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REVIEW OF DATA
RADIOACTIVE CONTAMINATION OF PACIFIC AREAS
FROM NUCLEAR TESTS

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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.

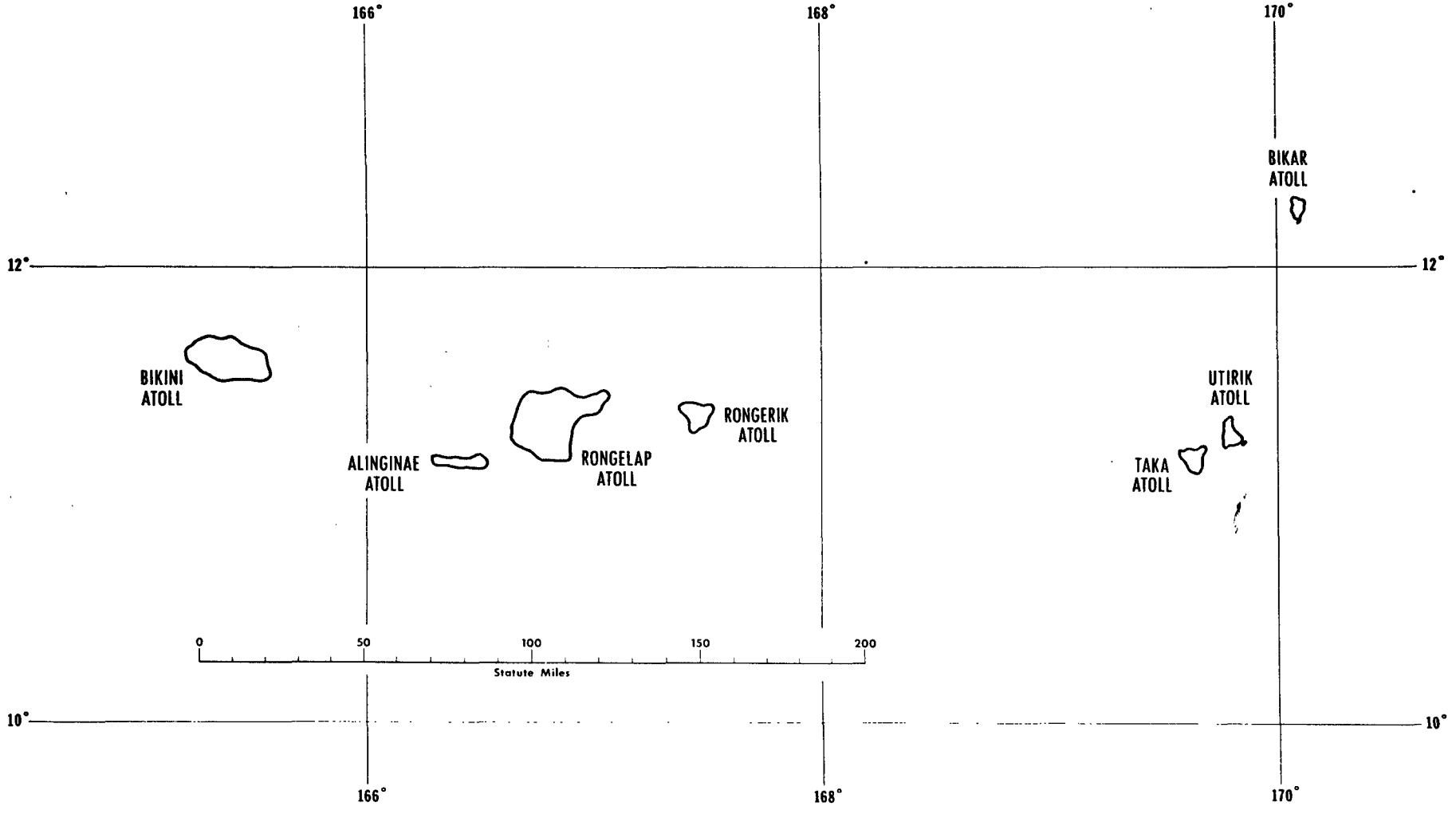
Graph One shows the decay with time of gamma dose rates on the Island of Rongelap. Similar decay curves were found on other islands in the Atoll and in nearby Atolls (Ailinginae and Rongerik). The decay of activity of mixed fission products is assumed to follow $(\text{time})^{-1.2}$ principle. This 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.

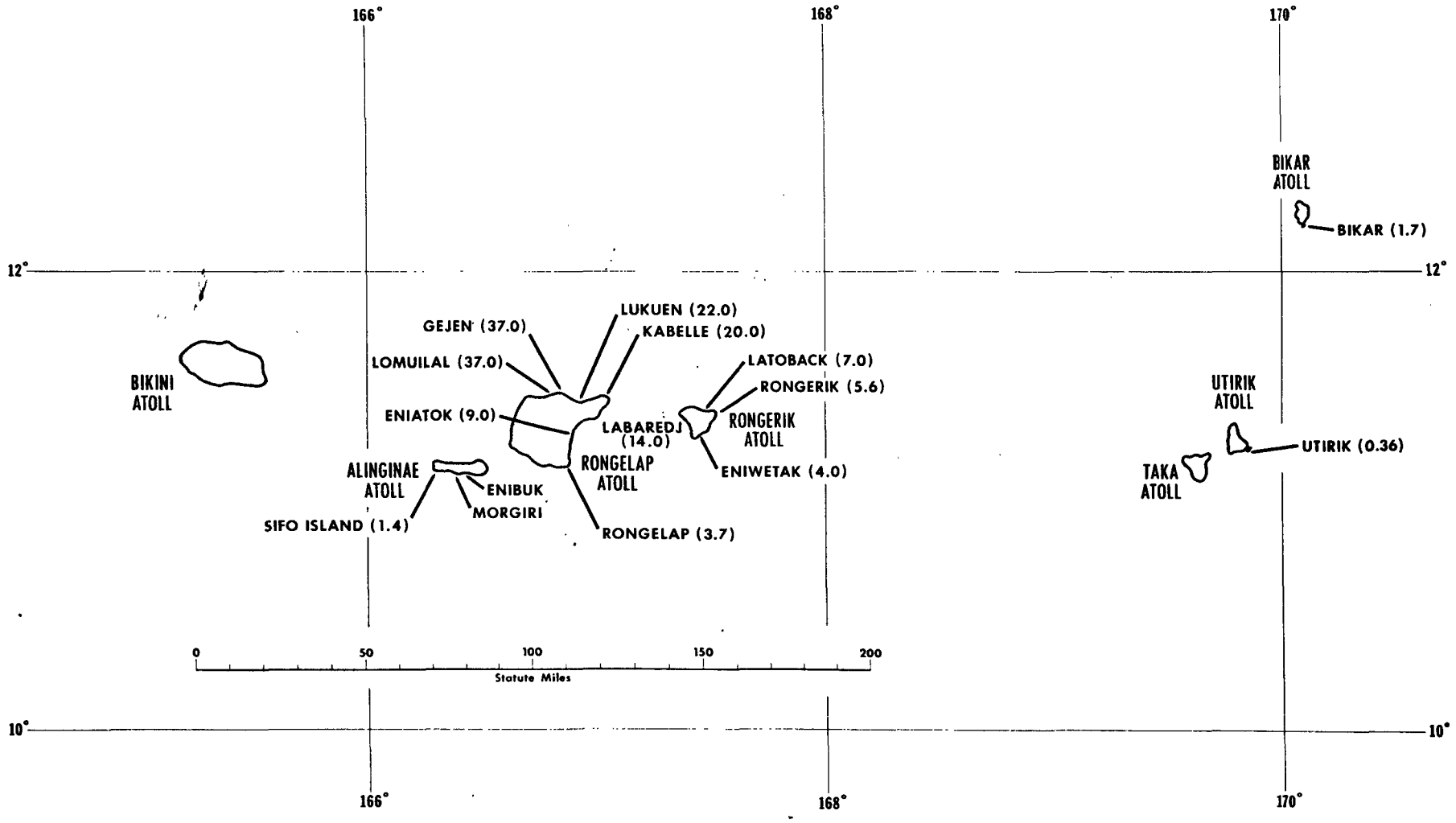
The theoretical curve of Graph One would flatten out with time due to the dominance of Cesium-137 with its 33 year half-life. The last survey of Rongelap Island in late July 1956 indicates a range of gamma dose rates at three feet above the ground of 0.2 - 0.5 milliroentgens per hour with an average 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

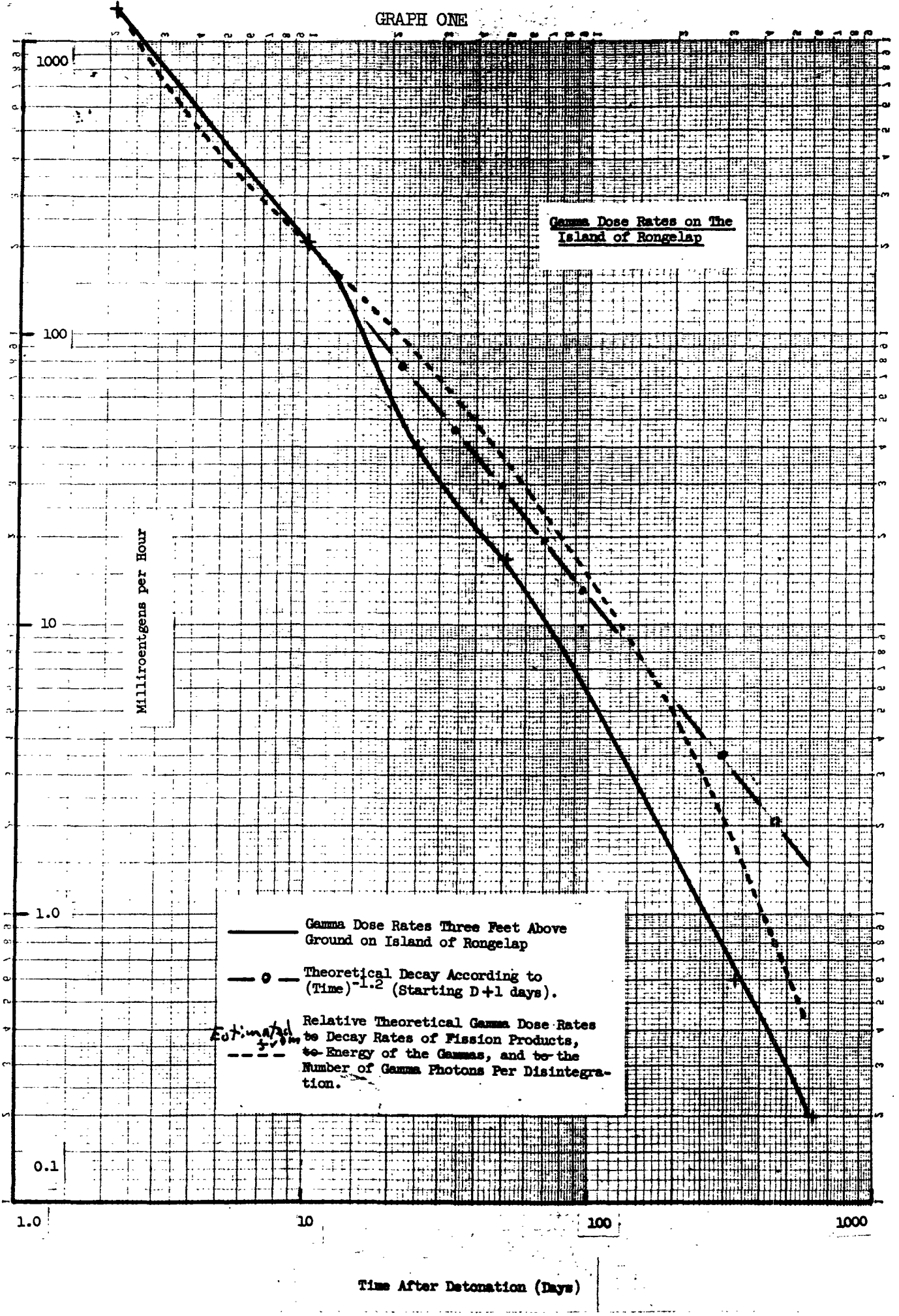


APPROXIMATE GAMMA DOSE RATES AT THREE FEET ABOVE THE GROUND ON D + 1 (One Day after Detonation)

(Roentgens Per Hour)



GRAPH ONE


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

II. GROSS ACTIVITY

A. Land Plants

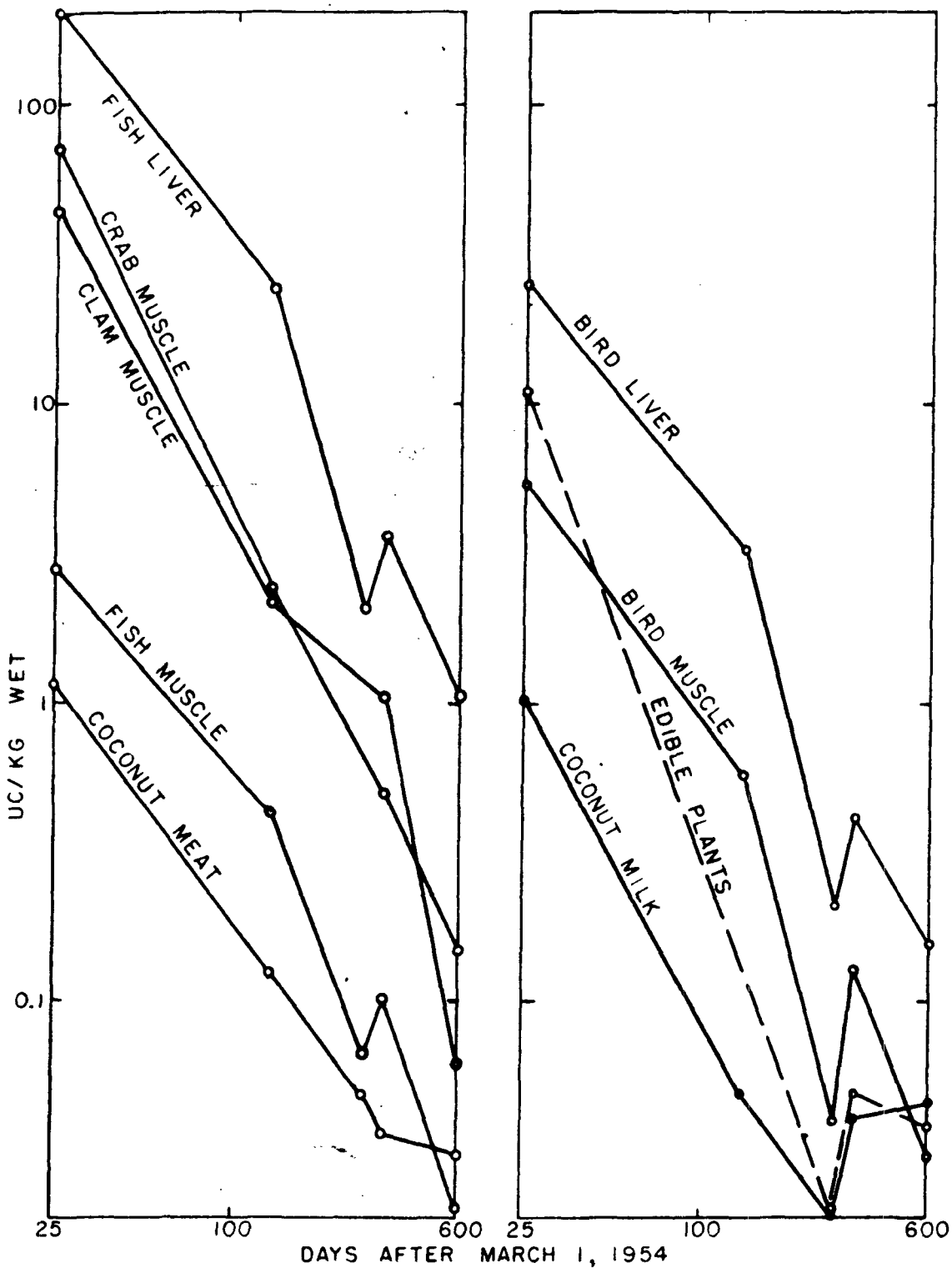
Graph Two indicates the general levels of activity of edible plants (pandanus, papaya, breadfruit, arrowroot), and coconut meat and milk at Rongelap Atoll together with their decline of activity with time.[1,2]

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})					
						Coconut	
Atoll	Island	Arrowroot	Breadfruit	Pandanus	Papaya	Meat	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, [illegible] Samples[a] (NRDL)

		Gejen	Eniwetak	Eniaetok	Rongelap	Sifo	Utirik	Likiep
Plant	Part	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

HASL 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	Sr-90 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	58.2±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	85.9± 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 45-49	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

3165	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±67.3		
3166	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
3198	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 ±0.34	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	(-0.06)±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	(0.35)±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	(0.07)±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

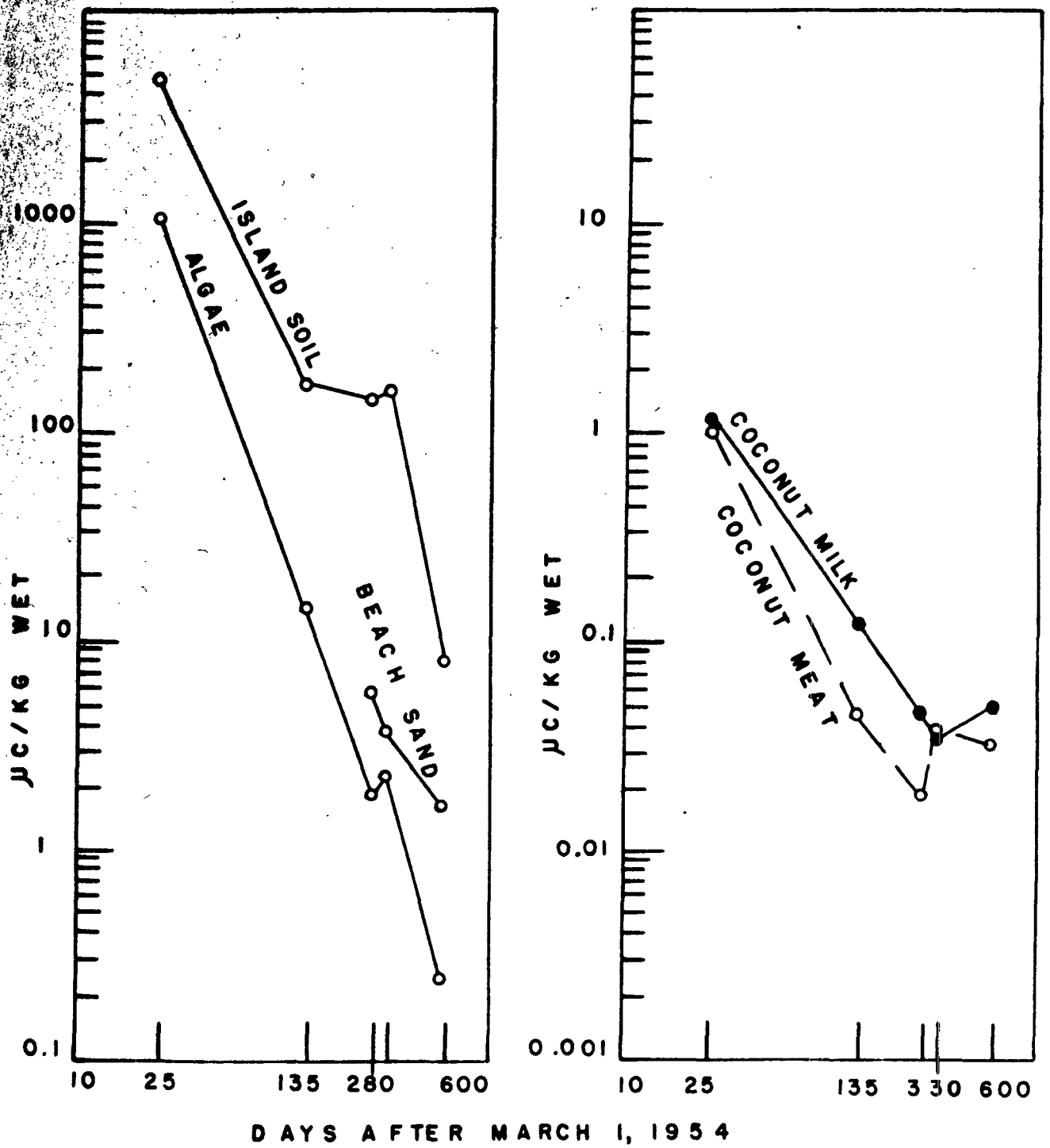
Results of Analyses Performed at HASL *

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.	% Sr^{90}	% Cs^{137}
		LAID PLAINS										
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	240±230	0.24	
3433	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	1.54	
				Meat and Milk	4-17-56	83±2.2	0.047±0.039		0.00001	1200±130	0.04	
3439	525	Rongelap	Coconut	Outer Husk	4-17-56	56±1.7	0.70 ±0.04		0.00035	375± 21	1.25	
				Inner Shell	4-17-56	35±0.7	0.081±0.071		0.00015	345±215	0.23	
				Meat and Milk	4-17-56	87±2.1	0.080±0.043		0.00020	136± 38	0.094	
3513	752	Utirik	Coconut	Entire	4-17-56	51±2.0	2.7 ±0.1		0.0096	104± 4.0	2.3	
3534	803	Likiep	Coconut	Entire	4-17-56	10±0.7	0.046±0.02		0.00031	47± 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	1.42	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	1372± 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.

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) (UNCL)*

Island	Fish	Wet Weight (g)	Radioactivity (μc x 10^3/Tissue)(b)											
			Total		Skin		Muscle		Bone		Gills		Viscera	
			β	γ	β	γ	β	γ	β	γ	β	γ	β	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 Lagoon	2 Pelargic	503	84	500	6	69	9	78	29	271	3	16	37	66
	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				
Eniwetak - 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
Ailingnae 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	86 ±95	0.17 ±0.07	0.48 ±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: HYOO 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
3163	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

3172	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± 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

*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

Summary of Beta Activity in Gross Samples of Soil (NRDL)*

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 15

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	% Ca Based on Wet Weight	I. U.
3182	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	506 ±4.7	548 ±5.1	27	652 ±7.7
3183	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		
3184	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	314 ±5.2
3185	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		
3186	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	5990±161	188 ±3.4	206 ±3.7		
3187	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	623± 88	678± 97	6.7±0.99	7.3±1.1	32	8.5±1.4
3188	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	26	460 ±7.7
3189	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	395± 78	4.9±0.47	5.4±0.52		
3190	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	4230±104	137 ±2.6	264 ±3.7	30	4.3 ±3.9
3191	A 10	10-22-55	Rongelap Island	Grass near well (10 feet W of well)	3 - 6"	0.3/0.9	0.05/0.3	0.05/0.2	406± 54	543± 72	11.8±0.68	15.8±0.91	31	17.3±1.1
3192	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	421 ±4.3
3193	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	50.4±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}	% Ce^{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	
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	Jegen		4-21-56	120± 69	1.0±0.48		0.348	1.3±0.63	0.84	
3462	842	Jegen		4-14-56	69400±470	1640 ±2.4	1535±60	0.305	2440 ±3.6	2.4	2.2
3533	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	732	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		
			Unfiltered	Filtered	
	Untreated	Treated		Filtrate	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-Praseodymium 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)

Lamont No.	Plant	Tissue	Island	Total β activity d/m/g wet	Sr^{90} d/m/g wet	Calcium g/g wet	"Sunshine units"	$Sr^{89}:Sr^{90}$
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	Total β 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 x 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)			
Gejen	Flat Fish	597	Muscle	40	0.6	0.5	5.6			
			Viscera	585	0.1	0.1	18		14.2	61
	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										
Eowetak	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.

February 1956

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) 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
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.	0.66	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	-

February 1956

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

February 1956

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

February 1956

Table 33 - See Table 4

Table 34 - See Table 5

Table 35 - See Table 11

TABLE 36

UWAFL - PORT MONITOR MARSHALL ISLAND SURVEY SAMPLES (HASL)

	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 gms/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	0.030 ± 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	Conchita	muscle	Kabelle	7-24-56		HSE			No - Wet - Weight - Data		4600 ± 300
	4048	I-49b	Conchita	skeleton	Kabelle	7-24-56		HSE			" " " "		3940 ± 170
	4049	I-49c	Conchita	liver	Kabelle	7-24-56		HSE			" " " "		4700 ± 300
	4050	I-50a	Conchita	skeleton	Kabelle	7-24-56		HSE			" " " "		2190 ± 80
	4051	I-50b	Conchita	liver	Kabelle	7-24-56		HSE			" " " "		2020 ± 130
	4052	I-50c	Conchita	muscle	Kabelle	7-24-56		HSE			" " " "		2860 ± 170
	4053	I-52	Conchita	skeleton	Rongelap	7-23-56		HSE			" " " "		2200 ± 120
	4054	I-51	Conchita	skeleton	Kabelle	7-24-56		HSE			" " " "		3600 ± 150
Fish	4035	F-266a	Reef fish	muscle	Rongelap	7-23-56	19	HSE		12	0.036 ± 0.003	0.000808	20 ± 1.9
	4036	F-266b	Reef fish	bone	Rongelap	7-23-56	19	HSE		31	1.9 ± 0.082	0.0711	12 ± 0.5
	4037	F-266c	Reef fish	liver	Rongelap	7-23-56	19	HSE		230 c.e.s	residue 1 c.e.s	0.000990	27±3
	4038	F-31la	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-31lb	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-31lc	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-31ld	Reef fish	liver	Kabelle	7-24-56	15	I,Inc.	10-10-56	7.2	0.061 ± 0.041	<0.00185	≥0
Land Plants	4024	RO- 1	Breadfruit	meat	Rongelap	7-23-56		HSE		31	0.26 ± 0.008	0.000847	260 ± 10
	4025	RO- 2	Papaya	seeds	Rongelap	7-23-56		I,Inc.	10-11-56	0.86	0.38 ± 0.01	<0.00208	≥ 56
	4026	RO- 2	Papaya	seeds	Rongelap	7-23-56		HSE		28	0.38 ± 0.002	0.00537	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		HSE		66(d/dkl)	0.034 ± 0.004 (d/ml)	0.000277 (gms/ml)	58 ± 7
	4034	RO- 8	Morinda	pulp & seeds	Rongelap	7-23-56		HSE		46	1.4 ± 0.048	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		HSE		63	1.2 ± 0.041	0.00108	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		HSE		145	1.9 ± 0.976	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	266 ± 4

	HASL Number	UWAFL 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	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	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/ft^2	Sr^{89}/Sr^{90}	Total Ca gms/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	8.6 ± 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	1705	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	8.2 ± 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

* 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	214.5	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.

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*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.

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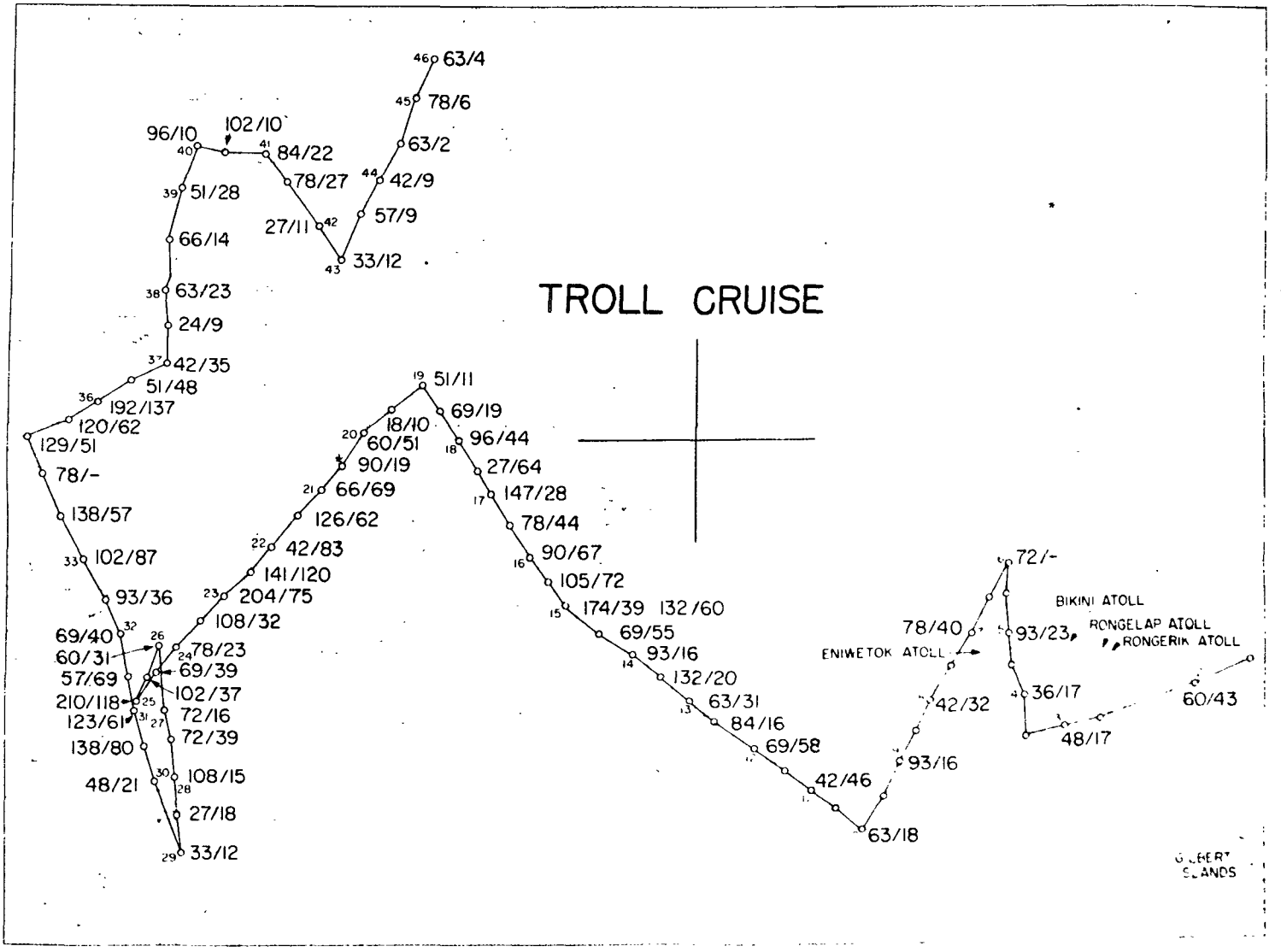
* Based on 1/10 m.p.c. of that for atomic energy workers.

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.

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	1000	26	2900	74	3900

References

1. UWFL-42 A Radiological Study of Rongelap Atoll, Marshall Islands, During 1954-1955. Applied Fisheries Laboratory, Lauren R. Donaldson, Director, University of Washington, Seattle, Washington, August 15, 1955.

2. UWFL-43 Radiobiological Resurvey of Rongelap and Ailinginae Atolls, Marshall Islands, October-November, 1955. Staff of the Applied Fisheries Laboratory, Washington University, December 30, 1955.

3. USNRDL-454. Residual Contamination of Plants, Animals, Soil and Water of the Marshall Islands One Year Following Operation Castle Fallout. Rinehart, R. W. et al U. S. Naval Radiological Defense Laboratory, San Francisco 24, California, August 12, 1955.

4. USNRDL-455 Residual Contamination of Plants, Animals, Soil, and Water of the Marshall Islands Two Years Following Operation Castle Fallout. Weiss, H. V. et al. U. S. Naval Radiological Defense Laboratory, San Francisco 24, California, August 15, 1956.

5. NRDL Marshall Island Resurvey - 1956 Results of Analyses Performed at HASL. Laboratory Report 56-7. Hardy, E. P., and Collins, W. R. Undated.

6. Rongelap Survey, October, 1955. Results of Analyses Performed at HASL. Laboratory Report 56-4. Hardy, E. P. and Hamada, G. H., March 5, 1956.

7. To be published by Applied Fisheries Laboratory, University of Washington, Seattle, Washington.

8. The Effects of Ionizing Radiation on Human Beings. Cronkite, E. P., Bond, V. P. and Dunham, C. L. (Editors), U. S. Government Printing Office, 1956.

9. Private communication, Dr. Stanton Cohn, NRDL to Dr. Gordon M. Dunning, Division of Biology and Medicine, Washington, D. C.

10. NYO 4656 Operation Troll. Harley, John (Editor) Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., April 1956.

11. UWFL-46 Survey of Radioactivity in the Sea Near Bikini and Eniwetok Atolls, June 11-21, 1956. Donaldson, L. R. et al, Applied Fisheries Laboratory, University of Washington, Seattle, Washington, July 23, 1956.

12. BNL 384(T-71) Twelve Months Postexposure Survey on Marshallese Exposed to Fallout Radiation, Cronkite, E. P. et al, Brookhaven National Laboratory, August 1955.

13. Medical Survey of Marshallese Two Years Post Exposure to Fallout Radiation. Conard, Robert A. et al. Brookhaven National Laboratory BNL 412(T-80) September 1956.

14. "Gamma-ray Activity of Contemporary Man." Science. Miller, C. E. and Marinelli, L. D. July 20, 1956 Vol. 124, No. 3212 p. 122-123.