Table 2. Alpha activity in thorium isolated from surface water, sample S-2.

Elapsed time after chemical processing (day)	Total alpha activity in sample (disintegration/hr liter)	
	Observed	Calcd.
0	9.6 (±0.5)	
3	13.5 (±1.0)	13.5
4	15.2 (±0.9)	14.6
7	16.6 (±0.6)	16.7
18	18.5 (±0.6)	19.0
21	19.1 (±0.6)	
35	18.7 (±0.6)	18.3
73	16.7 (±0.6)	16.0
161	14.8 (±0.6)	14.3
221	13.7 (±0.5)	13.7
363	12.8 (±0.5)	

indicates the presence of Th^{227} or Th^{228}, or both.

The fact that the activity at 73 days is higher than the initial activity shows that Th^{228} is present. If we represent the initial activities (in disintegrations per hour per liter of water) of the individual nuclides by $A_{Th^{232}}$, $A_{Th^{228}}$, and so forth, we may write for the total initial alpha activity

$$9.6 = A_{Th^{232}} + A_{Th^{230}} + A_{Th^{228}} + A_{Th^{227}}.$$

At 363 days over 99.99 percent of Th^{227} and daughters will have decayed. Allowing for Th^{228} and daughter activity growth and decay during the 363-day interval (*3*) and assuming 100 percent Rn^{220} retention, we write for the total alpha activity at 363 days

$$12.8 = A_{Th^{232}} + A_{Th^{230}} + 3.5\ A_{Th^{228}}.$$

At 21 days the activity of Th^{228} and its daughters will be 4.84 times the initial Th^{228} activity (*3*). The activity of Th^{227} and its daughters will be 2.31 $A_{Th^{227}}$. Hence we write for the activity at 21 days

$$19.1 = A_{Th^{232}} + A_{Th^{230}} + 4.8\ A_{Th^{228}} + 2.3\ A_{Th^{227}}.$$

Solving the above equations, we find:

$A_{Th^{227}} = 1.6$ disintegration/hr liter
$A_{Th^{228}} = 1.9$ disintegration/hr liter
$A_{Th^{232}} + A_{Th^{230}} = 6.1$ disintegration/hr liter

Calculated total alpha activities at various times for a sample which initially had this composition are shown in Table 2 alongside the observed activities in the S-2 surface sample. The calculated and observed values are in good agreement.

Taking the uranium content (*4*) of ocean water as 3.0×10^{-6} g/liter ($A_{U^{238}} = 130$ disintegration/hr liter), we see that in both samples the Th^{230} content is far below the amount required for secular equilibrium with the U^{238} present. In the surface water we find 5 percent or less of the equilibrium quantity of Th^{230}; in the deep sample less than 1 percent of the equilibrium amount.

The equilibrium Th^{227} activity corresponding to a uranium content of 3.0×10^{-6} g/liter is 6 disintegration/hr liter. A comparison with the experimental values listed above shows that the Th^{227} concentration in both the deep water and surface water samples is also below its equilibrium concentration with respect to U^{235}, indicating that not only Th^{230} but apparently also Pa^{231} or Ac^{227}, or both, are precipitated with the sediments.

Using the value 1.3×10^{-13} g/liter for the radium (*5*) content of deep ocean water, we calculate $A_{Ra^{226}} = 17$ disintegration/hr liter. Hence, for the deep sample,

$$A_{Th^{230}}/A_{Ra^{226}} < 0.05$$

The radium content of the water is far in excess of the amount which can be supported by the Th^{230} which is present. Koczy, Picciotto, Poulaert, and Wilgain (*2*) report a similar situation in their Skagerak and Gullmerfjord samples. They suggest that the excess radium may arise from redissolution of radium originating from Th^{230} in the sediments (*6*).

WILLIAM M. SACKETT
HERBERT A. POTRATZ
Department of Chemistry, Washington University, St. Louis, Missouri
EDWARD D. GOLDBERG
Scripps Institution of Oceanography, University of California, La Jolla

References and Notes

1. J. W. Barnes, E. J. Lang, H. A. Potratz, *U.S. Atomic Energy Comm. Rept. LA-1845* (1955).
2. These data on the deep ocean sample are in essential agreement with values reported recently by F. F. Koczy, E. Picciotto, G. Poulaert, and S. Wilgain for samples of coastal waters collected in the Skagerak and Gullmerfjord [*Geochim. et Cosmochim. Acta* 11, 103 (1957)]. The total thorium alpha activity in our surface water sample, however, is considerably higher than the average value reported by Koczy *et al.* Our surface water sample was collected near the coast and may not be a truly representative specimen of ocean surface water.
3. The growth factors 3.5, 4.8, and 2.3 were calculated by the method of H. Bateman [*Proc. Cambridge Phil. Soc.* 15, 423 (1910)]. Tables of these values for the naturally occurring radioactive series have been published by H. W. Kirby [*Anal. Chem.* 26, 1063 (1954)].
4. M. Nakanishi, *Bull. Chem. Soc. Japan* 24, 36 (1951); E. Rona, L. O. Gilpatrick, L. M. Jeffy, *Trans. Am. Geophys. Union* 37, 697 (1956).
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6. Contribution from the Scripps Institution of Oceanography, New Series No. 1008. This investigation was supported in part by a fellowship grant from the Aluminum Company of America to W. M. Sackett and was aided further by facilities provided by the Los Alamos Scientific Laboratory and by funds supplied under contract No. AT(11-1)-581 between Washington University and the U.S. Atomic Energy Commission.

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Relationship between Rate of Photosynthesis and Growth of Juvenile Red Salmon

Bare Lake, a 120-acre unstratified lake on Kodiak Island, Alaska, was fertilized annually during the period 1950–56 with inorganic nitrate and phosphate fertilizers. The total amount of fertilizer added each year was calculated to increase the concentration of phosphate phosphorus and nitrate nitrogen by approximately 0.05 and 0.25 mg/liter, respectively.

The purpose of fertilization was to determine whether this process will bring about an increase in the food supply of red salmon (*Oncorhynchus nerka*) during their lake residence, and thereby increase their growth and survival rate prior to their migration to sea, which may occur during the beginning of their second, third, or fourth year of age. Studies have demonstrated that fertilization during the years 1950–53 increased the rate of photosynthesis of the phytoplankton and increased phytoplankton production (*1*).

Phytoplankton are utilized by a variety of benthic insect larvae and zooplankton upon which the fish have been observed to feed. That these organisms have increased in production is strongly suggested by the fact that growth of young red salmon has increased since 1950 (Fig. 1*a*). The seaward-migrating red salmon, generally referred to as smolts, received no benefit from this fertilization in 1950, for they migrated prior to the July application and the juveniles during their first growing season probably received very little benefit by 27 August, the date their growth was calculated.

To obtain information about the size of red salmon smolts prior to 1950, measurements of scale radii were taken of smolt scales for the years 1950–53 and of the fresh-water zone scales from adult salmon that returned to the lake from the smolt migrations of 1947 through 1953. A significant correlation was found between the scale radii and fork length of smolts, and it was found that the fresh-water zone scale radii of adult red salmon were equal to or greater than scale radii measurements from samples of the smolts producing the adults. Since the scale radii of adult red salmon returning from the smolt migrations of 1947–49 were slightly smaller than those returning from the smolt migration of 1950, this is good evidence that the smolts of those years were no larger than those of 1950.

Thus, it appears that fertilization has brought about an increment in fish growth that has to date been rather progressive over the years. It is important to note that during the period no increase in growth of red salmon occurred

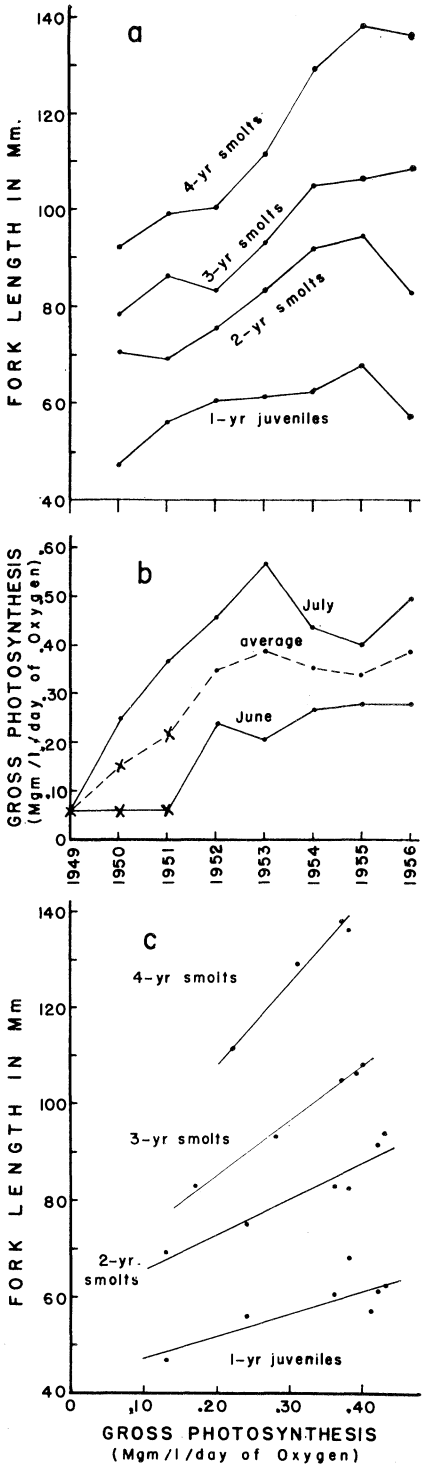

Fig. 1. (*a*) Curves showing the mean length of juvenile red salmon on 27 August of their first growing season and of red salmon smolts migrating to sea in the beginning of their 2nd, 3rd, and 4th year of life for the years 1950–56. (*b*) Curves showing the mean rate of gross photosynthesis during the years 1949–56 for the 40-day periods following the June and July fertilization. Also presented is a curve of the average of the two periods. Points on the curves marked by x's denote the values are estimated or partly estimated. (*c*) Scatter diagrams showing the relation between gross photosynthesis and fork length for each age group of fish. Regression lines are drawn by inspection.

in nearby unfertilized Karluk Lake. Because of the long life cycle of red salmon, data are not yet sufficient to demonstrate whether fertilization has increased the fresh-water survival.

The rate of growth of fish is very sensitive to influence by the food supply. Although plankton and bottom fauna have been sampled regularly, the time-consuming censuses have not yet been completed. However, data are available on the primary productivity as measured by the rate of photosynthesis of the phytoplankton (Fig. 1*b*). These measurements were made by the method originally described by Gaarder and Gran (*2*).

No actual determinations of rate of photosynthesis were made in 1949, but a few determinations were made prior to the July fertilizations of 1950 and 1951, years when the lake was not fertilized in June. On the basis of measurements made during those periods (*1*), it is believed the mean rate of oxygen production would not have exceeded 0.12 mg/liter per day and may well have been about 0.06; the latter figure is plotted as the rate during 1949 and during June of 1950 and 1951. Following the 1951 season the same amount of fertilizer was used as before, but it was applied during two periods, June and mid-July.

A cursory comparison of the curves of seasonal rate of photosynthesis and size of fish reveals a certain correspondence between them (Fig. 1*a* and *b*). To show the relation more clearly, diagrams were made (Fig. 1*c*). It was thought that three periods in time would be of importance in affecting the population size and growth of the new crop of insect larvae hatching in early summer and which would be fed upon by the young juvenile red salmon that had hatched earlier that spring. The period following July fertilization of the year prior was considered important to the survival of the brood stock of insect larvae which was to produce the new generation to be utilized by the fish. Periods following both the June and July fertilizations would influence the growth and survival of the newly hatched larvae. Thus, in Fig. 1*c* the length the first-year juvenile salmon attained each year is plotted against the mean rate of photosynthesis after the June and July fertilizations of that year and the period following the July fertilization of the preceding year. All three periods were weighted equally in establishing the mean. In a somewhat similar manner, smolt size was plotted against the mean rate of photosynthesis over those periods mostly responsible for the development of insect larvae upon which the fish feed during their lake residence.

It might be supposed, since so many steps exist between the original synthesis of food materials by the phytoplankton and growth of fish, and since fish are affected by so many environmental factors in addition to food supply, that a significant correlation would not exist. Nevertheless, the growth of smolts showed a very close relation with the rate of photosynthesis (Fig. 1*c*). The relationship with juveniles at the end of their first growing season is weaker. However, the figures indicate a much closer relation between fish growth and primary photosynthetic productivity than might have been expected a priori (*3*).

PHILIP R. NELSON

U.S. Fish and Wildlife Service, Washington, D.C.

References and Notes

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2. T. Gaarder and H. H. Gran, *Rappt. et proc. Conseil Intern. Explor. Mer* 42 (1927).
3. A more detailed account of the effects of fertilizing Bare Lake on the red salmon population is in press (*U.S. Fish Wildlife Serv. Fishery Bull.*).

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Role of Cyanoacetic Acid in Production of Lathyrism in Rats by β-Aminopropionitrile

β-Aminopropionitrile (BAPN) is the toxic factor in *Lathyrus odoratus* meal which produces lathyrism in young rats (*1, 2*). The mechanism by which BAPN exerts such profound effects on mesodermal tissue is not known. Metabolic studies have been performed with BAPN in order to gain some knowledge concerning its toxicity. During these investigations, an acidic metabolite of BAPN was discovered in phenol extracts of rat urine. This metabolite has been isolated from the urinary phenols and crystallized (*3*). The chemical structure of the crystalline derivative has proved to be cyanoacetic acid (*4*). Following an injection of C^{14} cyano-labeled BAPN into rats, 80 to 90 percent of the radioactive material is excreted within 20 hours. Approximately 40 percent of the activity is in unchanged BAPN, and 25 to 30 percent can be recovered in cyanoacetic

Table 1. Changes observed in rats following the feeding of aliphatic amines or nitriles.

Assay	Chemical ingested	No. of rats	Wt. gain (g)	Gross alterations
1	None	3 (0)	2.9	None
2	$HOOCCH_2C{\equiv}N$	4 (0)	2.8	None
3	$NH_2COCH_2C{\equiv}N$	4 (0)	2.8	None
4	None	6 (0)	2.6	None
5	$CH_3CH_2NH_2$	6 (0)	2.6	None
6	$HOCH_2CH_2NH_2$	6 (0)	2.5	None
7	$CH_3CH_2C{\equiv}N$	6 (0)	2.5	None
8	$NH_2CH_2CH_2C{\equiv}N$	6 (4)*	1.8	†

* Rats died during period of feeding.
† Gross alterations: Femur, fibrous proliferation, 6; Vertebra, kyphoscoliosis, 2; Aorta, ruptured, 3.