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SUBJECT OR TITLE **ROUGH DRAFT --
A Crude Guess as to the Effect of a Pile**

Explosion on the Aquatic Life of the U.

River.

TO

File

FROM

R. F. Foster

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FINAL DETERMINATION**

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ROUGH DRAFT

144-23792

U. S. ATOMIC ENERGY COMMISSION

This document consists of

13 pages

unclassified serial

U. S. OF A

A Crude Guess as to the Effect of a Pile Explosion
on the Aquatic Life of the Columbia River

The radiobiological result of a hypothetical explosion of one of the reactors adjacent to the Columbia River on aquatic organisms might be considered from three aspects: 1. The effect of the radiation emitted from the explosion itself; 2. The contamination of the river and its aquatic life as a result of the fall out from the explosion; 3. The hazard which would result from humans eating contaminated fish.

1. The effect of the radiation emitted from the explosion.

This aspect would probably be of relatively little consequence in comparison to the subsequent contamination problem. Many of the organisms would be afforded considerable shielding by the river bank due to the topography of the land, and by the depth of water in the river itself. Should a large number of lower organisms be killed by the initial radiation along several hundred yards of river course the loss would not be irreplaceable. Other factors being favorable, near-normal conditions would probably be restored in about a year's time from re-seeding and migration. Dependent upon the particular location of the explosion and the season of the year on the order of 100,000 valuable juvenile salmon might, however, be wiped out.

Little or no immediate effect was observed on aquatic organisms as a result of the aerial bomb (Test Able) at Bikini.

The contamination of the river and its aquatic life as a result of the fall out.

The amount of contamination reaching the river will obviously vary greatly with the character of the explosion and the pattern of the fall-out. If an explosion of the type postulated by Sutton (1949)

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should occur, one would expect comparatively little material to enter the river at the site of the explosion. The activity would go upward in the form of a cloud which would again settle to the ground and river many miles away causing the contamination. The amount of activity present at zero time from such a hypothetical explosion has been calculated locally to be on the order of 5.3×10^8 curies. Using Sutton's estimates adjusted for the greater initial amount of activity, one might guess that the active cloud settling on the river would deposit on the order of 250 curies per square meter of river surface. When this was distributed throughout the depth of the river, at a low flow stage, it would amount to something on the order of 50 $\mu\text{c/ml}$. At a low rate of flow about one hour would be required for the zone of active water to flow past a particular point.

Although uptake of fission materials is very rapid in fish and other aquatic life and may reach ten times that of the water within 24 hours it does not seem likely that fish would accumulate more than the 50 $\mu\text{c/gr}$. in the short period of one hour. With increasing distance downstream the zone of highly active water would be distributed over a greater linear distance and thus reduced in intensity by dilution. Compensating for the dilution, however, would be the increased time that aquatic life would be exposed to the radiation. Subsequent loss of the accumulated activity from the aquatic organisms would be quite rapid during the first few hours for soft tissues but for the calcareous parts might not be much faster than by decay alone.

If sizeable particles were present in the cloud and were deposited on the river, the heavier ones would tend to settle to the bottom in quiet areas immediately below the fallout. Lighter particles

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would be carried by the current farther downstream and particles of colloidal size would probably pass entirely through the forebays of dams and not be deposited until precipitated by sea water. The completely soluble materials that were not fixed by the aquatic organisms would eventually be washed out to sea. The bottom of the river would thus be contaminated from the site of the explosion to the mouth of the river by (1) particulate contamination especially in areas where silt is deposited and by (2) sedentary aquatic forms such as bottom algae and associated invertebrate organisms which have temporarily, at least, fixed the soluble materials.

Freshet stages of the river would tend to move active particles on down river at least as far as the forebay of a dam or else bury them in the bottom silt. On the other hand, bottom feeding fish such as suckers and carp would pick up and ingest the particles which would tend to convert the active material into soluble form and distribute it more widely, dissipating the "hot spots" but increasing the hazard to more organisms.

The Eniwetok Tests would appear to furnish a situation more comparable to the hypothetical pile catastrophe than other circumstances since aquatic marine forms were affected by the fallout of an atomic explosion taking place on adjacent land. In this case such invertebrate organisms as coral and clams were killed near the site of the explosion and for distances extending outward for over 300 yards from shore. The writer is not at all familiar with the fallout pattern but presumes that these marine organisms died as a result of a fallout occurring adjacent to the site of the explosion and not from a cloud which settled at some distance away.

The ability of the aquatic forms to accumulate fission product mixtures has been observed on a vast scale at Bikini and

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Eniwetok Atolls (WFL-19). The invertebrate organisms, plankton and algae, accumulated more active materials than did the fish by a factor of about 10 to 20 times. The longer lived beta emitters such as strontium, ruthenium, cesium, and rare earths could be easily detected in fish and lower organisms for at least two years after the underwater blast. On a laboratory scale, small non-feeding goldfish accumulated radioactive strontium, barium-lanthanum and fission mixture elements from solutions in which they were immersed (Prosser, et al, 1945). Analysis of tissues of fish subjected to radioactive fission products at the test atolls and in laboratory containers indicate that the feces and intestines will show the greatest amount of activity since the fish will be actively feeding upon the active lower forms. The gills, liver and bone will be next in order of activity and muscle and flesh will be the least active. Calcareous tissues, such as skeleton and scales, would probably accumulate about 75 per cent of the radio-strontium and radio-barium. Lanthanum and a mixture of cerium, yttrium and zirconium-columbium would likely accumulate in visceral tissues. Iodine would, of course, be deposited in the thyroid. Pick up of plutonium apparently was not great in fish at Bikini. By withdrawing the soluble elements from the water and fixing them in their bodies, the aquatic organisms would tend to hold the radio-isotopes in the river, and eventually transfer a portion of the activity to the terrestrial forms rather than allowing them to be flushed quickly out to sea.

It would seem likely that all aquatic forms of the river below the site of the fallout would become radioactive. The algae, plankton and invertebrate organisms would become more active than the fish by a factor of about 10 to 20 times the bottom feeding fish such as the salmon, carp and [redacted]

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suckers, carp and minnows, which are not commonly used for food would be more active than the carnivorous sport fish such as the bass, whitefish and trout. Sturgeon are bottom feeding fish which are occasionally caught. The flesh of the fish would retain much less activity than the skeleton or visceral parts which are not eaten.

A sufficient amount of radioactive materials would undoubtedly be taken up by fish and invertebrates to kill large numbers of them in a zone extending downstream for a number of miles. Economically the destruction of the salmon in the river would be of greatest consequence although if the kill extended below Bonneville Dam additional valuable species would also be involved. Under extreme circumstances up to 10,000,000 juvenile salmon might be destroyed if a sizable fraction of the fallout occurred into the river.

Important salmon spawning grounds exist in the vicinity of the 100-D, 100-H and 100-F piles and above the 300° Area. Additional spawning areas probably are present in the Columbia River below these sites but are not easily visible. Deposition of long lived materials on these spawning areas would probably destroy many of the developing embryos of the current season. Through activity decay and scouring by freshet stages of the river such spawning beds would probably not be hazardous during subsequent seasons. Adult fish migrating up the river to spawn and encountering the active zone of water would probably be in it for only a short period of time and since they are not actively feeding might well survive to spawn. If these adult fish accumulated enough active materials to expose the developing eggs to 100 or more rep than considerable numbers of their offspring would not survive or would be subnormal.

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3. The hazard of utilizing contaminated fish as food.

From the results observed at Bikini and Eniwetok, there seems little doubt but that local game fish such as the whitefish, bass, trout and sturgeon would constitute an immediate hazard. While the eatable flesh of the fish would be much less active than the skeleton, viscera, and skin, a sufficient hazard would probably exist to necessitate closing all fishing from the site of the explosion to perhaps the mouth of the river. Such closure would probably need to remain in effect for one or more years for non-migratory species.

While some juvenile salmon would probably die in the river from the accumulation of radioactive materials, many others would survive to reach the ocean even though they contained considerable amounts of radioactive fission products. During their growth in the sea this activity would be diminished by decay, by elimination, and by dilution as the fish increased in size. When these salmon were mature after two or three years at sea and re-entered the river their flesh would probably be considerably below tolerance and they could be safely eaten. However, there is a sports fishery and a commercial troll fishery operating near the mouth of the river which catch the immature fish during their growing period. This fishing would have to be stopped until extensive checking had showed these to be safe for human consumption.

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Report No. UWFL 19.

Sutton, O. G.
1949

Revised Calculations on the Danger from Air-borne
Products of an Atomic Pile Explosion PLP-20 1-10-49

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Acc. & Distrib. of radioactive strontium, Barium-Lanthanum
Fission Mixture & Sodium in Gold Fish.

After few days conc. ratio usually between 10 & 100

Conc. ratio independent of dose over range investigated
10 mc to 1000 mc $\pm$
(.01 mc to 1.0 mc/ml)

Calcareous tissues (skeleton & scales) accumulated about
75% of the radio-strontium & radio-barium in the whole
fish

Lanthanum or a mixture of cerium, yttrium, &
zirconium-columbium appeared to be acc. in visceral
tissues, especially the intestines

these elements taken up through gill & oral
membranes & were distributed by the blood.

uptake of strontium & fission mixture ⁸⁹
when surrounding pond water low in calcium (1.0 ppm)

When fish transferred from active to
inactive pond H₂O they lost some Ba-La &
fission mixture radioactivity from soft tissue
during the first few hours but they did not lose
the major part of their radioactivity, very little
lost by decay alone.

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Preparation of ^{89}Sr from slug
radioisotopes - ^{89}Sr (20-25%) rare earths 70-75%
zirconium columbium (< 5%)

^{89}Sr — 4 days after

$\text{H}_2\text{O} = 300 \text{ mc/Kilo} = \text{conc of fish}$

tissue = 2X

max 24 days = $\text{H}_2\text{O} = 250 \text{ mc/Kg}$ conc of

fish tissue = 200X

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Probably not fish but the ...
Goldfish

$Sr^{89} = \frac{100 \text{ mc/l}}{200 \text{ mc/l}}$ did not ...
life span

Parental conc. - Sr^{89}

0.1 mc/ml $\approx$ 100 mc/l, slightly less than
10 days, the conc of fish = 300

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Bikini Samples

Sample #1C-327 - Viseria Heart Urchin

Sample #2X-448 - Gut Parrot

Sample #3B-182 - Habmedia - ?

Sample #4B-6 - Canvas

Strontium

Sample #1 Less than 1%

Sample #2 Less than 1%

Sample #3 9%

Sample #4 3.6%

Cs

1 < 1%

2 Count

3 < 1%

4 < 1%

Rare Earth

Sample #1 39%

Sample #2 13%

Sample #3 7%

Sample #4 54%

Ruthenium

Sample #1 18%

Sample #2 4%

Sample #3 48%

Sample #4 6%

Alpha

Sample #1 3.8 Counts per minute

Sample #2 4.1 Counts per minute

Sample #3 1.0 Counts per minute

Sample #4 1.3 Counts per minute

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Total at zero time.

As	29	$\times 10^4$
Kr	151.05	
Pa	1060	
Se	4595	
Y	5275	
Zr	2363	
Cb	913	
Mo	2580	
Tc	68	
Ru	1046	
Sb	4352	
Te	4027	
I	5180	
Xe	3825	
Cs	1425	
Ba	5195	
La	5390	
Ce	4407	
Pr ^{Pr}	2340	
Nd	917	
61	353	

30 min.

532,120,000

= 5.3×10^8 C

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61

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