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BNL 16444
Informal Report

Mr. Conard
Thought this report might be of interest to you. Some work in the Contamination of the migrant program.

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Bob Conard

Fallout

The Experiences of a Medical Team In the Care of a Marshallese Population Accidently Exposed to Fallout Radiation

Robert A. Conard

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Robert A. Conard

September 1992

MEDICAL DEPARTMENT

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.
UPTON, NEW YORK 11973

UNDER CONTRACT NO. DE-AC02-76CH00016 WITH THE
UNITED STATES DEPARTMENT OF ENERGY

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Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

NTIS price codes:
Printed Copy: A04; Microfiche Copy: A01

Village at Utirik Atoll

PRIVACY ACT MATERIAL REMOVED

Dedication

This report is dedicated to who was the Marshallese Mayor of Rongelap Village at the time of the fallout in 1954. is a quiet, unassuming man, well liked, and a respected leader of the Rongelap people. His family suffered extremely from the effects of the fallout. He and four members of his family underwent surgery for removal of thyroid tumors. The tumor in his wife was malignant. His youngest son, who was one year of age at the time of the fallout, had a thyroid tumor removed at age 12 and later developed an acute form of leukemia when he was 19 years old. Although extensively treated in the United States, he died. His death was a cause of great grief to his family and to the Marshallese people.

In spite of all these troubles, including evacuation from their home island and socioeconomic disruption, I have never heard express bitterness. However, he has continued to champion the cause of his people. I am grateful that he has always appreciated and supported the efforts of our medical team to help his people. He has remained a true friend over the years and I treasure his friendship.

(Left), Mayor of Rongelap in 1964 standing beside the oldest woman on the island (over 100 years old?)

PRIVACY ACT MATERIAL REMOVED

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Foreword

More than thirty-six years have passed since the Marshallese people of Rongelap and Utirik were accidentally exposed to radioactive fallout following the detonation by the United States of a powerful thermonuclear device called "Bravo" at Bikini, March 1, 1954. The repercussions of this accident have been widespread. This was the first time that a human population had been seriously exposed to radioactive fallout and the carefully documented findings have formed an important basis for action in other types of accidents involving radioactive fallout, the most notable being the recent reactor accident at Chernobyl in Russia.

Medical teams from Brookhaven National Laboratory, sponsored by the Department of Energy (DOE), formerly the Atomic Energy Commission (AEC), have visited the Marshall Islands regularly since 1954 to examine and contribute to the medical care of the Marshallese. The medical findings have been published in numerous Brookhaven National Laboratory reports and in medical journals (see References, Section A).* I headed the medical teams from 1956-1979. In carrying out these examinations, the medical teams were faced with many problems and dilemmas, some of which were unforeseen and unique to a medical group. Some of the problems were related to cultural differences, and to the lack of understanding by the Marshallese of radiation and its effects, resulting in unfounded fears and psychological effects. Other problems were related to displacement of the people, socioeconomic disruption, and increasing resentment against the United States with political involvement and demands for compensation. Nevertheless, the medical teams and the Marshallese people developed a strong feeling of mutual respect and friendship in spite of these problems, and the people have expressed their gratitude for the benefits rendered them. In this report an attempt is made to review, in an informal, narrative style, some of the highlights of events that occurred, the human interest aspects, and our attempts to cope with some of the problems that developed. The medical findings will be referred to only briefly because they have been published elsewhere in great detail. (Section A, References.)

I first went to the Marshall Islands during World War II as a naval medical officer. The Solomon Islands campaign had just been completed and we were on our way to the Marianas Islands for landings at Saipan, Guam, and Tinian. My first sight of Kwajalein and Enewetak revealed the smoldering ruins from the invasion. Little did I realize that I would return to these islands for many years. As a naval radiological safety officer, I returned to participate in Operation Crossroads at Bikini, and later, in Operation Greenhouse at Einewetok. However, my real interest was in the biomedical effects of radiation. I took a course in radiation physics at the University of California, followed by a year's training in radiobiological research at Argonne National Laboratory. Later, I continued this research at the Naval Medical Research Institute and, still later, at Brookhaven National Laboratory when my tour of duty with the Navy ended in 1955. I participated in the initial examinations of the Marshallese in 1954, and from 1956 until my retirement in 1979, I was responsible for organizing the continuing medical surveys. For a short period after my retirement, Hugh S. Pratt and Eugene P. Cronkite headed the program. Since that time, the program has been ably handled by William H. Adams and I have drawn on his reports for findings since my retirement.

*The references are divided into two sections: A. Selected Technical Reports and B. Other References, including some of the numerous mass media articles.

Acknowledgments

In writing this report I am grateful for the help of several people at Brookhaven National Laboratory. Eugene P. Cronkite and Victor P. Bond, who have been closely involved with the project since its inception, have encouraged me in writing the report and given helpful advice. William A. Scott and Peter M. Heotis, who have worked with me in organizing and carrying out the examinations, have been of great assistance. I am grateful to Avril Woodhead and Katherine Vivirito for editorial assistance, Robert Crease, BNL Historian, for his help, and Bernice Armstrong for secretarial assistance. In the Photography and Graphic Arts Department I wish to thank Douglas Humphrey and Robert Smith for the photographs used, and Morton Rosen, Kenneth Boehm, Alan Schmidtchen, and Helga Pirozzi for their help.

John Tobin, former Trust Territory anthropologist, has been helpful regarding Marshallese customs. Roger Ray, former manager of the DOE programs in the Marshall Islands, has helped me regarding events that occurred since my retirement in 1979. We have been most fortunate in obtaining excellent physicians and technicians to participate in the program. Some worked in the islands on several occasions (see Appendix I).

The following resident physicians have provided invaluable service to the program in the Marshall Islands: Knud Knudsen (1972/74, 77/78); Konrad Kotrady (1974/76); William Grant (1979); Roger Rittmaster (1980/81); James Harper (1981/83); Paula Barclay (1984); and John Engle (1984/86).

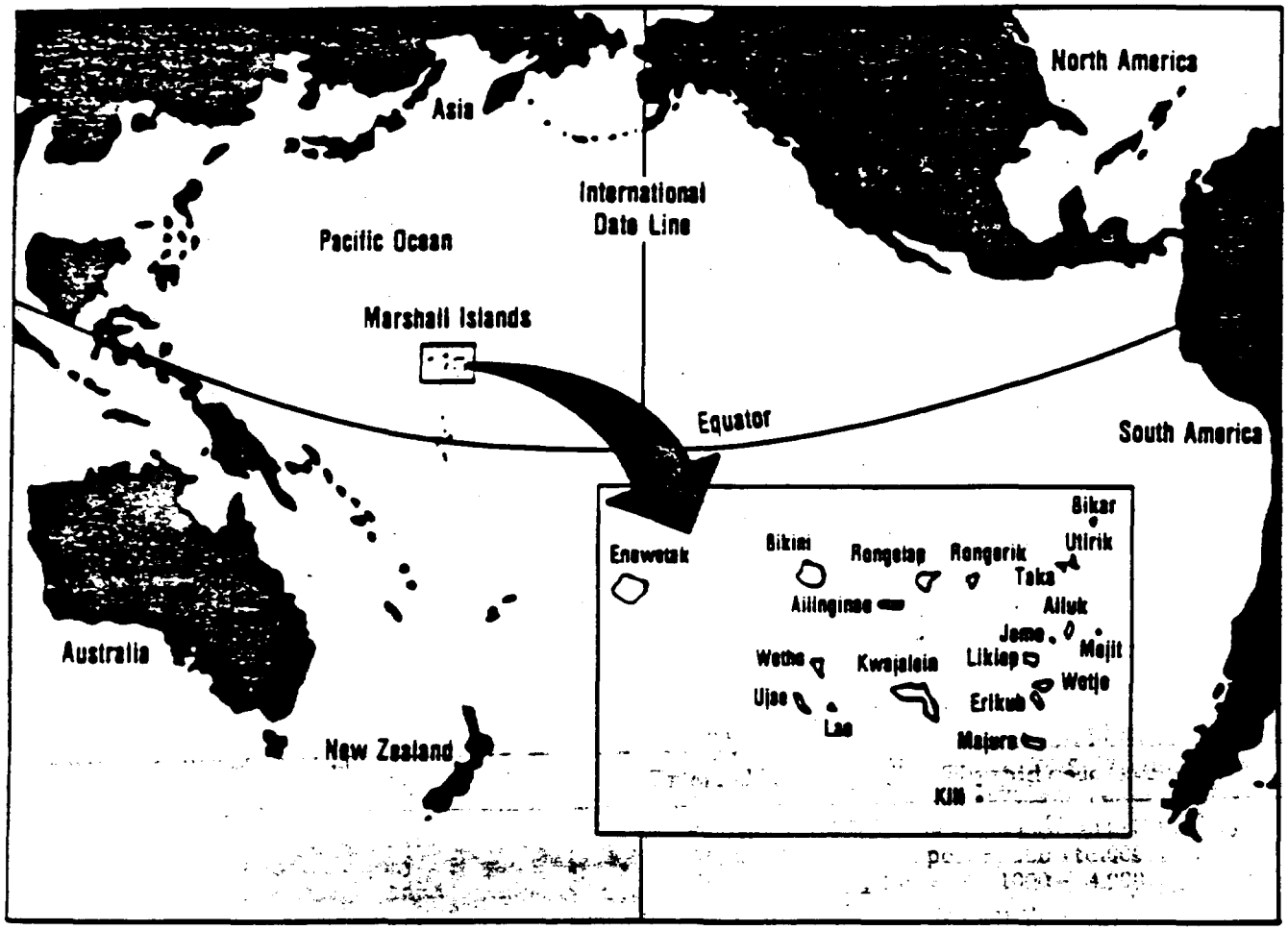
Also essential to the success of the program has been the staunch support of many agencies, particularly Brookhaven National Laboratory, the Department of Energy, the Department of Defense, the Department of Interior, the Health Services of the Trust Territory, and the Republic of the Marshall Islands.

I would like to name some of the many people who contributed a great deal during the 26 years I directed the program. At Brookhaven: Knud Knudsen, James Robertson, Stanton Cohn, Lee Farr, Donald Van Slyke, Richard Stoner, Harold Atkins, W. Alvord Finn, Daniel Slatkin, Lawrence Hankes, Michael Makar, Darrel Joel, Arjun Chanana, Jack Rothmann, Robert Brown, Clyde Sipe, Douglas Clareus, Edward Lessard, Peter Rathvon, Charles Meinhold, and David Potter. From other institutions: J. Edward Rall, Jacob Robbins, Jan Wolff, Baruch Blumberg, and Roger Rittmaster at the National Institutes of Health; Brown Dobyns and David Reid at Cleveland Metropolitan General Hospital; Wataru Sutow and Ernest Libby at M.D. Anderson Hospital; Edward Held of the University of Washington; Shields Warren, Bentley Colcock, William Meissner, and Marion Legg at New England Deaconess Hospital; Leo Meyer, Veterans Hospital, Brooklyn, NY; Lawrence Ackerman at SUNY-Stony Brook; P. Reed Larson at Brigham and Women's Hospital; William Moloney at Boston City Hospital; John Bugher, Charles Dunham, Merril Eisenbud, William Streenan, William Burr, James Liverman, and Harry Brown at AEC; and Ruth Van Cleeve at the Department of Interior.

The staff at the Hospital at Brookhaven provided excellent care for the Marshallese patients.

In the Marshall Islands, I am grateful for the support of Amata Kabua, President, and Oscar DeBrum, Chief Secretary of the Republic of the Marshall Islands. The participation of the Health Services of the Marshall Islands has been invaluable: practitioners Ezra Rikion, John Jaman, Arabati Hicking, Issac Lanwi, Armer Ishoda, Tregar Ishoda, Isao Kasino, Masao Korean, Jeton Anjain, and Maidher Kabua; technicians Sabeo Shoniber, Nelson Zetkeia, Joseph Saul, Kilman Gideon, Helmer Emos; and nurses Jenuk Kabua, Ruth Harris, and T. Leyjen.

I am grateful to Captain Keith Coberly and the crew of the *Liktanur* for their outstanding services to the medical team.



Location of the Marshall Islands

Chapter I — Background

To appreciate more fully some of the events that occurred during the medical examinations of the Marshallese people, I first briefly describe the Marshall Islands, their history, and people.

The Marshall Islands are located in the eastern part of Micronesia, roughly half way between the Hawaiian Islands and Australia, in a large ocean area (about 280,000 sq. miles) that includes also the Marianas and the Caroline Islands. The total land area is about half that of Rhode Island. There are thirty-four coral atolls and single islands in two chains, Ratak (sunrise) and Ralik (sunset) lying between four and fourteen degrees north of the Equator. An atoll is a ring of low-lying coral islands surrounding a lagoon. The islands have formed on the submerged rims of extinct volcanic craters. The waters abound in fish and marine life. The sandy soil of the islands supports growth of the ubiquitous coconut palms and other plants including pandanus, breadfruit, arrowroot, and, to a lesser extent, bananas and papaya. With the fish and marine life, these plants provide sources of food, thatching for houses and mats, and, more recently, copra from the palms for export. The sandy soil, scarcity of water, and the salt spray carried inland by the trade winds limits the growth of other vegetables and flowers.

In the northern Marshall Islands, rainfall is scarce during the six-month dry season, and because there are few wells, the Marshallese depend almost entirely on catchments from the roofs.

In the 16th century, exploration of the Pacific was beginning and in the 18th and 19th centuries ships from Russia, England, and America landed in the Marshall Islands. The Marshall and Gilbert Islands were named after English sea captains. During this period, trading ships visited the Marshall Islands in search of products that might be of commercial value (pearl shells, sea cucumbers, sandalwood, and sea otter skins (B-1); copra (the dried meat of the coconut) soon became the most profitable local product. There were several bloody encounters between ship's crews and the Marshallese which made colonization hazardous at this time. However, around the middle of the 19th century, Protestant and Catholic missionaries were allowed to settle in the Islands, which opened the door to colonization and to exploitation of the copra industry. Germany occupied the Marshall Islands in 1885 but this did not cause nearly as much disruption in the life of the Marshallese as occurred when the Japanese took the Islands in 1914. Following World War I, the Japanese held the Islands under mandate to the League of Nations. Clandestinely, the Japanese began fortifying the islands, and building landing strips to develop military supremacy in the Pacific. The life of the Marshallese was regimented to help achieve these purposes.

World War II brought hardship and misery to the Marshallese, some of whom were wounded and killed in naval bombardments, particularly during the invasion of Kwajalein and Enewetak; some were executed by the Japanese military. Many Marshallese made heroic efforts to aid the American forces.

Following the War, in 1947, the Marianas, Caroline, and Marshall Islands captured from Japan were formed into a Trust Territory of Pacific Islands administered by America under the United Nations, with a mandate to advance the interests of the people of the Territory. The administration was first under the Navy and later, starting in 1951, under the Department of the Interior. A High Commissioner, civilian political appointee, headed the administration, and its headquarters were first located at Honolulu, then at Guam, and later at Saipan. Administration in the six districts was located in the district centers. In the Marshall Islands, the center was at Majuro atoll. A Congress of Micronesia was formed with representation from the various districts to work with the High Commissioner and his staff.

After the war, the United States began further testing of atomic bombs. In 1946, Bikini atoll was chosen for the first atomic test because of its relative isolation from inhabited areas. The following year, the need for developmental testing resulted in the formation of the Pacific Proving Ground, with Enewetak as the base of operation (B-3). The Bikini people were persuaded to leave their atoll "for the good of mankind". The subsequent attempt to resettle this population, who finally ended up on tiny

Kili Island, was an unfortunate chapter in the United States' relationship with the Marshallese. The people of Enewetak also were later evacuated to a much smaller atoll. With the development of a naval station, and later, the Pacific Missile Range at Kwajalein, more Marshallese were displaced to other islands in that large atoll. The first Pacific test was Operation Crossroads, at Bikini in 1946, followed by Operation "Sandstone", "Greenhouse", and "Ivy". These operations resulted in a limited number of slight overexposures of personnel to radiation. During Operation Greenhouse, fallout was recognized as a problem. However, it was not until the "Bravo" detonation in the Castle Operation that the seriousness of high levels of radioactive fallout was adequately recognized. Until a moratorium on atomic testing in the Pacific was declared in 1958, 23 atomic devices were tested at Bikini and 43 at Enewetak Atoll.

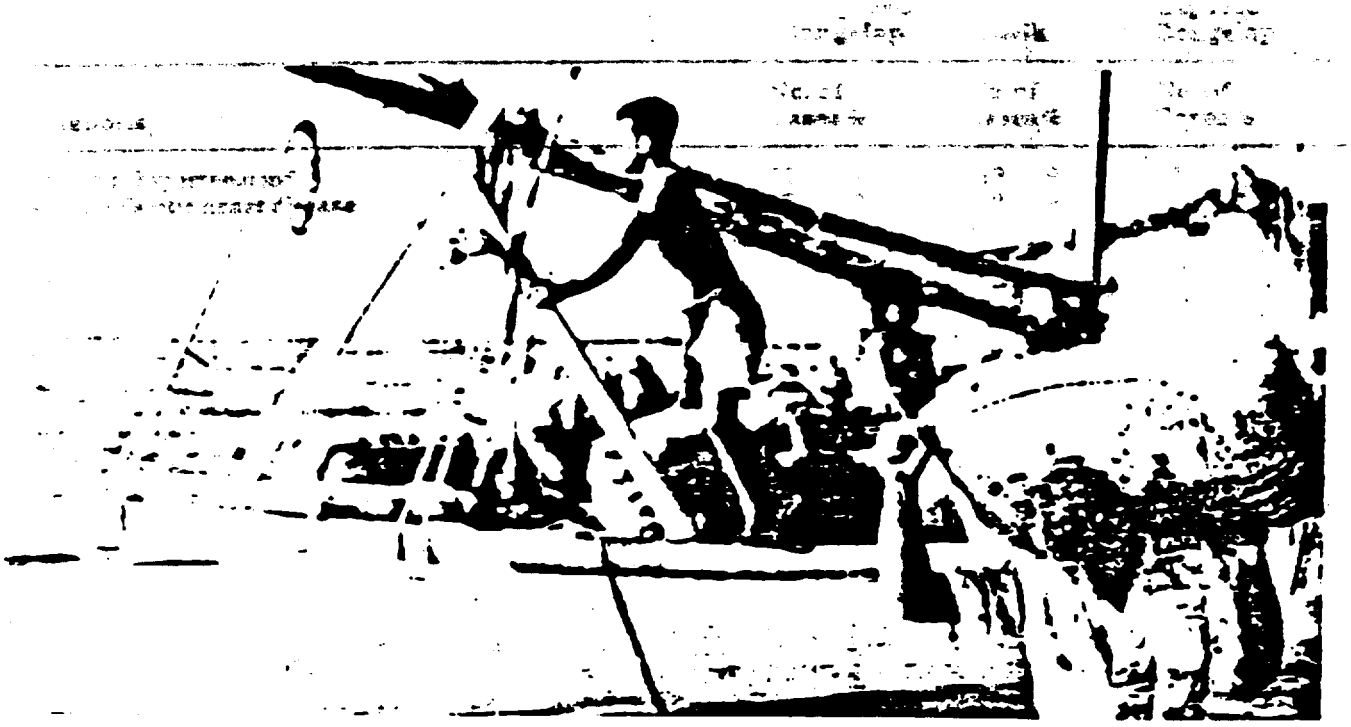
Marshallese children.

Rongelap woman strumming her uke.

Net fishing.

Elderly Marshallese male.

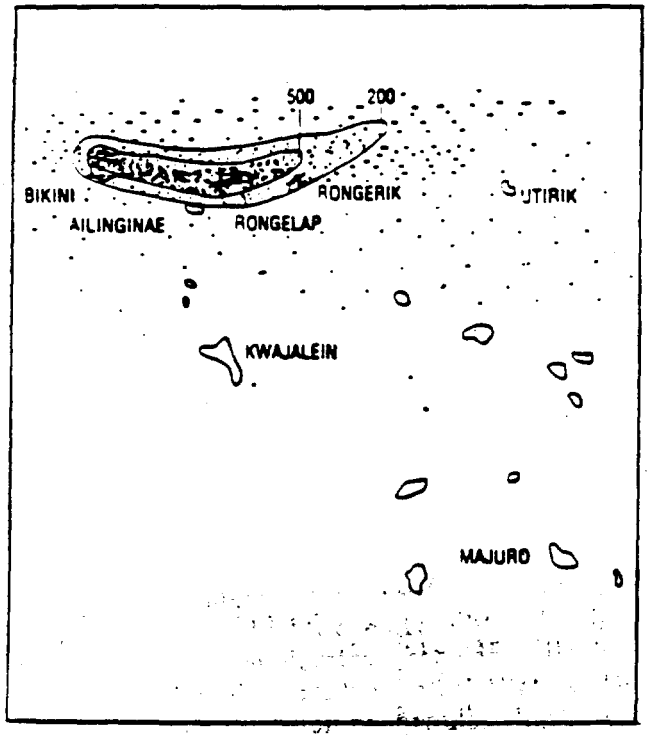
Health aide.



Handling copra, the dried meat of the coconut. A chief source of income in the Marshallese Islands.

Chapter II — The Bravo Accident

"Bravo", the first atomic test in the Castle series, was a large thermonuclear device detonated on the reef at Bikini Atoll on March 1, 1954. An unexpected shift in winds caused an unprecedented accidental fallout. Two hundred and thirty-nine Marshallese on Rongelap, Ailingnae, and Utirik Atolls, 28 American servicemen on Rongerik Atoll, and 23 Japanese fishermen on their ship, the *Lucky Dragon*, received significant exposure to radioactive fallout.



Fallout area in the Marshall Islands.

A. Early Events

Most of the following events were excerpted from Barton C. Hacker's report: *Elements of Controversy: A History of Radiation Safety in the Nuclear Testing Program (B-6).*

As was usual, numerous meteorological observations were made to insure that the radioactive cloud from the detonation would not move in the direction of the inhabited atolls to the east.

At midnight the weather still held, but low altitude winds now light and variable raised chances of fallout in the wrong place. Bikini's weather outlook was downgraded to unfavorable, and the task force ordered its ships 50 miles further out to sea. Assuming the worst, some winds might blow toward the nearest inhabited atolls, but predicted speeds and altitudes seemed to preclude any real danger; debris could reach Rongelap or Rongerik only after 12 to 15 hours, by then having decayed to safe levels. Two hours before shot time the earlier forecast remained valid. Task force commander Clarkson confirmed his order to fire at 06:45.

The actual yield of the detonation was considerably more than expected, a surprising 15 megatons (almost one thousand times the yield of the bombs over Hiroshima and Nagasaki). Winds high aloft carried the radioactive cloud in an easterly direction, depositing seriously high fallout on a Japanese fishing vessel and on the inhabited atolls of Rongelap, Ailingnae, Rongerik, and Utirik.

Several naval vessels, thirty miles east of Bikini, unexpectedly encountered heavy fallout with white flakes falling on the decks of the ships. Top-speed retreat was ordered and, with crews below decks and salt water washing down on the decks, the hazard was greatly reduced. (Later, several sailors developed mild radiation burns of the skin.)

The realization of the extensiveness of the fallout in the area east of Bikini emerged slowly because of a series of confusing and overlapping events. Difficulties were encountered with the cloud-tracking planes and there was confusion about the radiological situation on Rongerik atoll, where 28 American servicemen manned a radiological safety weather station.

On Rongerik, a blast wave hit the island and shook the buildings about eleven minutes after the men had observed the flash from the detonation. About four to six hours later, a mist-like haze was noted. At seven hours, the needle on a radiation- measuring instrument went off scale at 100 plus mr/hr. The Task Force

was preparing breakfast while his wife was nursing their one-year old child. Suddenly, there was a blinding flash, and they saw a huge red fireball ascending upward "...like the sun rising in the west." Minutes later, a tremendous blast knocked thatched windows out of the huts and coconuts out of the trees.

In the late morning the atmosphere became murky, and a snow-like, gritty material began falling from the sky; this continued for some hours, covering the ground and palm trees with a white coating, adhering to the skin and in the hair of the people, causing itching and burning of the skin and irritation of the eyes. Many children played in the ash; some of the children frolicked in the lagoon edge and thus, unknowingly, helped prevent or modify the development of radiation burns of the skin. The fallout settled on their food; some said the coconuts tasted bitter. Since it was the dry season, the water in the catchment systems was low, and a brief rain shower that evening caused the water in the cisterns to turn yellow. [redacted], the Health Aide, advised the people not to drink the water. However, many did.

During the night of March 1 many people lost their appetites and became nauseated; a few vomited and had diarrhea. These symptoms persisted into the next day.

On the afternoon of March 2, the Task Force sent two men on a seaplane to Rongelap to measure radiation levels. They were on the island only 10-20 minutes and did not speak to the people, perhaps because they did not know Marshallese.

At 7:30 a.m. on March 3, the *USS Philip* anchored in the lagoon at Rongelap. Shortly after, a seaplane arrived from Kwajalein with Marion Wilds, a Trust Territory Representative, and Oscar DeBrum, a Marshallese interpreter.[3] The following description is taken from the official account of the Captain of the *USS Philip* (B-10).

A radiological monitoring team went ashore with the landing party and measured radiation levels on the island. [redacted], the Magistrate, was informed that it was necessary to evacuate the people. He designated 16 people (older people, and those with sickness) to return to Kwajalein on the plane. The remaining 45 people left on the ship about noon for Sifo Island at Ailingnae Atoll where the other 18 Rongelap people were picked up, and the ship proceeded to Kwajalein. Shower facilities were made available to attempt to decontaminate the people, and some of their clothes were laundered. The ship arrived at Kwajalein at 8:30 a.m., March 4.

2. *Utirik*

The 159 people living on Utirik Atoll saw the flash of the detonation in the western sky in the early morning of March 1 and felt the concussion of the blast wave. Fallout was not seen on Utirik, probably because there was less and it had dispersed by the time it reached that island. It was later estimated that the fallout began at about 4:00 a.m. on March 2 (about 22 hours after the detonation) and continued for about 4-5 hours. The Utirik people did not complain of symptoms, such as skin irritation or gastrointestinal effects as the Rongelap people experienced. The first of two ships ordered to Utirik to evacuate the people was the *USS Renshaw*, which arrived about 6:30 a.m. on March 4 and sailed again at 1:30 p.m. The *USS Monroe* did not arrive until after the people were evacuated.

D. Atomic Energy Commission (AEC), Washington

The Joint Task Force Command notified the AEC in Washington about the evacuation of the Marshallese from Rongelap and Utirik and the servicemen from Rongerik and requested a medical team to evaluate possible fallout effects on the people.[4] John Bugher, Head of the Division of Biology and Medicine, called on the Surgeon General of the Navy to form a special medical team. E. P. Cronkite at the Naval Medical Research Institute was asked to head a joint AEC-Department of Defense emergency medical team. The expedition was outfitted in record time and left for the Marshall Islands on March 7.

On March 11, the Atomic Energy Commission made the following announcement:[5]

[3] DeBrum later became Marshall Island District Administrator under the Trust Territory Government, and then Secretary to the Republic of the Marshall Islands.

[4] In March, the AEC issued a terse release stating that a test detonation had occurred. There was little reaction in press. The Task Force personnel were advised not to talk about the accident. It was some weeks before the U.S. public became aware of the extend of the accident (B-8).

[5] Our group felt that this announcement was misleading and inaccurate since, at that time, some effects were being observed.

Headquarters was notified by radio.[2] Apparently, the message received by the Task Force was not clear, and was given no special handling. Later, a second, more urgent message made it apparent that the situation on Rongerik might be serious. The men were told to stay indoors with the windows closed. These precautions, no doubt, accounted for the mildness of the radiation burns of the skin that a few men later developed. The following morning (March 2), Captain L. B. Christensen (USA), a radiological safety officer, sent on the supply plane to Rongerik, found that the radiation levels were so high that evacuation was necessary. Unable to contact the Task Force by radio, he took eight men to Kwajalein in his plane. The other twenty men were evacuated that afternoon. Christensen recommended that planes be sent to measure radiation levels in the inhabited atolls and, realizing that Rongelap might have higher levels than Rongerik, he recommended that plans be made to evacuate the Rongelap people. About 36 hours post-detonation, planes measured high levels of radiation on Rongelap and Utirik, showing that evacuation was necessary. Lower levels were found on Ailuk, an atoll just south of Utirik, but the Task Force decided that evacuation of the 400 people on that atoll was unnecessary. On March 2, the *USS Philip* (DDE 498) was ordered to Rongelap to evacuate the people, and on March 3, the *USS Renshaw* (DDE 489) and the *USS Monroe* (DDE 422) were ordered to Utirik for the possible evacuation of the people there. Seaplanes with Task Force and Trust Territory representatives were scheduled to meet the ships at these islands.

What went wrong? In reviewing the events that occurred soon after the accident, I think that the state of confusion was responsible for the chronology of events that occurred. Certainly, no ulterior motive is evident. In retrospect, one does wonder why the people of Rongelap had not been evacuated for Operation Castle, as they had been for Operation Crossroads. The Commander, Joint Task Force 7, explains:

> The natives were not evacuated prior to the detonation because, on the basis of information available to us, it was not considered necessary, and no fallout was expected in the inhabited areas. (B-7)

B. The Lucky Dragon Episode

On March 1, a Japanese vessel, the *Fukuru Maru, (Lucky Dragon)*, with a crew of 23 men, was about 80 miles east of Bikini. The fishermen saw the detonation from their ship in the early morning, but were unaware of any danger. Soon a snow-like fallout covered the deck and stuck to the exposed portions of their bodies. That evening the crew experienced nausea and vomiting which lasted for twenty-four hours. The ship's captain decided they should return to Japan, where they arrived about two weeks later. By this time, skin burns were developing and the crew was put into hospitals.

The United States later compensated Japan in the amount of $2,000,000 for the effects of the fallout on the fishermen and on the fishing industry (A-38, B-3, B-9). The Japanese subsequently undertook several marine surveys in the Pacific to study the effects of fallout on ocean currents and on their fishing industry. The accident added fuel to the arguments of the anti-nuclear groups in Japan against the US testing program; these repercussions later caused problems and disrupted one medical survey.

The external radiation effects on the fishermen were similar to those in the Rongelap people. Their absorption of radioactive material via ingestion was less since their food and water, except for fresh fish, were in closed containers. No thyroid abnormalities were found (A-14, 38).

C. Evacuation of the Marshallese

1. *Rongelap*

On March 1, there were 64 Marshallese people on Rongelap island and 18 others were fishing and gathering copra at Ailingnae Atoll, about 18 miles southwest. Based on statements made by , the Magistrate of the village, and other sources, I have reconstructed the events of that fateful day.

[2] Merril Eisenbud, then Head of the Health and Safety Laboratory (HASL) of AEC New York Operations Office, told me: The HASL representative on the Estes (Bresiin) received word that the monitoring instrument on Rongerik went off-scale at H + 7 hours. He advised me about this in New York, following which the task force denied him the use of radiocommunications for about 30 hours. The first notification to the AEC/HQS was at about H + 24 when I told Bugher (Head of the Division of Biology and Medicine, AEC) about my TWX from Bresiin the day before. There were apparently no messages from CJTF7 to DC for at least 24 hours.

During the course of routine atomic tests in the Marshall Islands, 28 United States personnel and 236 residents were transported from neighboring atolls to Kwajalein Island, according to plan as a precautionary measure. These individuals were unexpectedly exposed to some radioactivity. There were no burns. All were reported well. After the completion of the atomic tests, the natives will be returned to their homes. (B-3)

E. Naval Station, Kwajalein

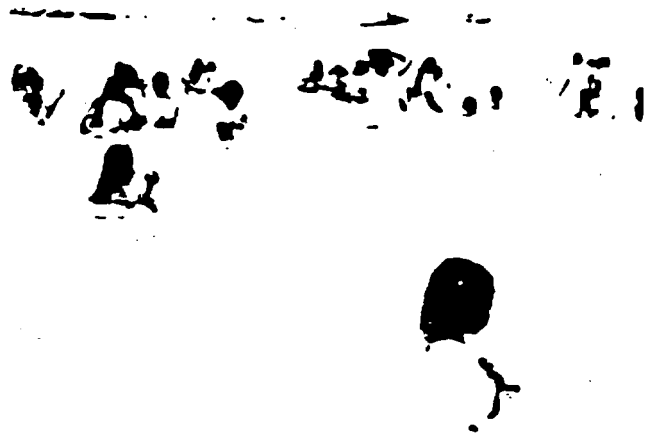
When the evacuated personnel arrived at Kwajalein, they were given brief physical examinations including blood counts at the Naval Dispensary. A shower facility for decontaminating personnel and laundry facilities were established. Most people still showed some residual radioactive contamination of the skin and clothing. Their clothing was laundered and, to aid in decontamination, they were encouraged to bathe in the nearby lagoon. Most people had few clothes, and some had to be discarded due to persistent radioactive contamination.

F. Initial Medical Examinations

1. Facilities

When the medical team arrived at Kwajalein on March 8, we found that the people were adjusting well to their new surroundings. There was some worry about possessions left behind, and they were told that their boats and livestock would be cared for. the magistrate, expressed concern that the Rongelap people might have the same fate as the Bikini people who had been away from their island for many years.

With the cooperation of the Navy, we set up examination and laboratory facilities in a building adjacent to the living quarters of the Marshallese. Further decontamination of personnel and clothing was instituted. Members of the team were assigned responsibilities for examinations. Daily sick call and treatment in the Clinic were established. Medical histories were taken and physical examinations were carried out with the assistance of Jack Tobin, a Trust Territory anthropologist; Kathleen [redacted], a Marshallese nurse, and Billiet Edmond, a school teacher, who served as interpreters.



Marshallese bathing in the lagoon of Kwajalein to remove fallout contamination.

Medical examinations at Kwajalein.

2. Medical Findings

The details of the medical findings in our initial survey can be found in Reference A-2.

During the first two days after detonation of the bomb about two-thirds of the Rongelap people experienced anorexia and nausea; a few vomited and had diarrhea. The majority had itching and burning sensations of the skin in exposed areas. Only one of the 18 people who had been on Ailingnae Atoll had these symptoms and none of the symptoms were noted in the Americans and people of Utirik.

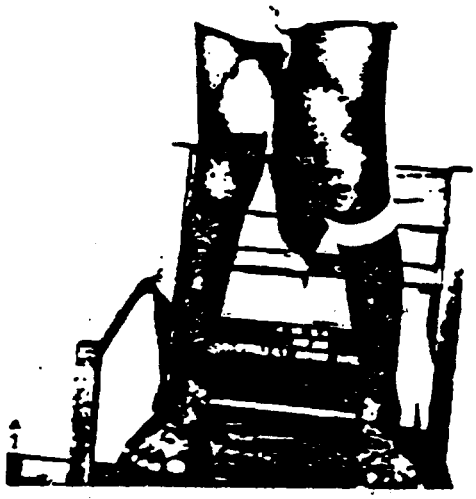
Significant exposure to radiation depresses some elements of the blood, particularly the white cells which protect against infection and

platelets which prevent bleeding. With large amounts of radiation, such depression may lead to death from infection and bleeding. Therefore, numerous examinations of the blood were carried out during the six weeks of examinations.

Increasingly severe depression of the white blood cells (lymphocytes) and platelets was noted during the first few weeks, failing to about one-half to one-fourth normal levels. The greatest drop occurred in the children. This depression was much less in the Rongelap people who had been on Ailingnae and the Americans who had been on Rongerik. The people of Utirik, who had received a much smaller radiation exposure, showed only slight depression of the average platelet count. By six weeks, when the initial examinations were concluded, the blood elements in the Rongelap group showed recovery approaching, but not reaching, normal levels.

Beginning about 10 days after exposure, radiation burns of the skin began appearing in the Rongelap people. These so-called "beta burns" appeared as dark pigmented spots on the scalp and on parts of the body that had not been covered by clothing.[6] The top layer of skin of these spots then peeled away, leaving depigmented areas: some lesions later became ulcerated. The majority of the Rongelap children had these burns. The burns were much less pronounced in the Ailingnae group and the American servicemen. No beta burns were noted in the Utirik group. Loss of hair was associated with the scalp burns. The burns were accompanied by itching and burning sensations, and some of the lesions on the top of the feet were painful, particularly during walking. Biopsies of the lesions showed severe injury to the skin surface, but little injury to the deeper tissues, showing that the effects of the beta radiation were superficial. After two to three weeks, the beta burns began healing, with repigmentation and regrowth of hair.

Except for the changes in the skin and blood, the exposed people appeared to be generally in good health, and there were no differences between the more exposed groups compared with the lesser exposed groups. Some slight weight loss was noted in the Rongelap people, which may have been related to the change of environment and diet.



Extensive radiation burns in a young Rongelap boy.

At the outset, the medical team had no way of estimating the whole body dose received by people. In accordance with good medical procedure, we decided that the clinical findings, particularly the degree of depression of blood elements, would be the index used to estimate the seriousness of the effects of the exposure. Animal studies had shown that such a "biological dosimeter" was valid. This decision proved to be a good one. The doses estimated later agreed well with the clinical findings that might be expected, based on animal studies.

During the first few weeks when the blood counts were dropping and numerous skin burns were appearing, serious consideration was given to the possibility that further medical assistance, such as the use of a hospital ship, might be necessary. Admiral Bartholomew Hogan, the Pacific Fleet Surgeon of the Navy at Hawaii, said that naval assistance would be available (B-12).

[6]The term "beta burn" is used, since injury to the skin was largely from beta radiation in the fallout.

fallout. They suffered no blast trauma nor thermal burns. The fallout material consisted of numerous radioactive fission products, some neutron-induced radioelements, and a small amount of fissionable material. The Marshallese were exposed to (1) penetrating gamma radiation resulting in whole body exposure, (2) skin radiation from deposition of fallout on the skin, and (3) internal absorption of radioactive materials from consumption of contaminated food and water and, to a lesser extent, from inhalation.

Calculation of the acute radiation doses received by the people depended upon the results of radiological surveys of the islands, the length of time of exposure to the fallout, the amounts of contaminated food and water consumed, and, later, urinalyses on the exposed people. There were many variables and uncertainties in these calculations. The estimated dose of gamma radiation probably was the most accurate. The skin exposure was spotty and the doses are not accurately known, although in many cases, they were estimated to be well above 1000 rad from soft beta rays. The amount of internal exposure was derived by radiochemical urinalyses carried out beginning at about two weeks after exposure. Only radioactive strontium (^{89}Sr) and iodine (^{131}I) were near the maximum permissible levels. Based on later studies, plutonium, a long-lived element, was present in small amounts and well within the Federal Guidelines (See Chapter VII). This element and strontium can be deposited in the bones. However, no effects of any of these absorbed elements, except for radioiodine, which concentrates in the thyroid gland, have been detected in the Marshallese people. By six months, there was barely detectable radioactivity in the urine of the Rongelap people.

In view of the extensive later development of thyroid abnormalities (largely from radioiodine exposure), it became apparent that the original doses estimated to this organ were too low; and re-evaluation of the doses received by the Marshallese, based on later data, are presented Table 1. The dose to the thyroid gland was much greater in the children due to the smaller size of their glands.

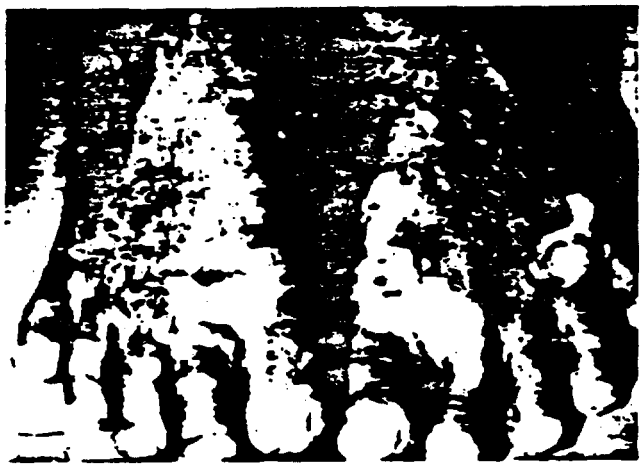
When the exposed Marshallese people were taken back to their home islands, they were exposed to low doses of radiation from residual fallout. This will be discussed in Chapter V.

Table 1
Dose Estimates (rad)*

Group***	Age	External Dose	Thyroid dose (est-max)**
Rongelap (67 people)	1 yr.	190	5000 – 20,000
	9 yr.	190	2000 – 8,000
	Adult		1000 – 4,000
Ailingnae (18 people)	1 yr.	110	1300 – 5,200
	9 yr.	110	540 – 2,200
	Adult		280 – 1,120
Utirik (167 people)	1 yr.	11	670 – 2,700
	9 yr.	11	300 – 1,200
	Adult	11	150 – 600

*From Lessard et al., 1985 (A-52)
**Does not include external dose
***Includes those exposed *in utero*.

Radiation burns of the neck.



Radiation burns of the feet.

Loss of hair in a young Rongelap girl due to fallout deposit on the scalp.

Fortunately, this course of action was unnecessary. The exposure to gamma radiation received by the people was sublethal. Based on the known effects of radiation in animals, an additional 100 rad of radiation might have resulted in fatalities, perhaps even with treatment. It is fortunate that no one lived on the northern islands of Rongelap atoll since the radiation levels there were definitely in the lethal range.

In spite of the significant degree of hematological depression, there was no evidence of bleeding nor evidence of increased susceptibility to infections in the exposed people. An epidemic of upper respiratory infections that occurred in the Marshallese during the period of the examination was no worse in the more heavily exposed than in the less exposed Utirik group. Blood transfusions were not considered. (Blood transfusions had been used in treating the exposed Japanese fishermen, one of whom later died of hepatitis.) It was decided not to use prophylactic antibiotics since the possible development of bacterial resistance to antibiotics might reduce their effectiveness if infections developed.

After the initial examinations were completed, the AEC decided to move the Utirik people back to their home island since the low residual radiation levels were considered safe for habitation (A-3). In June, they were returned and provided with supplementary food. However, surveys of Rongelap island showed that radiation levels were too high to permit the people to return. Therefore, they were moved to temporary quarters set up for them on a small island (Ejet) at Majuro Atoll several hundred miles south of Kwajalein. Following our initial examinations of the American servicemen, they were taken to Tripler Army Hospital in Honolulu for further examination by Army physicians. The exposed Marshallese would continue to be examined by our medical team.

G. Dose Estimates

The Japanese at Hiroshima and Nagasaki were exposed mainly to direct gamma radiation, with a small neutron contribution from the detonating bombs and the resulting fission products. They suffered extensive trauma and thermal burns. There was no significant fallout. On the other hand, the Marshallese suffered no direct effects from the detonation itself, and their exposure was due entirely to radioactive

Chapter III — Return to Rongelap

During the three years on Ejet Island, the Rongelap people longed to return to their atoll and were greatly disappointed at the length of time they were kept away. Meanwhile, the deserted village at Rongelap had deteriorated with overgrowth of weeds and vines, their thatched-roof huts were sagging or collapsed, and the church had burned (B-3).

By 1957, there had been 10 radiological surveys of Rongelap: seven by the Applied Fisheries Laboratory of the University of Washington and three by the Naval Radiological Defense Laboratory. As early as June 1956, surveys indicated that the radiation levels on Rongelap Island had declined to such a extent that the island might soon be habitable. The AEC, with the concurrence of the Trust Territory Government, authorized Holmes and Narver (a Los Angeles construction company) to plan a new village on Rongelap in conference with the AEC, Trust Territory, and the Rongelap people. The new village would include homes, a church, council house, dispensary, school, warehouses, and water systems. Plans also included some dwellings and cisterns on nearby islands. We designed plans for the dispensary and requested a two-way radio to be installed for medical consultations and emergencies.

In February 1957, the AEC, with concurrence of the High Commissioner of the Trust Territory, announced that Rongelap could again be inhabited and construction of the village began (B-3). By June, the construction was completed and an LST was sent to Majuro to transport the people home.

The following account is excerpted from the Holmes and Narver, Inc. *Report of Repatriation of the Rongelap People for the Atomic Energy Commission, Albuquerque Operation Office, Contract AT(29-2)-20, Nov. 1957.*

> Boarding the LST were 250 Rongelap people with their personal belongings carried in every conceivable kind of container, from woven mats to galvanized washtubs

New village at Rongelap.

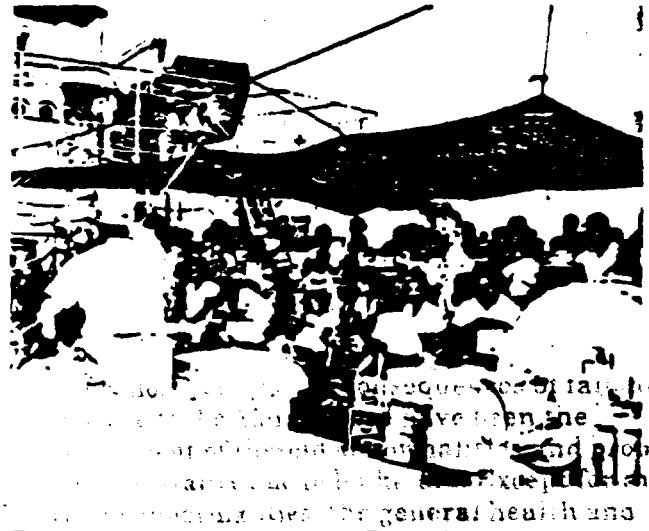
to new airplane luggage, 40 pigs, 60 chickens, 6 dogs, 1 cat, 1 duck, 1 pet pigeon. Also on board were 5 coffins bearing the remains of Rongelapese who had died during the 39 months since their forced evacuation in 1954. Before sailing, the people of Majuro gathered on board to wish them farewell and good luck and sing hymns of thanksgiving. The voyage home was pleasant and uneventful.

On arrival, before debarking, the people gathered under the deck awning and offered prayers and hymns of thanksgiving to God for their safe return to their native land. On the beach was a huge sign in Marshallese: Greetings, Rongelap People.

We hope that your return to your atoll is a thing of joy and your hearts are happy.

Food subsidization was provided on a diminishing basis for the first year by the Trust Territory. The cost of the rehabilitation program was about $560,000.

Unfortunately, the stay of the Rongelap people on their home island was not to be permanent. In 1985, the local Rongelap authorities, doubting the U.S. claim that Rongelap was radiologically safe, arranged to have the people moved to an island in Kwajalein Atoll. As of now, the people have not yet returned, and re-evaluation of the radiological situation of the island is in progress (see Chapter IX).



People on ship returning to Rongelap

Flag raising on Rongelap.

Chapter IV — Health Care in the Marshall Islands

In July 1947, the United States Navy assumed administration of the Trust Territory of the Pacific Islands with headquarters in Hawaii (B-4). The Navy's Bureau of Medicine and Surgery sent survey teams into the islands of Micronesia to assess the health status of the people; they found that malnutrition was widespread. Sanitation, health care, and treatment of diseases were usually primitive and there was a vital shortage of trained medical personnel.

The health conditions in the islands were graphically described in the comprehensive reports of a remarkable voyage of the *USS Whidbey* (B-5, A-1). The Navy outfitted this ship with a medical staff and clinical and laboratory facilities. The ship visited many islands in Micronesia, including the Marshall Islands, documenting vital statistics and incidence of disease. Briefly, the surveys showed that unsanitary conditions with regard to flies, garbage disposal, and excretory habits made for multiple intestinal parasitic infestations and diseases. A high percentage of people had positive Kahn tests associated with yaws, for which treatment with penicillin proved extremely effective. Diseases of the eyes and skin, acute and chronic respiratory diseases, and vitamin deficiencies were especially common. Poor oral hygiene resulted in widespread caries and loss of teeth, even in young adults. No malaria, filariasis, yellow fever, or cholera were seen.

Many of the health problems noted in the *Whideby* report were present in the Marshallese people when we began our examinations in 1954. (See Table 2 for a list of major medical findings in the Marshallese population on one of our early surveys.)

The Navy knew that improvement in the health care system in Micronesia was a formidable undertaking. Paramount was the critical shortage of trained medical personnel. Schools were established at Guam for training medical and dental practitioners, nurses, and technicians. Training of health aides to run the Outer Island dispensaries was undertaken at the

Table 2
Major Diagnoses

Diagnosis	Unexposed Rongelap* No. of Cases	%	Utirik No. of Cases	%	Exposed Rongelap No. of Cases	%
Essential hypertension*	11	11	13	9	7	7
Arteriosclerotic heart disease	3	3	2	2	3	3
Cerebral arteriosclerosis	1	1	6	4	1	1
Bronchiectasis	1	1	1	1		
Emphysema			10	7	1	1
Cancer			2**	2		
Tertiary syphilis			1	1	1	1
Primary yaws			1	1		
Pulmonary tuberculosis	1	1				
G.I. parasites			1	1		
Congenital abnormalities (all types)	8	8	13	9	10	11
Asthma			4	3		
Osteoarthritis	7	7	8	5	5	5
Rheumatic heart disease					2	2
Total examined***	95		140		93	

*Defined as systolic 140 mm Hg or diastolic 100 mm Hg.
**Orbital tumor, type unknown; basal cell skin carcinoma.
***Adults and children

District Centers. This training program was expanded under subsequent administrations of the Trust Territory and under the Republic of the Marshall Islands.

The Department of Health Services of the Trust Territory Government was responsible for health care in the Territory. In the Marshall Islands the District Medical Centers were under the Director of Health Services of the Trust Territory and, more recently, as part of the government of the Republic of the Marshall Islands. The hospitals at Majuro and Ebeye Islands are staffed with local practitioners and Micronesian nurses and technicians. At times, a few American physicians were on the staff. The local practitioner, with less formal education than an American M.D., by necessity learned to carry out medical responsibilities, including major surgeries, remarkably well.

In the Outer Islands, the dispensaries are manned by a health aide, often with limited training, and visits of the field-trip ships carrying medical supplies and personnel were often irregular because of poor communication with the District Centers.

The health services have faced many problems in rendering health care in these islands. There have been serious epidemics of diseases, such as poliomyelitis, influenza, chicken pox, and pertussis, which were brought into the islands.[7] These epidemics were particularly severe with high mortality before there were effective immunization programs. There were insufficient medical personnel to handle health care, including widespread diabetes and dental problems. One of the most serious problems has been population growth in these islands with limited habitable land.

There has been continued improvement in health care in the Marshall Islands (B-8, 14-17). A new $8,000,000 multi-wing hospital, planned as a referral center for Micronesia, was opened at Majuro in 1986. The hospital has been operated by Mercy International Health Services (a U.S. organization) under contract with the Marshallese government. The U.S. staff is being replaced with Marshallese medical personnel (B-14). The hospital has a rehabilitation center, which was begun in the 1960s following a polio epidemic and receives referrals from other areas. As part of the new College of Micronesia at Majuro, a School of Nursing has been established with a training program for health assistants to serve in the Outer Islands.

There remains a vital shortage of trained medical personnel, particularly doctors. Insufficient premedical education has made it difficult for Marshallese students to get into U.S. medical schools. Recently, a school was established at Pohnpei in the Caroline Islands for medical training of Micronesians, and efforts are being made to attract more young Marshallese into the field of medicine.

Increased emphasis is being given to improvement of health care in the outlying atolls (B-8). Medical teams regularly visit these islands on the *Canvasback*, a sailing vessel. In addition, a sailing vessel, the *Tole Mour*, furnished and outfitted with medical facilities by the Marimed Foundation, with a staff of volunteer medical personnel, also regularly visits the outer Marshall Islands. The operation of these ships is supported by the Marshall Island Government. In addition to general medical care, the visiting teams carry out dental treatment, inoculations, treatment of venereal diseases, and conduct educational programs on sanitation, family planning, and training of midwives. Radio communication has improved and air strips have been constructed on some islands, including Rongelap and Utirik, allowing for emergency visits of medical personnel and evacuation of patients.

Considering the isolation of these islands, travel problems, and shortage of trained medical personnel, in my opinion there has been good progress in health care. However, there is still considerable need for improvement.

[7] In 1963, poliomyelitis was introduced into the Islands by an infected sailor from a visiting ship. A widespread epidemic occurred, with nearly two hundred cases of paralysis.

Chapter V — The Continuing Medical Surveys

A. Need for Continuing Medical Surveys - AEC Mandate for the Examinations

Following the initial medical examinations, the people of Rongelap were reexamined by medical teams headed at six months by V. P. Bond (Naval Radiological and Defense Laboratory) (A-3), at one year by E. P. Cronkite (Brookhaven National Laboratory) (A-4) and at two years by me (A-5). In 1956, I resigned from the Navy and joined the staff at Brookhaven.

The Rongelap people had moved to a temporary village constructed for them at Ejet Island, Majuro Atoll. For the examinations, the people were transported by boat to the main island at Majuro, several miles away. An unexposed population of Rongelap people living at Majuro was selected as a comparison group and given the same examinations as the exposed people. This population was blood relatives of the exposed people, living under the same conditions, and matched reasonably well for age and sex.

Examinations during the first two years showed that the initial acute effects of the radiation exposure had largely subsided (see next Section). The people were reasonably healthy and no deaths could be attributed to radiation exposure.

The lack of further significant findings was most encouraging [illegible] significant radiation exposure the people had received. However, in view of studies of the Japanese exposed to the atomic bombs at Hiroshima and Nagasaki and of other irradiated populations, the exposed Marshallese were at greater than normal risk of late effects, such as leukemia and other types of cancer (B-31). Therefore, we recommended that annual examinations of the Rongelap people be continued indefinitely. Looking at the small radiation exposure of the Utirik population, we considered that examinations every three years would be adequate. (Later, when thyroid abnormalities appeared in that population, annual examinations were carried out).

The Division of Biology and Medicine of the AEC agreed with these recommendations, and in 1957, with the concurrence of the Trust Territory, requested that the examinations be continued under contract with BNL. I was asked to be the program director.[8]

The examinations by the Brookhaven medical team have been a joint project with the Trust Territory under the Department of Interior and, more recently, the Republic of the Marshall Islands. The participation of the health service personnel of the Marshall Islands has been indispensable to the success of this project. During the early phases of the examinations, the need for, and extensiveness of, the examinations had to be clarified with the Trust Territory officials. Also, there was concern that the Rongelap people were not adjusting satisfactorily since returning to their island and that the crew going ashore from the Navy LSTs at the time of the examinations might have a disrupting influence. Subsequently, the situation improved when Trust Territory ships were used and the number of survey personnel reduced.

B. Limitation and Expansion of Program

The Brookhaven medical program in the Marshall Islands was designated by the AEC as a research program with a mandate to examine and treat the Marshallese people who had been exposed to fallout. The responsibility for the general health care of the Marshallese, including the exposed populations, had been established as a responsibility of the Trust Territory Government. As time went on, it became increasingly apparent that the primary health care afforded by the Trust Territory in the Outer Islands was inadequate, and the medical team attempted to increase medical care. Our team was later criticized for not assuming greater responsibility for general health care of the Marshallese. Another criticism was that the people were being treated as "guinea pigs", which was probably related to the fact that numerous examinations and tests were being carried out by the medical team because of the limited knowledge about the effects of fallout

[8] It should be pointed out that the AEC naturally turned to agencies under contract to them, principally the National Laboratories, for assistance in handling radiation problems. Except for the military laboratories, there are few other agencies that have the capabilities for such assistance.

radiation in human beings, and perhaps also to the designation of the program as a research project".

In spite of limitations of the program established by the mandate, the AEC recognized that it would be necessary to examine a control, unexposed population and that the physicians would treat diseases other than those caused by radiation. Later on, the AEC/DOE further expanded the program. There was never any effort by AEC/DOE or any other agency to influence the conduct of the examinations.

During their stay on the islands, the medical team routinely carried out "sick call" for anyone needing medical attention. It should be emphasized that the amount of health care that could be given by the medical team was limited not only by the mandate but also by the time available for the examinations.

Since an unexposed population of Rongelap people were given the complete battery of examinations and tests given to the exposed people, the other unexposed people on Rongelap and Utirik eventually requested that they receive the complete examinations. Therefore, by 1972, all the people on Rongelap and Utirik were included.

Following the death of a young Rongelapese in 1972 from leukemia, which was probably related to radiation exposure, we decided that hematological examinations of the Rongelap people would be done every six months. Also, we became aware that the treatment program with thyroid hormone was not being sufficiently monitored, which could be serious, particularly in people who had had thyroid surgery. In addition, it was increasingly apparent that greater continuity was necessary in the medical care of the populations being examined. Therefore, a resident physician, Knud Knudsen, from BNL, was stationed in the Marshall Islands at the Ebeye Hospital near Kwajalein to coordinate the medical programs at Rongelap and Utirik, and the District Center at Majuro, in collaboration with the Department of Health Services of the Trust Territory.

Beginning in 1973, when thyroid nodularities were developing in the lower-dose Utirik population, we decided that more information was needed on the natural incidence of thyroid tumors in the Marshallese people. Therefore, more than nine hundred people living on atolls south of Rongelap and Utirik (namely, Wotje, Likiep, and Majuro) were given thyroid (neck) examinations. On arrival at these atolls, a meeting was held to tell the people that we would make "street surveys" starting at one end of the village and going down the street, asking the people to let us examine their necks. There was usually complete cooperation.[9]

In 1974, a "Fallout Survivors' Bill" (B-18) was passed by the Congress of Micronesia and later funded by the United States (B-47). Those who were ill were granted free hospitalization in the Islands and free travel, with *per diem* allowances. Both exposed Rongelap and Utirik people, and the unexposed control people could participate. When referrals to U.S. medical facilities for further treatment were necessary, the expense was borne by the Trust Territory government except for illnesses which might be related to radiation exposure, which continued to be funded by the DOE. Because of funding and administrative difficulties, payments were often delayed, which resulted in considerable unrest and criticism expressed at our village meetings. Later, representatives of the DOE accompanied the medical team to clarify these issues.

Following my retirement, Hugh S. Pratt headed the program in 1980. He was followed for a brief period by E. P. Cronkite, who headed the first team in 1954. Since 1981, William H. Adams has ably directed the program. In 1991 Jean Howard joined Adams in directing the program.

The examinations are now carried out twice a year. The first examination, usually in

[9] In 1982, the Marshall Island Atomic Testing Litigation Project (Los Angeles) supported a survey for thyroid nodules in the Marshall Islands (Hamilton, T.E., van Belle, G., and Lo Gerfo, J.F., Thyroid Neoplasia in Marshall Islanders Exposed to Nuclear Fallout. JAMA 258: 629-36, 1987). The study reported that there was an increase of thyroid nodules in people of the northern Marshalls (other than Rongelap and Utirik) compared with people in the southern atolls, which they believed was due to exposure to fallout from the Bravo accident. They claimed that the incident of nodules we reported for our control population was too high. If true, the risk factor for thyroid nodules in the Rongelap and Utirik people would be increased. However, when one considers the fact that the greatest damage to the thyroid gland was from the short-lived isotopes of iodine which decay in a matter of hours, it is hard to believe that, by the time the fallout reached more distant atolls, the thyroid dose would have been sufficient to result in later development of nodules. We concluded from our examination of people on two atolls in the northern Marshalls (Likiep and Wotje), and the Rongelap and Utirik people who had not been exposed in 1954, that the incidence of thryoid nodules in these people was similar to other world populations (A-15).

March, examines all available people: a second examination, about six months later examines those missed in the first examination, and provides follow-up medical care. Until 1985, resident physicians, sponsored by Brookhaven, continued to serve in the Marshalls for one to two years (See Appendix I). After 1986, the program director decided that it was not necessary to have a resident physician in the Islands since U.S. funds made available under the Compact of Free Association permitted the Department of Health Services to increase health care in the outer atolls, particularly in the northern atolls affected by fallout. Chapter IX discusses the Compact of Free Association between the United States and the Republic of the Marshall Islands, and the compensation granted to the people of the atolls affected by the atomic testing program.

[illegible] States [illegible] ... and he [illegible] recovered. At that time, [illegible] with no indication of [illegible] was to later develop [illegible] about 1970, two years before [illegible] his father recalls that he was beginning [illegible]

[illegible] injections of several antileukemia agents [illegible] Cytosine Arabinoside) in an attempt to [illegible] cancer cells in his blood. [illegible] was [illegible] well known journalist, who later wrote several [illegible] about him (B 65, 66, 67)

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Chapter VI — The Medical Examinations

A. Organization

1. *Supporting Agencies*

In organizing and carrying out our medical mission in the Marshall Islands, the assistance of many agencies, governmental and non-governmental, has been essential. Some of the key agencies include:

a) Brookhaven National Laboratory (BNL) which has been the base of operations for planning and organizing the surveys under contract with the Division of Biology and Medicine of the Department of Energy (DOE).

b) The Department of Energy, formerly the Atomic Energy Commission (AEC), the Energy Research and Development Administration (ERDA), and the Offices of DOE at Nevada, Honolulu, New York, San Francisco, and Enewetak.

c) The Department of Interior (DOI) and the Trust Territory of the Pacific Islands. The surveys were a joint project with the Marshall Island Department of Health Services of the Trust Territory. This collaboration has continued under the new administration of the Republic of the Marshall Islands (See Chapter IV).

d) Department of Defense (DOD), particularly the Bureau of Medicine and Surgery of the Navy and its laboratories at the Naval Medical Research Institute, the Naval Radiological Defense Laboratory, and the Pearl Harbor Command: the Army Medical Center at Walter Reed and Tripler; the Armed Forces Special Weapons Project/Defense Nuclear Agency; and the Army and Navy Commands at Kwajalein and Enewetak, which have furnished vital logistic support and have served as our advance bases in the Pacific.

e) The Department of State, the National Institutes of Health, and the Radiation Effects Research Foundation in Japan.

2. *Medical Participants in the Surveys*

We were most fortunate in obtaining outstanding physicians in many specialties and subspecialties and technicians from the United States to participate in the examinations, including many who were experienced in radiation effects and also endocrinologists specializing in thyroid problems. They provided extremely important diagnostic, therapeutic, and technical capabilities. Equally important has been the participation of a large number of medical personnel (practitioners, technicians, health aides, and nurses) from the Health Services of the Marshall Islands, who contributed vitally in carrying out the examinations, in obtaining medical histories, and in acting as interpreters.

The success of the program mainly has been due to the dedicated service of all of these participants. Appendix I lists the participants with their years of participation.

3. *Supplies and Equipment*

Since the beginning of the examinations there have been changes and additions in medical equipment due to advances in technology and to differences in medical approach. Blood counting by microscope has been supplemented with electronic counting and chemical analyses of the blood by electronic means. A mammography unit was added to the x-ray equipment. In 1957, a 21-ton steel room was constructed at BNL to measure internal radioactivity (described in Chapter VII). Some procedures were adapted to field conditions: for example, the staining of blood smears and cell culturing present special problems under tropical conditions. Getting together and packing the medical equipment, shipping numerous boxes to the Islands, and unpacking and setting up the examinations in the Islands are formidable tasks requiring considerable time and logistic planning.

4. *Examination Facilities*

Early in the examinations tents were used on Rongelap and Utirik, which were gradually replaced with more permanent structures. At Rongelap, sleeping quarters with adjacent shower and toilet were constructed, and a trailer was brought in for cooking and messing. The dispensary, school house, and council house were used for examinations. At Utirik, we acquired some butler-type buildings left over from the weather station, which were used for housing and examinations. Later, a new dispensary was constructed by the Trust Territory on the Island and was used for the examinations.

The setting up of the heavy 21-ton steel room, used during the early years for whole body counting, presented problems. It was installed aboard ship at Enewetak, along with a clothing change-room and shower room, and connected to the ship's power supply. The people were brought to the ship by small boats. Later, an arrangement of lead bricks ("shadow-shield") was substituted for the steel room and set up permanently ashore along with a clothing change and shower facility. A generator was installed on the Islands to furnish power for the examinations and for the operation of the whole body counter.

As more and more people from Rongelap and Utirik gravitated to the District Centers at Majuro and Ebeye (near Kwajalein Island), more permanent facilities were needed, so trailers were set up adjacent to the hospitals and furnished for the examinations and laboratory work.

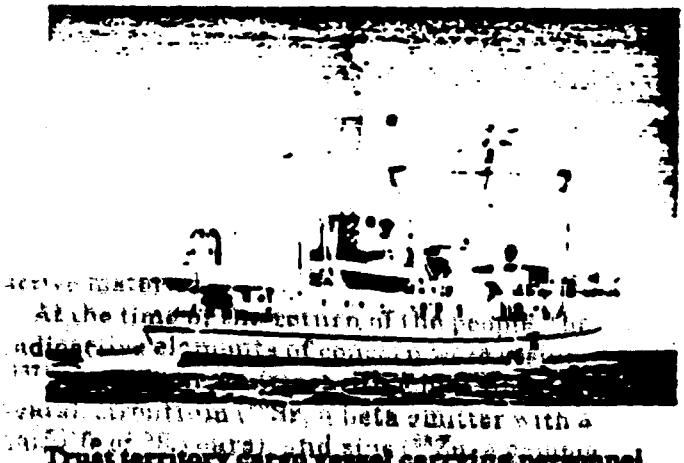
Since 1972, we were fortunate in having ships assigned to the medical teams. These vessels, though small, have adequate living facilities, and trailers installed on the cargo deck are equipped for the examinations, while an area below deck is used for the laboratory and x-ray examinations. There have been four such vessels (*Liktanur I, II, and III* and the *G.W. Pierce*). The Rongelap and Utirik people are brought by boat to the ship anchored near the shore. To avoid the risk of travel by small boat, the children are examined in the dispensary ashore.

At the District Centers at Majuro and Ebeye, the ship is moored to the docks where the Rongelap and Utirik people living at these locations are brought in for examination.

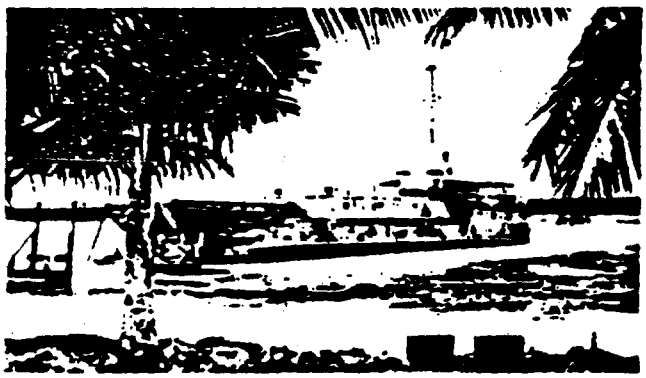
5. *Transportation*

During the early years, transportation from Hawaii to the Islands was by military prop aircraft. With the advent of jet planes, travel to the islands has been faster and more comfortable. Transportation in the Marshall Islands has been a problem, since, until recently, the only way was by ship except for a time when the Navy at Kwajalein helped by flying some of the team to Rongelap and Utirik by seaplanes. In 1958 and 1959 the Navy furnished LSTs that were beached at Rongelap and Utirik and the medical team lived aboard. Subsequently, we relied on Trust Territory cargo ships to get to the Outer Islands.

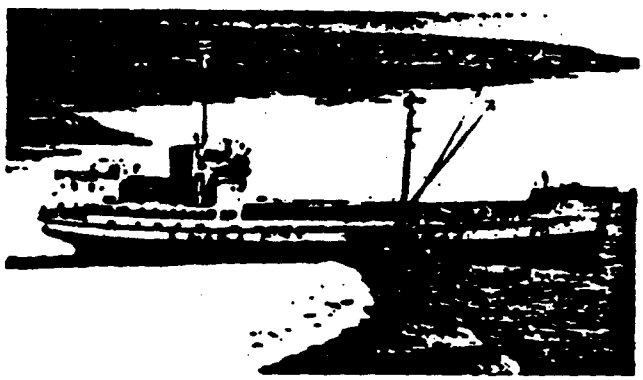
On arrival at the Islands, getting ashore was by small boat or by outrigger canoe. When the examinations were done ashore, it was difficult to get the heavy boxes of medical equipment and supplies ashore. Therefore, the later



Trust territory cargo vessel carrying personnel and supplies for medical survey, 1966.



Vessel assigned to the medical team for examinations, 1974.



Trust territory vessel stranded on reef after departure from Rongelap, 1972.

acquisition of our own survey ships was a great boon in carrying out our mission.

In recent years, airstrips have been built on Rongelap and Utirik and a local commercial airline at Majuro has a limited small-plane service to these Islands.

B. Scope of the Examinations

To detect and treat radiation effects in the Marshallese, it was necessary to conduct longitudinal, prospective follow-up studies, probably for the lifetime of the people. To accurately assess possible radiation effects, it was necessary to examine an unexposed population for comparative purposes because data on the incidence of various diseases in Micronesia were incomplete or nonexistent, and vital statistics were inadequate.

As a basis for planning the examinations, there was considerable information available on the effects of radiation in animals and also from exposure of human beings, such as the Japanese casualties to the atomic bombs, from people receiving radiotherapy, and accidental radiation exposures. However, the exposure of the Marshallese to the complex radiations of fallout was unique. There had been no previous serious exposure of a human population to fallout. Consequently, numerous examinations were necessary to diagnose and treat possible radiation effects at an early stage. As the examinations progressed through the years, new findings required new tests to be added to the protocol. As a result, a considerable battery of examinations and tests have been carried out: these are listed in the published medical reports.

Routinely, the examinations began with a medical history of the individual, taken by a Marshallese practitioner, followed by a complete physical examination, a detailed examination of the blood, and an x-ray examination. Examinations focused on the detection of any late effects of radiation, particularly cancer. Thyroid examinations, including hormonal studies of the function of the glands, and growth and development studies of the children received particular attention. Some other examinations were included to detect possible inherited effects of radiation, cataracts of the eyes, immunocompetence (ability to resist diseases), intestinal parasites, and dental problems.

Medical Team being greeted on arrival at Rongelap, 1971.

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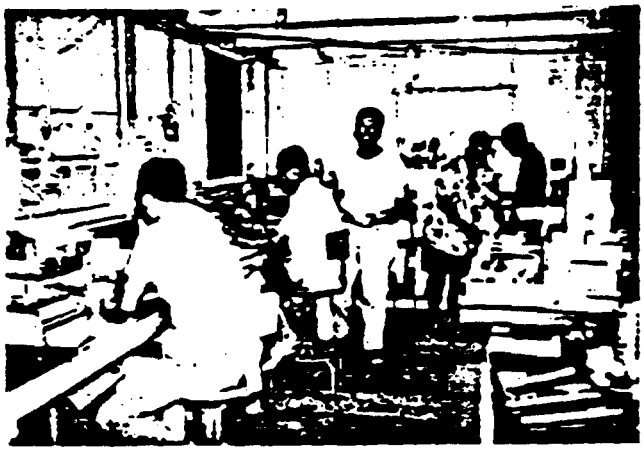
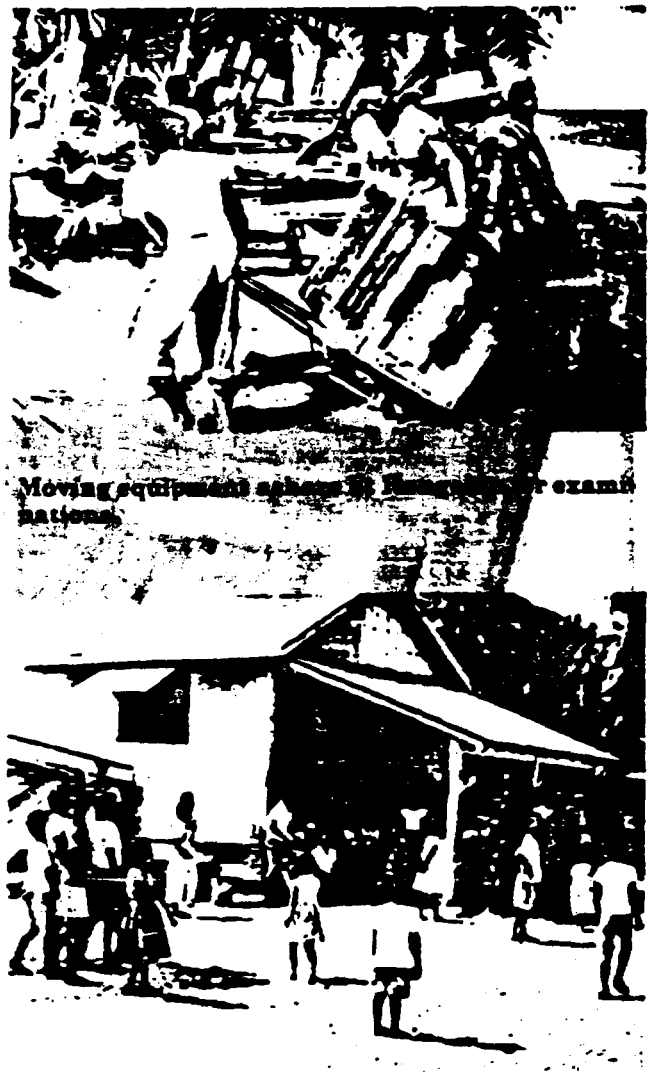


Laboratory set up in new dispensary at Rongelap.



Awaiting exams at Rongelap.

C. Problems Associated with the Examinations

There were several problems in carrying out the examinations. The language barrier hampered communications with the people. However, we were fortunate in having English-speaking Marshallese participating in the program who also acted as interpreters. Sometimes people were unsure of their exact age, which caused particular problems in assessing growth and development in the children. The diagnosis of an illness was often vague and the cause of death was often "too old", and it was difficult to obtain consent for autopsies, even at the District Medical Centers because of feelings against mutilation of the body after death. Some people complained that drawing blood made them feel weak, while others questioned the need for continued examinations, particularly during the early period when there were few significant findings.

Psychological reaction to the fallout was reflected in various ways. In the early years, fears regarding fertility were present, and there were complaints of weakness believed to be due to exposure. Many ailments common to the Marshallese were believed to have been made worse by the fallout, such as fish poisoning and inflammation of the mucous membranes from arrowroot flour, which, when improperly prepared, causes such effects. Almost all deaths were thought to be related to radiation exposure. When a young man died of leukemia, there was great concern that many people would die of that disease. With the development of thyroid tumors, many were concerned that they might develop such cancer.

Other complaints not related to the examinations were that the coconuts, when mature, were smaller than usual. There was considerable unhappiness that the coconut crab, considered a great delicacy, had to be banned from the diet for about ten years due to unacceptable levels of radioactivity. Further, during our examinations people could not forage for food adequately and requested that we furnish food. Recognizing that our visits disturbed the normal rhythm of life on the Island, we subsequently brought in food to cover the period of the examinations.

Village meetings were held with the people on our arrival at the island to explain the purpose of our visit, and at the end, another meet-

ing was held to explain the findings.[10] At such meetings, problems and fears were discussed and we attempted to correct misconceptions and explain the possible effects of radiation. Due to language difficulties, it was not easy to be sure about the interpretation of our remarks; indeed, as time went on, it became apparent that our explanations were not being fully understood. This is not surprising. People with more sophisticated backgrounds than the Marshallese have difficulty in understanding radiation and its effects and, as with the Marshallese, the issue is often charged with emotion.

D. Brief Summary of Medical Findings

The following is a brief summary of the medical findings. Detailed findings have been published in numerous BNL reports and medical journals (References, Section A).

Examinations of the exposed Rongelap people at six months showed that they had largely recovered from the acute effects and were generally in good health; no deaths were attributable to radiation exposure. There was further recovery of the blood elements, though they were not yet up to normal levels. The skin burns had healed with slight scarring and pigmentation changes in a few people, and hair had regrown to its normal color and texture.

The most serious late consequences of fallout exposure of the Marshallese have been the development of thyroid abnormalities and probably one fatality due to leukemia. Except for the thyroid abnormalities, the general health and mortality of the exposed Marshallese have been similar to that of the unexposed Marshallese populations, with about the same incidence and types of diseases. During the first few years, there was an increase in miscarriages and stillbirths in the exposed Rongelap women, but the numbers were small and it is uncertain if this increase was related to radiation effects. Based on birth rate, fertility has been about the same in the exposed and in the unexposed groups. The exposed people have not aged faster than unexposed people. At ten years post-exposure, the chromosomes in cultures of white blood cells from the people of Rongelap revealed a small number of aberrations which appeared to be related to radiation exposure but were not associated with any clinical findings (A-27). Some of the findings had been noted in studies of the Japanese fishermen (A-55) and Japanese exposed to the atomic bomb (A-63).

Examinations of babies and children of exposed parents for possible inherited effects of radiation have not revealed any unusual congenital anomalies. Although inheritance of radiation-induced genetic mutations has been seen in animal studies, such effects have not been demonstrated unequivocally in humans. Studies on large numbers of children born of exposed Japanese parents at Hiroshima and Nagasaki, many of whom received larger amounts of radiation than the Marshallese, have not demonstrated any clearcut genetic effects (A-28). James Neal was unable to demonstrate any inherited genetic effects in blood samples from the Marshallese (A-30) and in view of the dose of radiation and the small numbers of Marshallese involved, it seems unlikely that such effects will be detectable in this or future generations.

Regular examination of the eyes, including slit-lamp studies for cataracts, have not revealed any radiation- induced effects. An unexpected finding has been the failure of some blood elements (white blood cells and platelets) in the exposed Rongelap people to completely recover to levels in the control group. There has been concern that this slight depression might lower resistance to disease. However, compared with the unexposed population (types of diseases and resistance to diseases), the exposed people do not show any such effect.

The studies of the Japanese exposed to the A-bombs and other studies in humans have revealed that certain types of cancer are more likely to occur from such exposure, such as leukemia, cancers of the thyroid, stomach, and breast (A-31). Therefore, we emphasized cancer detection in the examinations.

We knew that the thyroid glands of the exposed people had received larger doses of radiation than other parts of the body because the thyroid selectively absorbs the several forms of radioactive iodine in the fallout. Therefore, the thyroid glands were examined carefully each year. However, the development of thyroid abnormalities was not expected since the early dose estimates for the thyroid were considered too low. Later, the dose estimates were revised upward and the importance of sev-

[10] Presently, people are given copies of their medical records and proposed treatment, and any special tests are discussed with the Marshallese practitioner.

eral forms of radioactive iodine in producing thyroid injury was more fully appreciated and accounted for the increased thyroid abnormalities noted (see Table 1).

Several years after exposure, a trend toward retardation of growth was noted in some of the exposed Rongelap children, particularly in boys exposed when they were less than five years old (A-22,24). At ten years old, two boys, exposed at one year of age, became markedly stunted. In fact, they were shorter than their brothers who were a year younger. At this time, they exhibited clinical signs of severe loss of thyroid function. It was not immediately apparent that the growth retardation was related to thyroid malfunction since the thyroid hormone levels were normal. Soon after, a more refined test of thyroid hormones showed that a form of protein in the blood, peculiar to the Marshallese people, had caused spurious readings of thyroid hormone levels. The hormone levels were depressed and were responsible for the growth retardation.

Nine years after exposure, thyroid nodules were detected in a 12-year-old Marshallese girl and the following year two other exposed children developed nodules of the gland. Tumors of the thyroid gland,[11] both benign and malignant, continued to develop in adults as well as children, particularly in the exposed Rongelap group, to a lesser extent in the exposed Ailingnae, and, later, a slight increase was noted in the lesser-exposed Utirik group. The incidence of thyroid tumors in the unexposed group was the same as in other world populations. About one-third of the exposed Rongelap people have developed thyroid abnormalities (see Table 2). The greatest incidence was in children exposed at less than 10 years of age, which is due to their smaller and more active thyroid glands. Two of the three Rongelap children exposed *in utero* later developed benign thyroid tumors, suggesting that radioiodines transferred from the mother to the fetus were partly responsible for development of the thyroid tumors.[12] The incidence of thyroid abnormalities in the Utirik population has been slightly higher than that seen in the unexposed population. Recurrence of non-cancerous tumors in two individuals following surgery has required a second operation. Table 3 lists the number and types of thyroid tumors diagnosed at surgery.

The time of development of thyroid tumors was related to the amount of radiation to the gland, i.e., the greater the amount of radiation, the earlier the development of the tumor.

We found later that the exposed Rongelap people generally showed reduced thyroid function, even those that had not had thyroid surgery (A-36); also, the degree of reduction in those that had had surgery was greater than would be expected from the amount of thyroid gland which was removed (A-19). One exposed Utirik man, who had not had thyroid surgery, had slight reduction of thyroid function. A treatment program giving thyroid hormone to Rongelap people, although not strictly adhered to, apparently prevented clinical effects of this reduced function. However, it was apparent that serious effects of loss of thyroid function could develop, and the importance of maintaining a strict program of thyroid treatment was

Two Rongelap boys with growth retardation due to radiation effects on their thyroid glands.

[11] The term "thyroid tumor" is used here to include adenomatous nodules, adenomas and cancer.

[12] Recently, a thyroid tumor was found in a Utirik man (one of eight) exposed *in utero*. It is less certain that his tumor was related to the mother's exposure.

Table 3
Thyroid Tumor Diagnoses at Surgery (through 1987)*

Group (No.)	Non-Malignant (%)	Cancers (%)**
Exposed***		
Rongelap (67)	19 (28.4)	5.(7.5)
Ailingnae (19)	4 (21.1)	–
Utirik (167)	15 (9.0)	4. (2.4)
Unexposed (227)****	5 (2.4)	2. (0.8)

*Modified from Adams et al. 1989 (A-19)
**Does not include occult cancers, which are not considered clinically significant
***Includes *in utero* exposed persons
****Includes all unexposed persons in the regular comparison group since 1957

emphasized for the lifetime of the Rongelap people.

It is encouraging that the development of thyroid tumors appears to be declining, that none of the thyroid cancers spread beyond the neck area, and none recurred or resulted in death (A-19). However, although the radiation-induced tumors, have not been lethal, the people have suffered considerable adverse consequences of the tumors, such as surgical procedures under general anesthesia with its attendant risks, inadvertent injury to the parathyroid gland in two cases, and effect on one of the nerves in the neck in one case: also, the widespread development of hypofunction of the thyroid gland requires medication for their lifetime.

In 1972, a 19-year-old Rongelap man, exposed at one year of age, developed acute myelogenous leukemia and, in spite of extensive treatment at the Clinical Center at the National Institutes of Health, he died several months later (A- 14). It is likely that his leukemia was related to radiation exposure.

Follow-up examinations of the beta burns of the skin showed only minimal scarring and pigment changes in a few cases. In spite of the extensive irradiation of the skin and prevalence of skin burns shortly after exposure in the Rongelap people, only one case of low-grade cancer of the skin has developed in an area of previous beta burn (A-19).

Three exposed women developed brain tumors. Two (pituitary tumors), which were successfully treated, could have been due to radiation injury to the thyroid gland. The third woman had a meningioma which proved fatal (A-19). It is uncertain if this tumor was related to radiation exposure.

In a recent report, Adams lists additional cases of cancer of various organs in both the exposed and unexposed populations (A-19). However, he observed no increase in cancer mortality in the exposed compared with the unexposed Marshallese population. Concern has been voiced about the present-day radiological safety of habitation on Rongelap Island. Adams reported that prolonged habitation of the unexposed Marshallese on Rongelap Island from 1957 to 1985 has not resulted in any shortening of life expectancy related to cancer nor in any increase in thyroid tumors (A-19, 56).

Over the years the medical teams have diagnosed and treated many diseases not related to radiation exposure, particularly the middle-age-onset type of diabetes, which is common in the Marshallese people and a leading cause of death. As a result, advice about the disease and its treatment has been passed on to the Marshallese medical personnel.

About one-third of the people in the original examination groups are still living. It is important that continued examinations be carried out for their lifetime since further late effects of radiation exposure might develop.

E. Human Interest Relations

1. *In the Islands*

On our visits to the islands, the medical teams enjoyed pleasant associations with the Marshallese people and learned to appreciate their lifestyle and culture. Lifelong friendships were established. When we arrived on the island, the people gathered on the beach and greeted us warmly, placing fragrant leis around our necks. Members of the medical team sometimes joined the Marshallese in softball and

volleyball games. The movies shown outdoors in the evenings were greatly enjoyed by the people, particularly by the children. The big event of our stay was the party given at the end of our examinations. We brought food and, in addition, the Marshallese furnished fish, sometimes longusta, and even turtle meat. They brought palm-woven baskets filled with coconuts for drinking. After the feast, the children were given candy and toys: a movie was shown and the Marshallese sang some of their songs. This was followed by a special ceremony in which the women, while singing a traditional song, slowly marched in a single file and presented each member of the team with gifts of handicraft and shells.

During our free time, we enjoyed the unique recreational features afforded by the

Children enjoying a Laurel and Hardy movie.

Marshallese entertaining the medical team at the party.

Party at the end of the examinations.

island, particularly swimming and snorkeling in the crystal-clear waters, marvelling at the beautiful coral formations and colorful fish. The Marshallese men took us fishing, longusta hunting, and on rides in outrigger canoes. Hiking across the island under the palms was pleasant, emerging through thickets of scaveola into the glaring sun on the beach with the steady trade winds blowing and large waves crashing on the reef. Especially enjoyable, on a weekend, was a trip by small boat to uninhabited islands in the atoll for exploration, snorkeling, shell collecting, and a picnic lunch.

F. The Marshallese Patients in the United States

As I discussed, we greatly regretted the harm that was done to the Marshallese from radiation exposure, and were keenly aware of our responsibilities to help them in every way possible. This was particularly true when it became necessary to bring patients who had developed thyroid tumors to the U.S. medical facilities for further treatment. We explained the need for this treatment and requested their consent. We realized that we had a considerable responsibility in taking them, since most had never left their small islands and would be faced with new situations of Western culture. Naturally, they were apprehensive about going so far from their homes for treatment, including surgery. We assured them that they would be well cared for and that one of our group and a Marshallese practitioner would accompany them. When the first group returned to the Islands after having had thyroid surgery, the people saw that even

though they had scars on their necks they appeared healthy and they heard many interesting tales of their sojourn in the United States. After this, there was less apprehension about going.

There were usually several Marshallese in the group going to the United States for hospitalization. In one group there were five patients. They were taken to Kwajalein, where they would meet the plane taking them to the United States. Meanwhile, we took them to the one department store on Kwajalein, and necessary clothing, including warm winter clothes, toilet articles, and suitcases were purchased for them.

The patients usually were taken to the Hospital of the Medical Department of BNL for one to two weeks for preliminary examinations before surgery at the New England Deaconess Hospital in Boston in the first years, and later, to the Cleveland Metropolitan General Hospital. The hospital rooms were warm, but the Marshallese were sleeping under several blankets and complaining of being cold. We had to turn the heat up to a level which was uncomfortably warm for us. At first, they were apprehensive about sleeping on the high hospital beds since they had been used to sleeping on the floor. By putting up the side bars on the beds, they were less afraid of falling out of bed.

The Hospital at Brookhaven was small, and the nurses and hospital staff were friendly and solicitous of the patients who had come from so far. In this informal milieu, the people became at ease with the hospital surroundings and the many examinations being performed on them.

Following the preliminary examinations at the Brookhaven Hospital, the patients were then taken to Boston or Cleveland hospitals for surgery.[13] At these large hospitals, the Marshallese patients were on wards with many other patients and, although they were given as much consideration as possible, they could not receive the personal attention that they had been given at our small hospital. As the time of surgery approached, they were naturally apprehensive. We stayed with them to reassure them during the surgical procedures.

It was gratifying to see the rapid recovery of the patients with only slight discomfort and, on healing, the surgical scar was usually hardly discernible.

During their stay in the United States, we took our Marshallese visitors on a number of sightseeing excursions, including automobile tours around the countryside and villages, as well as visits to our homes. Sightseeing visits to New York City included a boat trip around the harbor. They were greatly impressed with the big city and were awe-struck by the towering buildings, the streets crowded with bustling people and the congested traffic with cavernous sounds of honking horns and screeching brakes. They marveled at the view atop the Chrysler Building and enjoyed guided tours of the United Nations Building. The Marshallese were most grateful for these excursions and took back tales of their adventures to their fellow islanders.

Marshallese patients arrive at the hospital at Brookhaven National Laboratory for examinations prior to thyroid surgery.

Marshallese enjoy a boat trip around New York Harbor after visiting the United Nations Building.

[13] As of 1989, 77 Marshallese had thyroid surgery.

G. Families Most Affected by Fallout

Several families on Rongelap suffered the greatest effects of fallout exposure. This was particularly true of the Anjain family.

In 1966, developed a thyroid tumor and, along with several other Rongelap people, was taken to the United States for surgery. She was found to have a cancer of the thyroid which required extensive neck surgery. Hers was the first case of thyroid cancer found in the exposed people. Her recovery was satisfactory and we were able to keep her in good health with thyroid treatment. Within the next three to four years, the two older sons developed benign thyroid tumors which had to be removed.

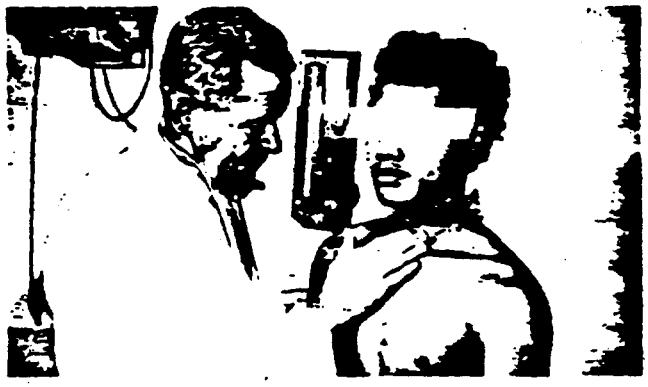
In 1963, there was an epidemic of poliomyelitis in the Marshall Islands, and several people on Rongelap were stricken. One was a younger son of and who had been born since the accident. As a result of his illness, one leg was paralyzed, requiring the use of a crutch. Seeing him hobbling about on a crutch, I could not help but reflect that his infirmity was an example of one of the ill effects of our incursion into their islands.

who had been exposed to fallout when he was a year old, returned with his parents to live on Rongelap in 1957. Just before he was ready to go away to high school in 1968, he developed a thyroid tumor and was taken to the United States for surgery. His tumor was benign, and he quickly recovered. At that time, he appeared quite healthy with no indication of the serious illness which was to later develop.

It was about 1970, two years before death, that his father recalls that he was beginning to show signs of not being well, tiring more easily. Later, he noted that he bruised easily and had some bleeding from his gums. Still later, he developed a swelling in his groin which was treated (unsuccessfully) by a Marshallese woman (B-85). We on the medical team were not made aware of these symptoms and did not see until September 1972, because in March 1972 our examinations were prevented for political reasons. We found that although he appeared otherwise healthy, his blood tests showed ominous signs of possible leukemia. I met with John Anjain and told him of the seriousness of our findings and that it would be necessary to take , back with us for further examinations to arrive at a more definitive diagnosis and to treat him.

The next few months were a sad and trying time. On arrival at BNL, the diagnosis of acute myelogenous leukemia was confirmed. This disease is almost invariably fatal. We arranged with the Hospital of the Clinical Center at the National Institutes of Health, one of the leading medical centers for the treatment of leukemia, to accept as a patient.

Sebeo Shoniber, a medical technician from Majuro, who had participated in many of our medical surveys, arrived from the Marshall Islands to serve as a companion and interpreter. underwent extensive treatment at the hospital. He was given continuous intravenous



being examined for thyroid tumor. He died six years later of leukemia.

injections of several antileukemia agents (including Cytosine Arabinoside) in an attempt to kill the cancer cells in his blood.

roommate was a well-known journalist, who later wrote several articles about him (B-65, 86, 87).

In view of the seriousness of illness, we sent for his parents. Their reunion with their son was sad, and the next few weeks were extremely painful for them.

Increased bleeding in required platelet transfusions. In order to get a more compatible blood, his older brother, was flown in from the islands for a transfusion. In spite of this, grew gradually worse, developed pneumonia, and died on November 15th.

In 1973, John Anjain was found to have a suspicious nodule in his thyroid gland and surgery was performed in the United States. The nodule was not cancerous, and he had an uneventful recovery. He was the fifth member of his family to undergo thyroid surgery.

PRIVACY ACT MATERIAL REMOVED

Another family that was strongly affected by the fallout was that of .. His wife, .. two daughters, and two sons had thyroid tumors removed. One daughter suffered injury to the parathyroid gland during surgery, requiring special treatment along with thyroid treatment for a lifetime. . later developed a brain tumor (pituitary) possibly related to radiation exposure, which was successfully treated. , was a school teacher on Rongelap at the time of the fallout. He and his wife, ., had a one-year-old son and she was about four months pregnant at that time. Their son, , suffered severe thyroid injury and was one of the two boys who developed marked signs of thyroid deficiency with growth retardation. The response of these retarded children to thyroid treatment, with recovery of growth, was one of the most gratifying results of our treatment program. Another son, who was exposed *in utero*, later developed a thyroid tumor which had to be removed. His tumor may have been partly caused from radioiodines absorbed by his mother from the fallout.

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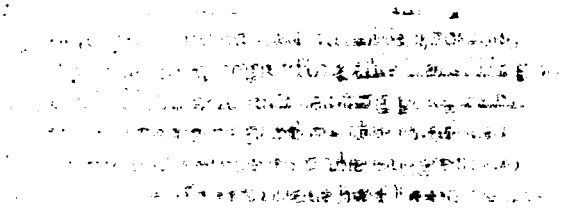
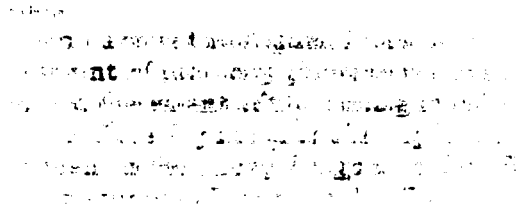




Chapter VII — The Radiological Surveys for Residual Radiation

A. The Surveys

The Atomic Testing Program in the Pacific contaminated the atolls of the Northern Marshall Islands to varying degrees. The greatest contamination on the atolls of Bikini, Rongelap, Ailingnae, Rongerik, and Utirik was from the Bravo detonation in 1954. Atolls just to the south of this group received a small amount of contamination, and there was slight additional contamination from other tests.

The effects of the testing program on their atolls have been deeply resented by the Marshallese people and have presented the United States with increasing problems since 1958 when the moratorium against testing in the Pacific was declared. The people who were displaced before and during the testing program have been disappointed in the length of time away from their homes. This is particularly true of the people from Bikini, who have lived elsewhere for 44 years. These displaced people have exerted considerable pressure on the U.S. authorities to return to their homes; even so, they had some uneasiness about residual radiation on their islands. Unfortunately, in spite of reports to the contrary, this fear of radiation and the suspicion that the U.S. authorities had played down the dangers of residual fallout resulted, in 1985, in the evacuation of the Rongelap people, who had been resettled on their island for 28 years.

Numerous radiological surveys of the contaminated atolls were carried out to (a) determine radiological safety for rehabilitation of the displaced islanders, and (b) study the radioecology of the fallout on the islands and surrounding ocean. These surveys were conducted before and continued after the return of the Rongelap and Utirik people; the surveys provided valuable information on the radiological safety for habitation, based on movements of radioactive elements from the soil through the marine and plant food chain to humans. The contaminated environment of these islands provided tracer quantities of tagged elements, on a scale impossible to achieve in a planned experiment. These studies have been an important adjunct to the medical assessment of radiation exposure to the Marshallese. Under the aegis of the AEC/DOE, the radiological surveys were conducted by the University of Washington School of Fisheries Laboratory (now the Laboratory of Radiation Biology) (A-41-45, 47), the Naval Radiological Defense Laboratory (A-2, 31), the Safety and Environmental Protection Division at BNL (A-52, 52, 54), and the University of California Lawrence Livermore Laboratory (A-49, 50). On several occasions, the University of Washington group accompanied the Medical Team on the surveys. The Japanese have independently carried out oceanographic surveys (B-8).

Shortly after the accident we obtained several animals (pigs, chickens, and ducks) from the deserted villages at Rongelap and Utirik; also, some fish and clams were brought back. The animals, although contaminated with radioactivity and malnourished, showed no effects of radiation exposure (A-31). Internally absorbed radioactive materials were found largely in the intestinal tract, with only slight activity in the lungs, suggesting that the most important route of internal radiation absorption was from ingestion of contaminated food and water rather than from inhalation of radioactive material.

At the time of the return of the people, the radioactive elements of concern were cesium (^{137}Cs, a gamma emitter with a half-life of 30 years), strontium (^{90}Sr, a beta emitter with a half-life of 28 years), and zinc (^{65}Zn, a gamma emitter with a half-life of 247 days). Small amounts of other radioactive elements, such as cobalt (^{60}Co) and iron (^{55}Fe) (A-45), were of much less concern. Low levels of plutonium were noted and will be referred to later. The radioactive iodines were no longer of concern, because they had practically decayed away. The other radioactive elements, cesium and strontium, were found in low amounts mainly in the pandanus, coconuts, breadfruit, and arrowroot plants grown on the islands. Unexpectedly high levels of radioactive cesium and strontium were found in the coconut crab, a great delicacy to the Marshallese (On Rongelap they were temporarily banned from the diet).

Examination of the Marshallese people when they returned to live on their home islands imposed a unique, added responsibility to the

medical team. Based on preliminary surveys, we did not expect that there would be overexposure of the people to radiation from the environment. However, our objective was to continuously monitor the people, so that if there was any indication of exposures higher than expected, appropriate corrective steps could be taken. Since gamma radiation had decayed to an acceptable low level, the most important determinations concerned the amounts and distribution in the body of internally absorbed radioactive elements from water, foods grown on the island, and marine life, particularly fish.

Radiochemical analyses of urine and direct measurement of radiation from the individual were used to determine the amount of absorbed radioactive elements. Studies of the dietary habits of the Marshallese permitted indirect assessment of the amounts of radioactive elements likely to be absorbed from consumption of water and food. Individual and pooled radiochemical urine analyses were done at various laboratories in the United States.[14]

About this time (1957), a relatively new method of determining the amount and type of gamma-emitting elements in an individual was being used at Argonne National Laboratory in Chicago. Gamma radiation was measured using a sensitive crystal-electronic setup in a steel room shielded to reduce background radiation. To test the potential of this method for use in the Marshall Islands, we arranged with Argonne to measure four Rongelap men (who had not yet returned to live on their home island) and two men living on Utirik Atoll. The results showed that low levels of radioactive elements could be easily identified and measured and were well within the permissible range. The two men from Utirik had radioactive zinc in their bodies which was later found to have come from eating contaminated fish (B-26). Since this method of measurement seemed feasible for our studies, a 21-ton steel room was constructed at BNL and shipped to the Marshall Islands.

The Marshallese on Rongelap were first measured for radiation in 1958, in the new steel room which had been placed on the tank deck of a naval LST. Before being measured, the people were required to shower and put on paper coveralls to reduce external contamination. Results showed that small amounts of radioactive cesium and zinc were present and the method was considered to give a sensitive estimate of the body burdens of gamma-emitting isotopes. Unfortunately, before this survey could be analyzed, a plane carrying the data to the United States experienced difficulties and jettisoned the cargo, among which were boxes with our data. A second survey was carried out by three of us from Brookhaven. The survey was fraught with difficulties. When we arrived in Enewetak, we transferred the steel room and equipment to a Navy LCU. During this time, a nuclear device was tested. Our LCU was transferred to Rongelap on a dry-dock ship, where we discovered that due to contamination at Enewetak the level of radiation on the LCU was too high for accurate measurements. Still worse, the deck beneath the steel room had been painted with non-skid paint which included radioactive sand from Enewetak. However, using a paint remover and with generous wash-

Steel room weighing 21 tons built at Brookhaven National Laboratory being used for measurement of radiation in the Marshallese people.

[14] From these analyses, it was possible to estimate the body burdens of the radioactive elements. Analysis for plutonium proved more troublesome, but later techniques permitted more reliable analysis for this element in the urine and estimation of body burden.

ing, we lowered the background of radiation sufficiently to permit measurements to be made.

The steel room was used for a number of years, but because of the difficulties of transportation and assembly in the cargo holds of ships, a less cumbersome portable assembly of lead bricks was devised and proved satisfactory for use on the island.

Arrangement of lead bricks used for whole-body counting.

A third method of estimating the body burdens of radioactive elements was to measure the amounts that might be absorbed in their daily diet. This method is not as reliable as the direct methods. On one occasion, one of us ate a diet for a week consisting of specific amounts of foods grown on the island. Daily measurements were made by gamma spectroscopy of the body and radiochemical analyses of urine and fecal specimens. The levels of radioactive cesium and strontium absorbed internally, though low, were measurable and gave important information on the absorption and excretion pattern of these elements in the body.

B. Findings

By the time the Marshallese returned to their home islands, most of the radioactive elements they had absorbed internally at the time of the fallout had been excreted (A-3). However, on their return, the consumption of foods grown on the island and local fish resulted in the absorption of radioactive elements, principally cesium (^{137}Cs), strontium (^{90}Sr), and zinc (^{65}Zn). The only food that was banned was the coconut crab at Rongelap; later, this ban was lifted in the southern part of the atoll. For the first five years the body burdens of the above radioactive elements increased, reaching equilibrium with the environment, and then gradually declined. On Rongelap, strontium levels reached a peak during 1962-1965, at 6% in adults and 11% in children, of the maximum permissible lifetime body burdens for world populations. Analyses of bone samples from several autopsies during the first 25 years showed that the level of radioactive strontium in the bones agreed reasonably well with estimates based on urinalyses. The radioactive cesium body burdens also reached their peak in 1965, at about 23% of the permissible level. The values for the Utirik population were about one-third those of the Rongelap population.

Analysis of the plutonium levels was more difficult. Urine samples analyzed at BNL in 1984 showed higher body levels than were estimated by the Lawrence Livermore Laboratory, based on plutonium intake from food. It was later found that BNL's method measured certain contaminating elements (naturally occurring polonium and uranium) giving spuriously high plutonium levels. A more refined, specific technique for plutonium (A-38) recently showed levels in the Rongelap and Utirik people agreed with those estimates of the Lawrence Livermore Laboratory and were well within the federal guidelines.

Unfortunately, the earlier discrepancy in plutonium levels reported by the two laboratories caused anxiety among the Marshallese people and may have been partly to blame for the Rongelap people being evacuated in 1985. (See Chapter IX.)

The cumulative estimate of dose for continuous habitation on Rongelap from 1957- 1979

was 4.5 rem (A-57). Because the Utirik people moved back earlier, their cumulative dose was about 16 rem, despite the fact that their initial exposure was less. However, since both groups were eating quantities of subsidized foods brought in during the early years, and because most of the people were away part of the time, these estimates were probably high.

The cumulative radiation doses received by the Marshallese are not very different from those received by the average U.S. citizen (about 5 rem in 25 years) or by inhabitants of Denver, Colorado (about 7 rem in 25 years). When the Rongelap people left their island again in 1985, the exposure rate was less than that of the people in the United States. This was partly due to lower levels of the natural background in the Marshall Islands.

Chapter VIII — The Displaced Bikinians

In 1946 Bikini Atoll was chosen as the site of the first atomic test, Operation Crossroads, in the Pacific that was designed to test the effects of atomic weapons on naval vessels. The atoll was chosen because of its relative isolation, and the large lagoon where naval vessels could anchor. Use of the atoll required the evacuation of the residents. In early 1946, representatives of the Navy met with the 166 people living on Bikini, and explained the importance of the test for U.S. national security. They were told that, in agreeing, they would contribute to world peace. The magistrate met with his island council and, after much discussion, they agreed to the request. There is little doubt that their acquiescence was influenced by their impression of the immensity of the U.S. military might in ousting Japan from the islands. The people and the Naval officials believed that their exile would not be long, and that they would move back when the test was completed.

There were few suitable locations to which the people could be moved. Rongerik Atoll was finally chosen because it was not far away (a little over 100 miles east of Bikini) and many of the Bikinians were related to the Rongelap people who owned Rongerik Atoll (B-32,33,77). In March 1946, the Navy moved the Bikinians with their belongings to Rongerik, where the SEABEES had constructed a temporary village. The people attempted to settle there, but this atoll proved to be a poor choice. The land area and the lagoon were only one-third that of Bikini. The local foods were insufficient, and the amount of marine life less than that available at Bikini. Consequently, there began a long series of requests to be moved back to Bikini. A naval officer visiting the island found that the people were malnourished and the island's resources inadequate. Therefore, in 1948, the Bikinians were moved to a tent city at Kwajalein, where they lived for eight months. Another location had to be found for them. Kili Island, several hundred miles to the south, was the only other site available. The island had formerly been used by the Germans for producing copra, and was quite verdant, with abundant rainfall. However, there were several overriding disadvantages. The island was small, only one-seventh the land mass of Bikini. There was no lagoon for fishing or anchorage, and rough seas made access to the island impossible much of the year. Fishing was very difficult.

When the people moved to Kili, they found the environment alien and had difficulty in adapting to it. In the years that followed, several devastating typhoons wreaked havoc on some of the southern atolls and one of the large vessels used by the Bikinians for fishing and traveling to other islands was sunk (B-33). At times, food shortages required that the Trust Territory Government provide supplies. Some people moved to nearby Jaluit Atoll to live, and some moved to the District centers at Majuro and Ebeye to work.

In 1956, the U.S. Government provided the Bikini people with a $300,000 trust fund, which helped relieve their economic distress.

The people continued to press their request for a return to Bikini. In 1966, the Department of Interior requested the AEC to consider this possibility. The AEC sponsored a radiological survey of the Bikini environment in 1967 to determine if the island was safe for habitation (A-46-48). The survey showed that the principal radioactive elements present were cesium (^{137}Cs), strontium (^{90}Sr), and slight amounts of other elements, including plutonium. Whereas radioactive contamination on Rongelap and Utirik was fairly uniform, the contamination at Bikini was quite variable due to contamination from the atomic tests. In 1968, the AEC convened an Ad hoc Committee, of which I was a member, to determine the radiological safety of Bikini Atoll for habitation (B-72). We decided that the two main islands, Eneu and Bikini, were safe, provided that certain measures recommended to reduce exposure were taken. These measures included habiting of Eneu first; covering the housing sites on Bikini with coral rock, as is the custom; removing scrap metal; reducing the land-crab population; removing top soil from planting sites on Bikini; and supplementing of powdered milk to the diet to reduce the possibility of radioactive strontium uptake. The estimated doses to the people who would live on Bikini were so low that medical surveillance was not considered necessary. Nevertheless, the Committee recommended that the inhabitants be monitored regularly to

insure their radiological safety. I was asked to head up the monitoring program (B-37).

I went to Kili Island in 1969 and explained to the people that Bikini Island was considered safe and that our medical team would monitor them to insure their radiological safety. Urine samples then were collected for baseline studies.

The cleanup of Bikini Island began in 1969 with bulldozing of scrub growth and other measures to reduce radiation, as recommended by the Ad hoc Committee. Thirty workers, camped on Eneu, began to construct the first 40 cement houses, provided with water cisterns and privies. Later plans called for 40 more houses, a council house, a church, and a dispensary. Unfortunately, the recommendation of the Ad Hoc Committee to begin habitation on Eneu Island, where radiation levels were much lower, was not followed. New plantings of coconut and pandanus trees began on Bikini and later on Eneu. In 1971, several families moved back to Bikini, and by 1978 there were 145 people living on the island. The Trust Territory Government furnished all their food, including powdered milk. We monitored the people annually, using the sensitive whole-body counting technique and radiochemical urine analyses, as used on the Rongelap and Utirik people; radiological surveys of the environment continued. Although medical examinations were not conducted on our visits (except on one occasion referred to below), the medical team was available for "sick call".

In April 1974, it was planned to return more people to live in the 40 houses which had been built on Bikini. However, the people had become concerned about the radiological safety at Bikini and declined to return. This refusal was believed to be partly based on their unhappiness about not having received a $3,000,000 U.S. compensation payment in their suit against the United States (B-41,42). They felt they deserved this payment, since the Enewetak people had received an *ex gratia* payment of over $1,000,000. As it turned out, their refusal to return proved to be to their advantage in view of subsequent events.

As part of the second phase of rehabilitation at Bikini, it was planned to build more houses in the interior of the island. In preparation, another radiological survey was conducted to obtain more precise radiation measurements in the interior of the island (A-50,51). The survey showed that the levels of radiation in the interior of the island were higher than had been reported in the 1967 survey, and that further housing would have to be built at nearby Eneu Island. Furthermore, the well water was found to be contaminated and consumption of pandanus and breadfruit grown on the island had to be restricted. Therefore, plans for the immediate return of the people to Bikini were cancelled.

In August, a meeting was held with the people at Kili to discuss the prospects for further resettlement of Bikini (B-38). Among those present were Roger Ray, DOE representative; Oscar DeBrum, District Administration of the Marshall Islands; and George Allen from the Micronesian Legal Services, Inc. The people expressed disappointment at not being able to return to Bikini. Some older people wanted to return regardless of radiation exposure, while a younger group was more vociferous in their complaints. As an aftermath of the meeting, Allen instituted a suit for the Bikini people against the United States, demanding further evidence that Bikini was safe for habitation.

Those families that returned to Bikini received a complete food subsidy from the Trust Territory Government. Before locally grown fruits (coconuts, pandanus, breadfruit) became available, radiological monitoring showed that the levels of absorbed radioactive materials were in the acceptable range. When these fruits became available several years later, the levels of radioactive cesium and strontium had increased and the people were told not to eat them. Examinations in April 1978 showed a sharp rise in body burdens of these radioactive elements due to consumption of these fruits (A-15, 54). Since continued habitation on the island could result in unacceptable levels of these radioactive elements in the people, they were evacuated from Bikini in August of that year (B-76). Most of the group moved to Majuro and received follow-up examinations by the medical team. Many of the Bikinians expressed further dissatisfaction with life on Kili and requested that a home be found for them elsewhere, such as Hawaii or Florida. During the examinations at Bikini in April, at the request of the Bikinians, we conducted a medical survey of the people on the islands. Our examinations showed no indications of radiation exposure.

Greenhouse et al. (A-51) calculated the dose equivalent from both internal and external

adiation for the people living on Bikini from 969 to 1978. The average dose was 1.2 rem. vith a maximum of 3 rem. These levels were not ery different from those received by other world populations and were not expected to produce any discernible effects.

In 1978, a comprehensive radiological survey of the northern Marshall Islands was conducted, using helicopters equipped with gamma-measuring instruments. Many food, water, and soil samples were collected from the Islands for radioassays. DOE's policy was to furnish copies of all of its technical reports and findings to the Trust Territory government and to the Marshall Island authorities. This practice was followed in the dissemination of radiological survey results in the 1970s, and because of the direct personal impact of these reports on the resident populations, the DOE commissioned a series of simple bilingual booklets, which were delivered and explained to the affected people (A, 53, 58).

In late 1978, the Trust Territory Government began new construction on Kili Island to make it more permanent and habitable (B-73).

The following personal communication from Roger Ray, former Manager of the DOE program in the Marshall Islands, describes more recent events regarding the resettlement of Bikini.

> At Bikini, DOE-directed Lawrence Livermore Laboratory initiated a program of agricultural and environmental studies in an effort to control and reduce the uptake of radioactive materials into the human food chain. One of the traditional residence islands, Eneu, had environmental radiation levels which were low enough to permit resettlement, but neighboring Bikini Island, from which the atoll takes its name, required further study and treatment. Bikini was the traditional population center and ancestral home of many Bikinians, and without the productive land of Bikini a resettlement was not apt to succeed.
>
> By the mid-1980's, the Livermore work had demonstrated several promising techniques for making Bikini Island habitable and for improving conditions at Eneu. The United States Congress authorized independent studies by a group of scientists selected by the Bikini people and their advisors to verify the Livermore conclusions.[15] In 1988 the Congress granted the sum of 90 million dollars to the Bikini people to enable them to select and implement remedial measures from Livermore and BARC studies.

In the meantime, the population on Kili Island had expanded to over 1000 people due to influx of Bikinians from other atolls. They now appear to have become better adjusted to life there. They have used financial assistance to improve housing, build a gymnasium, and a new dispensary. The village at Kili is looked upon by other Marshallese as a model village (B-73).

The long years away have not lessened the desire of the people, particularly older people, to return to Bikini. Most of the younger generation has never seen the island. Their nostalgia has been somewhat assuaged in the past few years by allowing small groups of Bikinians to make short visits to the island. The recently completed Council House on the island affords a center for activities.

DOE scientists are advising the Bikini people about possible methods for radiological clean-up of their Island. (B-104). It will probably be some years before resettlement is possible. Time has taken its toll, so that the numbers in the original group evacuated in 1946 are greatly reduced. It is sad that many of the older people may never realize their dream of returning to live on their home island.

[15] The Bikini Atoll Rehabilitation Committee (BARC), Chairman: Henry Kohn.

Chapter IX — Problems in the Aftermath of the Accident

A. Background

Several problems that affected the Brookhaven Medical Program developed in the aftermath of the accidental exposure of the Marshallese people to fallout. The background for these problems is complex and, I believe, related not only to the effects of the accident, but indirectly to the socio-economic and political upheaval brought about by the U.S. administration.

In carrying out the United Nations mandate to promote the development of the inhabitants of the Trust Territory toward self-government and self-sufficiency, the Government of the Trust Territory of the Pacific Islands faced many problems. I mention some of these problems as background for the developments that affected the medical examinations (B-34,39,40).

The Trust Territory Government was faced with the complicated task of governing about 1100 small islands scattered in a large ocean area about the size of the United States, often with inadequate travel facilities. Many populations with different cultures and different languages were involved. Some problems were related to the "strategic" nature of the Trust, with the overriding U.S. military interests such as the nuclear testing program, Pacific Missile Range in the Marshall Islands, and military bases in the Marianas Islands. Other problems were related to the difficulty of getting trained personnel to work in this isolated area of the world; the turnover of personnel with changing Presidential administrations (the High Commissioner with Ambassadorial rank was a political appointment); demands for war claims and compensations related to the nuclear testing program; difficulties in orienting the people toward self-sufficiency; increasing needs for expanded budgets; and political problems related to the development of independence of the various Micronesian groups.

The Trust Territory administration brought with it U.S. jobs. People flocked to the district centers. In the Marshall Islands, people from the outlying islands came to Majuro for government jobs and to Ebeye (near Kwajalein Island) to work for the Pacific Missile Range. The Outer Island population shifted toward more children and old people, which was aggravated by the population explosion taking place. The lure of the district centers at Ebeye and Majuro with bright lights, night life and opportunities for employment was irresistible to many. They acquired a taste for Western items such as beer, cigarettes, soda pop, canned goods, and other commodities in short supply in the Outer Islands (B-34,39,75).

The influx of people resulted in overcrowded living conditions on this small island. The situation was not as bad at Majuro as at Ebeye where the population increased from about 3000 to about 7000 in a few years and slum-like conditions soon developed, as relatives moved there to live with the working members of the family. Sanitary conditions became unsatisfactory and diseases such as influenza, pertussis, and poliomyelitis occurred in epidemic proportions. The hospital at Ebeye was often unable to handle such situations adequately. The good lifestyle of the Americans at nearby Kwajalein was in sharp contrast to the life on nearby Ebeye. The Marshallese were not allowed to live on Kwajalein nor use many of the facilities. The situation brought about criticisms of the U.S. authorities, by the Marshallese and others. Recently, there has been marked improvement in the conditions at Ebeye.

As pointed out, during our examinations we found that there were increasing numbers of Rongelap and Utirik people to be examined at Majuro and Ebeye which necessitated extending our medical facilities to include examination and laboratory trailers adjacent to the hospitals.

The increasing dependence of the Micronesians on the U.S. economy resulted in loss of self-sufficiency and lack of development of their own natural resources (B-34,35). Copra production lagged and fishing was low (B-40,75).

There were increasing criticisms that the Government authorities had not adequately promoted education and self-sufficiency in the people (B-24, 34, 40, 45) and the United Nations Trusteeship Council became more critical of the Trust Territory, as stated in their Report of the United Nations Visiting Mission to the Trust Territory of the Pacific islands in 1976 (B-43).

> The present Mission, while acknowledging that the people of Micronesia enjoy a standard of living which compares favorably with that of many developing countries, must also report that there has been surprisingly little progress towards self-sufficiency. Commodity exports amounted to just under $7,000,000 and earnings from tourism to about $5,000,000. Imports amounted to just over $38,000,000. Thus, the deficit in the balance of payments was over $26,000,000.

The attainment of self-sufficiency in Micronesia will not be easily achieved. Except for the abundant marine life and coconuts for copra production, economic resources are largely limited to handicrafts and tourism (B-40,44,45,75). For some years the Islands will require U.S. assistance in the Compact of Free Association.

In the years that followed the fallout accident in 1954, the Marshallese people became increasingly aware of the effects of the accident (the displacement of the people with disruption of lifestyle, the harmful effects of their radiation exposure, and contamination of their home islands) (B-34,39). When the Rongelap people returned to a new village on their home island after a three-year absence, their adjustment was not satisfactory. Copra production and fishing was low. The village became overcrowded with relatives from other atolls. The Utirik people, who had been returned to their village earlier, readjusted their lifestyle more satisfactorily.

In 1959, the Rongelap people submitted a suit through their lawyers for an $8,000,000 compensation for the harmful effects they had sustained from the fallout.[16] Although the U.S. Government recognized that the people were entitled to compensation, the suit was illegal because the United States could not be sued by the Marshallese, who lived in a foreign country. Finally, in 1966 the U.S. Congress passed a bill granting an *ex gratia* payment of $950,000 to the exposed Rongelap people, amounting to about $11,000 per exposed person (B-46).[17] At this time, those exposed had no detectable thyroid effects and no leukemia had developed. The people received the money in 1966. Payment was not made in the form of a trust fund, as had been recommended in the bill, but was paid directly to the individual or relatives of those who were deceased.

In the meantime, the Utirik people complained that they also had been exposed to fallout and had received no compensation. I explained that we had not found any harmful effects and that, in view of the estimates of the small amount of radiation they had received, we did not expect to find effects. They then asked me why it was necessary for us to continue examining them. I explained that although we did not expect to find effects, we should continue to examine them so that if any effects did develop we would be able to treat them. On my recommendation we later got a small payment of $16,000 for the Utirik people, amounting to about $100 per person, as an "inconvenience" payment. Later, when the Utirik people showed a slight increase in thyroid tumors, they were included in further compensation. A "Fallout Survivors Bill" in 1974, provided funding for treatment in the Marshall Islands hospitals, with travel and per diem allowances for the exposed Rongelap and Utirik people, as well as the control, unexposed population. In 1978, a bill was passed by the U.S. Congress compensating individuals who had developed radiation illnesses (those with thyroid surgery, and the parents of the young man who had died of leukemia) (B-47).

When the Trusteeship ended in 1986, the Marshall Islands became the Republic of the Marshall Islands. A Compact of Free Association was signed with the United States (B-19). The Compact granted the Islands full internal self-government with authority and

[16] Several political leaders from the Marshall Islands, including Dwight Heine and Amata Kabua appeared before the United Nations Trusteeship Council pleading the cause of the Rongelap people.

[17] The Bill stated "The affected individuals have already been given extensive medical care and treatment. They were provided housing, clothing, and subsistence during their absence from their island. Since their return, in addition to new houses, a school, a church, a community building, and other facilities, they have been given new livestock and agricultural aid, as well as subsistence in decreasing amounts. Small claims for property losses, such as clothing and handtools, were paid by the Department of Defense.

It cannot be said, however, that the compensatory measures heretofore taken are fully adequate. Enactment of H.R. 1988 is needed to permit the United States to do justice to these people."

responsibility for foreign affairs, including marine resources. However, the United States would maintain full responsibility for security and defense and would be allowed certain land rights for these purposes. During the 15 years of the Compact, the Marshall Islands would receive an estimated $750,000,000 in financial aid in addition to other assistance.

B. Problems Affecting the Program[18]

Some of the difficulties experienced in carrying out the medical examinations occurred mostly in the earlier years and were related to the lack of knowledge of the people about radiation effects and the need for extensive examinations. We were trying to explain a complicated subject hampered by the language barrier, and were often uncertain about the translation of our statements into Marshallese. The Marshallese are a very polite people and reluctant to express displeasure, so that it was difficult at times to know their true feelings. Not unreasonably, some people harbored suspicions about our motivations. We represented the American presence on their island and were considered part of the AEC (the "AEC doctors"), which had developed the bomb and brought about the catastrophic events that had disrupted their lives. There were increasing criticisms by local politicians and outside groups, particularly in Japan, regarding the handling of the aftermath of the nuclear testing program. There were criticisms regarding the medical care of the exposed people and the suggestion was made that the Marshallese had been deliberately exposed to fallout to study the effects of radiation.

In spite of these influences, the people continued to be friendly and cooperative, and, as time went on, became more cognizant of the importance of the examinations, particularly after the development of thyroid problems and the death from leukemia. However, there continued to be a smoldering distrust of the AEC's environmental and medical reports of the radiological safety of Rongelap, which eventually led them to evacuate the island in 1985.

Amata Kabua, Marshallese Senator in the Congress of Micronesia during our early surveys, questioned the need for the extensiveness of the examinations. Therefore, before our annual visit to Rongelap in 1963, we met with him and explained the need for the examinations. On our arrival at Rongelap, the people were at first reluctant to be examined, but learning that Kabua had approved, they cooperated fully.

Beginning about 1970, problems developed from an unexpected quarter: Japan. I had visited Japan on several occasions to confer with the doctors at the Atomic Bomb Casualty Commission (now the Radiation Effects Research Foundation) in Hiroshima and Nagasaki about the effects of radiation on humans and treatment of the exposed populations. Also, I had been corresponding with T. Kumatori, Director of the National Institutes of Radiological Sciences, who was in charge of the annual examinations of the fishermen exposed on the *Lucky Dragon*. We agreed that it would be mutually beneficial for me to participate in the examinations of the fishermen and for him to participate in the examinations of the Marshallese. Therefore, in 1964, I went to Japan and he returned with me to the Marshall Islands.

When I arrived in Japan, I was surprised at the amount of publicity given to the examinations and the extent of the strong emotional reaction of the Japanese to the exposure of the fishermen on the *Lucky Dragon*, to the effects on their fishing industry, and to fallout effects in the Marshall Islands (B-49). The Congress of Micronesia formed a "Special Joint Committee on Rongelap and Utirik" to look into the situation. In July, 1971, the Committee visited Japan to learn about the aid being given the Japanese people who had been exposed to radiation (B-50); they were impressed with the treatment being given. Later, they visited Rongelap and Utirik and interviewed the people there (B-51). The Committee reported that the people were uncertain about the effects of radiation and what they were being treated for; they wanted more frequent treatment. Further, they felt that the compensation they had received was inadequate compared with the compensation the Japanese fishermen had received.

As a result of their investigations, the Committee planned to ask an independent med-

[18] The problems discussed in this Chapter mainly concern the examinations of the Rongelap and Utirik people. Problems related to the Bikini people are discussed in Chapter VIII. Problems related to the evacuation and resettlement of the Enewetak people will not be discussed in this report since our medical team were not involved in examining that group.

ical group from the United Nations or other groups not related to the AEC to examine the people.

In August 1971, Ataji Balos, a representative of the Rongelap and Utirik people in the Congress of Micronesia, was invited to Japan to a symposium on nuclear bomb testing; he was accompanied by who had been Magistrate of Rongelap at the time of the accident (B-52). On his return, Balos stated that the Japanese were very interested in the fallout effects on the Marshallese people and that the United States was unwilling to give them information (B-53,54). I wrote a letter to Balos, published in the Marshall Island newspaper (*Micronitor*), setting the record straight about the availability of our publications and information on medical findings (B-55). This was followed by an exchange of friendly published letters in which Balos questioned me about the radiation exposure of the Marshallese, our findings, comparative radiation effects in the Japanese fishermen compared with the Rongelap people, how long our studies would continue, and the lower compensation of the Rongelap people compared with the fishermen (B-56). I was happy to answer these questions because I felt that I might clear up misconceptions about our examinations and improve our relations with the Marshallese. This was not to be the case. Further problems were developing.

On his visit to Japan, Balos invited a fact-finding group of Japanese to the Marshall Islands to examine the fallout victims. The group of six consisted of reporters, a photographer, and two doctors, one of whom was Hario Ezaki of Hiroshima University. The group asked Balos to help in obtaining visas. With tourist visas only, the team arrived in the Marshall Islands in early December (1971), only to find that the Trust Territory authorities refused their request to visit Rongelap because their objective was to engage in surveys and research for which prior permission was necessary (B-57). Ezaki then returned to Japan. The remainder of the group stayed on at Majuro, while Congressman Balos and Senator Kabua, as well as the Micronesian Legal Services, attempted unsuccessfully to get the decision reversed. The group then returned to Japan and abandoned plans for the survey (B-58).

This event caused considerable criticism of the U.S. authorities among the Marshallese. Senator Kabua made it known that "...he would not cooperate in any way hereafter in the AEC medical surveys..." (B-58,59). However, Balos was reported as saying "...I don't think there is anything to hide on Rongelap and Utirik. The people were just anxious to see the [Japanese] doctors..." On his return to Japan, Ezaki was questioned about the U.S. medical team (B-60) and stated "...To be honest, the U.S. conducts such detailed surveys and careful treatment that we felt it a shame to call ourselves "survey team"... The treatment given to the crew members of the No. 5 Fukuruyu-Maru (*Lucky Dragon*) Yazu is no comparison to theirs. A follow-up is made on each survivor. It is said that at one time a very extensive unit called a Human Counter had been brought there to determine the residual radiation in the body. Neither the Hiroshima University nor ABCC has such a unit. Not only the survivors, but also the inhabitants in general are well cared for, having to pay almost nothing for medical care..."

In retrospect, I believe it would have been better if the U.S. authorities had allowed the Japanese group to go to Rongelap or to accompany our medical team for their observations.

In March 1972, our medical team, consisting of six doctors, nine technicians, and several tons of equipment, arrived at Rongelap aboard the Trust Territory ship, *M. V. Militobi*, for the annual medical examinations. With us were Charles Dominick, a Congressman representing the Utirik people, and Mike Malone, a reporter (B-61). The people, as usual, welcomed us warmly, but it soon became apparent at the village meeting that the people were ill at ease. The main problem centered around the fact that they had been told not to submit to the examinations. The team held sick call and a few people came in to be examined, in spite of admonitions from some of their elders. The refusal of examinations was a discouraging and frustrating experience for our team, who were prepared for a detailed survey.

Before departing from Rongelap, I asked Dominick if he would be willing to let us examine the Utirik people, explaining that even though we had not found radiation effects, they should be under careful medical surveillance in view of the long latent period for development of thyroid tumors. He said that if they were not sick they should not be examined, and if they were examined they should receive compensation.

Malone wrote, "...The people on Rongelap got the short end of the deal. A lot of talent was on their doorstep this week and they were used like pawns in a chess game. Although Balos rejects the idea, compensation may well be the key to the Rongelap problem. But the Congressman insists he simply wants an independent non-government medical team to examine the people..." (B-61).

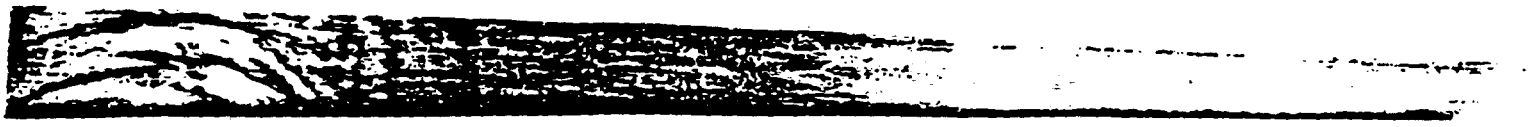
During our stay on the island, we found one woman who had an abdominal tumor and brought her back with us to Majuro for surgery. There were three Rongelap women who needed post-surgical checkup at Hawaii. They were not allowed to go and were returned to Rongelap. Unfortunately, one of the young men exposed on Rongelap, who died later that year from leukemia, missed our examination. His disease might have been treated earlier, although it still would probably have been fatal.

Following the aborted survey, the Joint Committee on Rongelap and Utirik of the Congress of Micronesia arranged for a special medical survey to take place in September 1972. They invited four well-known physicians to be consultants to accompany the medical team and evaluate the program, namely, Edward E. Pochin of the University College Hospital, Medical School, England;[19] Haruko Ezaki, and Tashiuki Kumatori of Japan, and William Cole, Associate Director of the Bureau of Public Health, from the U.S. Public Health Service. Our team consisted of five doctors, two Marshallese practitioners, and five technicians. Two representatives of the Congress of Micronesia, Hans Wilander and Ataji Balos, also accompanied the team. Below is a photo of the special medical team.

The survey proceeded smoothly and the people cooperated fully (B-62). Except for the findings of two Rongelap people with thyroid nodules requiring surgery, there were no other findings related to radiation exposure. However, on subsequent examinations of people living at Majuro and Ebeye, a young man, who had been exposed on Rongelap at one year of age, was found to have a very low white blood cell count. He accompanied us back to Brookhaven National Laboratory and acute

[19] Pochin had been most interested in the studies of the Marshallese and had helped previously with statistics on thyroid effects.

The March 1972 Medical Team with observers appointed by the Congress of Micronesia.



leukemia was diagnosed. He died several months later. His death and its repercussions are discussed in Chapter VI.

The medical consultants and the Committee observers seemed pleased with the examinations. Ezaki remarked that "...considering the location and logistics problems, the people of Rongelap receive medical treatment and examinations that would equal that provided by any big city hospitals..." (B-63). The Joint Committee published a report on the recommendations of the survey (B-18). In February 1974, a second report was published by the Committee on the actions taken regarding their recommendations (B-64). Most recommendations had already been instituted by the medical team before the 1972 survey. Some of these recommendations and the actions taken were as follows: continued presence of a resident physician in the islands (already planned); use of a special ship for medical purposes (already arranged); additional examining facilities at Majuro and Ebeye (new medical trailers were already in place); village meetings with the people to explain the results of the last examinations and answer questions (already done); statement in Marshallese to the people regarding findings (to be done). The Committee report also proposed further compensation for the Rongelap and Utirik people (PL 5-52, see Chapter 5) and a Senate Joint Resolution expressing "...the sorrow and sympathy of the Congress of Micronesia to the family and friends of for his untimely and unwarranted, irreplaceable loss..." An article by Stewart Alsop about death, was included in the report (B-65).

In March 1973, Borja and several members of the Joint Committee including Ataji Balos accompanied our medical team to Rongelap and Utirik for the annual examinations. They presented a questionnaire to the people on radiation effects and treatment. From their answers, it was apparent that our explanations about radiation and treatment had largely failed. The Consultants for the Congressional Committee also had recommended that communication between the medical team and the people should be improved. To remedy this situation, the following year we collected questions from the people about their radiation exposure and our treatment. Then, we published an illustrated question and answer booklet in Marshallese. (This booklet is duplicated in English as an addendum to our 20-year report.) (A-14). In addition, Jan Naidu of the Safety and Environmental Protection Division of Brookhaven National Laboratory spent four weeks on Rongelap and two weeks on Utirik island meeting the people and presenting informal illustrated talks, translated into Marshallese, about radiation effects and the Brookhaven program. Naidu feels that he helped the people better understand this difficult subject which, in the United States, is poorly understood by the general public.

When Senator Borja was with us for the 1973 examinations, he impressed on the people the importance of the medical examinations. This, in conjunction with our renewed educational efforts, did much to improve the people's understanding of the examinations. The AEC wrote to Senator Borja expressing general support for many of the recommendations that had been made by his Committee (B-66).

In spite of these favorable developments, more disturbing events followed before our medical program was out of rough waters.

In 1975, was Magistrate of Rongelap. He was the brother of who had been Magistrate at the time of the fallout. He had spent very little time on Rongelap and was not one of the exposed group, nor was he on the island at the time of our 1975 examinations, but was traveling in Japan. Upon his return, he submitted a letter to me which was published in the local newspaper, *Micronitor* (B-67). A few excerpts from his letter are as follows: "...Since leaving Rongelap, I have learned a great deal...you have never really cared about us as people--only as a group of guinea pigs for your government's research efforts...we want medical care from doctors who care about us...we no longer want you to come to Rongelap..." This letter was very discouraging to me, but I thought that it did not reflect the true feelings of the Rongelap people. Chips Barry, formerly an attorney with the Micronesia Legal Services at Majuro, published an open letter to Nelson Anjain criticizing his attitude and urging the people to continue being examined by the Brookhaven medical team (B-68). Ataji Balos told me not to worry about the letter, that the matter would be taken care of. It was gratifying that he now accepted the merits of our examinations: I believe that Congressman Balos has always sincerely had the welfare of the people at heart.

Beginning in the mid-1960s, several hundred Peace Corps volunteers came to Micronesia, including Rongelap and Utirik where they were most helpful to us. Others were critical of the U.S. Administration (B-34,39,40). This was a period when there was increasing criticism about the Bravo accident by local politicians and lawyers representing the Marshallese. While at Utirik, there were complaints that the people with diabetes had not been given insulin by our resident physician. We explained that we had been advised by specialists in the treatment of diabetes that such treatment was not appropriate for their type of diabetes (middle-age type) in these isolated islands. The Utirik people were also disturbed because we had told them they would not likely develop radiation effects and they had. We discussed the fact that our predictions had been based on estimates of the amount of radiation they had received, and later, revised estimates showed that they had received larger amounts of radiation, particularly to the thyroid gland, which caused the development of a few thyroid tumors.

Later that year I received a letter from the Magistrate (Mayor) of Utirik, expressing appreciation for the past work of the medical team and hoping we would continue the examinations.

In 1976, at the end of his tour, Knudsen was replaced by Konrad Kotrady. Before his retirement a year later, I heard that Kotrady had become critical of our medical program. Without consulting me, he wrote a report[20] and publicly criticized the program. The main thrust of his criticism was that the program was "too narrow". We, of course, were aware of the limitations imposed on our program by our mandate and financial restrictions. The primary health care of the people of Rongelap and Utirik always had been the responsibility of the Health Services of the Marshall Islands under the Trust Territory government. However, realizing the limitations of their capability, we had gone well beyond our mandate in providing health care and establishing a resident physician program to help in the interim. (The physicians were employed by BNL). Eventually, the United States made further funds available through the Compact of Free Association agreement which would help bring about an improvement in primary health care (B-19).

In Japan, there was continued interest in the *Bravo* accident and the Marshallese fallout victims. In March 1976, a Japanese movie team (NHK) accompanied us on our medical examinations at Rongelap and Utirik and produced a 50-minute movie, "Bikini Atoll", a reasonable portrayal of our examinations, which was later televised throughout Japan.

In May 1976, the Japanese Gensuikin anti-A and H-bomb groups obtained medical charts of 66 exposed Rongelap people. (It is not clear what these charts were nor how they got them.) The charts were turned over to the Nagasaki Red Cross Hospital and Nagasaki University for analysis, who reported the following (B-70).

> Some cases showed bone marrow disorder 18 years after the exposure differing greatly from the onset at 4-5 years later in case of Nagasaki. In any case, when the bone marrow is impaired, there is a great risk of hemopoietic disturbance appearing and careful surveillance seems to be indicated. However, these medical charts have been reported in Chapter 12 of "Atomic Medicine" printed in the U.S. in 1969 and the results of the analysis are nothing new to medical scientists.

Also at this time, the Gensuikin group invited two Rongelap men who had been exposed to the fallout to Japan, where they were examined at the Nagasaki Red Cross Hospital (B-71). Later, two Rongelap women were also examined at that hospital. The examinations revealed nothing that had not been reported by our group.

In 1977, a Japanese group from the Gensuikin organization visited Majuro and discussed with Ataji Balos the medical treatment of the Rongelap and Utirik bomb victims (B-74). Balos reassured them that he was satisfied with the way the examinations were being done. Since that time, as far as I am aware, there has been no further involvement by the Japanese in our examinations.

In the ensuing years, unrest continued among the Rongelap people. Their village had deteriorated considerably, with houses in need of repair. Since they had returned, they had not been satisfied about the radiological safety of their island despite our assurances from sensi-

[20] "The Brookhaven Medical Program to Detect Radiation Effects in the Marshallese People: A Comparison of the Peoples' vs. the Program's Attitude" (unpublished).

tive measurements of radiation on the island and in the people that the levels in the people remained well within the acceptable range and were lower than people in the United States (A-15).

Radiological studies had been conducted at Enewetak, Bikini, and other Northern Marshall Islands. The results were presented in several bilingual booklets with illustrated maps of the atolls. In the booklets describing the results of the 1978 Northern Marshalls Survey (A-53, 58), a numerical designator was used to show relative radiation levels on the various atolls. This mode of presentation was confusing and was misinterpreted as showing a radiation profile for Rongelap similar to that of Bikini. Before our medical visit, a team of DOE scientists and administrators visited each of the populated atolls in the survey area to explain the contents of the booklet. Regrettably, at Rongelap, a disturbance in the community terminated a DOE visit prematurely. Although there was no reason to believe that the disturbance was related to the DOE presentation, one DOE official was injured, and the party leader decided that it was prudent to move on (B-80). I was told by Roger Ray that this was done with considerable regret, and that had the party been permitted to complete its question and answer discussion, the later evacuation of Rongelap might not have occurred. Despite DOE's efforts to clarify the misunderstandings in discussions with the Marshall Islands authorities, there remained a degree of true and justified apprehension among the Rongelap people (B-81).

Finally, in 1985, things came to a head. The local Rongelap Council, under the leadership of Jeton Anjain, a Senator in the Nitijela (the Marshall Island Parliament), who represented the Rongelap people, permitted the Greenpeace Organization to send their ship, *The Rainbow Warrior*, to Rongelap to evacuate the island. The people were taken to a small island, Mejato, in Kwajalein atoll, where a temporary village had been set up. The island was most unsatisfactory, with minimal natural resources, and worst of all, no anchorage for ships.

The Rongelap Council began efforts to reevaluate the radiological safety of Rongelap (B-82). The Rongelap Reassessment Project was established under contract with the Republic of the Marshall Islands. Henry I. Kohn, an Emeritus Professor from Harvard Medical School, headed the program with ten consultants, three of whom were nominated by the Rongelap Council. After an exhaustive review of the DOE data on Rongelap, the project reported in 1988 (B-83) that Rongelap Island was safe for habitation for adults, but that further study was necessary to be certain that the island was safe for children. The Rongelap Council was unhappy with the Kohn report, claiming, among other things, that the data submitted by the consultants they had nominated were not properly used. Brookhaven National Laboratory and Lawrence Livermore Laboratory then carried out further studies which substantiated the earlier data, showing that Rongelap Island was indeed safe for habitation (B-79). In November 1989, a hearing on the radiological safety of Rongelap was held by the House Subcommittee on Insular and International Affairs (B-80). At this hearing, Kohn declared that on further review of the data on Rongelap the island was considered safe for habitation by both adults and children. Still dissatisfied, the Rongelap Council petitioned the U.S. Congress for funds for further independent surveys to evaluate the radiological safety of Rongelap and, if necessary, clean up the island and construct a new village (B-84). In February 1992 the DOE and DOI signed an agreement with the Republic of the Marshall Islands and the Rongelap people allocating 2.5 million dollars to continue studies of the radiological environment on Rongelap (B-103). The radiological analyses will be conducted by DOE's Lawrence Livermore Laboratory and Brookhaven National Laboratory. The National Academy of Sciences will carry out an independent review of the findings. With this action it appears that progress is finally being made toward the eventual resettlement of Rongelap. In the meantime the Rongelap people continue to live in an unsatisfactory situation on Mejato Island in Kwajalein Atoll.

The Compact of Free Association, passed in 1986, would provide an estimated 750 million dollars over 15 years to the Republic of the Marshall Islands. As part of the agreement (Section 177), 150 million dollars (of the 750 million allocated) would cover the claims of the people of the atolls of the Northern Marshalls resulting from the nuclear testing program, including radiation injury, property damage, and continuing medical care. The claims are handled by a Nuclear Claims Tribunal, chartered under the terms of the Compact of Free Association. Exposed individuals with certain diseases are automotically reimbursed; those with other diseases are reviewed.

Chapter X — The Marshallese Experience Related to Other Radiation Accidents

Before the *Bravo* accident, there had been some fallout from other tests, but it was not until this accident that the importance of the fallout hazard became fully appreciated. Some features of the accident and its consequences were unique in comparison with what might occur in other geographical areas. The detonation occurred on a tiny, isolated coral atoll with only sparsely inhabited islands 100 miles or more distant. This powerful detonation, greater than expected, deposited large amounts of incinerated coral dust mixed with radioactive elements in areas east of Bikini. Fortunately, because of their distance from the detonation site, the amounts of fallout on the inhabitants of the islands were too small to cause acute lethal effects. The radiation exposure of the Marshallese was due entirely to fallout. The people on Rongelap Atoll, where the heaviest fallout occurred, lived in the southern islands of the atoll and sustained a sublethal dose of radiation. Had they lived on islands 10 to 15 miles further north, undoubtedly there would have been deaths due to the exposure.

The Rongelap people (who were nearest to Bikini) were not evacuated before the scheduled detonation as they had been before *Operation Crossroads*, and, in the subsequent confusion, evacuation was delayed. Because there was no radio communication with the island, the Marshallese were unaware of the danger of the fallout and took no protective measures to reduce their exposure. Their houses offered little protection. They ingested food and water contaminated with the fallout and did not wash the fallout from their bodies nor change clothing. In contrast, the American servicemen on Rongerik atoll were aware of the fallout and its dangers and took protective measures which reduced their exposure.

The medical findings in the Marshallese are applicable to accidents involving nuclear power reactors where fallout has been shown to be a serious problem. The worst radiation reactor accident occurred at Chernobyl in Russia in 1986. Earlier, there were reactor accidents at Windscale in England (1957) and at the Three Mile Island plant in Pennsylvania (1979). These accidents were less serious, involving much less extensive fallout, with few, if any, detectable effects in the populations surrounding these plants (A-62). At Chernobyl, human errors resulted in melting of the reactor core which breached the shielding, sending a plume of radioactive material downwind over a considerable area of Western Russia; the plume was detectable in other countries of Northern Europe and, to a slight extent, in the United States (A-59-62). Inadequate emergency planning resulted in uncoordinated emergency action. One hundred and thirty- five thousand people were evacuated from a 30-kilometer area around the plant. There were 31 deaths from acute effects of people exposed at the reactor site. Over 200 people were treated in hospitals where extensive supportive care was instrumental in saving lives (A-60). Of concern is the large number of people exposed to radioactive fallout, particularly the large number of children, who are most sensitive to such effects. A large number of people, including 80,000 children (A-68), are believed to have received significant thyroid exposure and are being examined regularly. Thus far, no thyroid tumors have been reported but, based on the findings in the Marshallese people, I believe that thyroid abnormalities will eventually develop (A-59-62). There are reports of an increase in leukemia in the exposed children (B-101,102).

The Marshallese experience has shown that certain prophylactic measures are helpful in people receiving significant radiation exposure to the thyroid from fallout. These measures include early surgical removal of thyroid tumors and use of thyroid hormone. Consideration should also be given to the prophylactic use of stable iodine (potassium iodide tablets) to people at risk of such exposure to reduce the absorption of radioactive iodine by the thyroid gland.

Chapter XI — Closing Remarks

This report has presented an historical account of the experiences of the Brookhaven Medical Team in the examination and treatment of the Marshallese people following their accidental exposure to radioactive fallout in 1954.[21] This is the first time that a population has been heavily exposed to radioactive fallout, and even though this was a tragic mishap, the medical findings have provided valuable information for other accidents involving fallout such as the recent reactor accident at Chernobyl. Noteworthy has been the unexpected importance of radioactive iodine in the fallout in producing thyroid abnormalities.

The organization and carrying out of these examinations over the 36 years proved to be a complex and formidable undertaking. Many of the problems were unique to a medical program. Fortunately, many of us had had previous experience with radiation effects, some having participated in atomic tests. The mission could not have been successfully carried out without the participation of some of the finest specialists in the various fields of medicine and the staunch support of many agencies, particularly Brookhaven National Laboratory, Department of Energy,[22] Department of Defense, and the Trust Territory of the Pacific Islands. It is fortunate that since my retirement the medical program is continuing under the able direction of William Adams and his medical team.

Some of the difficulties in carrying out these examinations in a distant area of the world have been described, including organization of the medical teams, scope of examinations, triage problems related to assembling and shipping of medical supplies and equipment, and establishment of examination facilities on tiny, remote islands in the Pacific.

When we arrived in the islands, our medical team was faced with the medical care of a population with ethnic background, life style, customs, and language that are different from ours. In retrospect, due to a certain naivety on our part, we did not at first appreciate how these differences might apply to the conduct of our examinations. The language barrier made it difficult for us to communicate with the people and help them understand their radiation exposure and the need for the examinations, particularly blood tests. (Later, when they began to develop thyroid abnormalities, they came to realize more fully the importance of the examinations.) Unfortunately, they were never able to understand very much about radiation and its effects on them. They were afraid of this unseen, unfelt "poisonous powder" and its effect, and this became a strong psychological factor. They continued to believe that every ailment and every death was somehow related to radiation exposure.

It is understandable that with the disruption of their lives, the development of radiation effects, and the contamination of their islands, there was increasing bitterness towards the United States about the accident and, justifiably, increasing demands for compensation. The local politicians and lawyers representing the people became ever more vocal in their criticisms of the United States in handling the post-accident problems.

The criticisms increased and the years 1972 to about 1977 were troublesome ones for us. Unexpectedly, the Japanese anti-A and H-bomb groups became involved with the Marshallese politicians in criticizing the way the fallout victims were being handled. These groups were very active in Japan and created much publicity concerning the fallout exposure of the Japanese fishermen on the *Lucky Dragon*. The Marshallese politicians were greatly angered when the Trust Territory Government refused to allow a Japanese group that they had invited to visit Rongelap to examine the exposed people and the group had to return to Japan. This action precipitated a cascade of events: the abortion of our 1972 medical examinations after the team had arrived at Rongelap due to political interference; the formation of a special investigative committee on Rongelap and Utirik

[21] In Appendix II, a chronological outline of the principal events is presented.

[22] I have pointed out that the AEC/DOE necessarily had to call on their National Laboratories for assistance in radiation problems since there were no other agencies with the required capability and facilities. It should be repeated that although our program was under the aegis of BNL and funded by AEC, there was never any attempt to influence the conduct of the examinations which we carried out independently with the advice and participation of medical people from outstanding institutions in the United States.

by the Congress of Micronesia with arrangements for medical observers to accompany our examinations and other problems that developed during this time, as outlined in the report.

Following this difficult period, it was encouraging that there ensued a marked improvement in attitude toward the program. There were several possible reasons for this: the favorable report of the medical observers to the Congress of Micronesia on the conduct of the examinations; our efforts to increase communication with the people about the effects of radiation and the objectives of our program, and our increased efforts to expand primary health care by placing a resident physician in the Islands; and, last but not least, the increased response of the United States in compensation settlements. It was also encouraging that the Japanese groups no longer became involved with the program.

In retrospect, it was unfortunate that the AEC, because it was a research organization, did not include support of basic health care of populations under study. For this reason, the Brookhaven medical program in the Pacific could not be designated other than a research project, restricting the scope of the program to the diagnosis and treatment of radiation effects in the exposed people.[23] General health care of the Marshallese had been established as a responsibility of the Health Services of the Government of the Trust Territory of the Pacific Islands and later, the Republic of the Marshall Islands. With increasing effects of radiation in the exposed people and the need for more health care, particularly in the Outer Islands, the program was expanded (unofficially) within fiscal and time limitations beyond the limitations imposed by the original mandate. This expansion included establishing a resident physician in the Islands. The limitations of the program described above was the basis for criticisms of the scope of our program described.

During the early years of the examinations, when there were few findings related to radiation exposure, there were suggestions that the examinations might be reduced in scope and frequency. However, we felt that it was important to continue regular, detailed examinations because of the paucity of information about late effects of radiation in human beings. This decision proved to be fully justified when thyroid effects began to appear, and we were able to detect and treat them at an early stage before complications developed.

When the Rongelap people moved back to their atoll in 1957, there were persisting fears about the low levels of residual contamination of their island. This undercurrent of fear continued in spite of further comprehensive radiological surveys showing the radiological safety of the island, and our annual, sensitive monitoring of the people for internally absorbed radioactive elements and our reassurances that their radiation exposure from living on the island was less than that of people living in the United States. It was unfortunate that in 1986, after living on Rongelap for nearly thirty years, the people chose to evacuate their island. This event was followed by a complex series of actions initiated by representatives of the Rongelap people to investigate the DOE reports of the radiological safety of Rongelap. They requested funds to carry out an independent investigation of the radiological safety of their island for habitation. Recently DOE and DOI provided a fund for this purpose and such an investigation is in progress. In the meantime the Rongelap people continue to live on the unsatisfactory island of Mejato in Kwajalein atoll.

Equally discouraging has been the unfortunate saga of the Bikini people who were removed from their atoll 44 years ago before *Operation Crossroads*. Resettlement on Rongerik Atoll resulted in near starvation of the people and they have never been satisfied with life on Kili Island. The early attempt to recolonize Bikini with several families had to be abandoned when it was found that radiation levels on its island were higher than previously had been reported, and that there was an unacceptable increase in absorption of radioactive elements in the people due to consumption of newly grown fruits on the island. Although efforts have been made to make Kili Island more habitable, the people are not happy there and yearn for the long overdue return home. It can be hoped that the recent allotment of U.S. funds to the Bikini people to handle the radio-

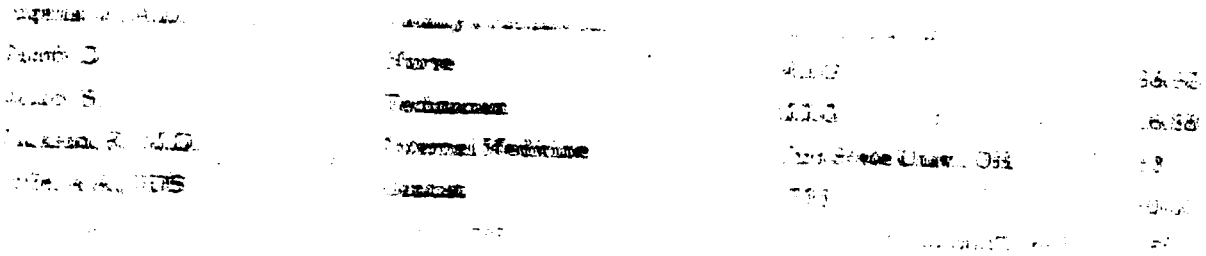
[23] The Radiation Effects Research Foundation, a joint AEC/Japanese project in Japan to study the effects of the atomic bomb, radiation on the Japanese people, likewise did not include AEC support for general health care of the populations under study.

logical clean-up of their island will be successful.

The dislocation of the people and increasing dependence on subsidization and compensation had a disturbing influence on the lifestyle of the exposed people, resulting in a loss of incentive to pursue their native skills. This was more apparent in the Rongelap people, who had suffered the greatest dislocation. The Utirik people, who were returned to their homes after only a few months absence, seemed to adjust better to these conditions. At present, there is a clamor among the people of the Northern Marshalls to benefit from the funds allocated by the United States in the Compact of Free Association Agreement for those affected by the *Bravo* accident. The number of people applying for radiation effects is far greater than was present on our list of exposed people. As is to be expected, determining which people are eligible to receive these funds is a difficult undertaking for the Tribunal appointed for this purpose.

Although there are continuing problems that need to be resolved, the relationship of the Republic of the Marshall Islands with the United States appears to be on a smooth course. The new government is facing up to problems such as the alarming population increase, the need for improvement in health care and education, and further development of their local resources.

During their history, the Marshallese, perhaps more than any other population, have been subjected to numerous perturbing influences, such as visitation of foreign ships, occupation by foreign governments, epidemics of disease, a major war partly fought on their soil with casualties among their people, adverse effects from our nuclear testing program, and problems associated with the missile test range at Kwajalein. Through it all, the Marshallese have maintained their individuality, their dignity, and their reverence for their past.



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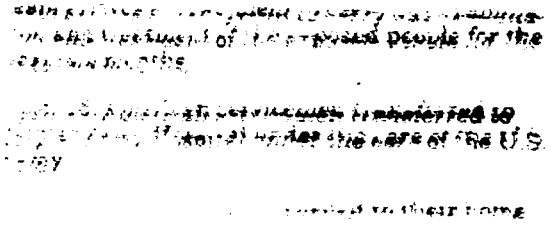

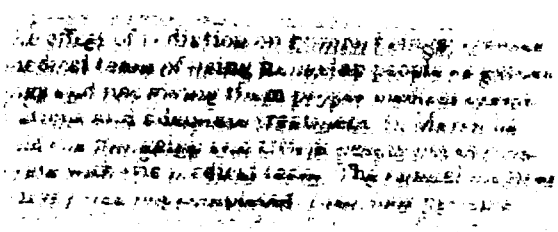

Appendix I — Marshall Island Survey Participants 1954-1990

Name	Specialty	Affiliation, Location	Year
Adamik, E.	Technician	BNL, NY	59,61-62
Adams, D.	Technician	BNL, NY	81-85
Adams, W.H., M.D.	Hematologist	BNL, NY	81-90
Anderson, J., M.D.	Geriatrician	NYU-Belleview Hosp., NY	87
Anjain, J.	Medical Translator	M.I.G.	77
Anjain, J., D.O.	Dental Officer	TTPI	64,72
Arelong, T., R.N.	Nurse	M.I.G.	82-85,87
Argonza, W.S.	Technician	US Navy, NRDL	54
Aron, D., M.D.	Endocrinologist	Case Western Reserve Univ., OH	89-90
Ash, J.A.	Technician	BNL, NY	74
Bach, S.A., M.D.	Physician	US Army, AFSWP	57
Barclay, P., M.D.	Allergist/Immunologist	Central Gen. Hosp., NY	82,84,87
Barton, M., M.D.	Physician	US Air Force, AFSWP	58
Bateman, J.L., M.D.	Internal Medicine	BNL, NY	69
Bauman, A., M.D.	Endocrinologist	V.A. Hosp., VT	88
Becker, D., M.D.	Radiologist	NY Hosp. – Cornell Med. Ct.	81
Bellu, W.	Technician	M.I.G.	83
Bender, B., Ph.D.	Anthropologist	TTPI	64
Benes, S., M.D.	Ophthalmologist	Ohio State Univ.	87
Benton, M.	Nutrition/Fitness	Private Business, NY	89
Bettrie, K.	Technician	M.I.G.	82
Beydoun, S., M.D.	Obstetrician/Gynecologist	U. Miami Sch. of Med., FL	86
Biancaniello, T., M.D.	Pediatrician	SUNY, Stony Brook, NY	81
Bien, P.	Medex	TTPI	70,74-75,81
Bliss, M., M.D.	Gastroenterologist	Boston City Hospital, MA	85,87,89
Blumberg, Baruch, M.D.	Endocrinologist	NIH, Bethesda, MD	59
Boccia, B., M.D.	Internal Medicine	Brookhaven Mem. Hosp., NY	79
Bond, V., M.D., Ph.D.	Physician	BNL, NY	54
Boon, R.	Technician	TTPI	61
Border, W.K.	Technician	NMRI, Bethesda, MD	55-56
Boyd, L.	Technician	BNL, NY	85
Brown, E., M.D.	Cardiologist	SUNY, Stony Brook, NY	82
Brown, R.A.	Technician	BNL, NY	73-74,77-81
Browning, L.E., M.D.	Physician	US Army, AFSWP	54

Name	Specialty	Affiliation, Location	Year
Bullis, J.	Technician	BNL, NY	86
Calmon, J., M.D.	Infectious Diseases	Medical Coll. of Pennsylvania, PA	89
Cannon, B., M.D.	Surgeon	Mass. Gen. Hosp., MA	56-57,63
Carter, E.L., M.D.	Internal Medicine	NMRI, Bethesda, MD	57
Carter, R.E., M.D.	Pediatrician	State Univ., Iowa	64
Carver, R.K.	Parasitologist	USPHS, Washington, D.C.	58
Carroni, M., M.D.	Physician	Walter Reed Army Med. Ct., Washington, D.C.	90
Catto, B., M.D.	Internal Medicine	Case Western Reserve Univ., OH	81
Chapman, W.H.	Radiation Scientist	NMRI, Bethesda, MD	54-57
Cheatman, W., M.D.	Endocrinologist	Walter Reed Army Med. Ct., Washington, D.C.	83-84,86
Cizinsky, J., D.Ph.	Pharmacist	BNL, NY	88
Clareus, D.	Electronic Specialist	BNL, NY	61-70,72-79
Clutter, W.G.	Technician	NMRI, Bethesda, MD	54-57
Cogswell, F., Ph.D.	Parasitologist	US Public Health Hosp., LA	86
Colcock, B.P., M.D.	Surgeon	Lahey Clinic, Boston, MA	67,75
Cole, W., M.D.	Radiologist	USPHS, Washington, DC	72
Cook, K., M.D.	Family Practitioner	Kwajalein Hosp., M.I.	81,88
Cook, L.	Technician	BNL, NY	63,65
Cooper, A., M.D.	Surgeon	Univ. of Pennsylvania, PA	75
Conard, R.A., M.D.	Physician	BNL, NY	54,56-80,82
Conn, S.H., Ph.D.	Scientist	BNL, NY	54,59,61,74
Cronkite, E.P., M.D.	Hematologist	BNL, NY	54-55,80-81
Cronkite, T.	Technician	Medical Coll. of Wisconsin, WI	79
Culbert, S., M.D.	Pediatrician	M.D. Anderson Hosp., TX	77
Davenport, D., M.D.	Obstetrician/Gynecologist	SUNY, Stony Brook, NY	82
DeBrum, R.	Medical Translator	US Dept. of Energy, Majuro, M.I.	80-90
Dec, W., M.D.	Cardiologist	Harvard Med. School, MA	85
Deisher, J.B., M.D.	Physician	TTPI	66
Dekle, M., M.D.	Physician	U.S. Public Health Hosp., CA	79
Demoise, C.F., Ph.D.	Scientist	BNL, NY	68-69
Dobyns, B.M., M.D.	Surgeon	Case Western Reserve Univ., OH	69-70,72-73,79-80,82,85,88-89
Donato, D., M.D.	Obstetrician/Gynecologist	U. of Miami Med. School, FL	90
Duhaimes, S.	Technician	SUNY, Stony Brook, NY	87

Name	Specialty	Affiliation, Location	Year
Dungy, C., M.D.	Pediatrician	U. of California, Irvine	82-83
Dunham, C., M.D.	Physician	AEC, Washington, DC	54-55
Dwyer, M., M.D.	Ophthalmologist	Walter Reed Army Med. Ct., Washington, DC	89
Eicher, M.	Electronic Specialist	NMRI, Bethesda, MD	57-59,65,73
Elanjo, L.	Technician	TTPI	74,76-81
Emil, M., D.O.	Dental Officer	TTPI	67
Emos, H.	Technician	BNL, NY	79-90
Engle, J., M.D.	Internal Medicine	BNL, NY	84-86
Evert, H., M.D.	Physician	Medical Coll. of Wisconsin, WI	79
Ezaki, H., M.D.	Surgeon	Hiroshima Sch. of Med., Japan	72
Farr, R.S., M.D.	Hematologist	NMRI, Bethesda, MD	54
Ferguson, F., DDS	Pediatric Dentistry	SUNY, Stony Brook, NY	82-85
Ferguson, R.	Technician	BNL, NY	82-84,88
Fikrig, S., M.D.	Pediatrician	SUNY Health Center, Brooklyn, NY	90
Flanagan, J.	Technician	NMRI, Bethesda, MD	54
Gardiner, M., M.D.	Rheumatologist	Medical Coll. of Pennsylvania, PA	89
Gatz, J.	Electronic Technician	BNL, NY	89
Gays, W.	Technician	TTPI	64-65
Geller, P., DDS	Dentist	Private Practice, NY	83
Giorgio, B., M.D.	Obstetrician/Gynecologist	Private Practice, HI	80,83-85,87
Giorgio, L., RN	Nurse	Private Practice, HI	85
Gibbs, W.H.	Technician	NRDL, Bethesda, MD	54
Gideon, K.	Technician	TTPI	64-65,78-81,86
Gilmartin, J.T.	Technician	BNL, NY	59
Glassford, K.	Technician	Bethesda, MD	59
Glynn, R., M.D.	Physician	US Public Health Hosp., CA	77
Goldman, M., Ph.D.	Parasitologist	USPHS, Washington, DC	58
Gomez, W.	Technician	TTPI	67,69
Grant, W., M.D.	Internal Medicine	BNL, NY	78-79
Green, A., M.D.	Endocrinologist	SUNY, Stony Brook, NY	89
Greene, G., M.E.	Pediatrician	U. of California, Irvine	85
Greenhouse, N.	Radiation Scientist	BNL, NY	74,78
Greenough, J.J.	Technician	BNL, NY	57,59
Griffin, D., M.D.	Physician	US Navy, NRDL	55
Gusmano, E., Ph.D.	Radiation Scientist	BNL, NY	61,65

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Name	Specialty	Affiliation, Location	Year
Hamby, J.W.	Technician	NMRI, Bethesda, MD	54-57
Hammerstrom, R., Ph.D.	Scientist	BNL, NY	63
Hansell, R.E.	Technician	US Navy, NMRI	54
Hartley, M.L.	Technician	US Navy, NMRI	58
Hayakawa, C., M.D.	Physician	Tokyo, Japan	72
Hechter, H.	Statistician	NRDL	57-58
Harper, J., M.D.	Family Practitioner	BNL, NY	80-83,86,88
Heidinger, H., M.D.	Pediatrician	Loma Linda U., CA	79
Heinrichs, J.	Technician	BNL, NY	87,90
Helkena, J., D.O.	Dental Officer	TTPI	60
Hendrie, J.C.	Technician	US Navy, NRDL	54
Heotos, P.M.	Technician	BNL, NY	73-90
Hicking A., M.O.	Medical Officer	TTPI	62-68
Hicks, E.	Technician	BNL, NY	82
Hill, S., M.D.	Endocrinologist	M.D. Anderson Hosp., TX	80
Hollingsworth, J.W., M.D.	Internal Medicine	ABCC, Japan	59
Howleson, J., M.D.	Radiologist	Oregon Health Services U., OR	90
Huggins, C.E., M.D.	Internal Medicine	NMRI, Bethesda, MD	56
Humphrey, D.	Photographer	BNL, NY	70
Hurowitz, J., M.D.	Internal Medicine	U. of Mass., Worcester, MA	88
Iaman, J., M.O.	Medical Officer	TTPI	59,76-77,79-82
Ingalls, J., M.D.	Family Practitioner	Maine Medical Center	80
Jacob, D.	Nurse	M.I.G.	86,88
Jacob, S.	Technician	M.I.G.	86,88
Jackson, R., M.D.	Internal Medicine	Ohio State Univ., OH	83
Jaffe, A.A., DDS	Dentist	TTPI	60-61
Jagannath, A., M.D.	Radiologist	New York Hospital/Cornell	88
Jensen, L., M.D.	Obstetrician/Gynecologist	U. of Miami School of Med., FL	85
Jesseph, J.E., M.D.	Surgeon	BNL, NY	65
Jomule, J.	Technician	TTPI	67,72
Jones, I.	Technician	So. Nassau Comm. Hosp., NY	61-63
Kabua, J.	Nurse	BNL, Ebeye, M.I.	78-90
Kabua, M.	Technician	M.I.G.	79
Kaiko, R.	Nurse	M.I.G.	81
Kaloyanides, G., M.D.	Nephrologist	SUNY Stony Brook, NY	83
Karnofsky, D., M.D.	Oncologist	Sloan- Kettering Inst., NY	61

Name	Specialty	Affiliation, Location	Year
Kehne, S., M.D.	Neurologist	Boston City Hosp., MA	84-86
Kenny, J.	Technician	NMRI, Bethesda, MD	55
Kern, J., M.D.	Physician	Walter Reed Army Med. Ct., Washington, D.C.	90
Ketchum, D., M.D.	Pediatrician	Tulane Aff. Hospitals, LA	81
Kilwe, H.	Nurse	M.I.G.	90
Kindermann, R., M.D.	Ophthalmologist	Private Practice, NJ	81,83,85
Knudsen, K., M.D.	Internal Medicine	BNL, NY	71-74,76-77
Korean, M.	Medical Officer	M.I.G.	78
Kotrady, K., M.D.	Family Practitioner	BNL, NY	76
Kramer, K., M.D.	Ophthalmologist	Walter Reed Army Med. Ct., Washington, D.C.	89
Krippaehne, M., M.D.	Physician	Oregon Health Sci. U., OR	90
Krotoski, A., DDS	Dentist	Private Practice, CA	79-80
Krotoski, W., M.D.	Parasitologist	US Public Health Service, LA	77-79,82
Kumatori, T., M.D.	Physician	NI Radiological Sci., Japan	64,72
Lakshmanan, M., M.D.	Endocrinologist	Nat. Institute of Health, MD	86-87,90
Lalimo, T.	Nurse	M.I.G.	90
Landsberger, E., M.D.	Obstetrician/Gynecologist	Albert Einstein Coll. Med., NY	86
Lang, J.	Technician	M.I.G.	81
Langrine, H.	Nurse	M.I.G.	85-86
Lanwi, I., M.O.	Medical Officer	TTPI	59-60,64,67
Larsen, P.R., M.D.	Endocrinologist	Univ. of Pittsburgh, PA	72,74
Lehman, W.	Technician	BNL, NY	81,86-90
Le Maire, W., M.D.	Obstetrician/Gynecologist	U. of Main Sch. Med., FL	88
Lerner, M., M.D.	Pediatrician	Univ. of California, Irvine	84
LeRoy, G.V., M.D.	Internal Medicine	AEC, Washington, D.C.	54
Lessard, E.	Radiation Scientist	BNL, NY	78
Lewis, H., M.D.	Cardiologist	Memorial Hospital, NY	59
Leyjen, T.	Nurse	M.I.G.	88-89
Libby, E.	Technician	TTPI	67-69,71-73
Lindborg, E., M.D.	Family Practitioner	Kwajalein Hosp., M.I.	89
Loes, L., M.D.	Obstetrician/Gynecologist	Women-Children Med. Ctr. MN	89
Lowrey, A., Jr., M.D.	Ophthalmologist	Walter Reed Army Med. Ctr., Washington, D.C.	56-59,62,64,67, 71-72,75,78
Lyon, H.W., DDS	Dentist	Bethesda, MD	59
MacDonald, H., M.D.	Physician	TTPI	60-61

Name	Specialty	Affiliation, Location	Year
Magner, J., M.D.	Endocrinologist	Michael Reese Hosp., Chicago, IL	90
Makar, M.S.	Technician	BNL, NY	69-78,79
Mandelkern, M., M.D., Ph.D.	Internal Medicine	U. California, Irvine	79
Malarkey, W., M.D.	Endocrinologist	Ohio State University, OH	83
Macisso, D.	Technician	Main Medical Center, ME	80
MacKay, D., M.D.	Infectious Diseases	Darmouth-Hitchcock Med. Ctr., NH	87
Maisel, J., M.D.	Opthalmologist	SUNY, Stony Brook, NY	85
Maxon, H., M.D.	Nuclear Medicine	U. of Cinn. Med. Center, OH	87
McClintock, C., M.D.	Gastroenterologist	Boston City Hosp., MA	83-85,88-90, 90
McPherson, S.D., M.D.	Ophthalmologist	NMRI, Bethesda, MD	55
Melkonian, R., M.D.	Obstetrician/Gynecologist	SUNY, Stony Brook, NY	87
Mellen, M.	Nurse	M.I.G.	87
Meyer, L.M., M.D.	Hematologist	V.A. Hosp., NY	61-65,67,72, 74
Miltenberger, R.	Radiation Scientist	BNL, NY	78
Miller, M., M.D.	Hematologist	BNL, NY	81
Mizutani, Kosan	Technician	TTPI	67,72,74-75, 89
Moloney, W.G., M.D.	Hematologist	Boston City Hospital, MA	62,63
Momotaro, F., D.O.	Dental Officer	TTPI	72
Morgan, D., M.D.	Pediatrician	U. of California, Irvine	82-84
Mueller, L., M.D.	Family Practitioner	Brookhaven Mem. Hosp., NY	80-81
Murray, W.G.	Photographer	NRDL, San Francisco, CA	57-58
Nakasone, K., M.D.	Obstetrician/Gynecologist	Honolulu Med. Group, HI	84
Naylor, R., M.D.	Radiologist	Darthmouth Med. Sch., NH	89
Nelson, W., M.D.	Pediatrician	National Inst. of Health, MD	78
Neamon, M.	Technician	M.I.G.	79
Netisul, N., R.N.	Nurse	BNL, NY	89
Nicoloff, J., M.D.	Endocrinologist	U. of California Sch. of Med.	78-79
Nicoloff, R., M.D.	Obstretician/Gynecologist	Permanenta Med. Center, CA	78-79,82
Obten, Antak	Technician	TTPI	62
O'Connell, B., M.D.	Obstetrician/Gynecologist	Univ. of Wisconsin, Madison, WI	90
Oh, Yang, H., Ph.D.	Scientist	BNL, NY	71
O'Sullivan, M., M.D.	Obstetrician/Gynecologist	U. of Miami Sch. of Med., FL	84
Otto, J.S.	Technician	US Navy, Naval Med. Center	58

Name	Specialty	Affiliation, Location	Year
Paglia, D.E., M.D.	Hematologist	UCLA, CA	68,76,79,81
Palmer, L., M.D.	Internal Medicine	Yale-New Haven Hosp., CT	82
Partin, J., M.D.	Pediatrician	SUNY, Stony Brook, NY	81
Pacifico, A., M.D.	Cardiologist	Baylor Sch. of Med., TX	87
Panebianco, R., M.D.	Internal Medicine	Private Practice, NY	85
Peck, W., M.D.	Physician	TTPI	72
Philip, R.	Technician	M.I.G.	80-81
Pochin, E., M.D.	Radiologist	U. Coll. Med. School, London, UK	72
Potter, D.W.	Scientist	BNL, NY	58-59
Pratt, H., M.D.	Internal Medicine	BNL, NY	78-80
Prem, K., M.D.	Obstetrician/Gynecologist	U. Of Minnesota Med. Sch., MN	88-89
Rai, K.R., M.D.	Pediatrician	BNL, NY	70
Rall, J.E., M.D.	Endocrinologist	NIH, Bethesda, MD	57,65,71
Randell, D., M.D.	Ophthalmologist	Private Practice, HI	81,83
Rantak, N.	Nurse	M.I.G.	89
Reidel, A.	Technician	M.I.G.	80-82
Richards, J.B., M.D.	Physician	NMRI, Bethesda, MD	56
Riklon, A.	Nurse	M.I.G.	88
Riklon, E., M.O.	Medical Officer	TTPI	59-63,69,72-73
Riklon, K.	Technician	TTPI	72
Rittmaster, R., M.D.	Endocrinologist	BNL/NIH	80-81,85
Robbins, J., M.D.	Endocrinologist	NIH	66,72,76,79
Robertson, J.S., M.D., Ph.D.	Scientist	BNL, NY	54,58,65
Rothman, J.C.	Technician	BNL, NY	74,77
Saul, J.	Technician	TTPI	71,72,82-86,89
Schaenen, W., M.D.	Internal Medicine	NY Univ. Bellevue Hosp., NY	88
Schlissel, E., DDS	Dentist	SUNY, Stony Brook, NY	81
Schork, P.K.	Technician	NMRI, Bethesda, MD	54,57
Scott, W.A.	Administration	BNL, NY	58-89
Severson, C.D.	Technician	NMRI, Bethesda, MD	56
Sherman, L., M.D.	Endocrinologist	SUNY, Stony Brook, NY	84
Sharp, R.	Radiation Scientist	NMRI, Bethesda, MD	54
Shoniber, S.	Technician	TTPI	59-83,85,87-90
Shulman, N.R., M.D.	Hematologist	NMRI, Bethesda, MD	54
Sipe, C.	Technician	BNL, NY	54-55,58

Name	Specialty	Affiliation, Location	Year
Slivka, W.	Pulmonary Technician	Walter Reed Army Ct., Washington, D.C.	90
Smith, E., M.D.	Family Practitioner	Brookhaven Mem. Hosp., NY	80
Smith, L.J.	Radiation Scientist	NRDL, San Francisco, CA	54
Smith, R.F.	Photographer	BNL, NY	59,67
Snow, L.D.	Technician	NMRI, Bethesda, MD	56,59
Soras, P.	Technician	TTPI	61
Stary, M., M.D.	Physician	US Public Health Service, LA	79
Stewart, D., M.D.	Pediatrics	U. of California, Irvine	85
Stone, M., M.D.	Obstetrician/Gynecologist	SUNY, Stony Brook, NY	83
Steele, J., M.D.	Pediatrician	TTPI	74
Stravino, M.	Technician	BNL, NY	87
Strome, C.P.A.	Technician	NMRI, Bethesda, MD	54-56
Sutow, W., M.D.	Pediatrician	MD Anderson Hosp., TX	58-59,63-65, 67-72
Sullivan, M., M.D.	Pediatrician	M.D. Anderson Hosp., TX	79
Symes, D., M.D.	Ophthalmologist	Private Practice, AZ	87
Taguchi, D., M.D.	Obstetrician/Gynecologist	Private Practice, CA	81
Takamura, B.	Technician	M.I.G.	90
Tenorio, P.	Technician	US Navy, NMRI	58,59
Territo, M., M.D.	Internal Medicine	U. of California, LA	79
Thomas, R., M.D.	Emergency Room Med.	Bradley Mem. Hosp., TN	80
Thomas, C., RN	Nurse	So. Missionary Coll., TN	80
Tomesch, C.	Technician	BNL, NY	71
Tommy, M.	Medical Translator	M.I.G.	87,88
Ugolini, V., M.D.	Cardiologist	Southwestern Med. Sch., TX	87
Ulyat, H.	Technician	BNL, NY	88,89
Urschel, H.C., Jr., M.D.	Physician	NMRI, Bethesda, MD	58
Waithe, W.	Technician	New York University, NY	64
Watne, A.C., M.D.	Surgeon	Univ. of West Virginia, WV	64
Wedon, E.A., Jr., M.D.	Physician	NRDL, San Francisco	54
Weldon, T.	Technician	BNL, NY	67,80
Werth, V., M.D.	Dermatologist	New York University, NY	86
Williams, K., M.D.	Internal Medicine	Cornell University, NY	86
Wilson, R., M.D.	Family Practitioner	Indian Health Service, NM	89
Wolff, J., M.D.	Endocrinologist	NIH, Bethesda, MD	74,77-78
Wolins, W., M.D.	Internal Medicine	BNL, NY	58
Woodward, K.T., M.D.	Radiologist	U.S. Army, AFSWP	55

Name	Specialty	Affiliation, Location	Year
Wynn, S., RN	Nurse	BNL, NY	79
Yoshizame, S.	Nurse	M.I.G.	81
Zetkeia, Nelson	Technician	TTPI	61,66-79
Zimmerma, S., M.D.	Internal Medicine	Main Medical Center, ME	81
Ysawa, W.	Student Nurse	M.I.G.	90

List of Acronyms

BNL	Brookhaven National Laboratory
M.I.G.	Marshall Island Government, Majuro
NMRI	Naval Medical Research Institute
NRDL	Naval Radiological Defense Laboratory
TTPI	Trust Territory of the Pacific Islands

Appendix II — Chronological Listing of Pertinent Events in the Marshall Islands

1946 Bikini people moved from home island to Rongerik Atoll. Later evacuated to Kwajalein and finally settled on Kili Island in the Southern Marshalls.

Kwajalein established as U.S. Navy Base.

Operation Crossroads at Bikini.

Trust Territory of the Pacific Islands established, administered by U.S. Navy.

1948 Enewetak people moved to Ujelang Atoll. Enewetak established as a base of operations for future nuclear testing.

1951 Administration of Trust Territory transferred to U.S. Department of Interior.

1954 March 1: Fallout accident following detonation of Bravo, a thermonuclear device. Evacuation of exposed people: 28 American servicemen from Rongerik Atoll, 82 Marshallese from Rongelap and Ailingnae Atolls, and 157 from Utirik Atoll. A Japanese fishing vessel, the *Lucky Dragon*, with 23 aboard, exposed to fallout and returns to Japan arriving March 14. The fishermen are hospitalized. Near panic in Japan about the effect of fallout on fishing industry.

March 8: AEC-sponsored emergency medical team arrives at Kwajalein to carry out examination and treatment of the exposed people for the next two months.

April 15: American servicemen transferred to Tripler Army Hospital under the care of the U.S. Army.

May: The Utirik people returned to their home atoll. Rongelap people moved to a temporary village on Ejit Island, Majuro Atoll.

1956 Regular, continuing examinations and treatment program of the Marshallese established under the auspices of BNL and coordinated with the Health Services of the Trust Territory. Robert Conard appointed Director of the program.

1957 Examinations of the Rongelap and Utirik people. New village at Rongelap completed and the Rongelap people returned to their home atoll. Periodic environmental radiation surveys continued along with the medical examinations.

1963 Poliomyelitis epidemic in Marshall Islands including Rongelap. Pacific Missile Range under U.S. Army Command established at Kwajalein.

1964 *Ex gratia* compensation granted Rongelap people by U.S. Congress ($11,000 per person).

Thyroid abnormalities begin to appear in the Rongelap people. Thyroid surgery performed on three children at Guam Naval Hospital.

1965 Thyroid surgery on 12 Rongelap people at New England Deaconess Hospital in Boston.

1969 Annual examination of Utirik people.

Clean-up of Bikini begins.

Thyroid surgery on five Marshallese at Cleveland Metropolitan General Hospital, Cleveland.

1971 Congressman from Marshall Island visits Japan and invites a Japanese team to examine the Rongelap people. Team arrives, but denied visit to Rongelap due to improper visas and forced to return to Japan. Return of two families to Bikini to live. BNL medical team assumes responsibility for radiological monitoring of returning Bikini People.

Documentary movie "Thyroid Neoplasia as a Late Sequela of Radioactive Fallout" filmed in Marshall Islands. Shows the medical team in action.

1972 Marshallese Congressman accuses the U.S. of knowingly allowing the Marshallese people to be exposed to radioactive fallout in order to study the effect of radiation on human beings; accuses medical team of using Rongelap people as guinea pigs and not giving them proper medical examinations and adequate treatment. In March he told the Rongelap and Utirik people not to cooperate with the medical team. The annual medical survey was not completed. Also, four patients who had been operated on for thyroid cancer and were to be reexamined at Tripler Army Hospital were stopped and told by the Marshallese political leaders to return home.

Congress of Micronesia establishes a Special Joint Committee to investigate the medical examinations at Rongelap and Utirik Atolls. Chairman: Senator Olympio G. Borja.

First resident physician stationed in the Marshall Islands.

Annual medical survey resumed, with cooperation from Committee from Congress of Micronesia and participation of four appointed medical observers from several countries. Comprehensive report generally favorable to the medical examinations published.

A young Rongelap man, found to have acute myelogenous leukemia, dies at the National

Cancer Institute, Bethesda, Maryland, and is returned for burial at Rongelap.

A group from the Safety and Environmental Protection Division at BNL carry out radiological surveys in the Marshall Islands to be coordinated with the medical examinations and personnel monitoring.

Special bills passed by Congress of Micronesia regarding further compensation to Rongelap and Utirik people, and providing special benefits and hospitalization privileges in case of illness from any cause.

Twenty houses completed at Bikini and more people returned.

Between 1969-74, 14 Marshallese, one exposed *in utero*, had thyroid surgery in the U.S. The total thus far is 26 people.

The first ship to be used for medical examinations obtained, named *Liktanur*.

1977 Marshallese nurse and laboratory technician hired by BNL to support the resident physician in the islands.

1978 Radiological monitoring of 140 people on Bikini reveals unexpected increase in absorption of radioactive elements from the consumption of freshly grown fruits on the island. Although no overexposures were found, it was necessary to evacuate the people in order to prevent unacceptable increases in their body burden of these elements.

Aerial radiological surveys of the Northern Marshall Islands completed.

Robert Conard retires, Medical Director of the program for 26 years. Hugh Pratt and Eugene Cronkite temporarily headed the program from 1979-81.

1981 William Adams assumes directorship of the Marshall Island Medical Program.

1985 Rongelap people, mistrustful of DOE reports of the radiological safety of their atoll, are evacuated from their island by Greenpeace to an unsatisfactory island (Mejato) in Kwajalein Atoll.

1986 BNL's resident physician program terminated because of increased U.S. funding for general health care in the Northern Marshall Islands.

1990 The appearance of thyroid tumors has declined in the past five years. About one-third of the exposed Rongelap people and a small number of Utirik people have developed tumors.

1991 Jean Howard joins Adams in administering the program.

Fallout

BNL 46444 Informal Report

The Experiences of a Medical Team in the Care of a Marshallese Population Accidently Exposed to Fallout Radiation • *Robert A. Conard*