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AUTHOR: Lawrence P. Donaldson

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SUGGESTED PROGRAMS FOR THE BIOLOGICAL MONITORING OF  
ENIWETOK ATOLL BEFORE AND AFTER THE TESTING PROGRAM,  
WITH A RESURVEY OF BIKINI ATOLL

Applied Fisheries Laboratory  
University of Washington  
Seattle, Washington

Lauren R. Donaldson  
Director

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Introduction

With the inception of the Atomic Energy Program early in the war and the proposal to construct reactors along the Columbia River in the State of Washington, it became evident that studies were needed to evaluate the problems associated with radiological contamination. In August 1943, the Office of Scientific Research and Development requested the University of Washington to enter into a contract with them to conduct fundamental studies on the effects of radiation upon biotic populations known to inhabit the Columbia River. The University of Washington, following the signing of the contract, established the Applied Fisheries Laboratory and provided the staff, equipment, and materials to conduct the research program.

The responsibility of the contract with the Federal Government changed from the Office of Scientific Research and Development to the Manhattan Engineering District and, with the passage of the Atomic Energy Act in 1946, shifted to the Atomic Energy Commission.

An additional area of study was added to the research program of the Laboratory in 1946 when the University of Washington, in

response to a request from the Atomic Energy Commission, accepted the responsibility for studies of the effects of radiation upon aquatic forms during and subsequent to the Bikini tests.

Following the Bikini tests of 1946 and the resurvey of 1947, the testing program shifted to Eniwetok where studies of biological contamination were conducted during the testing program of 1948, with follow-up resurveys during the summer of that year and also during the summer of 1949.

The field studies at Bikini and Eniwetok have been summarized in the following reports furnished the Atomic Energy Commission by the Applied Fisheries Laboratory:

- UWFL-7 Radiobiological Resurvey of Bikini Atoll During the Summer of 1947
- UWFL-16 Bikini Radiobiological Resurvey of 1948
- UWFL-19 Eniwetok Radiological Resurvey, July 1948
- UWFL-20 Proposed Program of Study of Radiation Biology at Bikini and Eniwetok During the Summer of 1949
- UWFL-22 Suggestion for a Program of Radiological Resurvey at Bikini-Eniwetok During July and August of 1950
- UWFL-23 Radiobiological Survey of Bikini, Eniwetok, and Likiep Atolls--July to August, 1949
- UWFL-28 The Need for Continuation of Studies of Radiation Contamination of Biotic Forms at the Bikini and Eniwetok Testing Grounds
- UWFL-30 Biological Monitoring Program for Eniwetok Prepared for the Biomedical Test Planning and Screening Committee

The studies completed to date, however, lack sufficient scope and continuity to give the specific information needed to form a basis for evaluating the impact, direction, and duration of biotic effects of contamination following atomic bomb bursts. The inadequacy of the biological monitoring program in keeping pace with the physical radiation measurements during the recent testing has been of concern to many biologists.

There is a lack of specificity in our knowledge of the many aspects of biological contamination following an atomic burst under water or near water, as would be the case were a bomb detonated in or near one of our fresh or salt-water harbors. Continual evaluation of the size of the area affected, the duration of effect, etc., for each of the bomb materials used is essential to an understanding of the problem.

The interest in radiological contamination has broader implications than an investigation of the immediate area about a bomb burst, for even in air bursts the fallout of radioactive materials finds its way into our waters, both fresh and marine. In addition, the very fact that the sea has been considered the practical dumping ground for radioactive wastes dictates the need for a broad understanding of the problems such dumping may produce.

Although the Bikini-Eniwetok testing sites have some disadvantages for doing certain types of biological testing, they

are ideal for measuring the faunal and floral contamination of a marine environment. The favorable climate, warm water, freedom from severe storms, protected waters of the lagoon, abundance of aquatic life of great variety, all contribute to their desirability as a base of operations. Another advantage is the fact that the atolls are isolated from other land masses with the result that repopulation of these areas from the outside does not confuse the interpretation of the data.

The natural history of Bikini and Eniwetok Atolls has been thoroughly studied and reported upon. During the testing program of the past six years the living forms, the geology, the currents, and the weather have been studied in detail. The three expeditions to Eniwetok by staff members of this Laboratory for study of residual radiation have provided a backlog of information and developed skills that will be invaluable to any continuation or expansion of the study.

#### Definition and Outline of the Problem

The present program of study at Bikini-Eniwetok may be divided, for convenience, into three phases:

1. Pretest evaluation of contamination at Eniwetok.
2. Resurvey of Bikini Atoll.
3. Posttest evaluation of biological contamination of Eniwetok.

To accomplish these objectives a tentative program of operation for each phase is suggested. During each phase of operation it will be essential to monitor the radioactivity and identify the radioisotopes found in the plants and animals as a result of the past and pending bomb detonations.

Collections should be made about the atoll at numerous locations to establish the level of natural and residual radiation from previous tests in order to form a base-line for evaluating the coming series of tests.

Following the tests it will be essential to map the distribution of the amounts and kinds of radioactive materials in the plants and animals.

It is important that additional basic information be gathered on the following:

1. The distribution of the radioactive material by currents, winds, and biological cycling should be studied.
2. The selectivity and concentration of radioactive materials by various organisms should be evaluated.
3. Studies at the test site should point the way for subsequent laboratory studies under controlled conditions.
4. The data obtained from the field study should be of value in the solution of practical problems such as:

- a. Destruction of aquatic food supplies.
  - b. Contamination of harbors and ship bottoms.
  - c. Relationship of fouling organisms to ship contamination.
  - d. Effect upon water purification plants.
  - e. Planning civil defense programs.
  - f. Development of public health procedures.
5. The field studies should provide a training area for biologists where concepts of radiological contamination of biotic material can be formulated.

#### Scope of the Field Program

To accomplish the objectives of the radiological contamination studies at Bikini-Eniwetok, the following three-phase program is suggested:

##### Pretest at Eniwetok

The main purpose of the field program would be the collection of data and material; processing of material, counting of the activity, and evaluation of the data will be completed in laboratories on the mainland.

For an evaluation of the present extent of radiation contamination resulting from previous weapons testing programs at Eniwetok, a number of collections should be made shortly before the new tests.



1. From at least six (6) stations on the rim of the atoll, collections of marine forms from the intertidal and shallow reef areas should be obtained for analysis of their radioisotope content. These collections should include the following:
  - a. Resident fishes with various feeding habits.
  - b. Invertebrates representative of the area, such as clams, coral, snails, and crustaceans.
  - c. Aquatic plants in the intertidal and shallow water areas.
2. Plankton samples should be taken from a grid of stations about the lagoon. Plankton samples from the surface, thermocline, and near the bottom are needed to evaluate the role planktonic forms play in the translocation of radioactive materials.
3. Water samples from the same locations where plankton samples are obtained should be taken to establish the radiation level of the sea water.
4. Dredged samples from the lagoon bottom should be obtained for evaluation of the bottom sediment and of the forms of life living in the deeper parts of the lagoon.
5. A careful survey of the terrestrial fauna and flora should be made to evaluate any changes that have

occurred in the land forms as a result of the previous tests. The number and kinds of mutations, malformations, and tumorous growths observed on previous field trips have aided in a more complete understanding of the biotic impact of atomic bomb detonations.

#### Resurvey of Bikini

During the weapon-testing program at Eniwetok a resurvey of Bikini might be included. If proper timing is arranged the Bikini survey could proceed simultaneously using the monitoring craft usually stationed at Bikini during weapon testing operations at Eniwetok.

The collections of material at Bikini should follow a pattern similar to that used in the studies of 1946, 1947, 1948, and 1949.

1. Collections should be made from waters adjacent to Bikini, Amen, Enyu, Erik, Boro, and Namu Islands.
2. The target area and any remaining floats in the target area should be studied.
3. Terrestrial areas at Bikini might be evaluated for long-lived radioactive materials that have been transferred from the lagoon up onto the land.

#### Posttest Survey at Eniwetok

Biological monitoring at Eniwetok as soon as feasible following the detonation is essential to:

- (1) Measure the magnitude of the biological contamination.
- (2) Determine the geographic distribution of the radioactive materials.
- (3) Determine the biological half lives of some of the radioactive materials.
- (4) Measure selective uptake and cycling of the contamination.
- (5) Provide another block of data for the better understanding of radiation contamination following a test with the kind of materials to be used and under the specific conditions of the test.

Field operations

- (1) Collection of biological specimens should proceed as soon as possible after the detonation.
- (2) Sampling stations should be the same areas or similar to those sampled in the preliminary survey.
- (3) Operations in the field should be devoted primarily to gathering the specimens and field data; the processing of material, counting of the activity, and the evaluation of data can be

best completed after return of the expedition to laboratories on the mainland.

- (4) Biological material collected in the field should be packaged, frozen, and dispatched to the Applied Fisheries Laboratory in a frozen state by Military Air Transport Service or other authorized carrier, accompanied by a member of the field party.

#### Operation Schedule

It is estimated that 30 to 40 days in the field should suffice to make the preliminary survey and to gather the samples needed to evaluate the immediate after-effects of radiation contamination. Time consumed in travel is difficult to predict but with sufficiently high priority it should be possible to complete the trip each way in 4-5 days.

If time permits, a collecting trip to Likiep Atoll should be undertaken to obtain additional "control" material from an uncontaminated area.

#### Pretest Survey of Eniwetok

##### Day

- 1-2 Flight, Seattle to Pearl Harbor via San Francisco.
- 3 Assemble gear at Pearl Harbor.
- 4-5 Flight, Pearl Harbor to Eniwetok via Kwajalein.
- 6 Make preparations for field work.

- 7 Survey Japtan Island.
- 8 Survey Igurin Island.
- 9 Survey Rigili Island.
- 10 Move vessel to northern area of lagoon.
- 11 Survey Engebi.
- 12 Survey Aomon-Bijiri.
- 13 Survey Runit.
- 14 Pack and assemble gear.
- 15 Flight, Eniwetok to Pearl Harbor, or move to Bikini  
for survey during tests at Eniwetok.

Bikini Survey

- 15 Enroute to Bikini.
- 16 Survey Bikini Island.
- 17 Survey target area.
- 18 Survey Amen Island.
- 19 Survey Enyu Island.
- 20 Move to western part of lagoon.
- 21 Survey Erik Island.
- 22 Survey Boro Island.
- 23 Survey Namu Island.
- 24 Pack and assemble gear.
- 25 Return to Eniwetok.

Posttest Survey of Eniwetok

- 26 Survey of entire area to firm-up plans for the collection of material.
- 27 Survey of Japtan Island.
- 28 Survey of Igurin Island.
- 29 Survey of Rigili Island.
- 30 Move to the northern part of the lagoon if feasible for resuming operations.
- 31 Survey Engebi Island.
- 32 Survey Aomon-Bijiri Island.
- 33 Survey Runit Island.
- 34 Pack equipment and materials for return to the mainland.
- 35-36 Return to Seattle via Pearl Harbor.

Organization

To carry out a program of biomonitoring the radioactive contamination of Eniwetok Atoll following the tests proposed for the late summer of 1952, it is essential that the project be synchronized with the testing program. The Applied Fisheries Laboratory, University of Washington, as a contractual representative of the Atomic Energy Commission would (1) provide the technical staff and equipment to do the field work; (2) gather the material and analyze the data; and (3) write the technical reports descriptive of the results.

The Weapons Testing Program, together with the military, should provide the supervision for the biomonitoring program as part of their over-all responsibility. Transportation to and from Eniwetok for personnel and equipment should be arranged through Military Air Transport Service to provide connections from Sand Point Naval Air Station, Seattle, to Eniwetok and return. Living accommodations, laboratory facilities, transportation should be provided by the task force or the contractor responsible for the facilities at the test site.

Personnel

1. The personnel of the Applied Fisheries Laboratory under Contract No. 28-094-eng-33 with the Atomic Energy Commission will provide the experienced personnel, which will give continuity to the research.
2. Some support will be needed from other areas to provide trained workers in plant pathology, taxonomy, soil chemistry, and medical counsel.
3. At least one naval officer experienced in radiation detection is needed to act in a liaison capacity between the study group and the task force.
4. Personnel should include the following specialists:
  - a. Group leader - aquatic biology, radiation biology
  - b. Senior scientist - vertebrates, taxonomy, physiology
  - c. Senior scientist - invertebrates, taxonomy, physiology

- d. Senior scientist - ocean ecology, plankton
  - e. Senior scientist - terrestrial botany, physiology
  - f. Senior scientist - algae, taxonomy, physiology
  - g. Soils chemist
  - h. Naval liaison officer to be drawn from the technical branch, Naval Reserve
5. Personnel for the ashing of material, determination of radiation content, and analysis of the data will have to be drawn from the regular Laboratory staff. This diversion from regular assignments will of necessity delay the progress of the present work programs.

Equipment, Transportation, and Living Facilities for Field Work and Evaluation of Data

1. Round-trip air transportation from Seattle to Eniwetok for six to eight men and 600-800 pounds of equipment. Heavy equipment, not to exceed 2,000 pounds, could be sent out in advance by surface vessels. Most of the heavy equipment needed is stored at Pearl Harbor. As soon as a final decision is reached on the biological monitoring program, the equipment stored at Pearl Harbor should be sorted, the excess disposed of, and the usable material either sent to Eniwetok or returned to the mainland.



2. Living accommodations for 6-8 men of officer status either on board ship or on one of the resident islands.
3. One hundred and fifty square feet of covered laboratory space. We should prefer to have deck space on a vessel such as an LSI or its equivalent.
4. A refrigerating unit of about 15 cubic feet capacity, operating at 0°F for use in freezing specimens. Refrigeration should be in a unit not being used for food storage.
5. Small surface vessels for transportation within the lagoon; also boats for daily collecting trips, plankton towing, and dredging. In addition to the boat crew at least two helpers should be assigned to aid with gear, collections, etc.
6. Supplies of dry ice to be made available at Honolulu and other stopping points for preservation of specimens.
7. Miscellaneous equipment as needed for collecting, preserving, storing, and shipping specimens to be provided by the Applied Fisheries Laboratory.
8. Equipment, facilities, and personnel required to process the material collected, obtain the data, and prepare the reports to be furnished by the Applied Fisheries Laboratory.

Budget Estimates for the 1952 Bikini-Eniwetok Survey

1. The basic contract, W-28-094-~~eng~~-33, between the University of Washington and the Atomic Energy Commission provides the framework for carrying out the field and laboratory problems planned.
2. Sufficient funds are available in the present budget to complete the first step of the problem as outlined. Some curtailment of the present laboratory program, however, will be essential to free personnel for reassignment to the Eniwetok study program.
3. An allotment should be set up for use by the Special Weapons Testing Program and/or the task force to cover cost of transportation, living quarters, laboratory space, assistance and transportation about Eniwetok Atoll.
4. Specific expenses that might be charged to a field budget over and above our present operations budget would include some of the following expenses:

|                   | <u>Minimum</u> | <u>Maximum</u> |
|-------------------|----------------|----------------|
| a. Salaries       | \$2,600        | \$2,600        |
| b. Per diem       | 2,430          | 4,320          |
| c. Transportation | 0              | 5,296          |
| d. Equipment      | <u>500</u>     | <u>1,000</u>   |
| Total             | \$5,530        | \$13,216       |

Basis for above calculations:

- a. All except two men would be Applied Fisheries Laboratory staff members. These two would be hired at a rate of \$650 per month for two months.
- b. Maximum, eight persons each at \$9 per day for 60 days; minimum, six persons each at \$9 per day for 45 days (would not include a resurvey of Bikini).
- c. Maximum, if Military Air Transport Service is not available between Seattle and Pearl Harbor and the personnel are returned to their home laboratories rather than remaining in Pearl Harbor between tests, then two round trips for eight people at \$331 per round trip would be needed; minimum, if Military Air Transport Service is available.
- d. Maximum, if supplies stored at Pearl Harbor are not usable; minimum, if Pearl Harbor-stored supplies are usable.

Laboratory Studies to Evaluate Material and Data Collected in the Field

1. The biological material collected in the field at Bikini-Eniwetok and preserved by freezing must be analyzed for radioisotopes.

- a. To evaluate the biological contamination of the Bikini-Eniwetok areas about 5,000 samples will be needed for ashing and counting of activity.
  - b. Beta-gamma counts should be made of all samples.
  - c. Alpha counts should be made of selected samples.
2. Detailed chemical analyses are needed to determine the relative abundance of different isotopes to the total activity found in the various forms. The services of Atomic Energy Commission personnel and of staff members of other Atomic Energy Commission contractor laboratories as consultants in this phase of the work would be most helpful, especially the technical staffs of the Hanford Works and the Atomic Energy Project, University of California at Los Angeles.
  3. Laboratory studies under controlled conditions are needed to measure the effects of the conditions observed in the field. This will require an expansion of our present program of study of the Eniwetok and Nevada materials.
  4. The time required to complete the laboratory studies will be about one year.

To complete the program of biological monitoring of Bikini and Eniwetok will require very close cooperation between the Atomic Energy Commission, the Special Weapons Testing Program, the United States Navy, Military Air Transport Service, and the Applied Fisheries Laboratory of the University of Washington. A sufficiently high priority must be assigned to this project by the above agencies to insure the progress of the program on schedule at all times.