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OPERATIONS OUTLINE FOR PROGRAM 19, MARINE  
SURVEY UNIT, OF OPERATION CASTLE

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University of Washington  
Seattle, Washington

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Director

February 15, 1954

OPERATIONS OUTLINE FOR PROGRAM 19, MARINE  
SURVEY UNIT, OF OPERATION CASTLE

With the initiation of the atomic energy program in 1943 for defense needs, the Applied Fisheries Laboratory, University of Washington, began studies designed to measure the effects of radioactive materials released into an aquatic environment. The initial studies were laboratory evaluations of the effect of X-rays upon aquatic animals. These preliminary studies were used to forecast the possible effects of the Hanford Works upon the Columbia River.

With the start of test programs at Bikini and Eniwetok Atolls in the Marshall Islands following the end of World War II, field studies were initiated at both atolls to measure the extent and nature of the contamination of the fauna and flora of the region from fission products. In addition, a limited amount of laboratory work on the cycling of radioactive materials has been carried on at the University of Washington.

Although a total of six field trips of two weeks to three months duration have been made to Bikini and/or Eniwetok to study the problems of contamination, these studies, made at irregular intervals, have lacked continuity and must be considered as only selected, partially complete investigations of the over-all problems, rather than continuous studies.

The results of the studies conducted to date have been summarized in reports by the Applied Fisheries Laboratory. Most of the data are to be found in the UWFL series.

#### FIELD PROGRAM

During Operation Castle the Applied Fisheries Laboratory, functioning as the Marine Survey Unit, Program 19 of Task Group 7.1, will be engaged in a twofold program.

1. A study will be made of the radiological problems before and after the Echo Shot, scheduled for Eberiru Island, Eniwetok, on March 29, 1954. These studies will be continuous for one year.
2. Spot checks of the amounts and distribution of radioactive materials in the fauna and flora of Bikini Atoll will be made on a quarterly schedule for the year.

#### Operations

Field operations will be started with initial preshot studies at Eniwetok about March 1, 1954. Work at Eniwetok will continue until March 1955.

The initial exploratory studies at Bikini should be made during late March 1954, full-scale studies in July, September and December, 1954, and additional collecting trips of about three days duration in March 1955.

Only collections of material, preliminary processing of samples, and recording of observational information will be carried out in the field. The processing of samples and counting of radioactivity, evaluation of data, and writing the final reports will proceed at the Applied Fisheries Laboratory, Fisheries Center, University of Washington.

For the studies at Eniwetok the area around Eberiru Island will be used as the focal point. Detailed studies of radiological effects will be made at Aitsu and Aaraanbiru Islands and at adjacent localities, while Mui Island, in the southern part of the atoll, will be used as a "control" area.

Transportation of men and materials from the base laboratory, 128 Building on Parry Island, to the collecting stations will be needed each day. For most operations the conventional "M-boat" or equivalent is most useful. Special pick-ups of men and material by light plane or helicopter will be needed on some occasions.

The field programs are divided into a number of sections, each designed to contribute to the over-all program and streamlined to make possible their completion with the limited personnel available to carry out the work.

#### Personnel

To accomplish the program in the field and in the laboratory, a major portion of the time and energy of the entire staff of the

Applied Fisheries Laboratory for the next eighteen months or more will be required.

The staffing of the field laboratory at Eniwetok to assure the necessary personnel for collecting material and data in all the fields of effort will require a rotation of available staff between the laboratories. A maximum number of skilled personnel must be available at the proving ground during the test program and each time an observation-collecting trip is scheduled for Bikini Atoll.

The tentative assignment for field work at Eniwetok and Bikini is given in Table 1.

Operation Program, General--Based on Aaraanbiru and Aitsu

The general plan for the succession studies of changes in the biology of Eniwetok Atoll following the Echo Shot must of necessity remain somewhat broad until the distribution of the fallout after the shot has been evaluated. It will then be possible to decide whether to concentrate our studies at Aaraanbiru, at Aitsu or at some other site. For planning, we have used the example of Aaraanbiru. However, in order to provide for any situation that may arise, changes following the early evaluation of the distribution of radioactive material should be taken into consideration.

Table 1. Tentative Assignment for Field Work at Eniwetok and Bikini Atolls

1954-1955	K. Bonham	L.R. Donaldson	E.E. Held	F.G. Lowman	P.R. Olson	R.F. Palumbo	A.H. Seymour	A.D. Welander	C.M. Barnes*	No. of men in the field***
Feb 25-Mar 14			x			x				2
Mar 15-Apr 4		x	x		x	x			x	5**
Apr 5-May 2			x		x	x			x	4
May 3-9			x		x	x	x		x	5
May 10-16					x	x	x			3
May 17-June 13						x	x			2
June 14-July 4		x		x		x	x	x		5**
July 5-11		x		x				x		3
July 12-Aug 29				x				x		2
Aug 30-Sept 5	x			x		x		x		4**
Sept 6-19	x					x		x		3
Sept 20-Oct 31	x					x				2
Nov 1-7	x		x		x	x				4
Nov 8-Dec 12			x		x					2
Dec 13-Dec 26		x	x		x			x		4
Dec 27-Jan 2		x	x	x			x	x		5**
1955										
Jan 3-Feb 20				x			x			2
Feb 21-Mar 13	x			x			x			3
Mar 14-Apr 3	x	x	x			x		x		5**

\* Major C.M. Barnes on assignment to Project 19.1 from the U.S. Air Force, VC, from March 9 to approximately July 17, 1954.

\*\* Proposed quarterly surveys at Bikini Atoll.

\*\*\* Additional personnel are needed for the Bikini surveys and as consultants on problems at Eniwetok. As available they will be fitted into the schedule.

This plan--using Aaraanbiru and Aitsu as examples--is dependent principally on detailed, minute study of small (3 feet square) areas at intervals of 50 to 200 feet along two transects which intersect the islands. One transect is at right angles to the reef while the other is parallel to the reef. Detection of large and general changes, such as extensive killing of corals or other organisms, will be possible only from general impressions gained when entering and leaving the areas under study and from successive aerial photographs.

Final choice of the locations of the transects and study areas thereon should be deferred until we have studied more detailed aerial photographs than are presently available and until the island is revisited both by helicopter and on the surface. However, there should be an early estimate of the number of quadrats which can be effectively studied with the man-hours available. The transects should cross as many ecological situations as possible.

The N-S transect on Aaraanbiru Island should probably pass through the existing bench mark on the south end of the island to insure a permanent reference point. The E-W transect should be at right angles to the N-W transect and should probably terminate in the lagoon on a large coral head which is visible in the aerial photograph. This would serve as a natural reference point in the event of disturbance or destruction of artificial markers

by storms. It would also provide anchorage for a safety and observation raft. Selection of this particular coral head causes the E-W transect to pass through what appears in the photograph to be two grassy clearings inland, thus including a type of area which is not common on this island. This transect also crosses an offshore coral reef in the lagoon which has promise of being an ideal study area for fish.

Selection of N-S and E-W transects at Aaraanbiru probably provides the nearest approach to including marine areas which are subject to differences in current and tidal effects without the addition of more transects. This is evidenced by the distribution of sand on the beaches as seen in the photograph.

The selection of the size and number of study areas or quadrats along each transect is important and perhaps more difficult than the selection of transects, unless actual "time trials" are made in the field. A detailed study of a belt of infinite width running the entire length of the transect would of course be ideal but is obviously impossible. The suggested "compromise" is a series of three-foot square quadrats, spaced at intervals of 50 to 200 feet, along each transect. The closer intervals would be reserved for areas obviously showing great change in conditions in a short space, such as those at the shore, across the coral reef in the lagoon, and at the center and margins of clearings. An exceptionally long interval of 300 feet would be allowed between

the coral head terminating the E-W transect and the first quadrat toward shore, unless it became evident that conditions were not similar between these two points.

In view of the tendency of many of the fish of the area to aggregate along or around living coral formations, it is suggested that the principal effort on the fish survey be concentrated along the coral reef in the lagoon from E-W transect N-W to the shore. This is a distance of approximately 500 feet.

Depth of study quadrat should as far as possible be held to a maximum of 30 feet (preferably under 20 feet) since greater depths will decrease efficiency in working with aqualungs. It is realized that this severely limits the situations which will be studied and omits the deeper areas which are least well known biologically. However, this omission is a practical necessity when available man-hours are considered. While the depth from 60 to 200 feet is of great biological interest, any efforts to increase available man-hours and facilities to include it do not seem justified from the point of view of such a succession study as we have proposed.

Beach areas, in so far as the invertebrates are concerned, should be studied nocturnally and include an area of several square yards rather than the small quadrat. This is necessary because of the habits of shore animals such as the ghost crab.

Bird studies might best be accomplished by noting numbers and species present at specific localities in the morning and

afternoon on successive days. The specific localities would be delineated following a survey of the entire island.

Rat trapping will be carried out along a line 50 feet north of and parallel to the E-W transect unless it becomes evident this is an unfavorable location. The trap line in any event should be established at some distance from the transects to avoid excessive tramping along the transects.

The soil-collecting stations will be located along lines parallel to the transects and 50 feet south of the E-W transect and 50 feet west of the N-S transect.

Field Work-Day Time Schedule. This is planned principally with the idea in mind that the follow-up surveys will be made by two men. Working under water is most tiring physically and requires the use of air tanks which have a limited capacity and which must be replenished every one to two hours. Hence, it would be advisable to allot the first part of each day to underwater work. The remainder of the day would be spent in shallow water or on land. This schedule should also minimize the number of spare air tanks required. Surveys of the outer reef area depend upon low tides for greatest efficiency. Priority should therefore be given to the outer reef whenever there is a low tide.

Approximately six hours daily is probably close to a realistic figure for the time that will be available for actual surveying of the areas. Permissible time ashore will, of course, be much less immediately after the shot.

The following estimate of required man-days does not include but presupposes time to be spent in the evening assembling notes, making entries in the log, recharging air tanks, preparing or repairing equipment, weighing, drying and caring for samples, etc.

(27 man-days without allowance for rest days or delays). This estimate was arrived at by making breakdown estimates from two points of view.

Inasmuch as the tendency is to underestimate rather than overestimate when considering these things at a desk rather than in the field, it is felt that this proposal is generally acceptable only if the succession study is limited to one island, Aaraanbiru (or Aitsu). This would then leave some time for studies of plankton, setting or fouling, and growth rate, and for observations of a general nature around the entire atoll in a two-week period. It might also leave sufficient time for each investigator to do a modest amount of exploratory work on matters of specific individual interest.

#### Operations Plan--Sectional Programs

##### A. Radiation Survey

(1) Since Eniwetok Atoll has been used for numerous tests of atomic weapons, some residual radiation, especially of the longer lived products, is to be found. The level of residual radiation, both as to amount and kind, must be determined before the present test series begins.

(2) To accomplish the preshot survey, readings will be obtained (a) from the emergent land areas (b) from dredged and collected bottom samples, with (c) special attention to the three islands of Aaraanbiru, Aitsu and Mui.

(3) Postshot radiation measurements should be made at all terrestrial collecting stations.

(4) On Aaraanbiru and Aitsu Islands, radiation surveys will be made along the transect lines each time collections and observations are being made, and in addition, as many extra readings as conditions indicate are needed.

(5) The measurement of radiation in the field must follow a very rigid pattern to avoid errors that might be introduced by variation in procedures.

In making readings the monitor will use only a calibrated instrument, the choice of instrument depending upon the radiation level. The following instruments will be available:

2 Junos SIC-17C	maximum reading 5 r
1 Juno S67-17C	maximum reading 25 r
1 Victoreen 263 A	
2 Nuclears GM MFGR model 2610 A, A.E.C. model SGM-4D	

(6) All readings are to be made over sand or smooth earth areas at (a) 3 feet, (b) 1 inch, (c) with shield open and shield closed at each height.

(7) Radiation measurements are to be used for two purposes: (a) radiation levels of the islands are to be used as measures of external exposure to radiation of the plants and animals living

on the islands and (b) as an additional safeguard and check on radiation exposure of the personnel working in the area.

(8) Rough calculations of the amount of radiation that may be encountered have been made. These data have been used in working out field programs and in the rotation of personnel (see Table 1).

#### B. Fish

This study will be based on observations made in the vicinity of transects across the reef as noted in the general plan, and on samples of fish taken close to, but not in, the transect area.

The observations on the lagoon side of the reef will have to be made for the most part under water using face masks, snorkles, aqualungs and other suitable diving gear, and perhaps underwater cameras. Some data may be gained by taking aerial photos close to the water by helicopter when there is a minimum of surface disturbance by winds.

Observations on the reef flat between the island and the lithothamnion reef will have to be restricted to times of low tide. Attempts should be made to make underwater observations at high tide if the currents and wave action permit, in that better visibility is obtained by the elimination of surface reflection.

It is suggested that the species which have made up the bulk of the data in radiobiological studies of former years be utilized

as much as possible in this study. Another suggestion would be to concentrate on those species thought to be more or less sedentary local residents of the area.

Observations will have to be recorded, as suggested in the general plan, according to quadrat, depth, and other features with special attention given to those quadrats on which the algologist and invertebrate specialist are concentrating. Observations in other nearby areas may be used supplementally. Care must be taken, of course, not to disturb the fauna and flora within the transect proper.

Samples for radioassay and other purposes will be taken a predetermined distance from the transect area. Past experience has indicated that poisoning by rotenone is one of the most fruitful ways of obtaining fish from shallow areas around a coral reef. Extreme care will have to be taken during poisoning operations to avoid drift of the poison near or across the transect--in effect poisoning should always be done down-current from the transect area. The amount of poison used should be at a minimum so that only comparatively few fish will be killed. The number of samples that can be processed through counting is limited.

Traps, some of which may have leads, should prove useful in obtaining certain kinds of fishes, especially large ones. These fish can be used either for radioassay or for other purposes such as tagging and noting movement, aquaria observations, etc. The

traps can be set in shallow water of the reef flat for migrating fishes and along coral alleys and walls in deeper water, using the aqualung.

On occasion specimens may be obtained over deep water or elsewhere by hook and line, by night fishing with dip nets or perhaps by other means.

### C. Invertebrates

The aim of this study is to determine the effect of physical conditions due to atomic weapons testing, particularly radioactive contamination, on the survival and succession of the invertebrate population.

Changes in the degree of radioactive contamination of and composition of the invertebrate populations in very limited areas representing different ecological situations should be recorded. The changes to be watched for will stress: (1) decline or growth of individuals (2) decrease or increase in numbers of individuals (3) succession of species on the same substrate (4) gross injury to individuals.

Methods. Different procedures will be used in each of the three major ecological situations--littoral, beach, land. The number and distribution of quadrats will be as outlined in the general plan to facilitate coordination with other studies. Whenever possible 5 specimens of each species chosen for radioassay

will be taken at each collection. Dissection of appropriate tissues or organs will be made. A total of approximately 160 samples will be required for each collection for radioassay.

Littoral (23-27 quadrats maximum). Quadrats will be studied in detail. Horizontal distribution will be sketched on acetate matte sheets marked off into 100 numbered squares. The quadrats will be visited as frequently as possible over a one-year period following the test. New sketches will be made every two months or more frequently if rapid changes are obviously taking place. Vertical distribution will be indicated by notes at all study quadrats and sketches of a single representative vertical face of a coral head in the lagoon. A count of large organisms such as the sea cucumbers and giant clams will be made in a three-foot wide strip extending the length of the transect.

Samples for radioassay will be taken a predetermined distance to one side of the transect. These samples will be limited to a few, more or less arbitrarily chosen, key species--probably Tri-dacna crocea (6 tissues), Holothuria atra (4 tissues), Acropora (1 tissue), Montipora (1 tissue), Porites (1 tissue), Nerita (5 tissues).

On the beach an area of at least 100 square feet will be studied for the presence of ghost crab holes, hermit crab tracks, etc. Nocturnal flash photos will be taken of this same area. Nocturnal observations will be made both in the dark and in the light of the moon.

Samples for radioassay will be limited to Cenobita and Ocypode or Eriphia.

Land (21 quadrats maximum). Quadrats will be studied in detail as indicated under littoral observations. Sweeping for insects will be done along a total of four 50-foot-long strips a few feet to one side of the transect. Baiting for insects will be done at three points on each of these 50-foot strips.

Samples for radioassay will be limited to one representative of each of the following groups when available: Coleoptera, Chrysomellids, and Carabids, or Staphlinids, Lepidoptera, Diptera, and Orthoptera.

D. Algae

Observations, general. A cursory survey of the area will be made along the transect(s) chosen in order to establish extent of damage to the algae. This will include physical damage or changes in substratum, such as destruction or toppling of coral heads, cluttering by debris, silt accumulation, etc. Observations of adjoining areas will be made to check damage of the algae in the entire area.

Observations, specific. Quadrats will be the same as for invertebrate collections. The mapped area will be checked periodically referring to a celluloid chart and noting changes since the last survey.

Type of observations to note will include general condition of the algae--size of individual or clump, color, dead, dying or healthy looking, new or different type of growth, plasmolysis of succulent forms--formation of new individuals or colonies, and abnormalities of any kind.

Species to observe in detail are Halimeda stuposa, Caulerpa racemosa, Udotea indica, Lyngbya sordida, Dictyota pinnatifida, Polysiphonia or Jania sp., Microdictyon or Dictyosphaeria sp.

Collections, preshot. At least five specimens of each species will be collected for later detailed observation. Collections will be made at different spots along the transect area.

Collections, postshot. Intervals between collections will be decided later. Major collections to check radioactivity will be made when personnel overlap.

Five specimens of the species to be observed in detail will be collected at different spots along collection lines. Three specimens only will be taken if found that counts for the same species are "constant." There should be a total of 30 specimens per collection. The five collections should total 150 specimens and 150 plates.

Special collections will be made immediately of Caulerpa racemosa and Lyngbya sordida for self-absorption, mass-absorption and decay curves, and chemical analysis, especially for strontium content. Just before return to the Applied Fisheries Laboratory

large amounts of Lynqbya and Caulerpa will be collected for freezing and later feeding to fish and invertebrates in aquarium experiments.

Special experiments will be carried out with Halicystis or Valonia. Sap from the alga will be collected with a small syringe to evaluate concentration of activity within the protoplasm. The cell wall is to be collected, stripped of epidermis, and counted. The epidermis and wall should be counted separately to get the total picture. One specimen should be kept going with the sap being removed periodically.

#### E. Plankton

Surface tows are the only tows feasible without power equipment. Two nets, one of each size mesh, will be towed for one-half to one hour depending upon abundance of plankton available to the net and amount of plankton needed. Station should be made in midday and mid-evening. One man plus boat crew can take care of this assignment. Three nets can be towed at one time if lines can be kept clear. The third net could be a check on the operation of one of the other two nets. For every sample dried for ashing, a comparable sample should be preserved in formalin for identification. Water temperature should be recorded.

Plankton station must be taken every time a complete survey is made of a reef and land station. If possible a continuing

series of tows should be made on a regular schedule in the vicinity of the laboratory.

F. Water Samples

Water samples of 500 cc will be taken at the time of plankton samples as long as practical from a radiological standpoint. The ferric hydroxide scavenge process should be used if no radioactivity remains in the evaporated filtrate. If unsatisfactory, the entire sample should be evaporated, and the salts saved for counting.

G. Land Vertebrates

Rat Collections

For the proposed work with rats a population of 50 should be considered the minimum and 100 the maximum. If rats are brought in from another atoll only those of the species Rattus exulans or R. hawaiiensis should be selected. No specimens of old-world rats should be brought into the area.

Imported rats should be marked by clipping one toe of the left front leg and one toe of the right rear leg. In this way rats with no previous history of radiation exposure may be differentiated from the native individuals which have been chronically exposed to small amounts of radioactive material throughout their lifetime.

Observations. Rats should be trapped daily, or at as frequent intervals as convenient, but released each time, except for

the limited number of samples that will be taken. A daily record is to be kept on a map sheet of the number of rats taken and the site of trapping and the condition of the animal. Pelt condition, eye condition, and activity should be noted. The specimens are not to be weighed or measured. Each trap should be set at a specific site along the east-west transect in the grassy area of the island and left at the same site throughout the remainder of the program. A total of twenty traps should be set.

A standard bait should be used in the traps. Bait made from fish meal, peanut butter, and corn flakes, and tied up in small pieces of cheesecloth has worked well in the past.

A vantage point in one of the grassy areas along the east-west transect should be selected for evening observations of the rat population. Counts of rats seen during a definite time-interval from the one vantage point should be recorded at weekly intervals. The vantage point should not be changed throughout the operation.

Radioactivity assay collections. Three specimens from Aaraanbiru are to be collected preshot. The collection schedule for rats postshot should be as follows:

<u>Time in Weeks</u>	<u>No. of Specimens</u>
Shot + 2	3
+ 4	5
+ 8	5

<u>Time in Weeks</u>	<u>No. of Specimens</u>
Shot + 12	3
+ 16	3
+ 20	3
+ 24	3
+ 28	3
+ 32	3
+ 36	3
+ 40	1
+ 44	1
+ 48	1
+ 52	1
Total	<u>38</u>

Rats may be taken either by trap or by shooting.

The following tissues should be taken: liver, kidney, ilium, femur , pelt, lung, muscle. The gut sample should be removed last to avoid cross-contamination from the gut contents. Getting dirt and hair from the skin on the other samples should be avoided.

The remainder of the carcass, with the digestive tract removed, should be dried and sent back to the Laboratory for future analysis for possible strontium content.

Stomachs of all rats sampled should be examined for food items and the items listed.

Lizards are to be collected on the same schedule as that of the rats.

#### Bird Collections

The size of the bird population will be impossible to determine as will also exact observations on changes in bird population size.

Observations. If a rookery is found on the island a weekly count of the fledglings should be taken.

Radioactivity assay collections. Birds should be collected on the following schedule:

Fairy Terns

<u>Time in Weeks</u>	<u>No. of Specimens</u>
Shot + 2	3
+ 4	3

Three fairy terns are to be collected each 4 weeks thereafter (4 weeks post-shot). Terns should not be collected immediately after shot.

If nesting sites are found on Aaraanbiru the fledglings are to be taken along with the adults. The size of the rookery will determine the number to be taken.

Other studies with rats and birds may present themselves in the field (i.e., histological studies, etc.). These might well be incorporated into the work at that time.

H. Plant-Soil Relationships

The preshot investigations will be an attempt to determine the residual activity in the soil and in the plants at different spots along the transects and on the islands. Samples of soil will be taken at 1-inch increments to a depth of 12 inches to determine the distribution of activity in a vertical direction at two locations along the transect. Leaf, root and stem samples of Scaevola frutescens will be taken at three locations along the

transect. These samples will determine surface and accumulated activity.

Samples will be taken for determination of residual activity in the sea water, lagoon water, rain water and fresh water of the island. A controlled experiment will be set up (if time permits) to determine the amount of surface contamination caused by fall-out, rain water splashing and wind action as compared to actual accumulation of radioactive materials due to plant metabolic activities. (See chart for details).

The effects of radiation on the plants will be studied by observing any changes in external morphology, coloring, necroses, wilting, sterility, etc., of some of the native plants. These are Scaevola frutescens, Lepturus repens, Tournefortia argentea, Ipomoea sp., Portulaca sp., Cocos nucifera, and others. Plants will be observed and some will be photographed before and after the shot.

Collections of internal tissues of the various plants will be made before and after the shot. These tissues will include stem, roots, leaves, flowers, and fruits.

The postshot investigations will be a repetition of those for the preshot period, but will include samples for radiochemical analyses, energy spectra, and decay rates of tissues of Scaevola frutescens.

Below is an outline in table form of the "controlled" experiment mentioned above using Scaevola frutescens.

<u>Plant</u>	<u>Soil</u>	<u>Autoradiographs</u>	<u>Purpose</u>	<u>Time</u>
Uncovered	Uncovered	Leaf, stem surfaces, stem internal	Total fallout + rain splatter + absorption	Preshot to duration
Uncovered	Covered	Leaves especially	Fallout on surface + accumulation internal	Preshot to postshot + 1, 2, 4, 8, 16 days, etc.
Covered	Uncovered	Base of plant, leaves--lower + higher	Soil splash + accumulation	Preshot to postshot + 1, 2, 4, 8, 16 days, etc.
Covered	Covered	Surfaces and internal sections	Accumulation only	Preshot to postshot + 1, 2, 4, 8, 16 days, etc.

Editor's Note

The soil-plant relationship study was originally planned as a major section of the program. Our inability to obtain the services of a soils chemist to supervise and carry out the field portion of the study has necessitated drastic curtailment of the planned program. We will, however, attempt as many phases of the study as possible, within the limits of our experience and available manpower, for we feel this program is essential.

Schedule for Measurements of Radiation and Taking Samples for Radiation Determination

I. Physical Measurements

- A. Radiation measurements of land areas will be made along the transect lines as often as these areas are visited.
- B. Water samples for radiation measurements will be taken at the time and location of the plankton tows.
- C. Soil samples will be taken along the transect lines as time permits.
- D. Dredged and/or collected samples from the lagoon bottom will be taken at intervals for radiochemical analysis.

II. Radiation Uptake by Plant and Animal Tissues

- A. Fish. One herbivorous species. Ten individuals per day. Five tissues per individual--liver, muscle, skin, bone, gut with content. Collect by spear.
- B. Invertebrates. Two species (possibly three).
  - 1. Sea cucumber. Ten individuals per day. Five tissues--body fluid, respiratory tree, muscle band, skin, gut with content.
  - 2. Clam or oyster (probably T. crocea, the boring tridacna). These would be planted before the shot. Ten individuals per day. Six tissues--muscle, mantle, liver, gill, kidney, visceral mass.
  - 3. Snail, if abundant and large enough to separate tissues into adequate samples.

C. Algae. Two species.

1. Caulerpa or Halicystis. Ten samples per day from one colony. Two portions per sample--cell sap, remainder.

2. Halimeda. Ten samples per day from one colony. Two portions per sample--living tissue, skeleton.

D. Plankton. Three one-half hour tows daily.

III. Periodic Radiobiological Survey for Comparative Purposes

A. Comparison of differences between types of organisms.

(Limited to one collection at Aaraanbiru)

1. Times of collection

a. 8th-10th day postshot

b. 30th-35th day postshot

c. Thereafter to be determined by conditions found in field, but at least every 60 days.

2. Samples to be taken

a. Fish. Five species, five individuals per species (except species used under II.A. Ten individuals). Five tissues per individual.

(1) Omnivore, three species (damsel, surgeon, blenny)

(2) Carnivore, two species (brown spotted grouper, wrasse)

b. Invertebrates. Seven species. Five individuals per species.

(1) Clam or oyster (probably T. crocea), six tissues

(2) Sea cucumber, five tissues

(3) Snail, five tissues

(4) Crab, four tissues (+ eggs when available)

(5) Coral, three species. Fragment of colony

c. Algae. Four species. Five samples of each. Two portions per sample.

d. Plankton. One-half hour tows. Number of tows to be determined.

B. Comparison of geographical differences throughout the atoll.

1. Radioactivity of arbitrarily chosen "key organisms"

a. Frequency of collections (see III.A.1.).

b. Ten stations approximately five miles apart (including Aaraanbiru, coral head "Mack", deep and wide passages).

c. Organisms

(1) Two species of algae (calcareous and non-calcareous).

- (2) One species of invertebrates (probably sea cucumber).
  - (3) Plankton, 15-minute tow at each station.
2. Setting studies at same stations as under III.B.1.b. There is much divergence of opinion as to the desirability and feasibility of this study. Consequently, the decision as to whether or not this study is to be implemented should be determined in the field.

Outline of Procedure for Preparation of Samples for Radioassay

Field procedure to be carried out at the Eniwetok Laboratory.

1. Assign specimen number and plate numbers. Record on punch card.
2. Take wet weight of entire specimen.
3. Take wet weight of soft parts only, where appropriate.
4. After dissection place samples of individual tissues in pliofilm bag.
5. Take wet weight of each sample at time of dissection. Record on punch card.
6. Dry sample 12 hours at 97°-99°C.
7. Cool sample in desiccator. Take dry weight. Record on punch card.
8. Seal sample in pliofilm bag.

9. Seal sample in pliofilm bag in paper coin envelope.  
Record plate and specimen number on envelope.
10. Pack envelope and punch card for shipment to mainland  
and check off on shipping log.

Laboratory Analysis to be Completed at the Applied Fisheries  
Laboratory

1. Check in samples and punch cards on shipping log.
2. Ash sample on correspondingly numbered plate without  
opening pliofilm bag.
3. Slurry ash directly on plate with glass rod, 95 per cent  
alcohol.
4. Dry under infrared lamp.
5. Wet with 1/2 per cent formvar and dry.
6. Take ash weight. Record on punch card.
7. Count in gas flow counter. Record on punch card.

Figure 1. Aerial photograph of Aaraanbiru Island, Eniwetok Atoll. This island is 1.75 nautical miles in a southeasterly direction from the shot site on Eberiru Island. It is "upwind" with respect to the usual wind pattern so should receive a minimum of fallout.

Figure 2. Aerial photograph of Aitsu Island, Eniwetok Atoll. This island is 1.25 nautical miles in a northwesterly direction from the shot site on Eberiru Island. If the normal wind pattern prevails at shot time this island should be in the fallout region.

Figure 3. Aerial photograph of Mui Island in the southern part of Eniwetok Atoll. This island is 17.50 nautical miles from the shot site on Eberiru Island. It should receive a minimum of contamination from the tests and will be used as a local "control" site.