



NATIONWIDE RADIOLOGICAL STUDY

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Subcommittee on Oversight and Investigations
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United States Nuclear Weapons Testing in the Marshall Islands

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EXECUTIVE SUMMARY

A great deal of interest exists among the citizens of the Republic of the Marshall Islands concerning the possibility of radioactive contamination outside of the northern atolls. Questions are constantly raised about health effects which may have been caused by the atomic tests at Bikini and Enewetak Atolls. Undoubtedly, many cases of disease or personal or land damage are the result of other causes. Yet, until sufficient information is available to determine the past and present radiation levels, it will be hard to separate fact from fiction. To better understand the true extent of damage, the Government of the Marshall Islands commissioned its own radiological evaluation of its nation in late 1989. The results from that study will be forthcoming in 1994. That information will likely be of interest to this committee and can be made available following a presentation to the leaders of the Republic of the Marshall Islands. Today's presentation will discuss the type of data that is now being collected and analyzed.

The second topic of discussion will be a limited amount of historical data which indicates that some degree of contamination did occur beyond the atolls of Bikini, Enewetak, Rongelap and Utirik. Similarly, there is some evidence that tests other than BRAVO also spread contamination to islands within the Republic. During most of the years of the testing program, there was little or no radiological monitoring on the atolls except at islands near the test sites, or at atolls immediately adjacent to the test sites. Even then, the monitoring activities were sparse. The exception to this is was a single passive monitoring device at Kwajalein which was part of a worldwide network of surveillance devices. Although the data from that monitoring station has been available since 1960, it is not clear why it has never been analyzed and the results discussed with government leaders of the Marshall Islands. The clear indication from the monitoring station was that deposition of fresh fallout occurred at Kwajalein Atoll within a single day following every one of the detonations over 1 megaton explosive yield.

The implications of this data are now being examined. For a number of years, the U.S. Department of Energy has implied that contamination did not occur at atolls outside of the northern group. Evidence for this is usually stated to be the low levels of 137-cesium at most atolls. The historical data at Kwajalein Atoll contradicts the assertion that there was no contamination. It is actually quite possible to have had measurable levels of fresh fallout and moderately high air concentrations of radioiodine and still show little or no trace of cesium today. The dynamics of deposition mechanisms, such as rainfall, played a role in determining whether measurable quantities of cesium were left behind as a tracer of the fallout.

Finally, a summary of the findings of a study of thyroid disease among 1400 Marshallese citizens will be presented. A surprisingly high rate of benign thyroid nodular disease was found, as well as a number of thyroid cancers. Although it is premature to interpret these findings as having been caused by radiation exposure, the prevalence rate suggests that more people should be examined.

INTRODUCTION

I would like to introduce myself. My name is Dr. Steven L. Simon. I work for the Government of the Republic of the Marshall Islands (RMI) and have done so for nearly 4 1/2 years. I reside in Majuro, the capital city of the Marshall Islands. My areas of expertise are in measurement of radiation, radiation risk assessment and, in general, radiation protection. I was hired by the Marshall Islands to conduct and direct studies to determine the geographical extent and degree of radioactive contamination on the atolls of the Marshall Islands from atomic weapons tests conducted by the United States at Bikini and Enewetak Atolls.

The financial resources to conduct these studies have been provided by Section 177 of the Compact of Free Association. The funds designated for scientific studies allowed the Government of the Marshall Islands to begin to take responsibility for assessing possible damages to the land of their nation or to their people from the atomic weapons testing program. In late 1989 the Government of the Republic of the Marshall Islands commissioned the independent scientific studies which I direct today. An international body of scientific advisors was assembled at that time to provide advice and guidance. The scientific advisors and I planned a nationwide monitoring program, thereby initiating the Marshall Islands Nationwide Radiological Study (NWRS). Although the U.S. Department of Energy has conducted extensive monitoring at Bikini and Enewetak Atolls and at a number of atolls near to the test sites, 70% of the land area of the over 1200 islands in the Marshall Islands was never monitored prior to the NWRS.

OBJECTIVES OF THIS PRESENTATION

The objectives of this testimony are several-fold. First, I would like to make it known to this Committee and others that the Republic of the Marshall Islands is conducting its own thorough and credible radiological evaluation, one that is peer reviewed by an international body of scientists and one that is winning a level of acceptance among the citizens of the Marshall Islands. This substantial body of work will not be reported on in detail today. However, I would like to brief you on the kinds of radiation related information that will be forthcoming this calendar year.

Second, I would like to discuss two other specific topics which I believe are of interest to this Committee. It is my understanding that this committee is specifically interested in evidence of contamination of islands of the Marshall Islands other than those in the atolls of Enewetak, Bikini, Rongelap and Utirik. The two topics that I will present here both relate to this matter. One is a summary of historical data from the years of the weapons testing program. This data shows conclusively that radioactive fallout on the atoll of Kwajalein was routinely detected during the years that the tests were conducted. Secondly, I would like to brief this committee on preliminary results from a screening program for thyroid disease conducted this past year at the nation's second largest population center, Ebeye Island within Kwajalein Atoll.

BACKGROUND INFORMATION

The Republic of the Marshall Islands is a small Pacific nation comprised of 29 atolls and 5 separate reef islands (see Figure 1 enclosed) with the total number of islands exceeding 1200 and a total land mass of approximately 180 km² (70 sq. miles). The nation's capital is located on Majuro Atoll in the southeast part of the nation, approximately 3800 km west of Honolulu, HI and 2700 km north of Fiji. The atolls are arranged in two island chains running roughly NNW to SSE: the western Ralik ("sunset") Chain and the eastern Ratak ("sunrise") Chain. The atolls are located within the latitude band extending from 4.5° to 14.5° N.

The land area of the various atolls cover a wide range of sizes from about 0.5 km² to 16.4 km². The lagoon areas also vary significantly, from 8.4 km² to over 2500 km², the latter belonging to Kwajalein Atoll, the world's largest lagoon.

The total population today numbers close to 50,000 and is one of the fastest growing in the world. There are numerous public health problems as there are in any country, particularly those which have incorporated western lifestyles and dietary habits within a few short generations. Almost every adult citizen of the Marshall Islands knows of the atomic weapons testing program conducted four decades ago. Most citizens, as well, believe that a variety of ailments, in particular, thyroid disease, are a result of that testing program.

The NWRS was designed to fill a need for information on the radiological conditions at all atolls within the Marshall Islands and at all islands of any significant size. Early in the planning of this study, it was decided that to prevent a lack of trust in the participating scientists, the staff must be resident fulltime in Majuro and be in full view of the local population. Over three years ago, we built a radiological laboratory in Majuro to support the field studies and sample analysis programs. This laboratory currently employs six full-time Marshallese assistants, three of whom represent the community of Rongelap.

The results of the NWRS are to be filed with the Government and the Nuclear Claims Tribunal and presented in an understandable fashion to the people of the Marshall Islands. Thus, there are educational and advising roles the NWRS provides the Republic.

Much has been written about the weapons testing period. However, in December of 1993, previously classified explosive yields for 48 of the 66 tests in the Marshall Islands were declassified and released to the public. The release of this data was in response to a request from the Government of the Marshall Islands which had been submitted about two years earlier. The test yield information is useful for constructing a perspective to show the sizes of the test in the Pacific compared with the Nevada Test Site.

The largest test at the Nevada Test Site was 74 kt (74 thousand tons) equivalent TNT. The largest test in the Marshall Islands was 15 MT (15 million tons) equivalent TNT. Fifty percent of the tests in the Marshall Islands were larger than the largest test in Nevada. A plot showing the distribution of the sizes of the tests in the Marshalls is shown in Figure 2.

I. THE NATIONWIDE RADIOLOGICAL STUDY

The need for radiological information that could be both trusted and understood was translated into three closely related programs.

- (1) An international scientific advisory body was formed following a lengthy search for qualified and unbiased advisors. Late in the selection process, the selection was limited to non-Americans. The RMI Scientific Advisory Panel was formed in 1989 drawing on expertise of five individuals.¹
- (2) A diagnostic medical program was initiated with the purpose of providing evidence for personal injury claims.
- (3) A comprehensive study was initiated to determine the radiological conditions at all locations in the nation with a reassessment of the conditions at Bikini, Enewetak, Rongelap and Utirik Atolls.

Over the past three years, all atolls of the Republic have been monitored, including the most southern atolls as well as the northern test site atolls. Environmental measurements over the entire country have varied tremendously. Any pattern of contamination will be apparent from these measurements. State-of-the-art gamma spectrometry instruments have been used in an environmental monitoring program which emphasizes the evaluation of 137-cesium (¹³⁷Cs) in the soil of the islands. The radiation monitoring instrument measures the rate at which energy is deposited in its detector crystal. Physicists refer to this measurement simply as a "count-rate". These count-rates will be used in a lengthy calculation to estimate the amount of radioactivity in the soil, what I call the "inventory of soil cesium." The end product of collecting and analyzing the environmental radiation data will be the capability to compare the soil cesium inventory at each atoll, island or location of interest.

Hundreds of samples have also been acquired for laboratory analysis including soil, coconuts, a variety of native fruits and animal life. In the Majuro laboratory, all samples are measured to determine the concentration of 137-cesium, 241-ameridium, and 239+240-plutonium.

Any locally grown food crop containing radioactive cesium must be obtaining its nutrients from contaminated soil. Similarly, when crabs, pigs and other animals show radioactivity in their bodies, it is a direct indication of the radioactivity in the soil. Thus, soil measurements are specially informative and contamination levels in plants and animals can be readily predicted from the soil measurements themselves.

Sampling and radiological analysis of certain native vegetation species used in traditional Marshallese medicine are also being carried out by the NWRS to complement the assessment of potential exposure via ingestion of foods. The uptake potential of these plants has not been

¹Dr. Keith Baverstock, of the WHO European Center for Environment and Health (Rome, Italy), Dr. Herwig Paretzke of the GSF Institut fur Strahlenschutz (Munich, Germany), Dr. Andrew McEwan of the National Radiation Laboratory of New Zealand (Christchurch, NZ), Dr. Klaus Trott of the Medical College of St. Bartholomew's Hospital, University of London (U.K.), and Dr. Krishna Sankaranarayanan of the Department of Radiation Genetics and Chemical Mutagenesis, University of Leiden (Netherlands).

extensively studied in the past and, although they likely constitute a small part of the plant material and radioactivity consumed by Marshallese, the dose contribution of this pathway is yet unexplored.

The environmental measurement data can be used in a variety of ways. For example, the soil inventory values can be used to determine the radiation dose to people living at a specific location. The dose is normally composed of two components, external exposure and internal exposure. External exposure refers the process of energy absorption in the human (or animal) body from gamma-ray emissions from radioactivity in the soil or environment outside of the body. Internal exposure is a measure of the radiation dose received from radioactivity within the body. Foods that are contaminated with radioactivity can contribute the internal dose. Other small contributors to internal dose are breathing radioactive dust particles and drinking contaminated water. These sorts of environmental radiation data can be used to predict the dose to inhabitants now and in the future.

Measurements made today can also be used to some degree to estimate exposures that have taken place in the past. The process of historical dose reconstruction is a very active research area today. An example of this is the study of the dose to Utah residents from fallout originating at the Nevada Test Site. I was an investigator on that project from 1986 to its completion in 1993. There are, however, numerous problems and uncertainties in trying to estimate past exposures. With the obvious level of concern expressed by the American people over the past few months on the subject of exposure of the public, this area of research will surely continue.

The interest of the American people is no different from the interest of Marshallese citizens. There is, however, differences in the cultural and educational background that are needed to understand the difficult and abstract concepts of radiation physics. For those concerned about bringing truth and understanding about radiation to the Marshallese people, it is important to communicate radiological concepts without causing undue alarm.

The results of the Nationwide Radiological Study are expected to be released and published in the open scientific literature this year. The environmental monitoring has been completed for approximately 99% of the Marshall Islands. The only islands remaining to be monitored are those used by the military at the U.S. Army at Kwajalein Atoll. Almost every island 0.5 km in length or larger has been monitored. Thus far, the overall average spatial density of gamma measurements in the environment is approximately ten per square kilometer.

Distinguishing Fallout From Other Nations

It is widely known by scientists that there are low levels of fallout radioactivity at all locations worldwide as a result of over 800 nuclear detonations conducted by the United States, the former Soviet Union, the United Kingdom, Republic of France, the People's Republic of China and India. Radioactivity from large weapons is known to enter the stratosphere where it can circulate around the globe for a number of years before falling to the earth's surface. This phenomenon is termed "global fallout" by scientists. It is important for this study to determine the portion of

the fallout radioactivity measured at each island that can be attributed only to the weapons testing program conducted in the Marshall Islands. Not only is that quantity relevant for the determination of land damage from the testing program in the Republic, but it will also serve to delineate those islands which did not receive any measurable fallout from Bikini and Enewetak.

To determine the global fallout at each atoll, I have estimated the level of ^{137}Cs from world wide events using a mathematical predictive model. This type of model is a tool commonly used by physicists. Every model requires data for calibration purposes. In this case, $^{137}\text{-cesium}$ data collected by other scientists at a number of locations in the Pacific outside of the Marshall Islands has been used. These locations include Pohnpei (Federated States of Micronesia), Guam, Hawaii and others. The model specifically uses the latitude of the island and annual rainfall rate to predict the deposition. Although these predictions are still under refinement, I have estimated an average value of 500 Bq/m^2 of ^{137}Cs from global sources for the atolls of the Marshall Islands.² This value will be used as a baseline above which the contamination will be assumed to have originated locally.

III. HISTORICAL CONTAMINATION DATA

The responsibility of the NWRS is to not only measure current levels of residual radioactivity but to also attempt to understand what level of exposure might have taken place in the past. Any radioactivity measured today can be precisely predicted at any other point in time whether it be in the future or the past. This is true because the rate of decay of most radioactive elements is known fairly precisely.

There is, however, a significant difficulty in estimating radiation dose from radioactivity which does not exist any longer. There are numerous radioactive elements created by atomic weapons that are relatively short-lived. In fact, there are more than 300 different forms (isotopes) of 36 elements created as fission products. Most of these radioactive byproducts emit what scientists call as "beta particles." The largest amount of radioactivity present immediately after the blast decays quickly.

Because some radioactive species cannot be measured today, the value of historical measurements is immense. Although historical measurements may suffer from a lack of precision when compared to modern measurements, they still can play a very important role in retrospective dose estimation. I have conducted several literature searches in an attempt to find historical radiation monitoring data in the Marshall Islands. The paucity of this kind of data is surprising. One very illuminating piece of information has been reconstructed, however.

The Health and Safety Laboratory (HASL) in New York City under the direction of Merrill Eisenbud during the 1950's made some of the most valuable measurements available today. This laboratory eventually became part of the Atomic Energy Commission and was later renamed the

² Bq/m^2 is an abbreviation meaning Bequerels per square meter. A Bequerel of cesium is equal to one disintegration per second.

Environmental Measurements Laboratory. Today it is part of the U.S. Department of Energy system and is world known for excellence in radiation measurements and associated research.

HASL developed a simple but effective monitoring instrument to detect fresh fallout. Using pieces of sticky or "gummed" paper as a collection device, HASL placed monitors at over 100 locations worldwide. The gummed film effectively collected fallout for 24 hours, after which the film was changed, and the used sheet mailed to HASL for measurement. The gummed film data represents the best available information on the quantity of early beta-activity deposition. The data were published over a number of years by Eisenbud and his collaborators in respected scientific journals. Since then, the gummed film data has been used extensively in the U.S. to assist in the reconstruction of doses to residents of Nevada and Utah and other states.

Several gummed-film stations were established in the Pacific area and the data from them may be of interest to this Committee. These locations include Hawaii, the Phillipines, several locations in Micronesia and a single station in the Marshall Islands at Kwajalein Atoll. Although it seems a pity now that there were not additional monitoring stations in the Marshall Islands, the foresight to have started this very valuable program is to be applauded. I have used the data from a 1960 report to produce a plot of the deposition over the years 1954 through 1958. As can be seen in Figure 3, there were at least three periods during which significant deposition occurred. I have also noted in this graph the months in which the major bomb tests took place. The high level of agreement of the data peaks and the test dates is quite revealing. All seventeen of the tests of a size of one-megaton explosive yield or larger were detected on the gummed film at Kwajalein. Please note that the data in this figure is currently being examined in detail. Several analytical correction factors have been proposed by scientists since this data was collected. The data as shown is taken directly from a 1960 report and does not include any of the correction terms.

The implications of detectable radioactivity in Kwajalein immediately following the large tests is relatively profound and deserves greater attention. First, it is important to note that Kwajalein has been a site of a sizeable population for many years. The 1958 census of the Marshall Islands indicates that 9% of the Marshallese population lived there then, nearly 1300 persons. Second, the early fallout is in many ways the most dangerous to human and animal health. The mixture of radionuclides is quite complex; in particular, the fallout contains significant amounts of radioactive iodine. It is possible that barely measurable amounts of ^{137}Cs now may have been accompanied by levels of radioiodine sufficiently high to give thyroid doses which are great enough to cause the onset of disease many years later.

Calculations of fission yields taken from the scientific literature indicate that the amount of 131-iodine (^{131}I) produced is about 700 times the amount of ^{137}Cs . Whether any of the short-lived radioiodine (^{131}I has a half-life of only eight days) existed at locations of interest depends entirely on the time interval between the explosion and the deposition at a location. Global fallout, because of its long residence time in the atmosphere is normally completely depleted of the short-lived radioiodines. However, any location in the Marshall Islands that received local fallout could not have been more than a few days transit time from the test sites. Thus, fallout from Bikini or Enewetok deposited at any of the atolls could have likely contained significant

amounts of short-lived radioiodines. It is easy to see that a line drawn to Kwajalein from either Bikini or Enewetak intersects a number of other populated atolls. The implication here is that if early fallout radioactivity was in the air at Kwajalein, it could have also touched other atolls and exposed the residents of those islands.

Finally, I would like to take note of at least one other mention of early radioactivity at Kwajalein. Merrill Eisenbud in his autobiography vividly tells of the efforts of HASL to monitor the Pacific tests. He mentions that the flash from the first thermonuclear test (MIKE) in the spring of 1952 was visible at Kwajalein. Eisenbud goes on to state that in the early hours of the day following the test, environmental radiation levels were about 10 times higher than normal. The MIKE test took place before the gummed film station was operational at Kwajalein. However, the personal records of Eisenbud confirm that shot MIKE behaved similarly to the other large events in spreading early fallout to Kwajalein.

III. THYROID STUDY

Introduction

It is generally perceived in the Marshall Islands that the major health damage as a result of the testing are various forms of thyroid disease. The NWRS initiated a study of thyroid disease in the Marshall Islands to answer lingering questions about previous contamination by radioactive iodine and its effects on Marshallese citizens.

Previous investigations mainly concentrated on the the the populations from Rongelap and Utirik which were known to have been exposed. Repeated surveys by medical teams from Brookhaven National Laboratory have maintained this surveillance. The last detailed and comprehensive report was published in 1989 as Brookhaven National Laboratory Report BNL-52192 by W.H. Adams, P.M. Heotis and W.A. Scott: *Medical Status of Marshallese Accidentally Exposed to 1954 BRAVO Fallout Radiation: January 1985 to December 1987*. The findings presented in this report can be summarized as follows: In the heavily exposed Rongelap and Ailinginae population totalling 86 people, 23 thyroids developed benign nodules and 5 developed cancer. The majority of nodules and all cancers occurred in women. All cases were operated on in the United States, usually by total thyroidectomy. More than 50% of the people operated on developed hypothyroidism as a consequence of the treatment, thus requiring life-long supplementation with thyroid hormone pills. In the much less exposed Utirik population which totalled 167 people, 15 thyroids developed palpable (i.e., those capable of being felt by an examining physician) benign nodules, 5 others developed cancer. Between the two groups of people, there was a pronounced difference in latency time for manifestation of these nodules. In Rongelap, the first nodules were found 9 years after BRAVO; the incidence rose quickly and reached a plateau after about 30 years. In Utirik, the first nodules were found after 15 years; the incidence rose more slowly and in 1987 had not yet reached a plateau. Moreover, there was a

pronounced difference in the incidence of thyroid nodules between age groups: In Rongelap, 59% of those who were children under ten years at the time of the BRAVO test developed nodules; 25% of those who were 10-18 years old also developed nodules as well as 14% of those who were adults. The comparison group which was used for the last BNL report consisted of 227 people. Among these, 5 developed benign nodules and 2 developed cancer.

Between June 1983 and March 1985, Dr. Thomas E. Hamilton examined 2,273 people from different atolls for the presence of palpable thyroid nodules. All of this group was alive in 1954 and most of these individuals were from locations north of Majuro. Hamilton found 87 new nodular thyroids in addition to 55 others previously identified and surgically corrected. Twenty-three of the cases lived in Rongelap or Utirik at the time of the BRAVO test. The remaining 119 cases of thyroid nodules suggest an overall incidence of thyroid nodules in the portion of the Marshallese population which was not exposed to the heavy fallout of the BRAVO test of 119/2162 or 5.5%. This value is similar to the comparison group in the Brookhaven study where the rate was 7/227 or 3.1%. Yet, there was a striking difference of prevalence among the different atolls with four groups apparent:

- Very high prevalence: 38% - Rongelap
- High prevalence: 8-10% - Utirik, Likiep, Wotje, Lae, Ujae, Wotho
- Average prevalence: 4-6% - Ailuk, Maloelap, Kwajalein, Jaluit
- Low prevalence: < 4 % - Mejit, Ebon, Mili

The Hamilton study clearly suggests that thyroid disease might also be a problem in many Marshallese who were not in Rongelap or Utirik at the time of the BRAVO test. As a consequence of Hamilton's findings and the concern of the Marshall Island's government and citizens about radiation induced thyroid disease, the international Scientific Advisory Panel and the Nationwide Radiological Study recommended that a comprehensive nationwide survey of the prevalence of thyroid disease in the Marshall Islands should be performed.

The study proposed 2 years ago was planned to build on Dr. Hamilton's investigations but also to collect new information. In particular, nearly ten years have passed since Dr. Hamilton's study. As the experience in Utirik has shown, latency to the development of radiation-induced thyroid nodules becomes longer if radiation doses are small, thus many cases with nodules might be found. Another area in which this study hopes to improve is in using all locations of residence which an individual might have had. Dr. Hamilton related his findings to the place of residence at the time of the BRAVO test. Yet there is evidence that other nuclear tests that were conducted before and after BRAVO deposited radioactive contamination on other atolls. Therefore, a comprehensive residence history of every participant will be examined. Both benign and malignant thyroid

disease is also being be studied, thus building on Hamilton's study which only reported the prevalence of nodules. Progress in the development of ultrasound imaging has made it possible to objectively measure, document and record characteristics of the thyroid pathology.

The Thyroid Disease Study in Ebeye, 1993

With the agreement of the Ministry of Health and the cooperation of the Ebeye Hospital, the Ebeye examination phase was begun early in 1993. Administration and financing was provided by the the Nationwide Radiological Study. Protocol development and general planning was assisted by Dr. Klaus Trott of St. Bartholomew's Hospital in London and medical examinations were conducted by three endocrinology surgeons from the Second Department of Surgery of Tohoku University in Sendai Japan. From January 15 to March 7, 1993, screening for thyroid disease was offered to all adult residents of Ebeye. Every participants received a physical and ultrasound examination of the thyroid. A blood sample was taken from most participants to study TSH (thyroid stimulating hormone) levels as a test for hypothyroidism. In addition, basic health data was recorded as well as information on past health conditions, diet, and residence history.

A main objective of the medical screening program was to examine persons alive at the time of the nuclear testing or those born a few years after it ended. Thus the study intended to concentrate on persons who are now 35 years or older with those between 28 and 35 also of interest for comparison purposes. However, no younger person was refused an examination if he/she wished it. Altogether, 1368 Marshallese residents of Kwajalien atoll were examined. Their ages ranged from 16 to 90 years. Of this group, 817 were female, 535 were male. Of the 817 women, 145 were younger than 28 years. In the younger group were 2 cases with palpable nodules and 3 with non-palpable nodules. There were 75 men examined who were younger than 28 years. In that group, no palpable nodules were found but two cases were identified with non-palpable nodules.

There were several strong points to the study design. Each patient was examined by two different medical doctors and received both a standard palpation exam and an ultrasound exam. Through the use of high-resolution ultrasound, the examining physician could visually examine the thyroid using sound waves displayed on a special video screen. The ultrasound machine can measure the size of abnormalities (nodules) and generate a paper copy reproductions of the image. In the Ebeye study, a photograph of the ultrasound image was given to each participant and added to the patient's medical chart with a written record of the sizes of any nodules detected.

Palpable nodules are nodules which can be felt by the examining physician. Palpable nodules were on average larger than nodules which were not-palpable. The median size of nodules which were not-palpable was 7.5 mm (about 1/4 inch), the median size of palpable nodules was 16mm (about 3/4 inch) although there was considerable overlap between both distributions. The smallest

palpable nodule was 7 mm diameter, the largest nodule not-palpable was 20 mm diameter. Nearly 20% of the palpable nodules were smaller than 10 mm and nearly 20% of the nodules not-palpable were larger than 10 mm. It is reasonable to assume that the size of a nodule is more strongly related to the potential impact on a person's health than the ease at which it can be palpated. Systematic studies on this question have not been published; however, in view of these data, the requirement of palpability for determining the presence or absence of thyroid disease should be reconsidered. That is an issue that the medical community worldwide must eventually address.

In the 128 patients with palpable nodules, a fine needle aspiration biopsy was performed. This is a procedure in which a very minute amount of thyroid tissue sample is removed for microscopic examination. The tissue sample was stained in Ebeye, sent to Japan and examined in the Second Department of Pathology of Tohoku University, Sendai. The percentage of biopsies which yielded sufficient material to permit an unequivocal diagnosis was about 60%. However, the experience of the surgeons who performed the ultrasound examination allowed them to make a probable histological classification of the nodule. In 16 patients, thyroid cancer is the most likely diagnosis. Five of this group had sufficient evidence to diagnose papillary cancer. Large follicular adenomas have a high tendency to contain malignant foci; there were another 6 of this diagnosis. Thus, there were 23 persons found with a high likelihood of thyroid cancer.

In agreement with most other studies, the prevalence of thyroid nodules was higher in females than in males. Also in agreement with other studies was a pronounced dependence of prevalence on age: nearly 50% of women over 60 have nodular thyroid disease. From the data as they are presented here, one should not make premature conclusions as to the probable causes of these benign or malignant nodules. It has to be stressed, however, that the total incidence of palpable thyroid nodules is rather high in the population of Ebeye: 13.5% of women over 30 years and 6.7% of men over thirty years have palpable thyroid nodules. The results from the Ebeye study are much higher than those which have been found elsewhere in the world except in the areas with significant iodine deficiency.

Preliminary Observations

The interpretation of disease-rate data to determine causal relationships requires considerable expertise and care in analysis. Thus caution is being exercised in interpreting the thyroid disease prevalence data from the Ebeye study. The number of persons examined is still somewhat small for proper interpretation. However, there is at least one pattern which is striking and deserves mention. Figure 4 of this briefing material shows the distribution of birth years for the 23 possible cancer cases and the atoll of residence in 1954 at the time of the BRAVO test. Forty

percent of these cases were children less than eight years old at the time of the BRAVO test. That young children exposed to external radiation or radioiodines are at higher risk is consistent with all studies. Fifty-five percent of the children under eight years of age during the testing years were born and raised on Ebeye in Kwajalein Atoll. The high number of the Kwajalein residents may only reflect the greater number of people living there. However, because the gummed film data indicates the presence of fresh fallout at Kwajalein on numerous occasions, these results require further careful examination.

Six of the persons in the group of possible cancers were born after the testing ended and their locations of residence as children is also shown. It is curious that two of the five younger subjects were born and raised on Rongelap. It is relatively well accepted in the scientific community that only the short-lived radioiodines are responsible for thyroid cancer. Since exposure to short-lived iodines is impossible in this case, alternative explanations will be required.

Consequences of the Findings

In the compensation scheme implemented by the Nuclear Claims Tribunals, Marshallese citizens are eligible to receive payments from \$12,500 for non-malignant palpable nodules to \$50,000 for nodules requiring thyroidectomy. Thus, to prevent unneeded and possibly dangerous surgery, the Thyroid Study has had the responsibility of recommending surgical intervention only when the ethics of proper medical care demanded it. The possibility of unneeded surgeries is a frightening scenario for an already overworked health care system. Therefore, careful but specific recommendations were made for the care of all patients. In particular, for those persons with nodules that are not-palpable and for all people with palpable adenomatous goiter which does not cause any difficulty with swallowing or compression of the trachea, no treatment is needed. No surgery should be performed on these cases. A follow-up examination has been scheduled for the spring 1995 for these persons to determine if any significant change in their condition has occurred. Surgery should only be performed on those people for whom ultrasound and/or fine needle biopsy examinations suggest either cancer or a large follicular adenoma. In a few patients, advanced age or other serious disease has suggested that thyroid surgery would not be in the best interest of the patient. After consultation with the doctors at the Ebeye Hospital, 14 patients have been selected for thyroid surgery because of suspected malignant thyroid nodules.

The possibility of 16 cancers out of 1368 persons is a prevalence rate of 1.2%. Thyroid cancer is rare in the world, normally ranging from 1 to 10 per 100,000 people depending on ethnic group, sex and age. This figure, if proven right deserves concern. Simple extrapolation to the total population alive at the time of the atomic testing yields an estimate of 80 to 100 thyroid cancers in the adult Marshallese population.

Plans for Further Study of Thyroid Disease

Overall, the Ebeye phase of the Thyroid Disease Study was successful. The local population accepted the offer of a thyroid examination to dispel or confirm their individual fears concerning thyroid disease. The results of the study confirmed the suspected high prevalence of palpable nodules in the population and a possible higher than expected incidence of cancer.

At a meeting with President Kabua and the Nitijela on August 30 1993, the leaders of the nation recommended an extension of the study to other atolls. Such a study would initially be based in Majuro and later extended to outer atolls. Currently, I am seeking support from the Centers for Disease Control and Prevention in Atlanta to continue this investigation.

The close association of the Thyroid Study and the Nationwide Radiological Study will provide an important analytical tool not previously available. Recently collected environmental radiation data at all the atolls can be extrapolated backward to estimate the likely exposure at the time of the testing for persons at locations throughout the Marshall Islands. Though this process is difficult and somewhat uncertain, it will be possible to compare the geographic pattern of thyroid disease with either the geographic pattern of present day residual contamination or with the geographic pattern of the exposure at the time of the bomb tests. The possibility of making these comparisons will improve the ability of this study to draw convincing conclusions over any other previous investigation. By using the largest database possible, the Nationwide Radiological Study and the Scientific Advisory Panel will be able to provide the most credible interpretation possible to date. Regardless of the outcome of scientific analyses which are intended to examine the relationship of thyroid disease and radiation exposure, many Marshallese citizens with heretofore unknown thyroid disease will be identified and provided the appropriate level of medical care.

CONCLUDING REMARKS

The United States atomic weapons testing program in the Pacific is now a part of the history of the Marshall Islands. Part of its legacy has been fear, misunderstanding, and, in some cases, true damage to persons or property. The passage of 40 years since the BRAVO test has not reduced the level of concern about radiation among adult Marshallese citizens. Even to trained scientists, it has never been apparent why the BRAVO incident was never openly investigated.

Today, there are still three communities of islanders displaced from their traditional home islands. Any hesitation of the islanders not to return to their homelands must be viewed with an understanding of the difficult concepts which they are being asked to understand. There are also numerous opinions as to the safety of these islands, and the differences of opinion only compound the difficult decisions for islanders considering whether they should return to their land. The hearing today is one further step to healing some long lasting scars. Openness and freedom of information can only serve to improve a situation in which misunderstanding and, in some cases, true damage, have obscured an understanding of the situation. Where real health effects are obvious, we hope they will be acknowledged and cared for. Where remediation activities are

necessary to return island land to a hospitable condition, we hope that this need will be acknowledged and satisfied.

On behalf of the Nationwide Radiological Study and the citizens and the Government of the Republic of the Marshall Islands, I express my thanks to this Committee for their openness and inquiry into these issues.

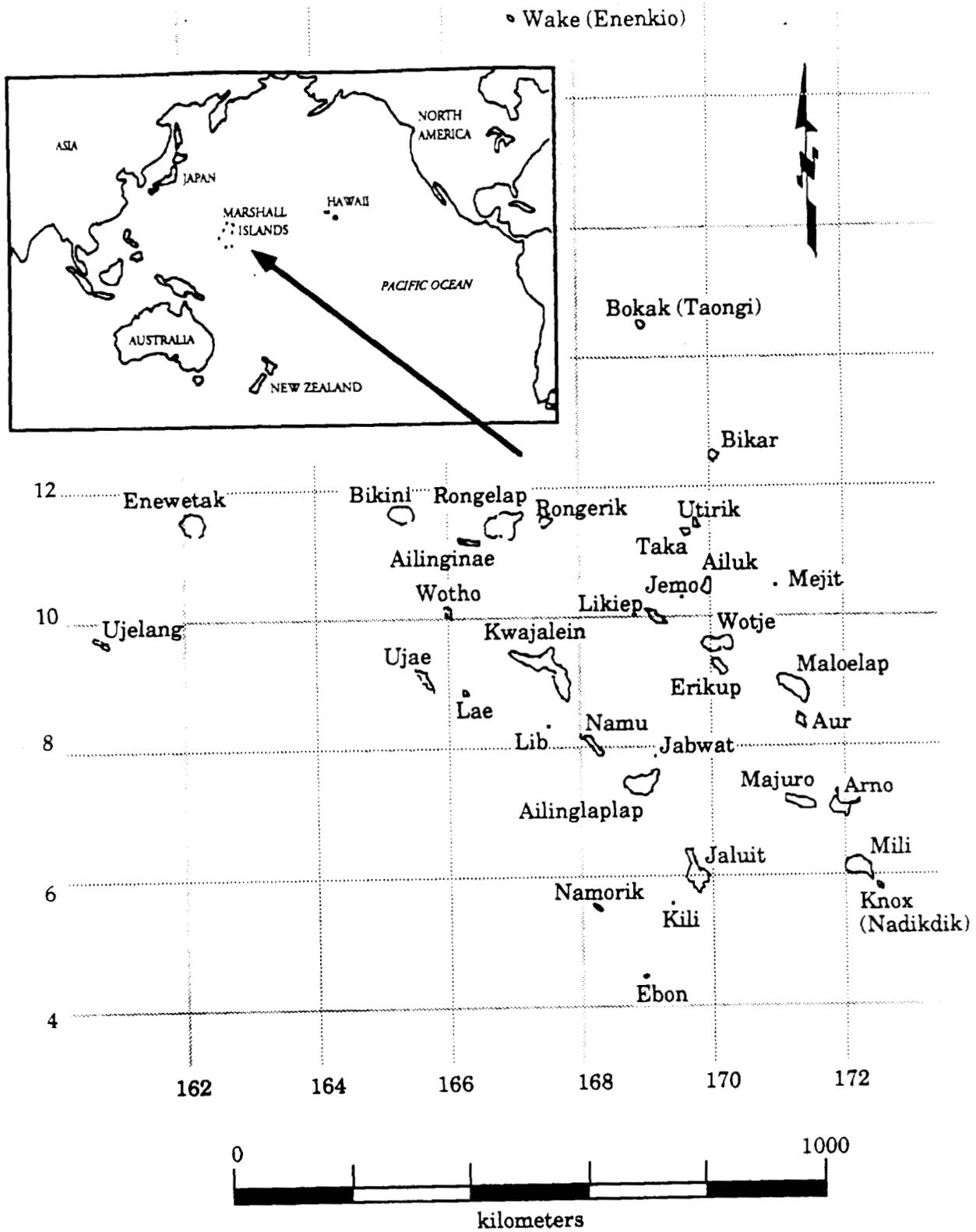


Fig. 1 Map of the Republic of the Marshall Islands

Fig. 2 Cumulative Distribution of Test Yields (kt)
in Republic of the Marshall Islands

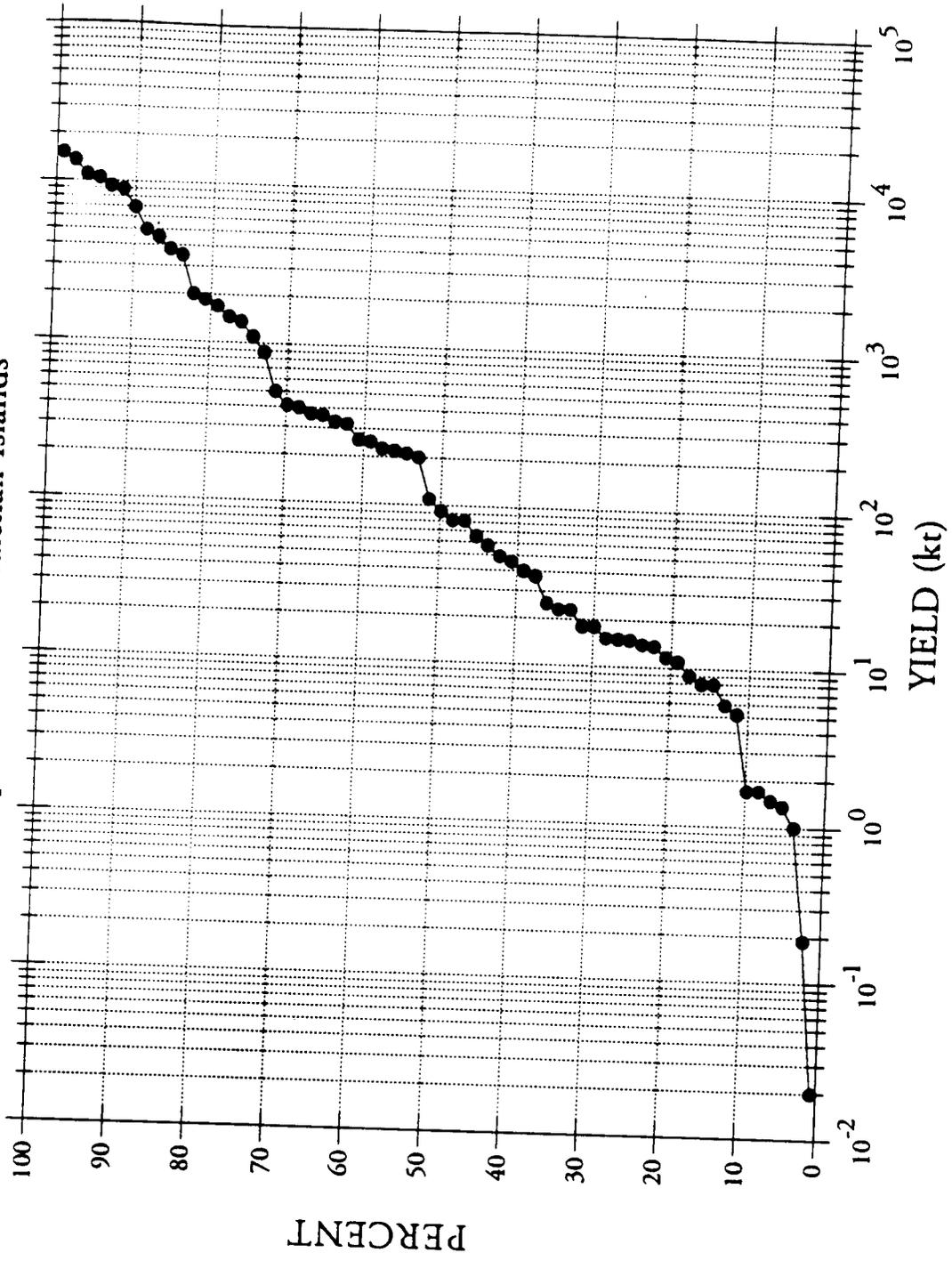


Fig. 3 Monitoring results at Kwajalein Atoll from gummed film network of HASL lab (1954-1959)

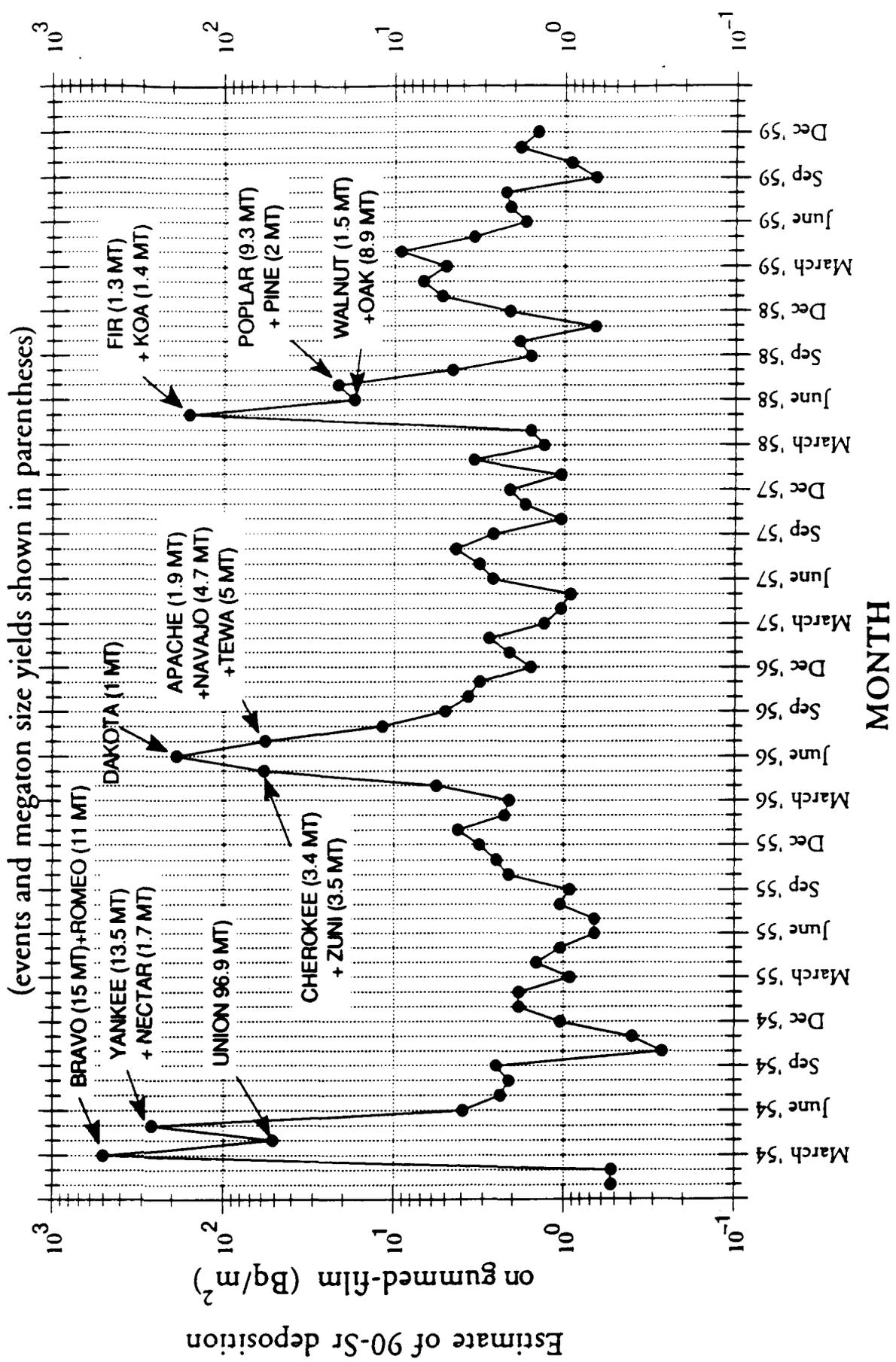


Fig. 4 Birth Years and Residence Locations in 1954 for Cases Suspected of Thyroid Cancer (or main locations of residences for younger cases)

