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GROSS BETA RADIOACTIVITY OF PLANKTON AT RONGELAP ATOLL, 1954-1958

by

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Gross beta ~~Levels of B~~ radioactivity of plankton at Rongelap Atoll, 1954-1958.

Abstract

This paper brings together available data on the beta-activity of plankton at Rongelap Atoll for the period 1954-1958 including the values of radioactivity reported in UWFL-42 and 43. Values are given on the ash as well as the wet weight basis, and are shown to be more consistent on the ash weight basis. In a comparison of results from nets of different mesh size, no significant difference appeared in levels of activity between fine and coarse meshed plankton nets. Rates of decay over a 2-3 year period are given for about 30 samples. The fallout in 1956 is considered to have contributed less than 1/100th as much radioactivity as that of 1954, and the 1958 fallout, less than 1/20th that of 1956. The 1954-55 fallout affected primarily the northern, and the 1956 and 1958 fallouts, the southern, parts of the atoll.

Introduction

Plankton in Rongelap Lagoon first took up large amounts of radioactivity from the fallout following Bravo detonation at Bikini Atoll on March 1, 1954. Since then, the radioactivity has declined with only relatively slight additions from the two succeeding series of tests in 1956 (Redwing) and 1958 (Hardtack). Since the writing of UWFL-43, plankton has been collected four times, July 1956 and 1957, and March and August 1958.

The present report gives available data through 1958 including a reevaluation of 1954-55 counts upon which UWFL-42:43 reported, but using ash weight as well as wet weight, with a modification of results, and a comparison of activity yielded by fine-mesh as contrasted with coarse-mesh plankton nets. The rate of physical decay of early samples is compared with the rate of change, herein termed decline, of successive samplings at later dates, up to more than four years after the original fallout.

Methods

Methods of collecting and processing of the 1954-1955 materials are described in UWFL-42:32 and UWFL-43:44. In 1956 and 1957, collecting differed from that of previous years in that amphibious air craft or rubber boats were used for towing the nets. Methods of processing were unchanged.

In 1958, plankton tows were made with 1/2-meter nylon nets of 70-80 meshes per inch by towing from an LSVP (March) or a DUKW (August) for from 10 to 30 minutes at a velocity of $2\frac{1}{2}$-3 miles per hour during daylight, and within 3 (usually 1-2) miles of the localities indicated in Table 2.

In August 1958, only, plankton was also collected from the support vessel LSM "Aloto" by means of pumping which not only permitted a more precise measurement of volume of sea water filtered, and pin-pointing of location of the sampling station than is possible with tows, but also allowed simultaneous sampling of the lagoon-bottom material. Thus, at the ten consecutively numbered stations indicated in Figure 1, ranging along the southern and eastern portions of the lagoon, both plankton and bottom material were sampled. At the first four stations sea water was pumped from astern of the "Aloto" by means of a high-speed, gasoline powered, firefighting pump with a capacity of about 40 gallons per minute, while at the other six stations a more reliable, submersible, electric pump operating alongside the ship gave 180 gallons per minute. Pumping continued for 30 minutes with the mouth of the net above water, so that all pumped water went through the net.

Pumping, as here done, although more quantitative, was less desirable than towing for two reasons. Smaller samples of plankton were obtained, and debris from the ship seemed unavoidable.

Preservation of the plankton was in alcohol except for the tows in August near Kabelle Island. Here the bucket was removed from the net and the end of the net tied closed. After towing, the net was washed down, drained, untied, and the plankton scraped directly into small plastic bags in which it was later dried at 80°C. without preservative. This simplification avoided the almost inevitable leakage at the bayonet-type fitting of the plankton bucket, and expedited the processing; it is recommended where radio-assay is the primary objective.

For laboratory processing of the March 1958 samples, the preservative fluid was filtered from the plankton and tested for radioactivity (practically lacking) before discarding. This avoided most

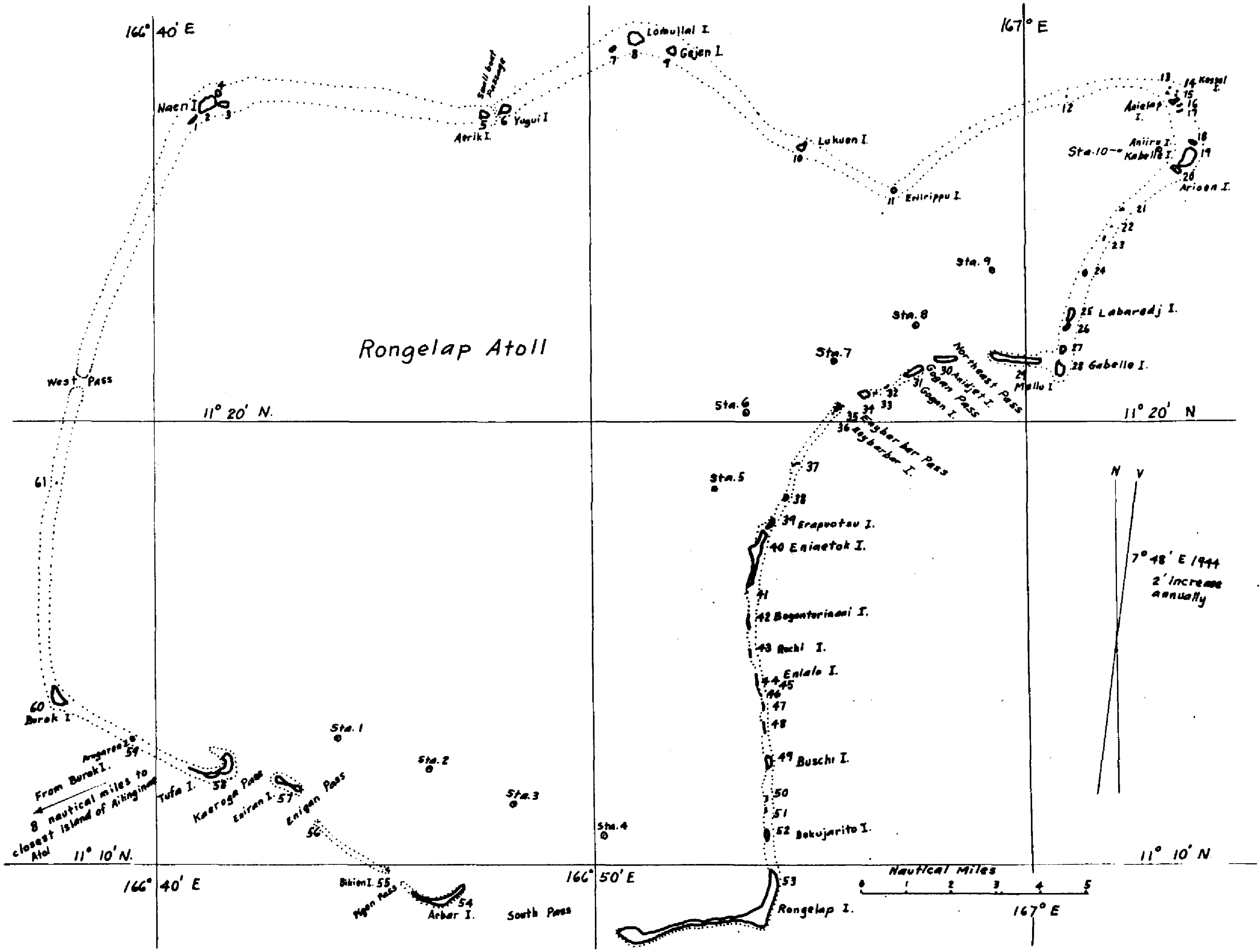

Figure 1. Map of Rongelap Atoll showing locations of ten plankton- and bottom-sampling stations in the southern and eastern portions.

sea salt which might unadvertently have been included at the time of preservation. The August 1958 samples including preservative, were evaporated to dryness, so that the sample from Station 7 including salt water accidentally used for washing the plankton bucket, appeared low in radioactivity. The careful work of Dr. Remzi Geldiay in processing the plankton samples of August 1958 is gratefully acknowledged.

Data after 1956 are presented as of the date of counting, rather than being corrected back to date of collecting as was done for the 1954-55 material. It is probable that if corrections for decay could have been applied to the 1956 data the levels on the date of collection would have been found to be about twice as high as those here given for the date of counting, but data from later collections would have been practically unaltered.

Results and discussion

Tables 1 and 2 give the plankton data from 1954 to 1958, including the values from which Table 12 of the preceding report, UWFL-43, was compiled. Individual plate values appear in order to show the degree of variability, and for 1954-55 to permit comparison of coarse and fine mesh net samples. Radioactivity is expressed per unit weight of both wet plankton and planktonic ash in order to assess the relative suitability of these two bases of reporting results.

Levels of radioactivity were equally high in coarse and in fine meshed nets. The equality prevails on either wet weight or ash weight basis among the ten pairs of simultaneous tows with coarse and fine

Table 1. Levels and decay rates of beta radioactivity of Rongelap-Ailinginae plankton, 1954-1957

Plate No.	Atoll	Island	Plankton net: Number designation	Plankton net: Meshes per inch	Plankton net: Material	Diameter of net inches	Date of collecting	Date of first counting	First count in uc/kg*: Ash basis	First count in uc/kg*: Wet basis	Decay slope from date of first counting to Oct. 30, 1957
8201	Rongelap	Labaredj	12	125	?	?	3-26-54	5-11-54	83	--	- 1.08
8202	"	"	"	"	?	?	"	"	2330	--	- 1.32
8303	"	"	"	"	?	?	"	"	4000	140	- 1.27
8239	"	Kabelle	6	74	Silk	20	7-16-54	8-11-54	68	2.1	- 1.32
8240	"	"	20	173	"	20	"	"	46	2.7	- 1.33
19005	"	"	6 or 20	--	"	20	12-8-54	1-3-55	168	6.2	- 1.75
19006	"	"	"	--	"	"	"	"	168	10.4	- 1.35**
19019	"	Labaredj	6	74	"	"	12-18-54	"	104	5.0	- 1.72
19020	"	"	20	173	"	"	"	"	32	3.9	- 1.73
19024	"	Rongelap	6	74	"	"	1-26-55	2-22-55	25	.54	- 1.68
19025	"	"	20	173	"	"	"	"	24	.95	- 1.72
19026	"	Labaredj	6	74	"	"	1-28-55	"	27	.93	- 1.56
19027	"	"	20	173	"	"	"	"	12	.41	- 1.55
19028	"	Kabelle	6	74	"	"	1-29-55	"	58	1.8	- 1.61
19029	"	"	20	173	"	"	"	"	93	5.8	- 1.61
19030	"	Lukuen	6	74	"	"	1-30-55	"	37	1.5	- 1.70
19031	"	"	20	173	"	"	"	"	95	4.4	- 1.70
19067	"	Kabelle	1	74	Nylon	"	10-21-55	11-26-55	6.4	.20	- 1.76
19068	"	"	2	157	"	"	"	"	6.9	.18	- 1.72
19069	"	Rongelap	1	74	"	"	10-22-55	"	2.1	.044	- .73***
19070	"	"	2	157	"	"	"	"	2.0	.047	- 1.38
19071	Ailinginae	Mojiri-Enibuk	1	74	"	"	10-23-55	"	4.5	.70	- 1.58
19072	"	"	2	157	"	"	"	"	5.5	.34	- 1.53
19073	"	"	1	74	"	"	10-24-55	11-27-55	4.6	.94	- 1.71
19074	"	"	2	151	"	"	"	"	7.4	.80	- 1.73
6076	Rongelap	Rongelap	20	170	Silk	12	7-23-55	8-23-56	41	2.2	- 5.3
6077	"	"	20	170	"	"	"	"	178	19	-11.4

Plate No.	Atoll	Island	Plankton net: Number designation	Plankton net: Meshes per inch	Plankton net: Material	Diameter of net inches	Date of collecting	Date of first counting	First count in uc/kg*: Ash basis	First count in uc/kg*: Wet basis	Decay slope from date of first counting to Oct. 30, 1957
6078	Rongelap	Kabelle	20	170	Silk	12	7-24-56	8-23-56	20****	.45****	--
6079	"	"	"	"	"	"	"	"	72	4.0	- 4.4
6121	"	Rongelap	6	74	Nylon	20	7-17-57	8-16-57	14	.20	- 3.7
6122	"	Kabelle	6	74	"	20	7-18-57	8-16-57	93	6.0	- 1.10

* As of collecting date for 1954-55, and as of counting date for 1956-57, samples.

** Last count 9-6-55. Plate missing.

*** Low plate count; large error.

**** Decay curve rose, invalidating the entry.

Table 2. Levels of beta radioactivity of plankton collected from Rongelap Lagoon in 1958.

Locality	Collection date	Collection number	Plate No. '58 series	First count: Month & day 1958	First count: uc/kg ash	Second count: Month & day 1958	Second count: uc/kg ash	Third count: Month & day 1958	Third count: uc/kg ash	Preservation of plankton
Rongelap I.	March 1	Tow 1	5001	9-16	.24	11-20	.25			alcohol
"	" "	" 2	5002	"	.37	"	.34			"
"	" "	" 3	5003	"	.32	11-21	.33			"
Kabelle I.	March 9	Tow 1	5004	9-16	.33					"
"	" "	" 2	5005	"	.077	11-18	.103			"
Rongelap I.	Aug. 16	Tow 1	5023	10-22	6.8	11-19	4.5			"
"	" "	" 2	5022	"	3.5	11-19	3.5	11-19	3.8	"
"	" "	" 3	5021	"	4.6	"	2.9			"
"	" "	" 4	5019	"	3.4	"	3.0			"
"	" "	" 5	5027	"	4.2	"	3.2			"
Eniaetok I.	Aug. 18	Tow 1	5026	10-22	3.3	11-19	2.7	11-21	2.7	"
"	" "	Tows 2-5	5020	10-22	3.7	"	2.7			"
"	" "	" 6-7	5024	10-22	2.6	"	2.7			"
"	" "	" 8	5025	"	1.6	"	1.3	11-19	1.0	"
Kabelle I.	Aug. 21	Tow 1	5006	9-16	1.1	11-18	.62	11-20	.59	dried"fresh
"	" "	" 1	5028	11-18	.43	11-18	.52			"
"	" "	" 2	5029	"	.66	11-21	.74			"
"	" "	" 3	5030	"	1.3	11-21	1.25			"
"	" "	" 4	5031	"	1.1					"
"	" "	" 5	5032	"	.63					"
"	" "	" 6	5033	"	.88					"
Enigan Pass	Aug. 15	Sta. 1	5017	10-22	5.7	11-20	4.0			alcohol
Pigen Pass	" "	" 2	5014	"	.021	"	.021			"
South Pass	" "	" 3	5015	"	.034	11-21	.019			"
Rongelap I.	" "	" 4	5018	"	.53	11-20	.41			"
Eniaetok I.	Aug. 19	" 5	5011	"	.78	"	.59			"
Enybarbar I.	" "	" 6	5016	"	.46	"	.37			"
Kieshiechi I.	" "	" 7	5010	"	.057	"	.019	11-21	.019	"
Gogan I.	" "	" 8	5012	"	.077	11-21	.094			"
Mellu I.	" "	" 9	5013	"	.29	"	.14			"
Kabelle I.	" "	" 10	5009	"	.026	11-20	.026			"

meshed nets listed in Table 1. The higher value of the pair was from a coarse mesh net 5 times and from a fine mesh net 5 times on the ash weight basis and the same was true on the wet weight basis. In only half of the cases was the same mesh size higher on both the ash and the wet basis. All of this indicates randomness, or in other words, a lack of correlation between mesh size and specific activity.

In our earlier reports, beta radioactivity of plankton as determined in methane flow counters has been reported on the wet basis so that the specific activity of plankton may be compared with that of other substances. This involves attempting to drain water uniformly from the plankton samples at the time of preparing the plates. The varying water content of the planktonic organisms causes uncertainty in evaluating the amount of wet plankton being radio-assayed. It was shown (UWFL-53:19) that if results were based on the amount of planktonic ash rather than on the amount of wet plankton, the variability in radioactivity of replicated tows was reduced to only one half the value obtained on the wet basis.

Similarly, the present data for Rongelap Atoll were more consistent on an ash than on a wet basis. The greatest disparities between the two values for paired tows occurred in the 1956 collections, as seen in Table 1. At Kabelle I., the ratio between the two values was only 3.6 on the ash basis, but 8.9 on the wet basis, and at Rongelap I. only 4.3, ash basis, but 8.6, wet basis, so that here, as at Eniwetok Atoll, the variability is only half as great on the ash as on the wet basis.

Further, the average level of activity in plankton from Ailinginae Lagoon in October 1955 was noted (UWFL-43:44) to be higher than in Rongelap Lagoon on the wet weight basis. But if the radioactivity per unit of ash weight instead of wet weight is used, the Ailinginae levels are no higher than in Rongelap Lagoon near Kabelle Island (Table 1).

Thus, it seems desirable to report radioactivity of plankton on an ash weight basis, even though other organisms and substances might more desirably be considered on a wet weight basis.

Figure 2 shows the trend of radioactivity in the plankton samples from Rongelap Lagoon (from 1954 through 1958) related to time, using a log-log plot of the beta activity on an ash weight basis as determined with a methane flow counter. Data are from Tables 1 and 2. The dotted line showing a decline slope of -3.5 was fitted by inspection to the minimal points near 300, 600 and 1500 days, points removed as far as possible from the effects of the Redwing and Hardtack series of detonations.

The maximum level of the lagoon plankton a day or two after March 1, 1954 may be conjectured by extrapolating back one cycle on Figure 2. It is evident that maxima must have been at least 20,000 μc/kg of ash.

Further reference to Figure 2 shows that Bravo must have contributed 100 times as much activity as Redwing, and Redwing 20 to 100 times as much as Hardtack. The decline picture is characteristic in its pattern. Rises result from the fallouts, followed by steep declines until the next fallout. An exception appears in the

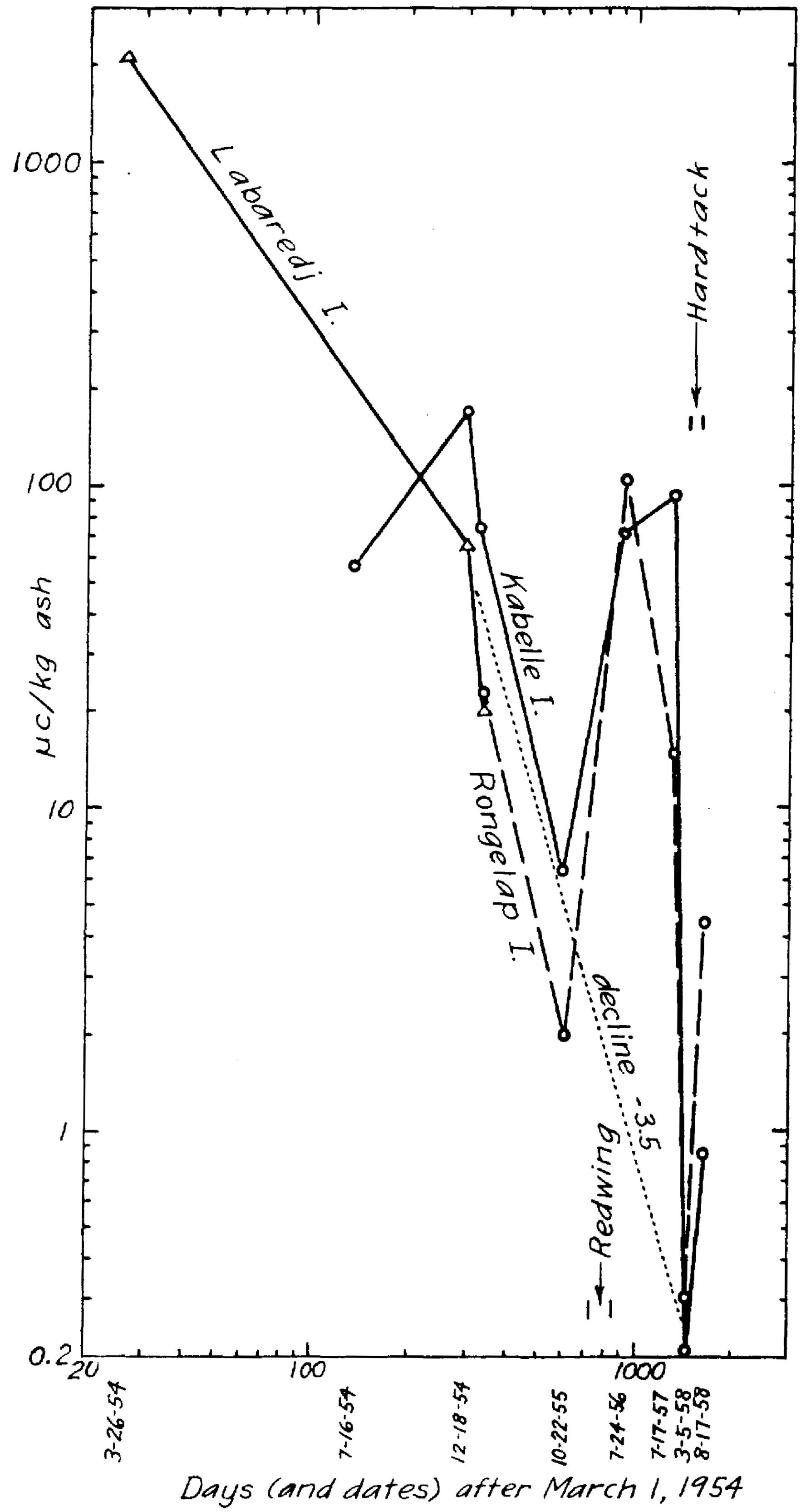

Figure 2. Trends in beta radioactivity of plankton in the eastern part of Rongelap Lagoon from 1954 to 1958.

region of Kabelle Island in late 1954 and from 1956 to 1957.

The unusual pattern near Kabelle Island is undoubtedly associated with its geographical location. Isolated in the northeastern corner of the atoll, it is so located that unless fallout occurs directly there, a long time may be required for activity to drift there by lagoon currents. Although fallout in March 1954 did hit Kabelle Island, the adjacent lagoon area may have been temporarily refreshed by relatively uncontaminated ocean water entering from the inter-island channels at the time plankton was first sampled near Kabelle in July 1954. Then, by December 1954 an influx of contaminated lagoon water could have occurred near Kabelle.

The rise from 1956 to 1957 probably resulted from a similar influx near Kabelle Island of contaminated lagoon water, since in this case it is fairly certain from data on terrestrial sampling, that the 1956 fallout did not affect Kabelle Island as much as it did the more southern islands. Because of its isolated location this northeast bay of the lagoon may be expected to vary in the radioactivity of its plankton.

Figure 3 shows, on log-log plot, the decay patterns of six samples counted on more than three occasions. ~~Original~~ Ordinal values apply only to each curve separately, and do not permit comparison of absolute radioactivity between curves. The date of reference is taken as March 1, 1954 because the detonation of this date is believed to have contributed many times as much radioactivity to the atoll as

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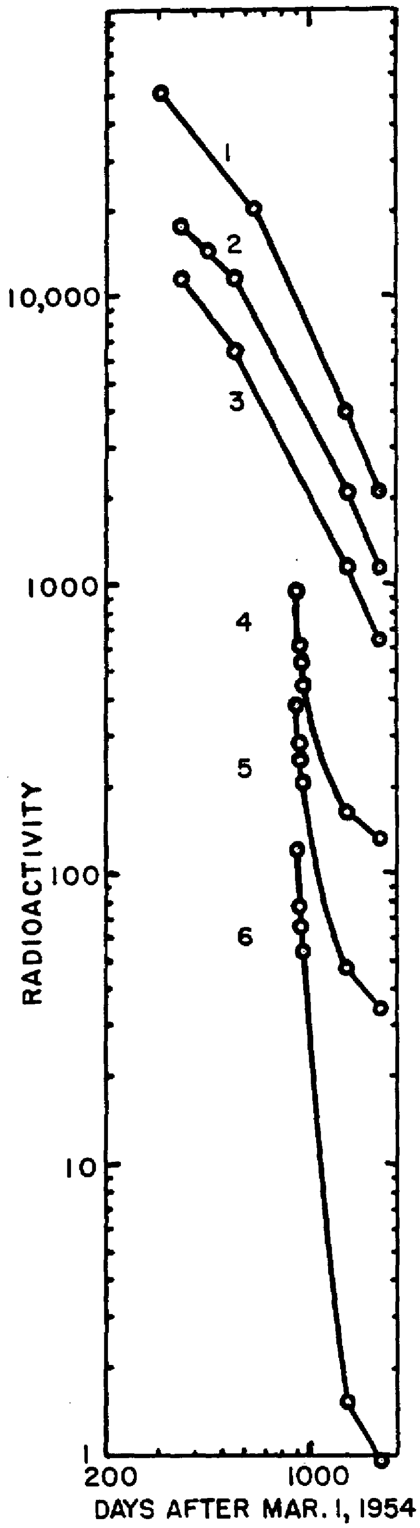

Figure 3. Radioactive decay patterns of plankton samples from Rongelap Lagoon.

1. Plate 19020, Labaredj, 12/18/54
2. Plate 19029, Kabelle, 1/29/55
3. Plate 19025, Rongelap, 1/26/55
4. Plate 6079, Kabelle, 7/24/56
5. Plate 6076, Rongelap, 7/23/56
6. Plate 6077, Rongelap, 7/23/56

did succeeding series. Curves 1-3 represent the radio-decay of samples collected 10-11 months after March 1, 1954, while curves 4-6 pertain to samples collected shortly after the Redwing series. The two groups differ in both steepness and direction of curvature. The first group, curves 1-3, decayed with a log-log slope of -1.3 to -1.4 which agrees with the slopes of the remarkably straight decay curves over almost the same period of time for the Eniwetok Atoll plankton samples (UWFL-53:21). However, the Rongelap Atoll plankton decay curves differ from those of Eniwetok Atoll in having a downward flexure. In fact, curve 2 displays up to the 1350th day almost a uniform half-life of about 310 days, and from days 1350 to 1740, a 430-day half-life. Curves 1 and 3 deviate only slightly from this pattern, being steeper in the early sections. Gamma-spectrometry of the sample of curve 2 on November 6 and December 9, 1957 showed Ce^{144} of 285-day half life to be the primary constituent, which is presumable accompanied by small, undetected amounts of longer-lived isotopes, contributing to the 430-day half life after 1350 days. The second group, curves 4-6, decayed rapidly (slopes -4.1 to -10.8) because of recent origin (Redwing), but with a distinct upward flexure.

In studying the decay rates it was evident that there was a more rapid decay of the radioactivity in plankton from the part of the lagoon near Rongelap Island than occurred near Kabelle Island. This is interpreted as indicating the influence of recent Redwing detonations ~~probably within a month preceding Tewa (7-21-56)~~ whose fallout thus presumably affected the southern more than the northern part of Rongelap Atoll.

Samples 6076-77 of plankton collected July 1956 from the Rongelap Island vicinity of Rongelap Lagoon were more radioactive when first counted one month after collecting than the corresponding sample (6079) from the lagoon near Kabelle Island. One of the Rongelap Island samples (6077) was about 2½ to 9 times more radioactive than the other two samples and decayed most rapidly of those studied. Within 6 weeks it was less than half (.44) as active as when first counted, while the other two samples decayed only to 0.5 - 0.6 of their original values. When recounted as much as a year still later, this sample that had originally been the highest of the three was least radioactive of all, thus verifying its earlier rapid decay. Furthermore, the other Rongelap Island sample, also, had decayed more than had either of the Kabelle Island samples.

Decay of March 1958 samples was negligible during the two months from September to November 1958, while August 1958 samples decayed during the month of November 1958 fairly rapidly, with a half-life of about 100 days, thus supporting the assumption that the increased levels were attributable to the Hardtack series of detonations.

The rate of decay of the samples collected in 1954 was less steep than the rate of decline of radioactivity in Rongelap Lagoon plankton. In Figure 3 the decay slopes of curves 1 to 3 range from -1.6 to a maximum of -2.4, even in the steep portion from 660 to 1740 days, while in Figure 2, the decline slope shown by the dotted line is -3.5. Compensating for the additions from the 1956 fallout would only imperceptibly steepen the decline, thus increasing the difference between decay and decline slopes.

The consistent agreement in decay rate between the two plankton samples resulting from paired tows (last column of Table 1) is a phenomenon of special interest. As examples, the pair of samples from Ailinginae on October 23, 1955 had decay slopes of -1.58 and -1.53 while the pair of samples from the same lagoon on the following day had slopes of -1.71 and -1.73; the counts in January 1955 also show nearly equal decay rates for the paired tows. This uniformity in decay rate for paired plankton tows suggests uniformity in radiochemical compostion at any one time and locality, but different composition in the plankton at differnent times or localities.

During the first 2 years (1954-55) Kabelle Island samples were 2-3 times as radioactive as those from Rongelap Island. The 1956 Redwing series raised the July 1956 values of the Rongelap Island region above those of Kabelle, but by July 1957 Rongelap values declined to a level far below Kabelle, only to exceed (although not significantly) Kabelle again in March 1958. By August of 1958 Rongelap was ~~still~~ significantly higher than Kabelle. The fallout from the Hardtack series is reflected in the higher levels of activity in August, than in March 1958.

Considering the atoll as a whole, and the three successive test series, the evidence from Figure 2 suggests that the 1956 series contributed not more than 1/100 as much radioactivity as the original 1954 fallout, and the 1958 series, not more than 1/20th as much as the 1956 series.

It is concluded that the northern part of Rongelap Atoll received a heavier fallout from the March 1, 1954 detonation at Bikini than did the southern part. In contrast, the relatively slight fallout from later detonations affected the southern more than the northern parts of the atoll, as is evidenced by the higher levels of radioactivity at Rongelap Island than at Kabelle Island.

Summary

1. Levels of activity of the plankton for the eastern lagoon were sampled nine times in 1954-58. The first observed level on March 26, 1954, 25 days after detonation of "Bravo" at Bikini, was, expressed in microcuries per kilogram of planktonic ash, about [illegible]. By mid-December 1954, it had decline to 50, and by late October 1955, to 6. Fallout from the Redwing series raised the July 1956 level to approximately 100. In July 1957 levels were still between 15 and 100, but by early March 1958, had declined to 0.5. Fallout from the Hardtack series raised August 1958 levels to only 0.8 -4 μc/kg ash, the last observation.

The decline rate, disregarding the two peaks following Redwing and Hardtack, but including their later residual effects, was steep with a slope of -3.5.

2. From the data for the years 1954-57, it was shown that results were nearly twice as consistent when based upon ash as upon wet weight, and that there was no significant difference in activity between samples taken with fine and coarse meshed nets.

3. On the ash weight basis, the levels in 1955 at Ailinginae Atoll were no higher than at Rongelap Atoll, whereas they were higher on the wet weight basis.

4. Decay slopes of pre-Redwing samples ranged from -1.6 to -2.4, while the decline slope for the lagoon as a whole over this period was -[illegible], so that the decline was more rapid than the decay.

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