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PROBLEMS OF LIQUID WASTE DISPOSAL

Summary prepared by Lauren R. Donaldson

Historical

During the early planning days of the atomic energy program it was deemed advisable to initiate studies leading to a better understanding of the effects of radiation upon aquatic organisms. The need for a better understanding was accentuated by the proposal to build on the Columbia River the water cooled piles of the present Hanford Operations.

It was proposed by the Office of Scientific Research and Development, that long range studies be undertaken on the over all effect of radiation on aquatic organisms. Forms that were common and of commercial importance in the Columbia River were to be used as test animals as much as possible. The impetus to this program, first provided by the O.S.R.D., was continued by the Manhattan Engineering District and its successor the Atomic Energy Commission.

To carry out the proposed studies the Applied Fisheries Laboratory of the University of Washington was established. This laboratory, assumed the responsibility for the long range program of measuring the effect of X-ray radiations upon a variety of aquatic forms in various stages of development.

With the completion of the Hanford piles it was decided to construct and staff a laboratory in the 100-F Area so that some plant effluent water and other processed or non-processed water could be by-passed through the 146 Building Laboratories for study of the effects on aquatic forms. This laboratory was established and operated by the contractor, the DuPont Company, during the period during which they held the contract. The General Electric

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Company, presently, is responsible for the operations. The program of the Applied Fisheries Laboratory and that of the aquatic laboratory of the Hanford Operations Office parallel and complement each other but do not overlap.

I. List and give a brief description of specific projects now under way that are directed primarily to Hanford Operations problems.

A. Applied Fisheries Laboratories.

1. Long range studies of the effect of exposure of chinook salmon adults, males and females to whole body doses of 25, 50 or 100 r. The progeny of the exposed and "control" parents are being studied for possible latent effects.

2. Studies to parallel the above are being conducted with adult sockeye salmon that were exposed to 25, 50 or 100 r X-rays.

3. Chinook salmon eggs in the "eyed" stage were exposed to 25, 50, 100, 250, 500, 1000, 2500, 5,000 or 10,000 r X-rays. Data were accumulated and analyzed on mortalities, rates of growth, tissue changes, etc.

4. Adult male silver salmon were exposed to 25, 50, 100, 250, 500, and 1,000 r X-rays and the resulting effect on the skin and certain other tissues studied.

5. Chinook salmon fingerlings were treated with 100, 250, 500, 750, 1,000, 1,250, 2,500 or 5,000 r of X-rays and the mortality, rate of growth and tissue modifications were studied.

6. Maturing rainbow trout were exposed to 50, 100, 500, 750, 1,000, 1,500 or 2,500 r of X-ray. Studies on the mortality of adults and offspring were conducted. The growth of the offspring and gross genetic modifications in subsequent generations are being studied.

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7. Adult steelhead trout from the Columbia River were treated with whole body irradiation of 25, 50, or 100 r of X-rays and the offspring are being studied to determine their ability to survive in competition with "controls" in fresh water and in the sea.

8. Goldfish were exposed to 25, 50, 100, 250, 500, 750, 1,000, 1,250, or 2,500 r of X-ray and studies made of mortalities and color modification.

9. Experiments were undertaken to provide information on the sensitivity of <u>microplankton</u> to single mass dosages of X-rays. Both phytoplankton and zooplankton organisms were used and the changes in numbers of organisms per unit volume following irradiation were determined by counting.

10. Amphipods were exposed to X-ray doses of 150 r, 930 r, 8,000 r, 16,000 r, 32,000 r or 62,000 r and compared with similar lots of control organisms to determine the differential mortality.

11. Gastropods were exposed to X-rays of 500 r to 30,000 r and the mortality incident to radiation determined by comparison with control forms.

B. <u>Aquatic Biology Experiments at Hanford Operations.</u>

1. Determination of the effect of the effluent from the pile area on aquatic life.

a. A continuous biological check on water is maintained so that irregularities or catastrophies in plant operation which might affect aquatic life can be evaluated.

b. Studies to determine the types of water and the contained chemicals that are responsible for toxic effects are being conducted.

c. Cross genetic studies of the effect of exposure of fish to effluent waters are being made with rainbow trout that may be maintained at the laboratory during their life span.

d. Absorption studies of accumulated radioactivity in forms found in the Columbia River are in progress. All aquatic organisms collected below the pile areas which have been analyzed have contained radioactivity many times that found in the surrounding water of their environment.

e. Studies are now in progress to determine the nature of the materials and type of organism involved in transferring the radioactive material, and the level of activity at which an equilibrium is reached in the various forms.

2. Radiobiological survey of the Columbia River.

a. Bottom contamination along the west bank of the Columbia River between the pile areas and Pasco is being studied. Preliminary studies indicate that the concentration of activity in this area is of the order of three curies per mile. Some work has been done on determining the abundance of various types of organisms present and the amount of activity accumulated in each.

b. Fish studies in the Columbia River adjacent to the Hanford Reservation have measured the amount and kinds of radioactive materials deposited.

c. Plankton studies of an exploratory nature indicate that an appreciable proportion of the radioactive materials discharged into the Columbia River is picked up and carried along in the plankton.

II. Lists of presently planned future projects.

A. Applied Fisheries Laboratory.

1. To continue the genetic studies of delayed effects of irradiation.

2. To explore the differences in radiation induced damage attributable to sex.

3. To continue and to place increased stress on the physiological modifications that result from exposure to radiation.

4. To explore further and fill in the gaps in the "curve" of radiation "tolerance". We have started to measure the "tolerance" of aquatic forms to irradiation. Representative forms of the aquatic fauna and flora systems are being studies to provide data for the LD_{50} curve.

5. By the use of selected and/or mixed active materials we expect to continue the study of selective absorption and concentration of active materials by aquatic forms.

6. To continue to study the changes in tissues that result from irradiation with the effort directed toward determination of those tissues most sensitive. Effort also will be directed toward detection of the early stages of radiation damage.

7. A complete library bibliographic study on algal growth and control is underway and will be kept up-to-date.

B. Aquatic Biology Project planned for Hanford Operations.

1. Continue the monitoring studies on the plant effluent liquid wastes. Using chinook salmon eggs and larvae, a 24 hour a day biological monitoring will be maintained on the plant wastes.

2. Since fish represent only the final stage in the complicated ecological environment, and since their existence is dependent upon the lower aquatic forms that serve as food, studies are to be made on the sensitivity of the lower forms to effluent water.

3. Continuation of present studies to determine the effect of pile effluent water on spawning and successive generations of trout.

4. Studies with fish confined to tanks spiked with radioisotopes of the kinds found in the effluent water are planned to give a better understanding of the absorbed-activity effect on the genetic pattern.

5. A more detailed study is planned of the selective concentration of active materials by the floral and faunal forms found in the Columbia River below the outlets of pile effluent water.

6. Studies of the transmission of active materials through the aquatic forms, particularly the food chains are contemplated.

7. The construction of McNary Dam and the impounding of water behind the dam demand an expanded program of study of the active waste materials in areas beyond the Hanford reservation.

8. Exploratory ecological studies of the Columbia River in the plant area and down river areas are planned to provide information on abundance and conditions of growth, etc. of the forms living in the river. It is realized that the complete study of the ecology of the Columbia River would require large numbers of specialists and vast sums of money, so it is proposed that those forms of particular interest to the problems of absorption and concentration of radioactive materials be investigated first and others be explored as time and support warrant.

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III. Projects for which facilities are available and which are recommended by the Committee on Liquid Process Waste Disposal and Reclamation as a part of the Commission-wide program.

"J. Biological Processes. Investigation should be made into the use of various organisms such as zooglea* for concentrating activity. Work of this nature has been started at Los Alamos."

Studies of the selective concentration of activity by primitive forms, particularly some of the algae, have been made by various investigators of the Hanford Operations. The mass of algal growth in the 107 basin is a parallel problem to the zooglea studies of the Los Alamos Laboratory.

IV. Funds for the Fiscal Year 1949 and the Fiscal Year 1950 which will be available for projects referred to in parts I, II, and III above.

A. Applied Fisheries Laboratory

The annual allotment of funds for the operations of the laboratory is $50,000 of which about one-half or $25,000 is budgeted for carrying on fundamental work on the evaluation of radiation effects on water organisms. The other half is for Marshall Islands studies.

A like amount of money is contemplated for this program in 1950.

B. Aquatic Biology program for Hanford Operations.

During the fiscal year 1949 a total of $54,000 have been allocated for study of liquid waste disposal programs.

The amount budgeted for the fiscal year 1950 has been increased to

* zooglea - "A colony or mass of bacteria embedded in a mucilaginous or jelly like substance formed by swelling of the cell membranes by the absorption of water." "The term is also applied to certain of the lower algae"

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$133,000. This increase was made in contemplation of the need for a more extended study of the increased pollution problems following the completion of the additional piles in the 100-areas and the increase in potential danger of concentration of active substances in the faunal and floral forms in the backwaters of McNary and other dams.

V. Personnel and physical facilities available for projects referred to in parts I, II and III above.

A. Applied Fisheries Laboratory

Facilities are provided by the University in Fisheries Halls 1 and 2 for offices and laboratories. Ponds for rearing and retaining animals are available in the area between the two buildings. The laboratories and ponds are provided with running, filtered (chlorine removed) water.

By the fall of 1949 improved and enlarged facilities will be available in the Fisheries Center now under construction. Studies on absorption of specific isotopes by aquatic organisms will be accelerated after moving to the new quarters where facilities for balanced aquaria will be greatly increased.

Technical personnel of professional grade available in the Applied Fisheries Laboratory include the following:

Bonham, Kelshaw — Biologist, specializing in aquatic invertebrates.

Dettmer, Frank Herbert — Chemist, special training in aquatic chemistry and radioisotope work.

Donaldson, Lauren R. — Aquatic biologist, specializing in salmonoid nutrition and histology.

Lowman, Frank — Zoologist, specialty - genetics.

Ordal, Erling — Bacteriologist, specialty - aquatic bacteria.

Seymour, Allyn H. — Aquatic biologist, special field - biomathematics.

Melander, Arthur D. Aquatic biologist, specialties - taxonomy and histology.

B. Hanford Operations - facilities and personnel

The present facilities for the study of liquid waste disposal problems are centered in and around the 146 Building in the 100-F area. These facilities include office space, a small laboratory for tissue work, a well equipped hatchery and numerous small ponds adjacent to the buildings for rearing animals and aquatic plant cultures. The facilities are not elaborate but functional.

The technical personnel of professional grade available at the Aquatic Biology Laboratory, 146 Building, include the following:

Berry, E. C.	Botanist, consultant on microbiology.
Coopey, Raymond W.	Zoologist, specialty - aquatic invertebrates.
Foster, Richard F.	Aquatic biologist.
Olson, Phillip A.	Aquatic biologist.
Davis, Jared J.	Zoologist, specialty - aquatic insects.

VI. Approximate time schedule for the work contemplated above.

Biological work does not lend itself to time schedules. The life cycles of the forms used dictate the schedule. Primitive forms with short life cycles can be studied and the data completed in a matter of days or weeks, while genetic studies on such forms as the chinook salmon with a four-year average life span require eight or nine years to obtain data for three generations.

The problems at the Applied Fisheries Laboratory are scheduled for completion in 1953, while the work at the Hanford Operations should continue as long as radioactive wastes are dumped into the Columbia River.

VII. The completed reports of the Applied Fisheries Laboratory that pertain to radiation of aquatic forms are listed below by number and titles.

UWFL-1 Equipment and Procedures used in the Study of the Effects of Irradiation of Fish with X-rays.

UWFL-2 Studies of the Effects of Roentgen Rays on the Growth and Development of the Embryos and Larvae of the Chinook Salmon (Oncorhynchus tschawytscha).

UWFL-3 Section 10 of Series of Experiments Involving the Effect of X-ray on Fishes: Fingerling Chinook Salmon (Oncorhynchus tschawytscha Walbaum).

UWFL-4 Histological effect of X-rays on Adult Male Silver Salmon, Oncorhynchus kisutch (Walbaum).

UWFL-5 Lethal Effect of X-ray upon four Marine Microplankton Organisms.

UWFL-6 Section I and II of series of experiments involving the effect of X-ray on fishes: Chinook Salmon (Oncorhynchus tschawytscha) "Preliminary report concerning X-ray effects upon chinook salmon (Oncorhynchus tschawytscha Walbaum) observed through more than one generation."

UWFL-[illegible] The Effects of Roentgen rays on the embryos and larvae of the chinook salmon.

UWFL-11 Concentration of active materials by hydroids in the Bikini lagoon during the summer of 1947.

UWFL-12 "Some effects on embryo and young rainbow trout (Salmo gairdneri gairdneri Richardson) from exposing the parent fish to X-rays."

UWFL-13 Progress Report of the Samish Chinook Salmon Project (Sections I and II) through the summer of 1948.

UWFL-14 Lethal effects of X-rays on Marine Amphipods.

Completed reports produced by the Hanford Operations on problems arising from liquid waste disposal are listed below by number and subject.

7-4759 Some Effects of Pile Area Effluent on Young Chinook Salmon and Steelhead Trout.

7-4243 Occasional heavy mortalities among fish held in 100-F area effluent water and some effects of "Calal" on steelhead trout fingerlings.

[illegible] Effects of Pile Area Effluent Water on Young Silver Salmon.

3-[illegible] Accumulation of Radioactivity in Fish Immersed in Pile Effluent Water.

3-5064 Studies in the Accumulation of Radioactive Elements in Oncorhynchus tschawytscha (chinook salmon) Exposed to a Medium of Pile Effluent Water.

3-5501 Radioactivity in Various Species of Fish from the Columbia and Yakima Rivers.