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of "Dose" to
Health Physics*

DOSIMETRIC RESULTS FOR THE BIKINI POPULATION

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During the mid 1940's through 1958, the United States conducted high yield weapons tests at Bikini and Enewetak Atolls. These areas were contaminated with fallout from the tests. A restoration program, concentrating on the main residence islands of Bikini and Eneu Islands at Bikini Atoll, began in 1969. Approximately thirty Trust Territory residents including some former Bikini Atoll inhabitants participated in the initial cleanup and redevelopment of the Atoll. During subsequent years, the Bikini population increased to some 140 individuals at the time of their departure in August 1978.

Between 1969 and 1974, scrub vegetation on Bikini and Eneu Islands was cleared and indigenous food crops were planted. These crops consisted mainly of coconut, pandanus and breadfruit trees but included a garden development where squash, papaya, bananas and other crops were grown (RO 77). During the maturation interval for most of the tree crops (5-7 years), the majority of the food consumed on Bikini Island was imported by Trust Territory supply vessels. As the local vegetation developed, the diet became less restricted to imported foods so that by 1978, the diet contained substantial quantities of locally grown items.

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Bioassay and external exposure monitoring programs were initiated for Bikini Island residents in anticipation of the changing dietary situation, and with the realization that it was essential to do personnel monitoring on those individuals living on Bikini Island.

Extensive external radiation monitoring was performed in 1975 through the joint efforts of Brookhaven National Laboratory and Lawrence Livermore Laboratory. Data were collected using an environmental ionization chamber to quantify exposure rates, portable NaI scintillation survey meters to map the external radiation fields, a portable gamma spectroscopy system to define the major energy components of the external field and to determine energy dependence correction factors for the ion chamber, and LiF thermoluminescent dosimeters to measure long term integral exposures. External exposure estimates were developed based on these measurements and an assumed living pattern (GU 76, GR 79).

Urine samples for radionuclide bioassay were collected during BNL medical field trips to Bikini between 1970 and 1976 (CO 75, unpublished results). This program was reinstated by BNL Safety and Environmental Protection Division in 1978 with systematic 24 hour urine collections from all adult Bikinians. Urine bioassay results were used to calculate ^{90}Sr - ^{90}Y and ^{137}Cs - $^{137\text{m}}\text{Ba}$ body burdens and resultant radiation dose equivalents for all Bikinians from whom a satisfactory urine sample was obtained.

Whole body counting was performed in 1974 and 1977 by the BNL Medical Department (CO 75, CO 77), and the program continued in 1978

under the BNL Safety and Environmental Protection Division along with the follow-up whole body counting of former Bikini Island residents currently residing on Ejit or Majuro Islands, Majuro Atoll, and on Kili Island (MI 79). Field Measurement of gamma-emitting radionuclide body burdens was accomplished with a trailer-mounted shadow-shield whole body counter. Dose commitments were calculated from the measured body burdens for many persons residing at Bikini Island during the years 1969 through 1978.

In addition to retrospective dose equivalents, whole body counting and bioassay techniques provided the data base from which dose equivalent commitments were calculated. These calculations, together with external radiation measurements, provided a complete assessment of dose to the Bikini population from chronic exposure to important fallout radionuclides in their home atoll environment.

Results

In the following tables, the dose equivalent during the residency interval and dose equivalent commitments to bone, bone marrow and the total body are presented. The mean for the dose equivalent and dose equivalent commitment was determined from individual data points which represent a wide distribution of residence intervals. The mean value corresponds to the mean residence interval (years) for the population described. Residence intervals were determined through verbal interrogation of participants in the personnel monitoring program.

Tables 1 and 2 represent the bone and bone marrow mean doses and ranges in mRem which were the result of ingesting ^{90}Sr - ^{90}Y during the residency interval. These data were derived from measured urine activity concentrations during the uptake period. Constant continuous ingestion of activity was assumed in the models used to calculate the dose equivalents and dose equivalent commitments.

Table 3 depicts the external dose equivalent resulting from living on Bikini Island. The dose equivalent during the residency interval varies for subgroups within the population according to the assumed living pattern selected. Since these values were obtained from ion chamber measurements and hypothetical living patterns, no range of results has been provided. In this report, one Roentgen is assumed equal to one Rem.

Table 4 presents the average whole body doses due to the ingestion of ^{137}Cs . Data were derived from whole body counting measurements made in 1974, 1977 and 1978. Constant continuous uptake of ^{137}Cs in the diet was not assumed. For these calculations, the uptake period was divided into three intervals during which the ^{137}Cs activity ingestion rate for a given interval remained constant, but increased stepwise with time to account for observed increases in ^{137}Cs body burdens.

Table 5 summarizes the total body dose equivalent during the residency period from internal ^{137}Cs and man-made external radiation, and the total body dose equivalent commitment upon departure from Bikini Atoll in August 1978. A standard deviation for these quanti-

ties of approximately $\pm 40\%$ of the mean was observed in adult subgroups. Internal dose equivalent distributions in figures one through three were constructed by first calculating mean daily activity ingestion rates for different subgroups of the Bikini Island population based on the individual measurement data from which Tables 1, 2, and 4 were derived. Secondly, these mean activity ingestion rates and individual residence interval values were used as input data to mathematical models applied to inhabitants who did not participate in our personnel monitoring programs. The models describe various regimes for the uptake, retention and excretion of internally deposited radionuclides. Finally, dosimetric models which allow for constant continuous uptake of ^{90}Sr and stepwise increasing uptake for ^{137}Cs were chosen to determine the internal dose equivalent and dose equivalent commitment for all inhabitants. Thus for residence periods between the years 1969 and 1978, these figures evince a maximally exposed person receiving a whole body dose equivalent and commitment of 3 rem, and a population average dose equivalent and commitment of 1.2 rem from man-made radioactivity on Bikini Island.

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Table 5: Total Body Dosimetric Average for External Plus Internal Sources for Former Bikini Residents

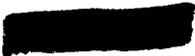
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TABLE 1

 ^{90}Sr - ^{90}Y Bone Dosimetric Averages for Bikinians

Population Description	Number of Persons	Mean Residence Interval, Years	Dose Equivalent During Residence Interval, mRem			Dose Equivalent Commitment, mRem		
			Mean	High	Low	Mean	High	Low
Adult males	19	4.2	28	120	.59	68	230	7.3
Adult females	15	4.1	15	42	.35	42	110	5.8
Male children (11-15 years of age)	3	5.3	47	120	13	130	310	29

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TABLE 2
⁹⁰Sr-⁹⁰Y Bone Marrow Dosimetric Averages for Bikinans

Population Description	Number of Persons	Mean Residence Interval, Years	Dose Equivalent During Residence Interval, mRem			Dose Equivalent Commitment, mRem		
			Mean	High	Low	Mean	High	Low
Adult males	19	4.2	27	120	.57	61	210	6.7
Adult females	15	4.1	14	41	.34	38	98	5.3
Male children (11-15 years of age)	3	5.3	47	120	13	120	290	26

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TABLE 3

External Total Body Dosimetric Average for Bikinians

Population Description	Number of Persons	Mean Residence Interval, Years	Dose Equivalent During Residence Interval, mRem Mean
Adult males	17	4.9	600
Adult females	16	4.3	500
Children (5-14 years)	12	4.4	500

TABLE 4

 ^{137}Cs - ^{137m}Ba Total Body Dosimetric Averages for Bikinians

Population Description	Number of Persons	Mean Residence Interval, Years	Dose Equivalent During Residence Interval, mRem			Dose Equivalent Commitment, mRem		
			Mean	High	Low	Mean	High	Low
Adult males	17	4.9	470	810	120	110	200	43
Adult females	16	4.3	330	770	91	85	190	29
Children (5-14 years of age)	12	4.4	670	920	270	140	270	57

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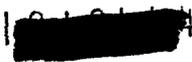
TABLE 5

Total Body Dosimetric Average for External
Plus Internal Sources for Former Bikini Residents

Population Description	Number of Persons	Mean Residence Interval, Years	Dose Equivalent During Residence Interval, mRem	Dose Equivalent Commitment, mRem
Adult males	17	4.9	1100	110
Adult females	16	4.3	830	85
Children (5-14 years)	12	4.4	1200	140

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- Figure 3: Total Female Distribution of Dose Equivalent (During and Post Residence) or Residence Interval for Inhabitants of Bikini Island, Bikini Atoll


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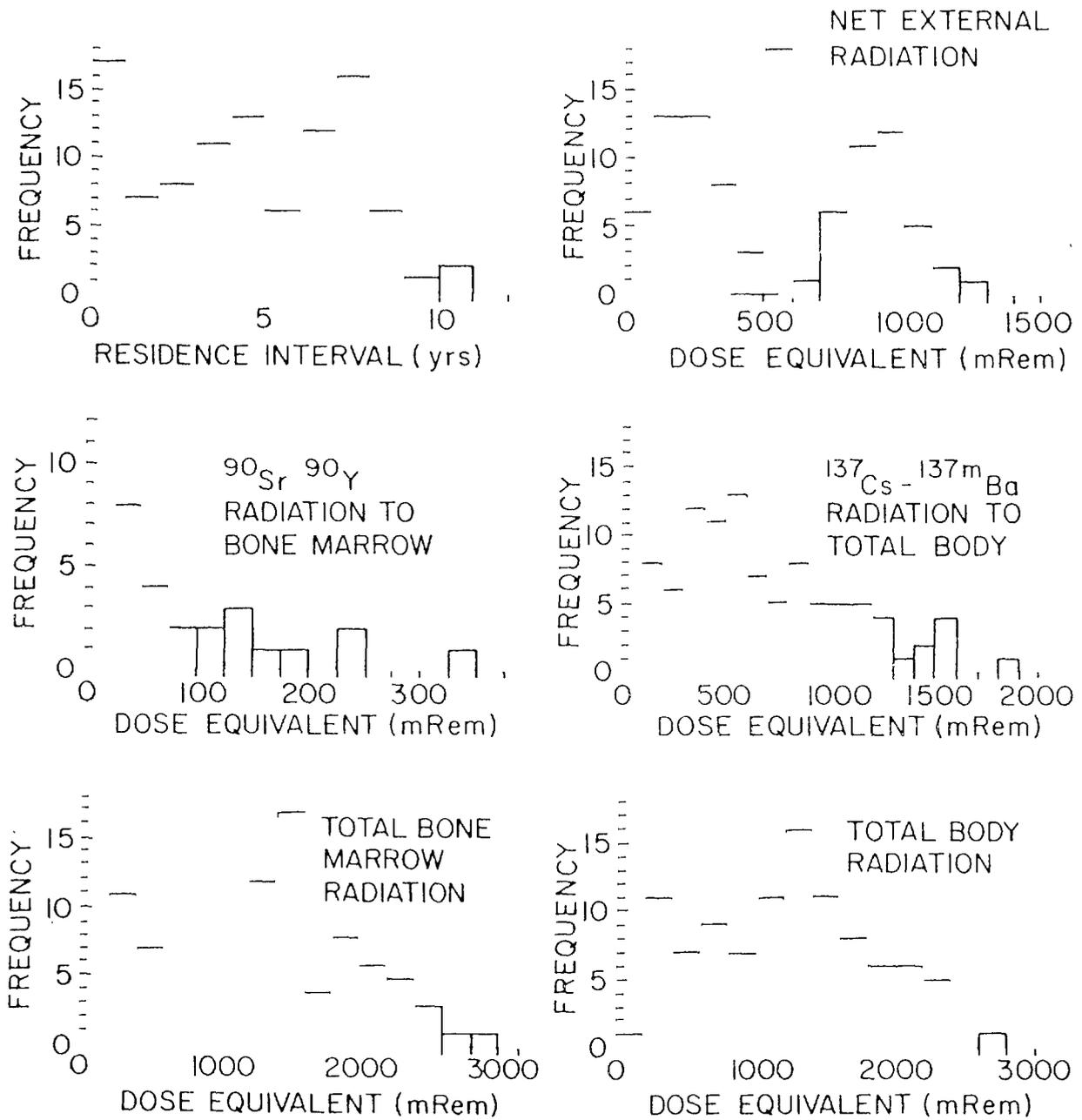


Fig. 1. TOTAL MALE AND FEMALE DISTRIBUTION OF DOSE EQUIVALENT (DURING AND POST RESIDENCE) OR RESIDENCE INTERVAL FOR INHABITANTS OF BIKINI ISLAND, BIKINI ATOLL

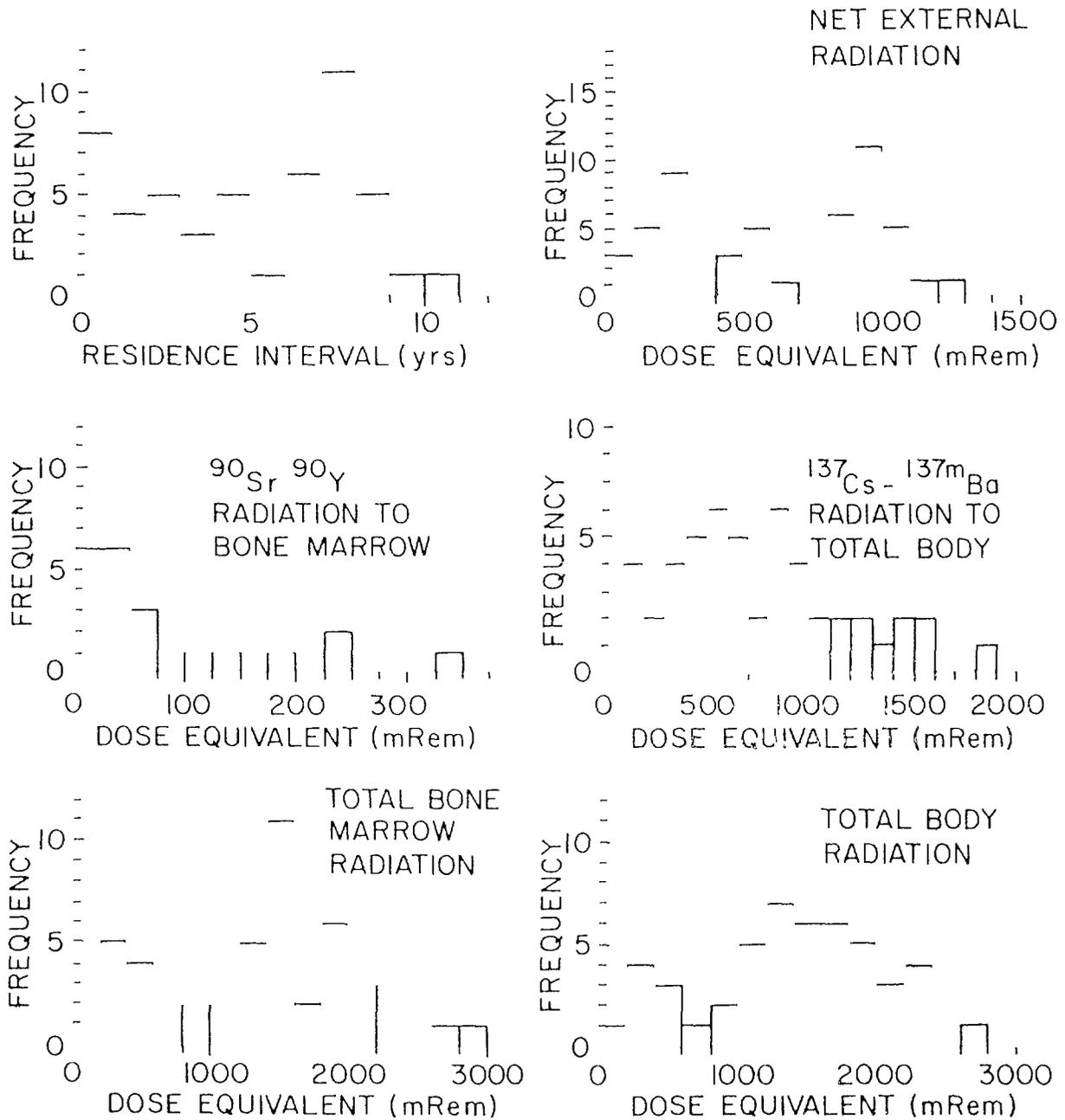


Fig. 2. TOTAL MALE DISTRIBUTION OF DOSE EQUIVALENT (DURING AND POST RESIDENCE) OR RESIDENCE INTERVAL FOR INHABITANTS OF BIKINI ISLAND, BIKINI ATOLL

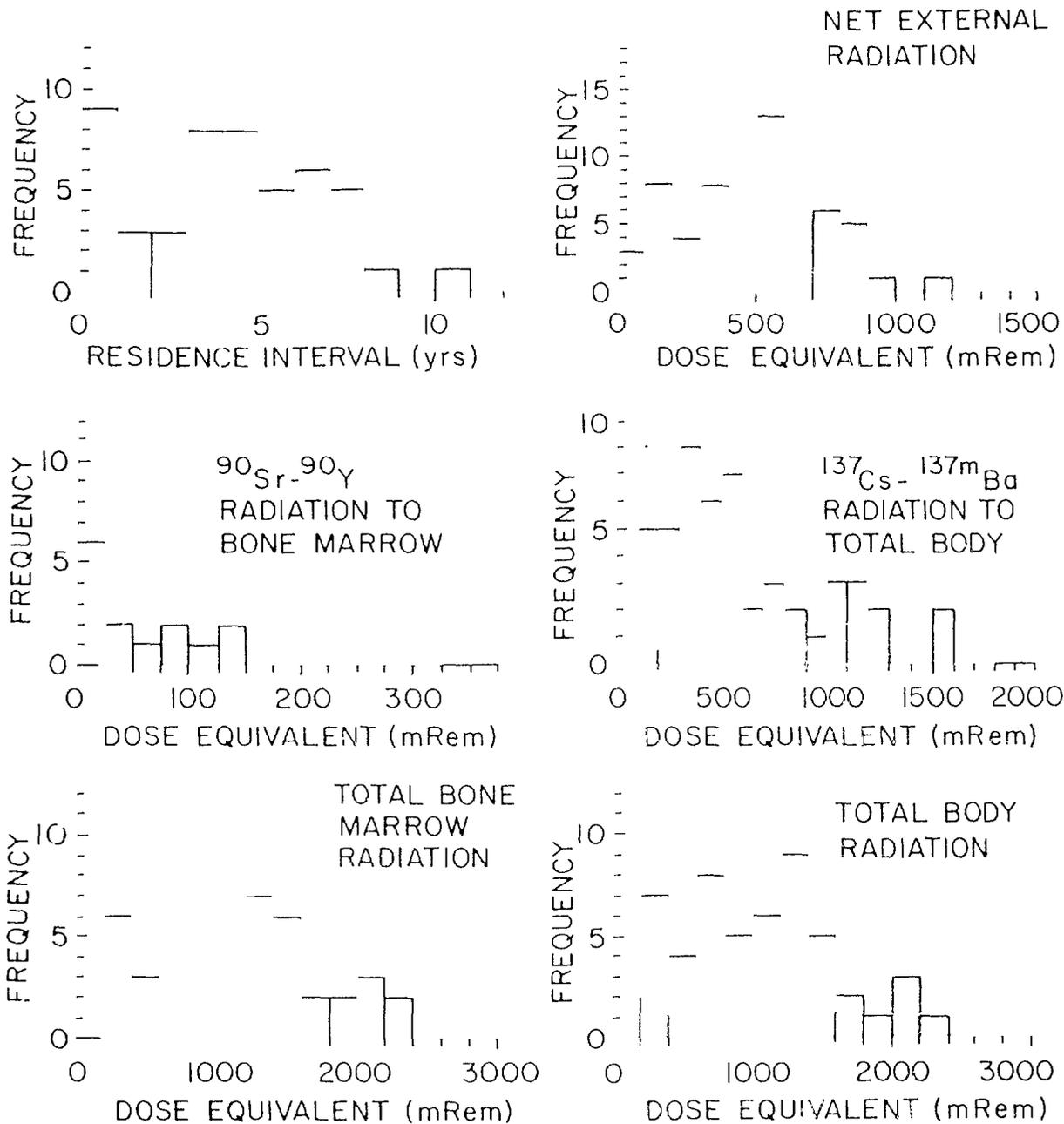


Fig.3. TOTAL FEMALE DISTRIBUTION OF DOSE EQUIVALENT (DURING AND POST RESIDENCE) OR RESIDENCE INTERVAL FOR INHABITANTS OF BIKINI ISLAND, BIKIN' ATOLL