Fred M. Toelen

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UPTAKE AND RETENTION OF ZINC-65 FROM CERTAIN FOODS (a)

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J. F. Honstead (b) and P. W. Hildebrandt (c)
Battelle Memorial Institute, Pacific Northwest Laboratory
Richland, Washington
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REPOSITORY PNL
COLLECTION 65 Zinc
BOX No. N/A
FOLDER N/A

Introduction

Zinc-65 is one of the radionuclides formed by neutron activation in Hanford reactors and released to the Columbia River in cooling water effluent. This radionuclide has a relatively long half-life (245 days) and is an isotope of an element utilized in the metabolism of most aquatic life forms. The nuclide is, therefore, found in fish and shellfish in the river and is also present in crops irrigated by water from the Columbia. The transfer of Zn-65 to foodstuffs of man has been an object of study by Hanford scientists for a number of years.(1)(2)(3)

The half-life of Zn-65 is long enough for it to enter complex transport and transfer processes in various food chains and to persist in the Columbia all the way to its mouth. Enough of the nuclide is discharged to the Pacific Ocean by the Columbia River so that it can be detected by modern sensitive radiochemical methods in samples of water and sea organisms from nearby locations. In particular, Zn-65 is readily detected in samples of those organisms such as shellfish which concentrate zinc by metabolic absorption.

Upon decay, Zn-65 emits a 1.1 Mev gamma photon which is easily detected by conventional scintillation counters. The ease and accuracy of Zn-65 analyses on environmental samples makes the nuclide useful as a radioactive tracer, and it has been used in this way. For example, Zn-65 has been used at Hanford to identify fish and other foods exposed to Columbia River water containing reactor effluent and to estimate the amount of such foods in the diets of individuals analyzed in the Hanford whole-body counter. The interpretation of such whole-body analyses, and estimates of population exposure from the consumption of foodstuffs containing radionuclides, requires knowledge of the uptake and retention of Zn-65 by people. The experiment reported here was conducted to provide information on the uptake and retention of Zn-65 from one such food, oysters.

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(b) Research Associate, Radiation Protection Department, and (c) Technical Director of the Air Sanitation and Radiation Control Section of the Washington State Department of Health.

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Experimental Design

The experiment was designed to evaluate the uptake and retention of Zn-65 from the consumption of oysters collected on the Washington coast. The oysters were furnished by a commercial fishery and were analyzed by gamma spectrometry before being eaten. The Zn-65 content of the entire oyster meal was determined in this way to avoid the uncertainties of sampling. The analyses were performed in the radiochemical laboratory of the Washington State Department of Health. The oysters were eaten by one of the authors (P. W. Hildebrandt) who was given whole-body counts at irregular intervals to follow the build-up of Zn-65 in his body. P.W.H. lives in Seattle and, thus, has very little opportunity of acquiring Zn-65 from a source other than the oysters.

Figure 1 shows the course of the experiment. The first oyster meal was eaten in October, 1963 but previous to that date, P.W.H. had been counted in the Hanford whole-body counter to establish an initial background count. During the next 20 months he ate 81 meals of oysters, an average of about one meal per week. As is evident from Figure 1, the meals were not uniformly distributed during that time. There was one period of more than five months during which fresh oysters were not available and none were eaten. As P.W.H. lives some distance away, he could only be counted in the whole-body counter when visiting in Richland where the counter is installed. A total of 13 whole-body counts were made during the course of the experiment.

The whole-body counter used to observe the build-up of Zn-65 utilizes a 9 3/8 inch x 4 inch sodium iodide crystal activated with thallium, in a room shielded with 26 cm of iron.[4] A counting time of 20 minutes per measurement permitted an accuracy of ± 5 per cent and a lower detection limit of approximately one nanocurie in the whole body. Figure 2 shows the counting arrangement used.

The total Zn-65 ingested by P.W.H. during 20 months was 709 nanocuries included in 17,430 grams of oysters. Thus, he ate an average of 215 grams of oysters at each meal and the oysters averaged 41 picocuries per gram. The amount of Zn-65 transported by the Columbia River during the period of the experiment is shown in Figure 3. A seasonal fluctuation resulting from sedimentation processes is clearly evident, the Zn-65 load varying from about 25 to more than 150 curies per day. On the same chart is shown the concentration of Zn-65 in the oysters used in this experiment and which were collected near the mouth of the Columbia. The concentrations shown range between 20 and 60 picocuries per gram. As one might expect, the retention time of Zn-65 by oysters is long enough to mask seasonal fluctuations or correlations with the Zn-65 burden of the river.

Experimental Results

The maximum Zn-65 body burden attained by P.W.H. was 40 nanocuries. The amount of radioactive zinc present in the body as a result of ingesting Zn-65 is a function of the fraction of dietary zinc absorbed

and the rate of turn-over of zinc in the body. The values for these parameters used by the International Commission on Radiological Protection for calculating acceptable drinking water levels are ten per cent absorption and an effective whole-body half-life of 194 days (including biological elimination and radioactive decay). These are quoted for a "standard man"; individual values may differ markedly from this average. The best fit values obtained for our experimental data for the case of Zn-65 from oysters were 13.5 per cent absorption and 100 days effective half-life.

The whole-body counting data obtained during the course of this experiment is shown in Figure 4. The solid line is the calculated body burden using a fractional absorption (F_W) of 0.135 and an effective half-life ($T_{1/2}$) of 100 days. The fit of the measured body burdens to this theoretical curve is faily good except for the first two points. The initial high Zn-65 body burdens cannot be explained. Possibly P.W.H. included foods in his diet, other than oysters, that contained some Zn-65 (e.g. Pacific shrimp). Another possibility is a metabolic change at this time reflecting the rich zinc diet resulting from eating oysters. During the period from day 199 to day 366 no oysters were consumed, and the whole-body counts were used to calculate an effective half-life for zinc in the body. The 102-day half-life obtained agrees well with the value of 98 days measured during the decay period at the end of the experiment. The apparent fractional uptake for Zn-65 from oysters ranged from 0.061 to 0.169 with an average of 0.135 and a standard deviation of 0.027.

The vertical bars on some of the points showing whole-body counts in Figure 4 reflect an uncertainty resulting from the possible presence of unabsorbed Zn-65 in the GI tract contents. The data reported by Wallace (5) on the passage of barium sulfate through the digestive tract of 55 subjects was used to evaluate this uncertainty. The points evaluated were those made within five days after an oyster meal. The GI tract retention data are summarized in Figure 5. The figure shows the GI tract passage curves for the minimum, median, and maximum individual examined by Wallace. From his data we derived a population mean (dotted line) which was used to calculate the uncertainties shown in Figure 4.

Conclusions

The fractional absorption (13.5 per cent) and effective half-life (100 days) measured for Zn-65 from the consumption of Pacific oysters seems to be somewhat different from those values used by the I.C.R.P. (10 per cent and 194 days) for calculating permissible drinking water concentrations. However, the experimental results reported here are for a single subject and cannot be used to draw valid conclusions for a "standard man." The results support data earlier reported for the case of Zn-65 uptake from consumption of Columbia River fish.(2)(3) The Zn-65 uptake from fish was also significantly different from the values given by the I.C.R.P. for water. It is probable that the "specific activity"

of Zn-65 (concentration of Zn-65 relative to that of stable zinc) in the flesh of aquatic organisms is actually lower than that in other foods and is responsible for the high turn-over rate obtained for zinc from these sources. There is some evidence that zinc is absorbed more readily from such foods than from drinking water which might reflect some differences in chemical form, but more probably simply indicate individual differences in the metabolisms of the subjects studied.

The accumulation of Zn-65 from a very heavy consumption of Pacific oysters resulted in a body burden of only 40 nanocuries. This may be compared with the maximum permissible body burden recommended by the I.C.R.P. of 6000 nanocuries, based on an assumed lifetime sustained level. P.W.H. averaged about one meal of oysters per week. To have maintained a body burden equal to the limit recommended by the I.C.R.P. would have required him to eat an average of 150 meals of oysters a week. The likelihood of any individual eating more than 70 lb. of oysters a week seems small. The results of this experiment thus support the conclusion previously derived from the Hanford environmental evaluation program that the Zn-65 in Pacific oysters does not contribute significantly to the radiation exposure of members of the public.

References

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(2) Foster, R. F. "Accumulation of Zn-65 from Prolonged Consumption of Columbia River Fish," Annual Meeting, Health Physics Society, New York City, June 11, 1963.

(3) Honstead, J. F. and D. N. Brady, "The Uptake and Retention of P-32 and Zn-65 from the Consumption of Columbia River Fish," Annual Meeting, Health Physics Society, Los Angeles, June 14, 1965.

(4) Roesch, W. C., R. C. McCall, and H. E. Palmer, "Hanford Whole-Body Counter - 1959 Activities," HW-67045, December, 1960.

(5) Wallace, R. P., et al, American Journal of Roentgenology, 39, 64, 1958.

Acknowledgement

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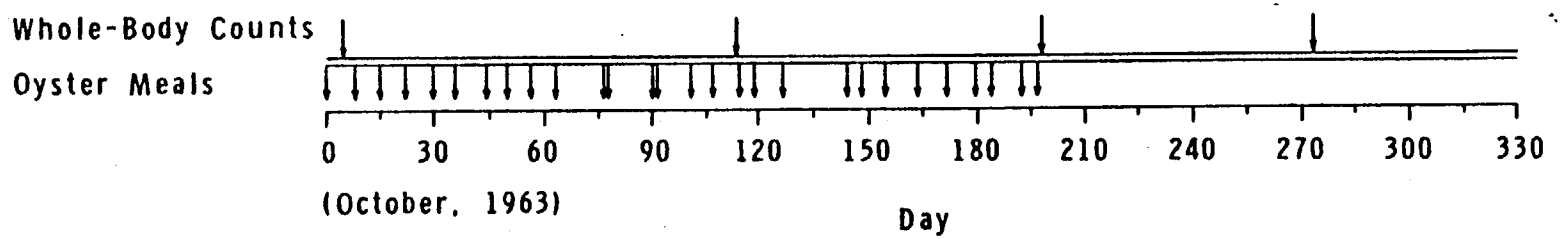
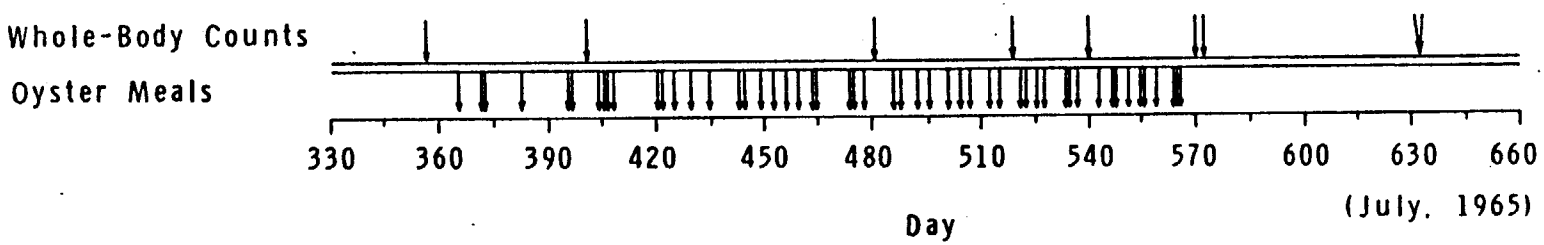
FIGURE 1

EXPERIMENTAL DESIGN
UPTAKE AND RETENTION OF ZINC-65 FROM OYSTERS





Total of 81 Oyster Meals
Including 709 nCi Zn-65

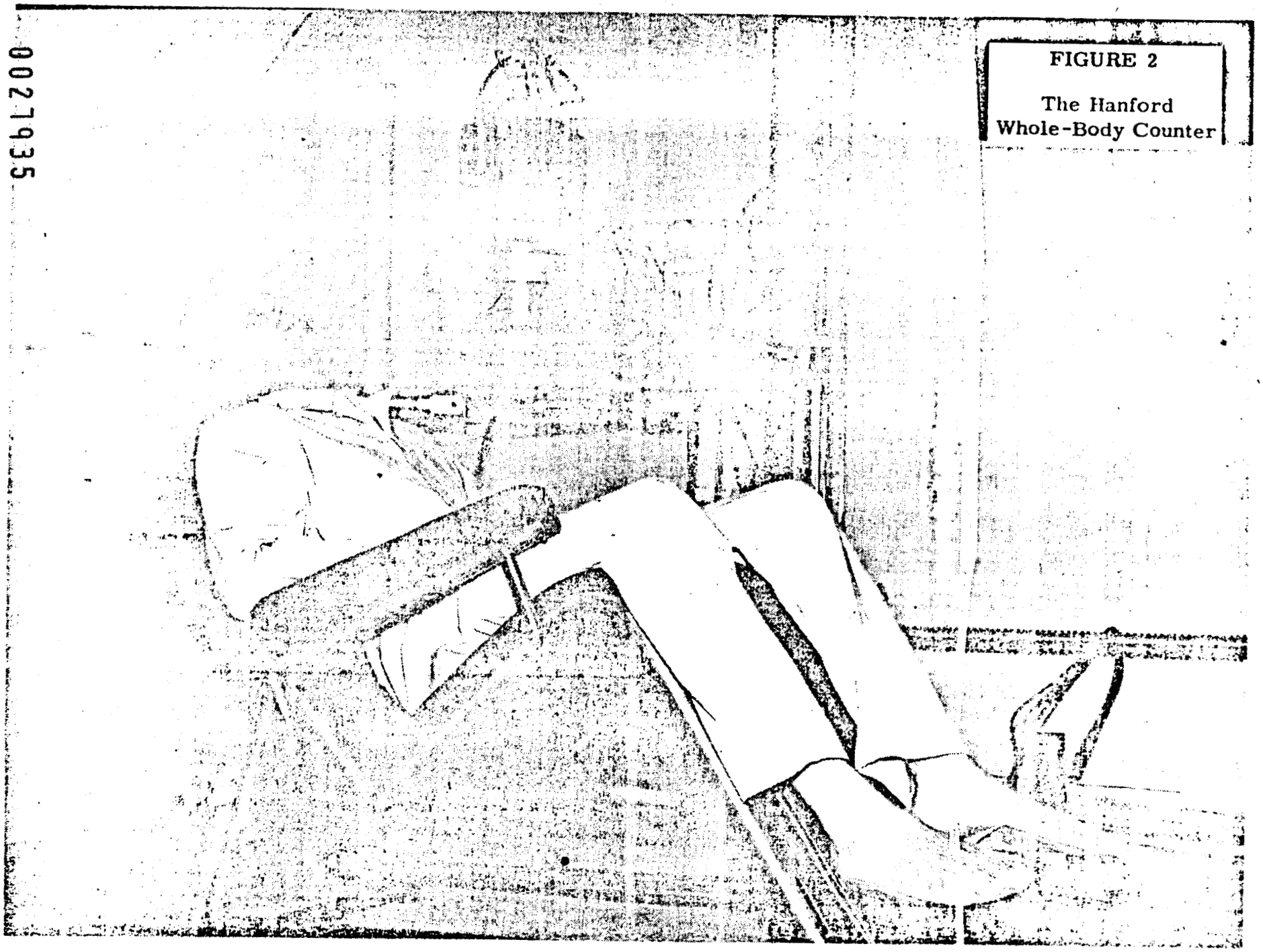


FIGURE 2

The Hanford Whole-Body Counter

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FIGURE 3

ZINC-65 TRANSPORTED BY THE COLUMBIA RIVER AND CONCENTRATION IN WILLAPA BAY OYSTERS

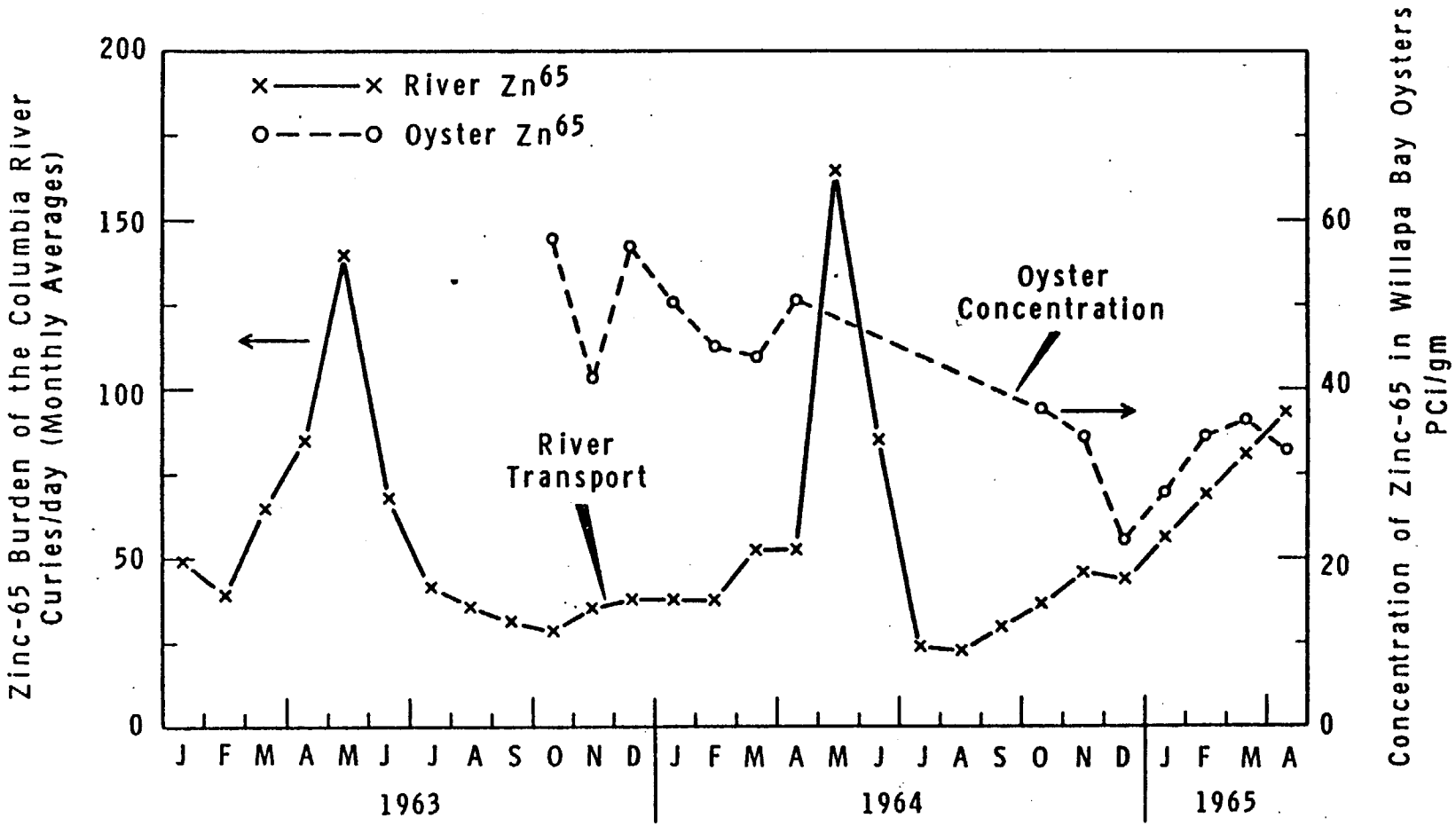

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FIGURE 4

UPTAKE AND RETENTION OF ZINC-65 FROM OYSTERS

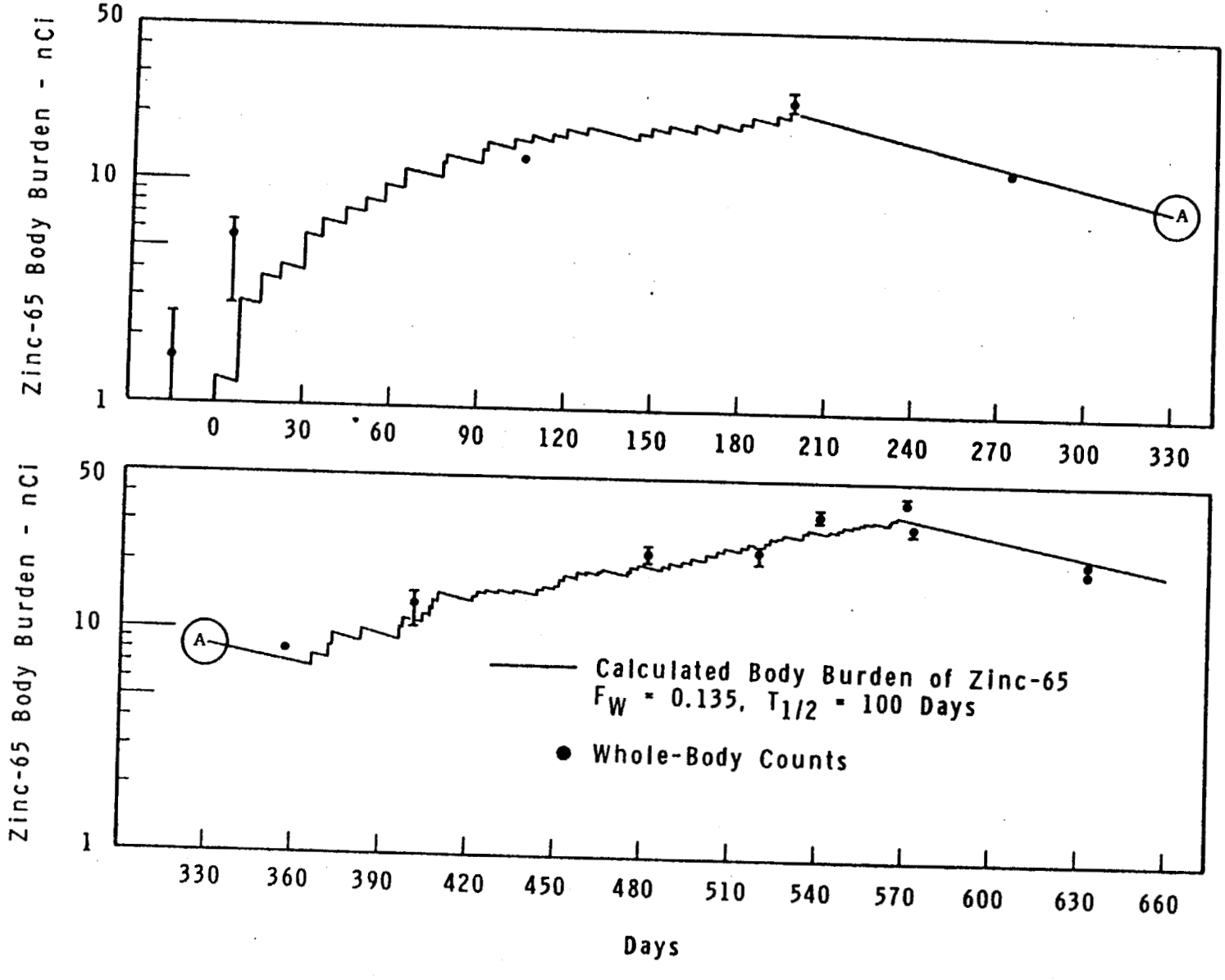

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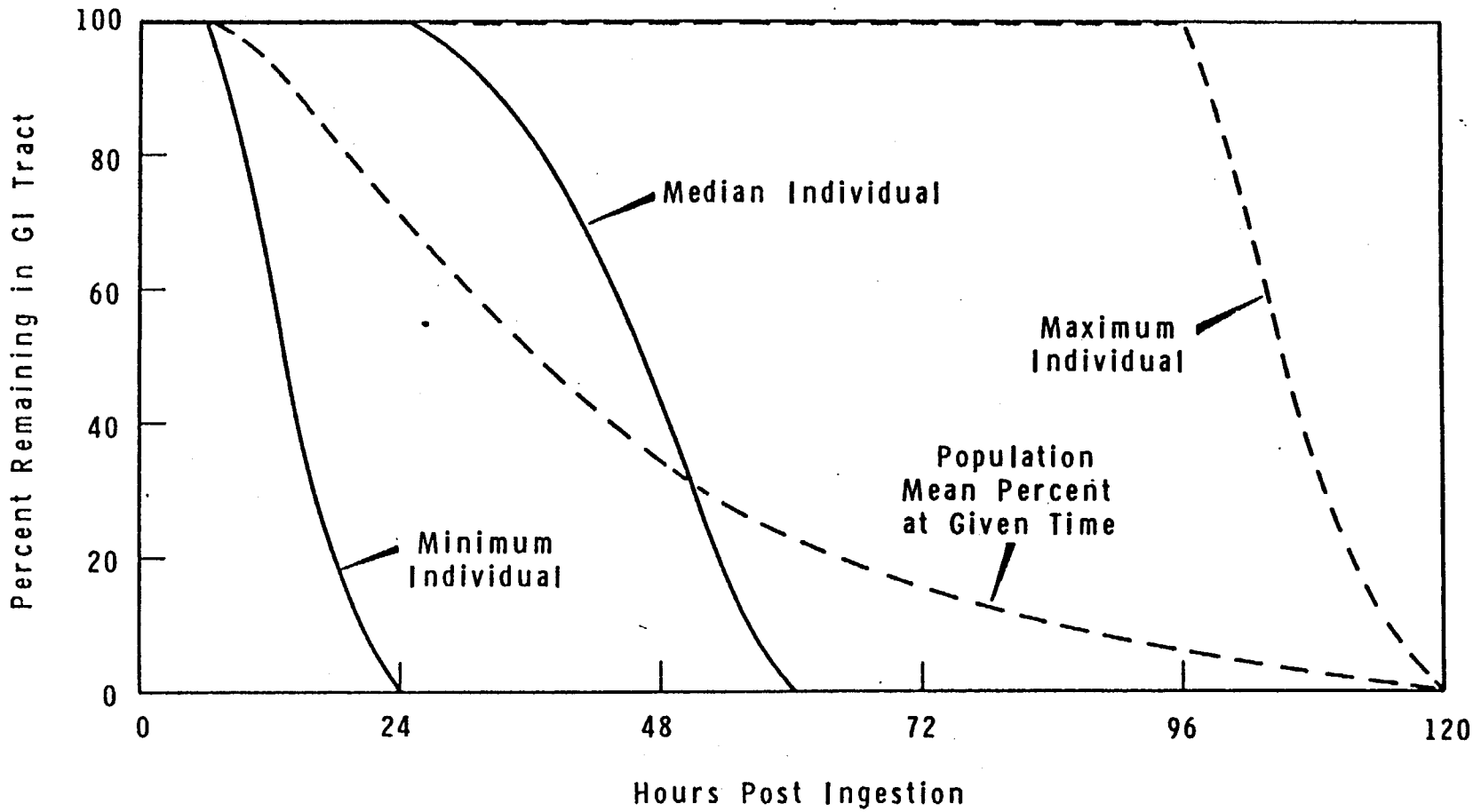
FIGURE 5

RATE OF PASSAGE OF INSOLUBLE MATERIAL THROUGH GI TRACT