1	0.26	0.23	0.33
Stomach	2.0	0.29	0.13	0.30
Intestine (Small)	2.6	0.83	0.88	0.88
Kidney	3.1	0.14	0.19	0.52
Remaining tissues	220	-	-	-
Total	8870	5107	534	702
Urine Sample, 24 hrs	6.2	4.4	0.40	0.54

SUMMARY

Gross Beta Activity	Skeleton	Total Body	Urine (24 hrs.)
Sr 89	62.0	58.0	69.0
Ba 140	6.8	6.5	7.9
Rare Earth	9.7	9.0	10.5
	78.5	73.5	87.4

All values corrected for decay.

TABLE 40

Summary of Gross Beta and Gamma Activity in Rongelap Island Animals (NRDL)

Sample	No. of Samples	Average Weight (g)	Radioactivity			
			Beta		Gamma	
			(d/m/sample x 10^{-4})	(d/m/kg x 10^{-4})	(d/m/sample x 10^{-4})	(d/m/kg x 10^{-4})
Rooster	1	2250				
Skeleton		560	52	93	101	181
Muscle		1050	5.1	4.9	6.9	6.6
Gastrointestinal Tract		185	0.8	4.3	1.6	8.7
Liver		192	2.4	12.5	9.4	49.0
Respiratory Tract		32	0.2	8.7	0.4	17.4
Total Activity			60.5		119.3	
Rats	4	62.9				
Skeleton		4.1	0.73	179	0.15	35.5
Head		5.4	0.15	36	0.1	18
Muscle		39	0.03	7.5	0.04	10.2
Gastrointestinal Tract		10	0.32	32.0	0.27	27
Liver		3.6	0.08	21.7	0.06	15.6
Respiratory Tract		0.5	0.03	62.0	0.02	36.0
Total Activity			1.34		0.64	

February 1956

TABLE 41

ANALYSIS OF RATS AND A ROOSTER COLLECTED

ON ISLAND OF RONGELAP FEBRUARY 1956

Rats	Wet Wt.	d/m Sr^{90}/sample	Ca/sample(gm)	S.U.*
1515 Carcass**	44.7	642 ± 23	0.533	545 ± 19
1516C "	62.5	315 ± 62	0.315	453 ± 90
1517C "	32.3	367 ± 21	0.353	470 ± 27

** Does not include head, femurs, tibiae and viscera.

Rooster				
1510 Femur	26.0***	1210 ± 39	5.19	105 ± 3
1510 Tibia	41.0	5702 ± 119	9.50	272 ± 5

*** Dry weight of 2 femur halves.

---

*S. U. = $\frac{2.2 \text{ d/m } Sr^{90}}{\text{gm Ca.}}$

V. RESIDUAL ACTIVITY IN PACIFIC OCEAN

During February-May, 1955, a survey was made by the Health and Safety Laboratory of the U. S. Atomic Energy Commission and the Office of Naval Research (Operation Troll) of the Pacific Ocean extending from the Marshall Islands westward across the Pacific, northward to Japan, then west to San Francisco.

The Chart represents data on activity found in sea water and plankton. Table Forty-two shows some representative data on activity versus depth of water sample.[10] Tables Forty-three and Forty-four show representative data for marine life.[10]

Below is a summary of some of their conclusions:

1. Sea water and plankton samples show the existence of widespread low-level activity in the Pacific Ocean. Water activity ranged from 0-570 d/min/liter and plankton from 3-140 d/min/g wet weight.

2. There is some concentration of the activity in the main current streams, such as the North Equatorial Current. The highest activity was off the coast of Luzon, averaging 190 d/min/liter down to 600 m (April 1, 1955).

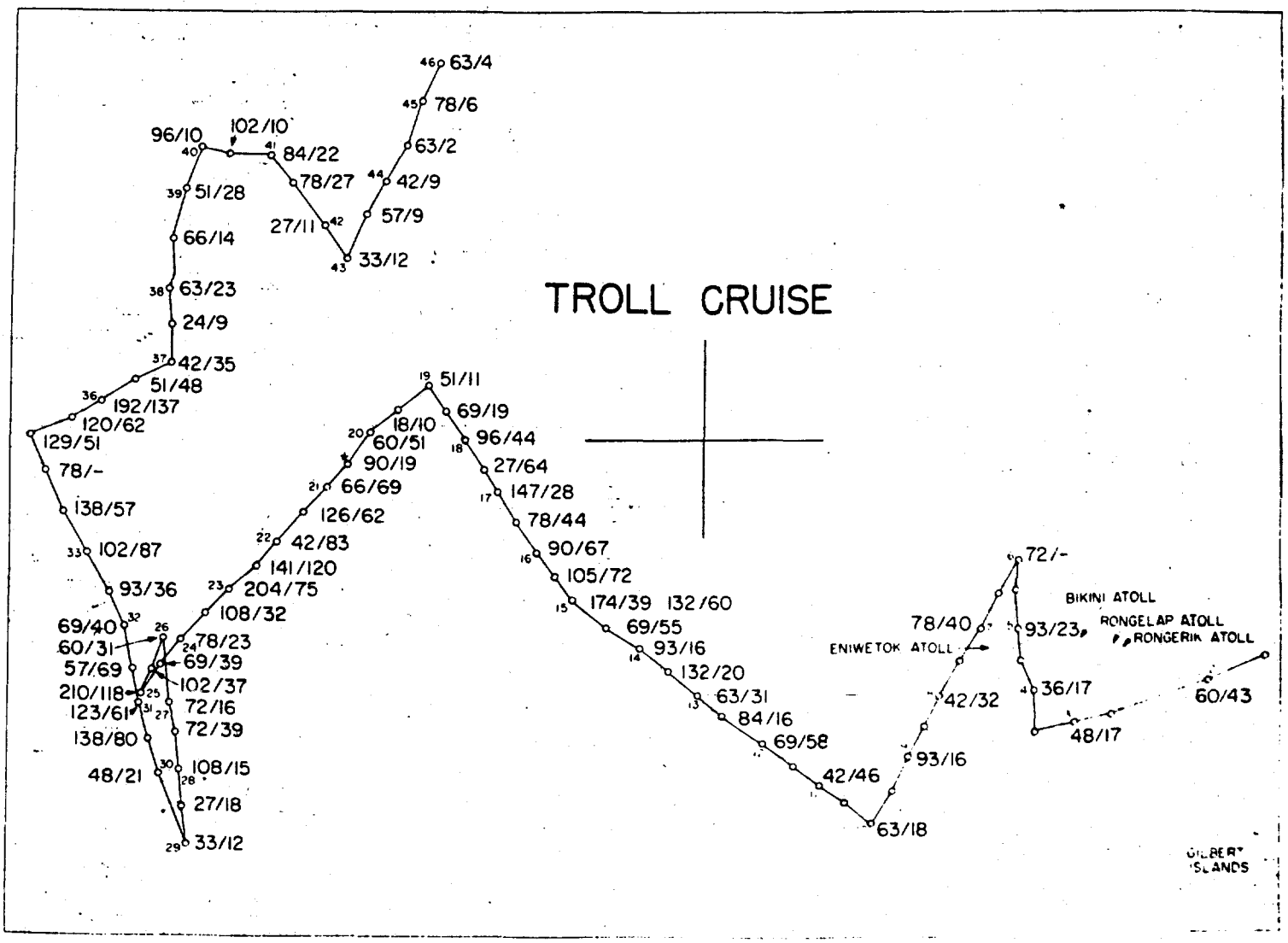
3. Analyses of fish indicate no activity approaching the maximum permissible level for foods. The highest activity in tuna fish was 3.5 d/min/g ash, less than 1 percent of the permissible level.*

4. Measurements of plankton activity offer a sensitive indication of activity in the ocean.

---

* Based on 1/10 m.p.c. of that for atomic energy workers.

On June 11-21, 1956 another survey of radioactivity in the sea was conducted near Bikini and Eniwetok Atolls by the AFL. Since June the survey was conducted during the Spring 1956 test series of detonations, relatively higher activities might be expected. Table Forty-five summarizes some of the data.[11] It will be noted that the average (see separate report) activity value for plankton is about 7,000 greater than the average surface water value.



Disintegrations per minute per liter of seawater/disintegrations per minute per gram of plankton.

5002146

TABLE 42

Water Samples at Stations

Stations	Sample No.	Depth, m	d/min/liter
1	3	0	24
	4	8	-
	5	24	60
	6	43	-
	7	64	42
	8	88	-
	9	128	96
	10	169	-
	11	250	30
	12	340	-
	13	437	90
	14	552	-
2	18	0	3
	19	9	-
	20	25	6
	21	44	-
	22	63	120
	23	85	-
	24	119	110
	25	155	-
	26	222	9
	27	296	-
	28	370	120
	29	468	-
3	34	0	60
	35	9	-
	36	28	60
	37	55	-
	38	79	42
	39	110	-
	40	164	(-15)
	41	Pretripped	-
	42	325	57
	43	426	-
	44	534	84
	45	646	-
4	49	0	36
	50	9	66
	51	25	87
	52	51	18
	53	71	24
	54	98	160
	55	136	27
	56	184	0
	57	279	0
	58	373	45
	59	478	36
	60	590	100
5	66	0	51
	67	9	210
	68	26	120
	69	52	45
	70	73	160
	71	98	96
	72	142	36
	73	190	(-320)
	74	280	110
	75	369	87
	76	468	72
	77	579	110
6	81	Doubtful Cast	66
	82		72
	83		78
	84		(-66)
	85		48
	86		72
	87		96
	88		(-9)
	89		57
	90		60
	91		84
	92		72
7	96	0	66
	97	9	0
	98	27	100
	99	54	120
	100	76	3
	101	108	(-140)
	102	154	6
	103	205	42
	104	202	27
	105	293	130
	106	404	260
	107	519	0
8	112	0	66
	113	9	140
	114	27	9
	115	54	96
	116	77	30
	117	109	(-9)
	118	153	21
	119	197	100
	120	281	18
	121	357	100
	122	449	99
	123	552	99

TABLE 43

Radioactivity by Tissues of Yellowfin Tuna and Shark from the "TROLL" and Other Areas. Values in Disintegrations per Minute per Gram Wet Weight.

Area	Date	No. of Fish	Skin	Light Muscle	Dark Muscle	Bone Rib-Vert.	Liver	G.I. Tract	Gonad	Gill
Yellowfin Tuna										
Off Morotai	4-1-55		0	19,16	10,10	4,24	9,4	5	17	10
Off Morotai	4-1-55		3	4,9	12,8	0,0	13,16	9	7	6
Off Morotai	4-1-55		2	10,21	8,8	9,22	10,22	0	6	13
Average		3	2	13	9	10	11	5	10	10
Eniwetok	2-12-55	1	785	70	608	286	2820	272	90	
Ponape	12-16-54	6		79		101	742			
Shark						Cartilage			Kidney	
Stn. 4	3-14-55		20	22	15		19		8	Carcharhinus
9A	3-18-55		11	10	11	0	13		9	menisorrah
9A	3-18-55		15	32	19	4	28			
10	3-18-55		0	18	19	0	40		9	
151	3-24-55		171	13	30	9	4		52	
29	4-1-55		44	11	26	8	56		39	
Average		6	44	18	20	4	27		23	
Bikini	12-5-54			142			671			
Rongelap	1-29-55	1	687	125		191	2670	490		Carcharhinus melanopterus
Eniwetok	12-1-54	1	1320	173		728	18900	583		

TABLE 44

Observed Values of the Radioactivity of Tissues of Reef Fishes by Area and Species from the "TROLL" Collections. Values in Disintegrations per Minute per Gram Wet Weight.

Truk	Squirrel	Damsel	Grouper	Surgeon
Skin	48,16,45,29,38	26	48	29,0,10,35,0
Muscle	12,14,16,12,11	4	9	16,12,14,10,7
Bone	10,32,39,42,0	25	55	27,56,36,0
Liver	70,58,58,52,53	30	323	35,5.72,15,307
G.I. tract	33,28,31,10,18	49	10	76,47,47,57,65

Guam				Blenny	Wrasse	Siganid	Snapper
Skin	10,18,24	71	44		21,37	13,22	23
Muscle	14,12,12	17	20		17,19	17,11	17
Bone	28,45,13	40	44		66,43	5,33	14
Liver	126,27,51	408	310		116,68	86,51	19
G.I. tract	105,82	2344	64		74,633	387,289	340
Entire		194,160,144,184,207		115,337,728,321			

Parece Vela				Brotulid
Skin	4,5	13,13,0,14,13		
Muscle	8,13	15,15,9,12,14		
Bone	7,9	38,30,17,0,172		
Liver	12,0	36,65,98,138,81		
G.I. tract	6,88	10,12,9,79,132		
Entire		85	335	20,18

Okinawa		Butterfly Fish	"Catfish"		Cardinal
Skin	17,0	6			13,17,15,0,5
Muscle	13,9	13	14,15		21,5,12,6,10
Bone	0,0	0	10,14		32,0,12,18,30
Liver	12,0	19			0,0,0,19,31
G.I. tract	10,15	20	8,21		32,25,44,12,7
Entire				18,0,12	

TABLE 45

Average Value for All Stations for Plankton, Residue from Water, and Filtered Water (less K^{40}) as of Date of Collection (June 12-21), 1956 (AFL)

Depth in Meters	Plankton d/m/g(wet)
0-200	71000

	Residue from Water		Filtered Water		Total
	d/m/l	% of Total	d/m/l	% of Total	d/m/l
0	5900	58	4200	42	10000
25	280	4	6500	96	6800
50	1800	19	7800	81	9600
75	1300	19	5500	81	6800
100	1100	26	2900	74	3900

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