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RADIONUCLIDE CONCENTRATIONS IN FISH AND INVERTEBRATES FROM BIKINI ATOLL

ABSTRACT

This report is prepared to have in a single document a summary of all of the available data on the concentrations of radionuclides in samples of fish and invertebrates that were collected from Bikini Atoll between 1977 and 1984 for our analysis. Some results were presented in other published reports, and more detailed discussions of previously unpublished results are planned for future publications. Therefore, only a brief discussion of some results is provided here. As in other global studies, ^{137}Cs was found in the highest concentrations in edible flesh of all species of fish and in the lowest concentrations in the bone or liver. The mean concentration of ^{137}Cs in muscle of reef fish from the southern part of the atoll is comparable to the global-fallout concentration measured in market samples of fish collected from Chicago, IL, U.S.A., in 1982. Strontium-90 is associated generally with non-edible parts of fish, such as bone or viscera. Twenty-five to fifty percent of the total body burden of ^{60}Co is accumulated in the muscle tissue; the remainder is distributed among the liver, skin, and viscera. The mean concentration of ^{60}Co in fish has been decreasing at a rate faster than radiological decay alone. Most striking is the range of ^{207}Bi concentrations among different species of fish collected at the same time and place. Highest concentrations of ^{207}Bi were consistently detected in the muscle (and other tissues) of goatfish and some of the pelagic lagoon fish. In other reef fish, such as mullet, surgeonfish, and parrotfish, ^{207}Bi was usually below detection limits by gamma spectrometry. Over 70% of the whole-body activity of ^{207}Bi in goatfish is associated with the muscle tissue, whereas less than 5% is found in the muscle of mullet and surgeonfish. Neither $^{239+240}Pu$ nor ^{241}Am is accumulated significantly in the muscle tissue of any species of fish. Apparently, ^{238}Pu is in a more readily available form for accumulation by fishes than $^{239+240}Pu$. Based on a daily ingestion rate of 200 g of fish flesh, dose rates to individuals through the fish-food ingestion pathway are well below current Federal guidelines.

INTRODUCTION

Bikini Atoll is located in the northern Marshall Islands at about 11°36' N, 165°22' E. The atoll now consists of 23 small coral islands surrounding a lagoon 35-km long, 21-km wide, and 630 km^2 in area. The average depth of the lagoon is 45 m. The total land area of the atoll is 6.2 km^2. The Marshallese island names and the code letters and numbers we have assigned for reference to the islands of the atoll are shown in Table 1.

Bikini Atoll is one of two sites in the northern Marshall Islands used by the United States as testing grounds for nuclear devices from 1946 to 1958. The U.S. code names for the nuclear tests[1] are shown in Table 2, and the approximate locations[2,3] of these tests are indicated in Fig. 1. The locations in Fig. 1 designated by the letter "K" are old disposal sites for island debris removed in the 1969 cleanup of Bikini and Eneu Islands.[4] Most of the tests were detonated on barges anchored in the lagoon or on the reef. Two tests were air drops, two were under water, and three were surface

Table 1. Present islands of Bikini Atoll.

Assigned island locator letter and number[a]	Marshallese name	Assigned island locator letter and number[a]	Marshallese name
B-1	Nam	B-13	Aerokoj-Aerokojlol
B-2	Iroij	B-14	Bikdrin
B-3	Odrik	B-15	Lele
B-4	Lomilik	B-16	Eneman
B-5	Aomen	B-17	Enidrik
B-6	Bikini	B-18	Lukoj
B-7	Bokantauk	B-19	Jelete
B-8	Iomeler	B-20	Adrikan
B-9	Enealo	B-21	Oroken
B-10	Rojkere	B-22	Bokoetoktak
B-11	Eonjebi	B-23	Borkdrlul
B-12	Eneu		

[a] Names and codes underlined designate islands with fishing sites.

Table 2. Announced nuclear detonations at Bikini Atoll.

Test	Date	Type	Map ref. (Fig. 1)
Able	6/30/46	Air drop	A
Baker	7/24/46	Under water	A
Brovo	2/28/54	Surface	B
Romeo	3/26/54	Barge	B
Koon	4/6/54	Surface	C
Union	4/25/54	Barge	D
Yankee	5/4/54	Barge	D
Cherokee	5/20/56	Air drop	E
Zuni	5/27/56	Surface	C
Flathead	6/11/56	Barge	F
Dakota	6/25/56	Barge	F
Navajo	7/10/56	Barge	D
Tewa	7/20/56	Barge	G
Fir	5/11/58	Barge	B
Nutmeg	5/21/58	Barge	H
Sycamore	5/31/58	Barge	B
Maple	6/10/58	Barge	I
Aspen	6/14/58	Barge	B
Redwood	6/27/58	Barge	I
Hickory	6/29/58	Barge	H
Cedar	7/2/58	Barge	B
Poplar	7/12/58	Barge	J
Juniper	7/22/58	Barge	H

explosions. Different quantities of the radioactive fission and activation products, generated during the explosions, were deposited on the lagoon and on the islands of the atoll.

The U.S. moratorium on testing began on October 31, 1958, and marked the end of all nuclear testing at the atoll. However, even today quantities of long-lived fission products, such as ^{137}Cs, ^{90}Sr, ^{155}Eu, and ^{113m}Cd; activation products, such as ^{55}Fe, ^{60}Co, and ^{207}Bi; and transuranium

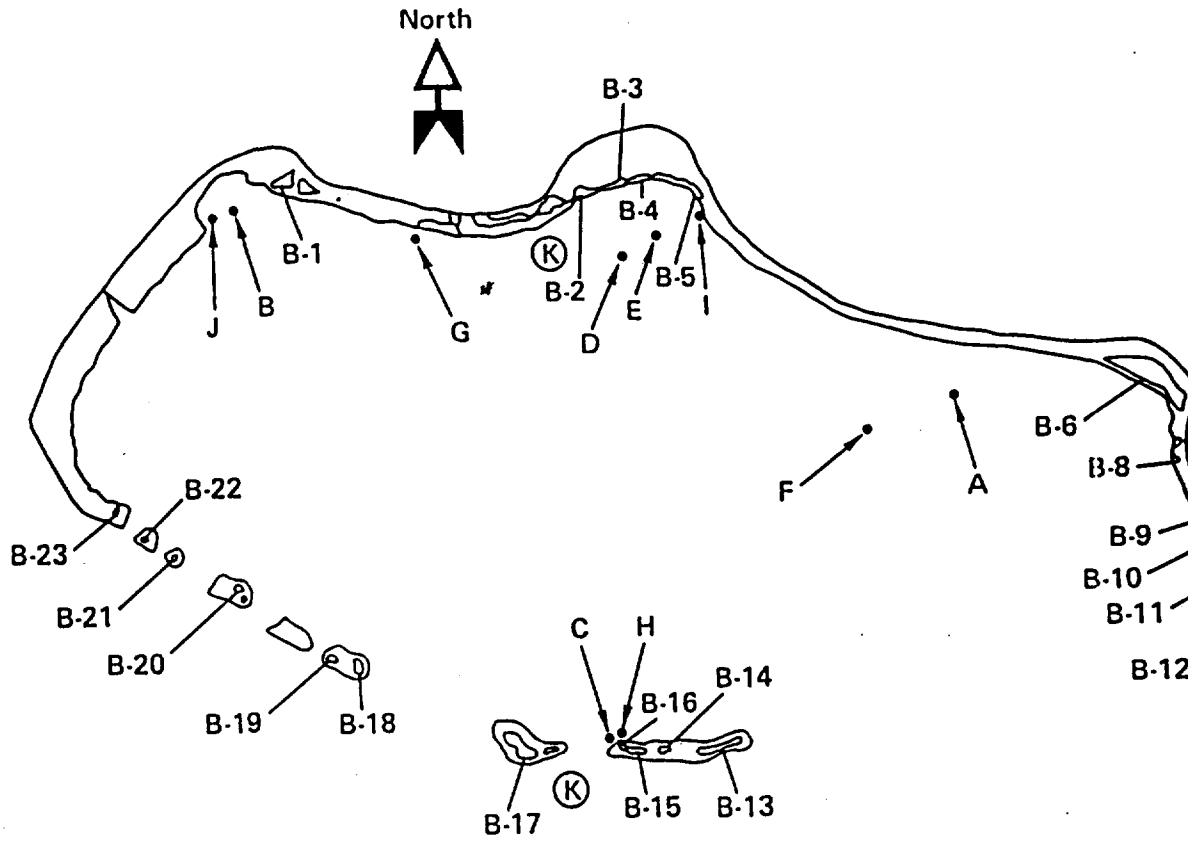

Figure 1. Bikini Atoll showing assigned island locator letters and num
locations of nuclear tests, and soil-disposal sites.

radionuclides, such as ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, and ^{241}Am persist i
atoll's environment. They are accumulated to different levels by indig
terrestrial and aquatic plants and animals that may be used as food by p

In the marine environment, the contaminated lagoon sediments are
major source of man-made radionuclides for fish and other marine organ
In 1977, we initiated detailed studies at Bikini Atoll to define the phy
chemical, and biological transport mechanisms and the fate of transuran
other long-lived radionuclides in this environment. A variety of speci
fish was collected for radionuclide analysis. One objective of our st
was to provide an updated assessment of radiological dose to individual
the marine food pathway, fish being one of the major marine-food produc

the Marshall Islands. Data from this assessment were published in 1982.[5] Our second objective was to evaluate the biological accumulation and behavior of the transuranium isotopes at the atoll. This task continued through 1985.

In conjunction with on-going studies at Enewetak Atoll, the collections and analyses of fish samples were conducted with several additional research objectives in mind. Among these objectives were studies to assess the differences in the concentrations of specific radionuclides in fish from different trophic levels, the magnitude of radionuclide concentration factors for different species of fish, the changes in body burdens of radionuclides in fish with time, the tissue distributions of different radionuclides in different species of fish, the differences in radionuclide concentrations in fish from different regions of the atoll, and the usefulness of the current data for modeling concentrations of radionuclides accumulated by species of fish in similar or different marine environments.

The marine program at Bikini Atoll, supported by the Office of Health and Environmental Research of the Department of Energy, was phased out in 1985. Some of the results generated from this program were discussed in published reports.[6-10] However, a great deal of data on radionuclide concentrations in fish have not been included in the documents referred to above. This report is prepared to have, in one document, all available data on the concentrations of radionuclides in samples of fish and invertebrates that we collected from Bikini Atoll between 1977 and 1984. This document and previously published reports[6-17] contain nearly all of the historical data on concentrations of radionuclides in fish from Bikini Atoll since the initiation of nuclear testing.

The radionuclides for which data are reported include all those detected by gamma spectrometry. In addition, the concentrations of ^{90}Sr, ^{113m}Cd, ^{238}Pu, $^{239+240}Pu$, ^{241}Am, ^{210}Po, ^{210}Pb, and ^{210}Bi are reported for those samples where radiochemical analysis was performed.

COLLECTION METHODS

Throw nets were used exclusively to catch reef fish in shallow water from the islands noted in Table 1. (We used the letter and number island identification system in Fig. 1 rather than the Marshallese name only for convenience.) Large pelagic fish were collected on sport fishing gear while

trolling in the lagoon. All fish were returned to the research ship, segregated by species, sealed in plastic bags, and frozen. The samples w shipped by air to Lawrence Livermore National Laboratory (LLNL), Livermore for processing. Over 1550 fish representing different reef and pelagi species were caught for analysis at Bikini Atoll between 1977 and 1984.

SPECIES COLLECTED, FEEDING HABITS, AND TROPHIC-LEVEL RELATIONSHIPS

The principal species collected are those that are commonly eaten by Marshallese people. These fish are relatively abundant, have differen feeding habits, and, in some cases, represent species for which previou radiological data were available for comparison. The feeding habits ar trophic level assignments described below are from descriptions by Hiatt Strasburg.[18]

Mullet, Crenimugil crenilabis and Neomyxus chaptalii, are herbivoro detrital feeders that ingest considerable quantities of bottom sediment a with their food. Convict surgeonfish, Acanthurus triostegus, are herbivo browsers that feed on small algal fronds and filamentous algae that grow reef rock or on the base of dead coral. Mullet and surgeonfish belong to second trophic level. Goatfish, Mulloidichthys samoensis, consume fossor and other benthic fauna, including small clams, crustaceans, other invertebrates, and small fish. This species belongs to the third troph level. Parrotfish, Scarus sordidus, are common reef-dwelling, grazing omnivores that feed on live coral heads and occasional algae. Parrotfish placed in the fourth trophic level because their food source (live coral p that feed on zooplankton) is assigned to the third trophic level.

Larger benthic, midwater, and surface carnivores were also occasiona collected near islands from the lagoon. Jacks, Caranx melampygus (Ulua) Elegatis bipinnulatus (rainbow runner), are fast-swimming carnivores that on small fish and squid. Elegatis bipinnulatus may occasionally eat swim crustacea. Snappers, Aprion virescens (grey snapper) and Lutjanus bohar snapper), are hovering, midwater-to-surface carnivores. Another snappe Letherinus kallopterus (pigfish), is a bottom dweller that feeds primaril benthic crustacea. Jacks and snappers are in the fourth trophic level. T Euthunnus affinis (bonito) and Gymnosarda nuda (Dog Tooth Tuna), and mack Grammatorcynus billineatus, are large, rapid-swimming carnivores that fee

small fish and any other prey of proper size. They represent species of the fifth trophic level. In the remainder of this report, common names rather than scientific names will be used for convenience.

SAMPLE PROCESSING AND ANALYSIS

Sample processing and analysis began with counting and partially thawing the fish from each location. The total weight, length, and sex of each fish was recorded. Each fish was dissected into muscle tissue, bone (cranial, thoracic, vertebrae, ribs, pelvic and pectoral girdle), skin and scales (fins discarded), stomach (gizzard) contents, liver, and remaining viscera that generally included large and small intestines with contents, stomach wall, spleen, kidney, and mesenteries. The concentrations determined in the viscera samples are regrettably less descriptive than those for other tissues because of the matrix of organs and tissues represented. In some instances, however, a finer division of the visceral components was made. Each separate tissue and organ of the species from the same catch was pooled. It was necessary to pool tissues from a particular catch for analysis because of the low concentrations of transuranic radionuclides anticipated in edible muscle tissue. This resulted in the mixing of fish from several populations (weight classes) and of different sexes. Because mixing masked any differences in concentration related to weight (size), sorting of different size classes for processing was accomplished, in some instances, to assess the relationship of radionuclide concentration with weight. We were unable to relate any differences in concentrations of specific radionuclides with sex. Gills were separated from the fish but not analyzed. Our experience at Bikini and Enewetak Atolls showed that gills were frequently contaminated with sediment. Gills are not eaten and questionable information would be gained from their analysis because of the possible contamination.

After the wet weight was determined, each pooled fish tissue sample was dried in ovens at 90°C to constant dry weight and ashed in muffle furnaces at 450°C. The only samples not prepared in this way were the samples to be analyzed for ^{210}Po. In those cases, wet tissues and organs were used.

The scientific objectives for the analysis of fish in the Marshall Island program changed over the years. For example, initially fish were collected to assess the concentration of radionuclides in tissues of different species of

Table 3. Mean dry/wet weight ratios of fish tissues and organs.

Fish common name	Tissue or organ - mean dry/wet wt ratio					
	Muscle	Bone	Gizzard contents	Viscera	Skin	Liver
Mullet						
Crenimugil	0.23±0.01	0.60±0.07	0.62±0.05	0.35±0.07	0.53±0.05	0.24±0
Neomyxus	0.23±0.01	0.58±0.03	0.58±0.03	0.41±0.06	0.51±0.03	0.28±0
Surgeonfish	0.22±0.01	0.59±0.03	0.15±0.04	0.19±0.04	0.38±0.03	0.23±0
Goatfish	0.23±0.02	0.52±0.05	0.22±0.08	0.29±0.05	0.50±0.05	0.25±0
Parrotfish	0.22±0.04	0.56±0.02	0.44±0.09	0.41±0.04	0.43±0.03	0.40±0
Ulua	0.24±0.01	0.65±0.02	0.19±0.03	0.26±0.03	0.41±0.03	0.27±0
Jack	0.24±0.01	0.62±0.05	0.25±0.03	0.25±0.02	0.38±0.05	0.25±0
Rainbow runner	0.26±0.01	0.62±0.03	0.22±0.02	0.32±0.05	0.48±0.02	0.33±0
Snapper	0.23±0.01	0.61±0.05	0.11±0.04	0.23±0.01	0.44±0.07	0.27±0
Mackerel	0.24±0.01	0.54±0.03	0.26±0.02	0.25±0.02	0.35±0.02	0.26±0
Bonito	0.29±0.01	0.64±0.02	0.24±0.02	0.22±0.01	0.56±0.01	0.32±0

fish. As the program progressed, dose assessment became an important issue so our attention focused on the analysis of edible muscle tissue from fish collected at different locations. Later our interests shifted to evaluate t concentrations in muscle among different species collected simultaneously fr the same lagoon location. As a result, not every tissue and organ separate from the fish collected over the years were processed for radionuclide analysis.

The mean dry/wet weight ratios for the tissues and organs most frequent analyzed are shown in Table 3. The dry/wet weight ratios of the stomach contents are of particular interest, because the differences noted attest t the different feeding habits of different species. The percentage that th organ or tissue was of the whole body fresh weight was also determined for several species. These values are given in Table 4.

The ashed samples were transferred to aluminum or plastic containers, sealed, and analyzed by gamma spectrometry at LLNL using a variety of Ge(Li diode detector systems. Counting times were usually 1000 min or longer fo each sample. A general purpose computer program, called GAMANAL,[19] was use

Table 4. Mean percent of whole body weight of tissues and organs of fish.

Tissue or organ	Mean %				
	Crenimugil	Neomyxus	Surgeonfish	Goatfish	Snapper
Muscle	58.9	55.3	66.3	66.3	76.7
Bone	6.9	5.5	8.0	8.0	9.1
Skin	7.1				
Scales	7.0	*			
Skin and scales	14.1	14.1	11.6	11.6	9.3
Eyes	1.2	0.7	1.2	2.6	1.8
Ovary	1.0	2.4	1.5		
Testes	1.8	1.2	1.1		0.23
Gill	1.8	1.4	1.6		0.7
Liver, viscera, and gizzard	13.6		7.9		
Viscera and gizzard	12.7	17.9	7.2	6.5	1.8
Viscera and liver	11.8				
Viscera	10.9	16.1	6.5		
Gizzard	1.8	1.8			
Liver	0.9	1.7	0.7	0.4	0.5
Gizzard contents	0.7	0.7	0.7	0.08	0.03

for the data reduction of all gamma-ray spectra. In GAMANAL, the observed photopeak in the measured spectra is compared with a library of gamma-ray fission and activation products and naturally occurring radionuclides to identify the radionuclides in the sample. The program then applies correction factors for sample size, density, counting time, counting geometry, and decay to convert the measured counting rate to pCi/g of sample on the date of collection. The program also generates an upper-limit amount of specific spectral radionuclides based on those spectral regions where signals would be seen if the radionuclide were present in detectable quantities. Our minimal detectable concentrations (based on a counting time of 1000 min) for each of the longer-lived, man-made, gamma-emitting radionuclides routinely or occasionally detected in samples from the Marshall Islands are shown in Table 5.

Table 5. Detection limits (1σ) of selected gamma-emitting radionuclides ir the Bikini Atoll environment as a function of sample size.

Sample size (g)	pCi/sample - 1000 minutes counting time							
	^{40}K	^{60}Co	^{110m}Ag	^{125}Sb	^{137}Cs	^{155}Eu	^{207}Bi	2
3 ± 2	10	1.0	1.0	1.2	0.5	0.9	0.8	
10 ± 5	15	1.6	1.8	1.7	0.8	1.4	1.5	
70 ± 30	20	2.4	3.2	2.9	1.2	2.4	2.2	
160 ± 60	30	3.6	4.5	4.6	1.8	4.0	3.2	

After gamma analysis, a number of samples were selected for radiochemic analysis for ^{90}Sr, ^{137}Cs, ^{113m}Cd, $^{238,239,240}Pu$, ^{241}Am, ^{210}Po, ^{210}Pb, and ^{210}Bi. Activities of these radionuclides were measured using either alpha spectrometer systems or low-background beta detectors. Measurements of the radionuclides were conducted because some were judged to be of potential significance for dose assessments and others were analyzed to meet specifi programmatic objectives. The ^{137}Cs was often radiochemically separated fr muscle tissue and analyzed to confirm the measurements made by gamma spectrometry, which, in turn, provided a useful laboratory calibration fo quality control.

Quality of data has always been an important aspect of our analytica measurements. As a standard practice, 5 to 10% of our time is devoted to quality-assurance work in all projects involving analytical measurements. This quality-assurance work includes

- Analysis of background samples and blanks.
- Instrument calibration.
- Duplicate sampling and analysis.
- National and international interlaboratory standardization.
- Replicate measurements.
- Analysis and calibration traceable to National Bureau of Standar samples.
- Appropriate statistical analysis of the results.

RESULTS AND DISCUSSION

Collection information, such as island sampled, common and scientific names of fish, number of fish pooled per sample, sex, average whole body weights, and average lengths, is presented in the odd-numbered tables in the Appendix. There is an odd-numbered table for fish for each collection period and a final odd-numbered table for invertebrates. Each of these tables is followed by an even-numbered table showing the radionuclide concentrations in the separated tissues and organs from the species collected. The radionuclides detected most frequently in the muscle tissue and other organs by gamma spectrometry included (in addition to naturally occurring ^{40}K) ^{137}Cs, ^{60}Co, and ^{207}Bi. Occasionally the radionuclides ^{155}Eu, ^{241}Am, ^{125}Sb, ^{108m}Ag, ^{102m}Rh, and ^{113m}Cd were also detected (by gamma spectrometry) in the viscera, liver, or stomach (gizzard) content samples of fish collected from the more contaminated regions of the atoll. The concentrations of the transuranics and other radionuclides in tissues and organs analyzed by wet chemical methods are also listed. The locations of the islands sampled (island locator letter and number) are shown in Fig. 1. All concentrations are listed relative to dry weight, but the dry/wet weight ratios provided may be applied to convert concentrations to a wet-weight basis.

Representative whole fish concentrations of several radionuclides were reconstructed from the tissue and organ concentration data, and the percentages of the respective tissues to whole body weight are given in Table 4 for species representing three trophic levels (surgeonfish, mullet, trophic level II; goatfish, trophic level III; snapper, trophic level IV) collected from different islands of the atoll in 1978. These values were used to compute the percent of the whole body activity associated with the respective tissues. The results from these calculations are shown in Table 6 and are discussed in the following sections.

CESIUM-137 IN FISH

The results in Table 6 show that most ^{137}Cs accumulated by fish from the atoll is found associated with the edible flesh; the lowest percentages are associated with bone or liver. Concentrations of ^{137}Cs in the flesh of all four species are approximately equivalent to the concentration in the reconstructed whole body. There is no straightforward relationship between

Table 6. Reconstructed total body radioactivity associated with tissues and organs analyzed[a] and measured muscle-tissue concentration.

Radionuclide	Common name of fish	Island locator	Percent of total body activity in tissue or organ						Reconstructed whole fish concentration pCi/kg wet wt[b]	Measured muscle tissue concentration pCi/kg wet
			Muscle	Bone	Skin	Liver	Viscera	Gizzard contents		
^{137}Cs	Surgeonfish	B-10	75	0.7	15	0.5	2	0.7	42	47
	Mullet	B-1	53	0.3	13	2	26	1	206	198
	Goatfish	B-27	68	<0.9	7	<0.4	17	<0.2	47	48
	Snapper	B-23	92	<0.3	4	<0.2	0.7	10.01	123	147
^{90}Sr	Surgeonfish	B-10	2	46	10	0.2	34	1	23	0.62
	Mullet	B-5	0.06	2	3	0.07	82	8	518	0.52
	Goatfish	B-17	2	40	29	0.05	22	<0.1	109	3.2
	Snapper	B-1	0.9	63	34	<0.1	<0.1	<0.02	19	0.23
^{60}Co	Surgeonfish	B-10	36	6	19	12	17	4	47	26
	Mullet	B-23	28	3	17	22	25	0.5	810	410
	Goatfish	B-17	38	2	12	5	35	0.3	462	263
	Snapper	B-23	48	0.1	14	25	11	0.1	331	206
^{207}Bi	Surgeonfish	B-10	<18	<13	<9	33	19	<3	2	<0.6
	Mullet	B-23	5	1	4	5	76	5	54	4
	Goatfish	B-17	67	4	10	1	10	<0.1	225	226
	Snapper	B-23	81	<0.1	3	2	2	<0.01	279	330
$^{239+240}Pu$	Surgeonfish	B-10	0.2	5	3	2	80	4	29	0.1
	Mullet	B-23	0.2	0.5	0.5	5.3	82	7	380	1.1
	Goatfish	B-17	0.1	0.7	0.9	0.8	90	0.1	44	0.07
	Snapper	B-1	4	26	50	11	6	0.3	2	0.1
^{241}Am	Surgeonfish	B-10	0.1	2	2	1	85	5	12	.03
	Mullet	B-23	0.9	0.2	0.5	4	69	21	69	1.0
	Goatfish	B-17	0.1	1	1	1	89	0.2	14	0.03
	Snapper	B-1	2	24	51	17	5	0.3	1	0.04

[a] Muscle, skin, bone, liver, viscera, and gizzard contents account for 93 to 98% of total fish weight. Data are from 1978 collections. Concentrations in gills, eyes, and reproductive organs were not determined.

[b] $$\frac{\left(\Sigma \frac{\text{pCi}}{\text{kg wet tissue}} \times \%\ \text{tissue of whole body wt}\right)}{\Sigma\ \%\ \text{tissue of whole body wt}} = \frac{\text{pCi}}{\text{kg wet wt}}\ \text{whole fish}$$

Table 7. Mean concentrations of ^{137}Cs in the flesh of reef and pelagic fish from different islands and during different collection periods.

Island locator	Number of samples	^{137}Cs (pCi/kg wet wt) Mean	Range
B-1	11	265 ± 111[a]	130-460
B-5	9	181 ± 138[a]	40-370
B-6	12	66 ± 70[a]	12-240
B-10	3	26 ± 18[a]	14-50
B-12	6	24 ± 20[a]	7-62
B-13	2	16 ± 7[a]	11-21
B-17	6	42 ± 28[a]	12-90
B-23	2	33 ± 16[a]	20-45
Pelagic species	13	164 ± 113[b]	60-380
All reef fish (all lagoon locations)			
1977-1978	28	119	
1980-1981	11	146	
1982-1984	12	97	
1977-1984	51	113	

[a] Mean concentration for all mullet, surgeonfish, goatfish, and parrotfish collected between 1977 and 1984.
[b] Mean concentration from all pelagic species collected between 1977 and 1984.

the trophic position of the fish and their muscle burden of ^{137}Cs. The largest fraction of the ^{137}Cs is found in the muscle tissue of the fourth-trophic-level fish, snapper, and the lowest fraction in the second-trophic-level fish, mullet. However, surgeonfish, also a second-trophic-level species, have a larger fraction of the total ^{137}Cs in muscle tissue than is found in the third-trophic-level fish, goatfish.

The data on the concentrations of ^{137}Cs in the muscle tissue of fish are presented here in several ways to help in the interpretation of results. Table 7 contains a summary of the mean and range of ^{137}Cs concentrations (no corrections were made for radioactive decay) in the muscle tissue of reef fish

from different islands and of pelagic species from the lagoon during the
period. Concentrations of ^{137}Cs in the muscle tissue of all species of
during this period ranged from 7 to 460 pCi/kg wet weight. The maxim
concentration of ^{137}Cs in flesh, 460 pCi/kg wet weight, was measured
surgeonfish collected from island B-1 in 1983, and the mean concentratio
the flesh of all reef fish during the 8-year period was 113 pCi/kg we
weight. The computed annual whole-body dose-equivalent rate to individ
from ^{137}Cs in the fish ingestion food pathway would have been less than 1
(assuming a consumption rate of 200 g of fish flesh per day and a
concentration of 113 pCi/kg wet weight).

Between 1977 and 1984, generally higher concentrations of ^{137}Cs w
measured in muscle of reef fish from the northwest quadrant of the atoll
to B-5), and the lowest levels were found associated with reef species
the eastern reef of the atoll. In 1982, marine fish fillets purchased
stores in the Chicago area of the United States, contained 23±2 pCi/kg
^{137}Cs derived from global fallout.[20] Table 7 shows that the mean
concentrations of ^{137}Cs in fish from islands B-10 to B-23 are now compar
to the fallout levels in the store-purchased fish.

In Table 8 are shown several examples of the different concentratio
^{137}Cs (pCi/kg wet weight) measured in the muscle tissue of different r
species collected from the same island during different years. The m
concentrations determined for all lagoon species during yearly intervals
shown in Table 7. There does not appear to be any precise trend indica
that the concentrations of ^{137}Cs in the muscle of these fish have be
changing over the years at some consistent rate. There also appears to
clear trends of consistent differences in concentrations among the diff
reef species simultaneously sampled from the same location (see Appendix)
1978, for example, at island B-1, the highest concentration among th
different reef species was measured in mullet (Crenimugil). At Island B
1983 and at B-6 in 1980, the concentration in surgeonfish exceeded t
measured concentration in mullet and goatfish. In 1984, the measure
concentration of ^{137}Cs in the muscle tissue of goatfish was larger thar
concentration measured in any of the pelagic species collected off the i
however, at B-6 and B-23 in 1978 and at B-6 in 1980, the concentration
goatfish was lower than the levels detected in pelagic species from t
respective islands.

Table 8. Concentrations of ^{137}Cs in the muscle tissue of fish collected from locations at Bikini Atoll at different times.

Period sampled	^{137}Cs (pCi/kg wet wt)					
	Mullet (Crenimugil)		Surgeonfish (Acanthurus)		Goatfish (Mulloidichtys)	Mullet (Neomyxus)
	B-1	B-6	B-1	B-5	B-6	B-17
1/77	263					40
11/78	397		133	226	21	12
9/80		51			12	
2/81	227	60		320		
8/83	287		430	43		
9/84		53			16	13

Unless there is some unforeseen impact on the lagoon, such as the disposal of uncontained, contaminated soil to the lagoon floor, there should be no significant change in the mean concentration of ^{137}Cs in the flesh of fish collected from Bikini in the near future (other than a continuous reduction from radioactive decay). Any concentrations of ^{137}Cs in the muscle tissue of fish caught at the atoll in future years should fall below the upper limit noted in the last 8-year period. Hence, future dose rates to individuals from ^{137}Cs in the fish-food pathway may be predicted with a reasonable degree of certainty from a knowledge of the islands to be fished, the consumption rate of reef and pelagic fish, and parts of the fish normally eaten.

STRONTIUM-90 IN FISH

Concentrations of ^{90}Sr were measured in the tissues from a small subset of the fish, primarily from the collections made in 1978. Inspection of Table 6 shows that most of the ^{90}Sr accumulated by fish is, unlike ^{137}Cs, associated with non-edible parts such as bone and viscera. In surgeonfish, goatfish, and snapper, most of the body burden of ^{90}Sr is found in the bone tissue. In mullet, however, the viscera contains the major fraction of ^{90}Sr. The high concentration of ^{90}Sr in the viscera is probably due to ^{90}Sr associated with the bottom sediments, which are ingested with food and are

present in the intestinal tract. Intestinal tract contents were not separ from the viscera sample.

Concentration of ^{90}Sr in the muscle tissue from all fish ranged from (to 5.7 pCi/kg wet weight. The mean concentration in muscle tissue is 1.7 pCi/kg wet weight. At this concentration and a consumption rate of 2(of muscle tissue/d, the resulting mean dose-equivalent rate from ^{90}Sr in marine fish-food ingestion pathway is less than 0.1 mrem/y. Concentration ^{90}Sr associated with muscle tissue are less than 3% of the concentration the reconstructed whole fish (Table 6). Estimated dose-equivalent rates ^{90}Sr from muscle only or from whole fish ingestion will differ by orders magnitude. Therefore, it is misleading to use whole fish (or eviscerat whole fish) concentration data for ^{90}Sr to estimate radiological dose t individuals from ^{90}Sr in the marine fish-food pathway.

COBALT-60 IN FISH

Between 1958 (the end of nuclear testing at the atoll) and 1984, 6(levels in the atoll environment decreased by a factor of 5 from radioact decay alone ($t_{1/2}$ = 5.26 y). However, measurable concentrations of ^{60}Co still found in fish and other aquatic organisms. In fish, 25 to 50% of total body burden of ^{60}Co is present in the muscle tissue, with most of remainder distributed among the liver, skin, and viscera (see Table 6). levels of ^{60}Co in the muscle tissue of reef fish from different regions ir atoll differ somewhat in the same way as that of ^{137}Cs except that fish t the southwest portion of the atoll contain concentrations comparable to t in fish caught in the northwest quadrant of the atoll. Concentrations of in the muscle tissue of bottom-feeding mullet and goatfish were consiste higher than levels in other reef species, such as surgeonfish and parrotf and in pelagic species caught from the same island of the atoll. This pa is repeated when concentrations in other tissues and organs of the diffe species are compared.

In Table 9 are shown mean concentrations in the muscle of reef ar pelagic fish collected from the lagoon during different periods between and 1984. The mean concentration of ^{60}Co in the muscle tissue of fish been decreasing at a rate faster than that from radiological decay alor When appropriate data were found, a comparison was made between the concentrations in specific tissues and organs measured in the 1977-to-1

Table 9. Mean concentrations of ^{60}Co in the muscle tissue of reef and pelagic fish collected at different times.

	Collection year intervals	Number of samples	^{60}Co (pCi/kg wet wt) Mean concentration	Range in concentrations
All reef species	1977-1978	27	235±209	19-897
	1980-1981	12	146±110	31-430
	1982-1984	12	60±51	7-180
All pelagic species	1977-1978	4	166±124	
	1981-1984	6	81±56	43-199

collections to those detected in the same tissues of the species collected from the same locations during 1964 and 1969.[11,13] A least-squares fit of the appropriate present and historical data shows that the mean level of ^{60}Co has been declining in the tissues of fish from Bikini with an effective decay constant of $0.22 \pm 0.05\ y^{-1}$ (effective half-life of 3.2 y). The effective decay constant is the sum of the physical decay constant ($0.1317\ y^{-1}$) and an environmental loss rate term that reflects the removal rate of ^{60}Co. This removal rate is usually expressed as the ecological half-life (or decay constant) and has a value for ^{60}Co of 7.8 y. The disappearance of ^{60}Co from Bikini lagoon and its availability to fishes is controlled both by radiological decay and by processes of remobilization, transport, and dilution. If ^{60}Co continues to decline in the environment at the present rate, the mean concentration of ^{60}Co in the edible muscle tissue of fish from the lagoon should be less than 20 pCi/kg wet weight by the year 1990.

BISMUTH-207 IN FISH

The presence of ^{207}Bi ($t_{1/2}$ = 33.4 y) was first reported in marine samples obtained from the Pacific Proving Grounds in 1961.[21] It was formed possibly from a series of nuclear reactions such as $^{207}Pb(p,n)$ or $^{206}Pb(p,\gamma)$, assuming stable lead was present during testing as shielding material near the nuclear devices.[22] Other than a recent report describing ^{207}Bi as a component

in global fallout debris,[23] it has not been detected elsewhere as a compone of any waste discharged to aquatic environments from nuclear facilities.

Most striking was the range of concentrations found in tissues and orga among different species of fish collected at the same time and place (see Appendix). For three species of reef fish, mullet, surgeonfish, and parrotfish, ^{207}Bi in most parts of the fish was usually below detection limi by gamma spectrometry. However, the radionuclide was consistently detected the muscle and other organs of goatfish and the pelagic lagoon fish. Over 7 of the whole-body activity of ^{207}Bi in goatfish and pelagic fish is associat with the muscle tissue, whereas less than 5% (when detected) is found in th muscle of mullet and surgeonfish. Between 1977 and 1984, the concentration in goatfish muscle ranged from a high of 1360 pCi/kg wet weight to a low o 17 pCi/kg wet weight, with the lowest levels found in fish collected from t eastern reef of the lagoon. There was no clear trend in the data to indica that the concentration of ^{207}Bi in the muscle of goatfish was changing wit time at some constant rate. At B-1 and B-5, for example, the levels in musc tissue were significantly less during the period of 1981-1983, compared to t concentrations measured in 1978. On the other hand, at B-6 and B-12, the concentrations measured in the muscle tissue of goatfish collected in 198 were no different than the concentrations detected in 1978.

TRANSURANIUM RADIONUCLIDES IN FISH

Several reports on the concentrations of the transuranium elements i Bikini fish have been published by this laboratory.[9,10,24] Only previousl unpublished results and a few highlights from published data will be discus in this report.

The data in Table 6 show that both $^{239+240}Pu$ and ^{241}Am are not significantly accumulated in the muscle tissue of any species of fish. Le than 1% of the total body burden of both $^{239+240}Pu$ and ^{241}Am is associate with the muscle tissue of all reef species. Somewhat higher fractions, bu lower concentrations, were found associated with muscle tissue of pelagi species. The distributions of $^{239+240}Pu$ and ^{241}Am among the other tissues the reef and pelagic species are also different. For example, the bone a skin of reef fish contain much less of the total body burden than that o

snapper. These differences appear to be independent of location and the level of contamination and much more dependent on species.

Arithmetic mean concentrations of $^{239+240}Pu$, ^{238}Pu, and ^{241}Am in edible muscle tissue from all fish collected at Bikini during different periods between 1977 and 1984 are shown in Table 10. The results also show that there has been essentially no change in the mean concentration of $^{238+240}Pu$ during the years of collection. Mean concentrations of the transuranic radionuclides in the flesh of fish from Bikini Atoll are a fraction of a pCi/kg wet weight. Barring any major impact on the lagoon environment that might affect the availability of the transuranic radionuclides to marine organisms, mean concentrations in the flesh of fish collected over the next 10 to 20 years should not differ greatly from present-day values. The 30-y committed-dose equivalent to the bone marrow of individuals from the transuranic radionuclides in the fish-flesh-ingestion pathway (using 200 g/d as the ingestion rate and the mean value for flesh concentration) ranges from 3 to 6 mrem. This range results from increasing the adult gut-transfer coefficient for plutonium[9] from 1×10^{-4} to 5×10^{-4}.

In fish with relatively high body burdens of $^{239+240}Pu$, the ^{238}Pu to $^{239+240}Pu$ activity ratio in the muscle and other internal organs was usually higher than the activity ratio found in the material ingested by the fish. In many cases, the error associated with the measurements of ^{238}Pu was large, and it could be argued that the differences among the samples were not real.

Table 10. Summary of transuranic concentrations in the flesh of all fish from Bikini Atoll.

		pCi/kg wet wt [a]		
	Period	$^{239+240}Pu$	^{238}Pu	^{241}Am
Arithmetic mean	1977-1978	0.39±0.34		
	1977-1981	0.37±0.32		
	1977-1984	0.29±0.30	0.020±0.021	0.18±0.28
Range in values	1977-1984	<0.007-1.1	<0.002-0.08	<0.01-1.1

[a] If the radionuclide concentration was below limits of detection, the value of the concentration was not included in the average.

However, the patterns repeat themselves regardless of the error associated with counting, indicating that the trends found for the different ratios among the tissues and gut-content samples of the fish are real. This pattern pointed to the possibility of discrimination between isotopes of plutonium, which is difficult to accept from a purely chemical viewpoint. The following steps were taken to analyze if discrimation between the isotopes of plutonium was taking place. Gizzard and intestinal contents were removed from samples of mullet collected from the more-contaminated regions of Bikini and equilibrated with seawater for 5 hours. (Five hours is the normal time for the ingested material to pass through the gut of mullet.) From this experiment, the ^{238}Pu:$^{239+240}Pu$ activity ratio was determined in the solid phase and in solution. Five sets of results are shown in Table 11. In every case, more ^{238}Pu relative to $^{239+240}Pu$ is measured in solution, which indicates that ^{238}Pu in the material ingested by fish must be in a more readily soluble form than $^{239+240}Pu$.

The concentrations of $^{239+240}Pu$ and ^{241}Am in fish from the lagoon differ markedly from organ to organ and species to species. Less than 20% of the samples showed the same relative amounts of ^{241}Am and $^{239+240}Pu$ in the body parts analyzed. Concentrations of plutonium in most fish parts from any location collected during different years have comparable concentrations, showing that the fish maintain restricted feeding territories. The concentration ratio of ^{241}Am to $^{239+240}Pu$ in muscle, bone, skin, or liver was always either equivalent to or less than the ratio in the gut contents or

Table 11. Activity ratios of ^{238}Pu:$^{239+240}Pu$ in liquid and solid phases of gut contents after equilibration with seawater.

Solid phase	Liquid phase	Solid:liquid phas
0.0081	0.13	0.062
0.048	0.11	0.43
0.003	0.14	0.021
0.010	0.22	0.045
0.0034	0.27	0.13

viscera. If the internal body burdens of transuranic nuclides are accumulated by the fish through the gut, then it could be concluded that in most cases there is a discrimination against ^{241}Am relative to $^{239+240}Pu$ in different tissues.

The radionuclides ^{242}Cm, ^{243}Cm, and ^{244}Cm have been detected in some fish tissues from Bikini. Concentrations of ^{243}Cm and ^{244}Cm are a few percent of the $^{239+240}Pu$ concentrations and ^{242}Cm is less than 1% of the $^{239+240}Pu$ levels in the entire fish. The detection of ^{242}Cm ($t_{1/2}$ = 163 d), approximately 25 years after the end of testing, indicates the presence of a parent radionuclide, ^{242m}Am, in the environment.

OTHER RADIONUCLIDES IN FISH

Concentrations of ^{113m}Cd and naturally occurring ^{210}Pu, ^{210}Po, and ^{210}Bi determined in fish samples are listed in the Appendix. Discussions of the concentrations and significance of these radionuclides at Bikini Atoll have been presented in the literature[6-8] and will not be repeated here.

RADIONUCLIDES IN INVERTEBRATES

Edible species of clams and a few other invertebrates were sometimes collected by hand (free diving) in shallow areas of the lagoon. Collections for radionuclide analyses were terminated in 1980 for fear of depleting this valuable food resource at the atoll. Radiological concentration data from analysis of these few samples are included here for reference.

The clams were weighed, measured (total length), and dissected. Adductor muscles, mantle plus siphon, kidney, and remaining viscera that included gills, gonad, stomach, intestine and contents, crystalline style, heart, and nervous system were removed for analysis. Tissue samples were dried in ovens at 90°C to constant dry weight and dry ashed in muffle furnaces at 450°C for approximately 72 hours. Radionuclide concentrations in tissues of invertebrates were determined by the same procedures used to measure concentrations in fish tissues (see Sample Processing and Analysis, page 7). Collection information and radionuclide concentrations are shown in Tables A-15 and A-16 of the Appendix.

Too few samples were collected and analyzed to develop trends or meaningful relationships with the concentration data. However, it is noted

that the concentrations of $^{239+240}Pu$, ^{241}Am, and ^{60}Co were consistently higher in the edible tissues of invertebrates than in the flesh of fish collected at comparable atoll locations. Highest levels of ^{60}Co were associated with the kidneys of each species of clams. Concentrations of ^{207}Bi, ^{137}Cs, and ^{90}Sr in the edible mucsle and mantle tissue were very low and, in most cases, were undetectable in the samples analyzed.

SUMMARY

Over 1550 fish representing species from all trophic levels were collected from regions of Bikini lagoon between 1977 and 1984. Concentration of gamma-emitting radionuclides accumulated in the different tissues and organs of these fish were determined. A number of samples were selected for the radiochemical analysis of ^{90}Sr, ^{113m}Cd, $^{238,239,240}Pu$, ^{241}Am, ^{210}Po, ^{210}Pb, and ^{210}Bi. Activities of these radionuclides were measured in the tissues using appropriate alpha-spectrometer systems or low-background beta detectors. All the radionuclide concentration data are tabulated in the Appendix.

Over the 8-year period, a reasonable amount of data was developed to define adequately the range in concentrations of the different radionuclides in edible muscle tissue and other organs of fish from the lagoon at Bikini Atoll. Unless there is some unforeseen impact on the lagoon that would significantly alter the environmental concentrations of the different radionuclides, there is little reason to expect that concentrations of the different radionuclides in fish in future years will exceed the upper concentration limits determined over the last 8-year period. The present mea levels of radionuclides in edible muscle tissue of fish can be used with a reasonable degree of confidence to predict the magnitude of future radiological doses to individuals from the marine fish-food pathway at Bikin Atoll.

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APPENDIX A: CONCENTRATION DATA

TABLE OF CONTENTS

Table A-1. 1977 Fish collections - Bikini Atoll.

Island locator	Month collected	Common name	Scientific name	Number of individuals pooled/sample	Average whole body wet wt (gm)	Average standard length (mm)	Male	Female
B-1	January	Mullet	Crenimugil crenilabis	8	n/d[a]	325	1	7
B-2	January	Mullet	Crenimugil crenilabis	21	n/d	287	11	10
B-12	January	Mullet	Crenimugil crenilabis	11	n/d	271	1	10
B-13	January	Mullet	Crenimugil crenilabis	22	n/d	279	0	22
B-1	January	Mullet	Neomyxus chaptalii	14	n/d	221	5	5
B-10	January	Mullet	Neomyxus chaptalii	43	n/d	226	11	32
B-17	January	Mullet	Neomyxus chaptalii	58	n/d	229	9	47

[a] "n/d" means not determined.

Table A-2. 1977 Concentrations of radionuclides in fish tissue - Bikini Atoll.

Sample ID	Island locator	Tissue	Dry/wet weight	pCi/kg dry weight[a]							
				^{40}K ($\times 10^3$)	$^{239+240}Pu$	^{241}Am	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu	Other
Name:	Mullet - Crenimugil										
2896	B-1	Muscle	0.253	15.1 (2)	1.5 (5)		1040 (3)	1200 (2)	<4	<0.02	
2897		Bone	0.585	1.3 (13)	19.0 (3)		38 (23)	540 (7)	<5	0.93 (8)	
2898		Viscera[b]	0.414	4.0 (8)	6300 (2)		750 (5)	4150 (1)	140 (12)	29.5 (3)	
2899		Stomach cont.	0.645	2 (35)	7340 (1)		740 (8)	680 (6)	190 (18)	53 (3)	
2900		Ovary	0.232	10 (16)	58 (2)		540 (29)	7400 (5)	300 (29)	0.9 (50)	
2901		Gill	0.189	2.2 (12)	120 (25)		150 (19)	6350 (1)	<10	1.0 (28)	
2902		Skin	0.532	4.7 (4)	134 (7)		320 (5)	1610 (1)	23 (26)	5.6 (6)	
2880	B-2	Muscle	0.245	16.4 (1)	2.2 (5)		1550 (2)	1110 (1)	<2	0.10 (25)	
2881		Bone	0.629	0.9 (11)	38.0 (3)		55 (14)	280 (4)	<5	1.33 (5)	
2882		Viscera[b]	0.317	5.9 (3)	13700 (6)		1660 (14)	7500 (1)	104 (11)	590 (2)	^{102m}Rh 50 (20)
2883[c]		Stomach cont.	0.637	1.6 (24)	25300 (5)		1840 (3)	1710 (4)	252 (10)	1090 (2)	^{102m}Rh 95 (19)
2883[c]		Stomach cont.	0.637		25500 (5)					1120 (2)	
2883[c]		Stomach cont.	0.637		28700 (5)					1240 (2)	
2883[c]		Stomach cont.	0.637		28400 (6)					1250 (2)	
2884		Ovary	0.256	9 (30)	46 (5)		1140 (28)	14100 (3)	<200	3 (40)	
2885		Gills	0.229	1.8 (13)	200 (25)		120 (18)	2200 (2)	<9	7.0 (6)	
2886		Testes	0.213		630 (5)		1470 (15)	10500 (9)	<100	19 (24)	
2887		Skin	0.509	4.6 (1)	110 (24)		430 (3)	1030 (1)	<3	6 (14)	
2860	B-12	Muscle	0.235	16.0 (2)	0.56 (6)		110 (6)	320 (6)	<2	<0.01	
2867		Bone	0.575	0.5 (18)	6.9 (3)		<6	90 (13)	12 (26)		
2862		Viscera[b]	0.311	5.7 (2)	710 (1)		53 (12)	1400 (2)	41 (11)	4.3 (6)	
2863		Stomach cont.	0.568	3.0 (21)	1070 (5)		<40	220 (18)	<30	9.4 (12)	
2864		Ovary	0.315	7.3 (10)	10 (6)	6.8 (17)	<40	1060 (6)	<30	<0.4	
2865		Gills	0.226	2.3 (21)	32 (25)		<30	550 (6)	86 (18)	0.5 (23)	
2861		Skin	0.500	4.0 (3)	82 (10)		35 (20)	260 (4)	<4	5.8 (8)	
2851	B-13	Muscle	0.238	16.5 (1)	0.38 (14)		88 (5)	273 (5)	<2	<0.04	
2852		Skin	0.529	3.7 (3)	16 (17)		17 (28)	320 (3)	<4	0.32 (13)	
2853		Bone	0.562	0.8 (10)	7.2 (3)		<5	110 (7)	<3	0.33 (7)	
2854		Viscera[b]	0.309	7.1 (2)	440 (3)		33 (22)	2140 (3)	25 (20)	7.0 (10)	
2855		Stomach cont.	0.709	1.3 (30)	1130 (4)		<30	<40	<20	20.0 (4)	
2856		Ovary	0.298	9.0 (4)	12 (4)	5.0 (6)	<20	1700 (4)	<10	0.5 (35)	
2858		Gills	0.241	1.3 (18)	27 (25)		<20	980 (3)	<10	1.0 (11)	

Table A-2. (Continued)

Sample ID	Island locator	Tissue	Dry/wet weight	pCi/kg dry weight[a] ^{40}K ($\times 10^3$)	$^{239+240}Pu$	^{241}Am	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu	Other
Name: Mullet - Neomyxus											
MSA 458	B-1	Muscle	0.244	12.2 (2)	3.3 (3)		950(3)	2080(3)	<12	0.03(26)	
459		Bone	0.476								
460		Gizzard cont.	0.552		9800 (2)		1100(23)	1400(20)	<150	46.1 (3)	^{155}Eu 3980(12)
461		Gizzard	0.185								
462		Liver	0.237								
463		Intestine cont.	0.450	3.5 (22)			1115(7)	1660(6)	210(16)		^{155}Eu 2880(10)
464		Viscera[d]	0.423								
465		Scales	0.576								
466		Skin	0.342								
2888	B-10	Muscle	0.315	13.0 (2)	2.5 (7)		55 (10)	670 (2)	7.2 (30)		0.04 (70)
2889		Bone		0.5 (21)	8.2 (2)		<5	110 (9)	<5	0.13 (21)	
2890		Viscera[b]	0.338	4.9 (4)	2000 (1)		65 (16)	1650 (1)	77 (10)	11.7 (3)	
2891		Stomach cont.	0.568	2.0 (15)	2970 (5)		<20	300 (8)	60 (21)	14.8 (7)	
2892		Ovary	0.334	5.5 (5)	25 (2)		<20	2300 (2)	<10	<0.07	
2893		Testes	0.210	15 (35)	33 (12)		<300	2400 (16)	<200	2.3 (70)	
2894		Gills	0.182	2.7 (14)	61 (2)		<20	1340 (4)	80 (25)	0.8 (50)	
2895		Skin	0.513	4.4 (4)	8.1 (5)		20 (24)	550 (4)	<4	0.15 (26)	
2872	B-17	Muscle	0.237	14.4 (2)	3.7 (9)	0.4 (33)	167 (4)	1590 (1)	22 (13)	0.37 (22)	
2873		Skin	0.490	4.5 (2)	15.0 (10)		64 (13)	1550 (1)	34 (11)	1.20 (13)	
2874		Viscera[b]	0.392	3.7 (3)	3050 (3)		450 (4)	3000 (1)	920 (2)	510 (2)	^{102m}Rh 180 (6)
2875		Stomach cont.		2.0 (7)	5600 (7)	1010 (2)	1230 (2)	210 (7)	1050 (1)		^{102m}Rh 270 (3)
2876		Ovary	0.331	4.9 (4)	78 (5)		40 (29)	5200 (1)	42 (21)	9.4 (6)	
2877		Gill	0.170	3.3 (11)	190 (6)		<30	3900 (2)	70 (22)	23 (7)	
2878		Testes	0.228		50 (15)		<400	5400 (10)	<300	7.5 (50)	
2879		Bone	0.606	1.1 (14)	16 (5)		<8	410 (3)	<7	1.4 (8)	

[a] Numbers in parenthesis are the 1-σ counting error expressed as percent of the value listed.
[b] Viscera sample includes gizzard (stomach), intestine with contents, and liver.
[c] Replicate analysis.
[d] Viscera sample includes remainder of G.I. tract without contents and gonads.

Table A-3. 1978 Fish collections - Bikini Atoll.

Island locator	Month collected	Common name	Scientific name	Number of individuals pooled/sample	Average whole body wet wt (gm)	Average standard length (mm)	Male	Female
B-1	November	Mullet	Crenimugil crenilabis	12	641	298	11	1
B-5	November	Mullet	Crenimugil crenilabis	8	712	303	5	3
B-13	November	Mullet	Crenimugil crenilabis	8	492	275	3	5
B-17	November	Mullet	Crenimugil crenilabis	9	545	297	0	9
B-1	November	Mullet	Neomyxus chaptalii	18	183	208	13	5
B-5	November	Mullet	Neomyxus chaptalii	24	181	202	12	12
B-12	November	Mullet	Neomyxus chaptalii	21	209	212	13	8
B-17	November	Mullet	Neomyxus chaptalii	18	177	204	9	9
B-23	November	Mullet	Neomyxus chaptalii	35	151	193	23	12
B-1	November	Surgeonfish	Acanthurus triostegus	4	62	109	0	4
B-5	November	Surgeonfish	Acanthurus triostegus	20	65	108	12	8
B-6	November	Surgeonfish	Acanthurus triostegus	55	64	103	31	24
B-10	November	Surgeonfish	Acanthurus triostegus	46	68	108	30	16
B-12	November	Surgeonfish	Acanthurus triostegus	64	64	110	45	19
B-13	November	Surgeonfish	Acanthurus triostegus	31	88	115	8	23
B-1	November	Goatfish	Mulloidichthys samoensis	33	91	162	25	8
B-5	November	Goatfish	Mulloidichthys samoensis	22	147	187	11	11
B-6	November	Goatfish	Mulloidichthys samoensis	39	127	180	26	13
B-10	November	Goatfish	Mulloidichthys samoensis	42	111	173	32	10
B-12	November	Goatfish	Mulloidichthys samoensis	42	91	166	38	4
B-13	November	Goatfish	Mulloidichthys samoensis	31	88	115	8	23
B-17	November	Goatfish	Mulloidichthys samoensis	37	93	171	11	25
B-23	November	Goatfish	Mulloidichthys samoensis	47	86	160	36	11
B-17	November	Parrotfish	Scarus sordidus	5	840	293	0	5
Lagoon (near Bravo Crater)	November	Snapper	Aprion virescens	2	2270	520	1	1
Lagoon (W of B-6)	November	Snapper	Lutjanus bohar	1	2971	530	1	0
Lagoon (Off B-23)	November	Snapper	Lutjanus bohar	1	2214	480	0	1
Lagoon (Near Bravo Crater)	November	Jack	Caranx sp.	1	1125	490	0	1
Lagoon (W of B-6)	November	Mackerel	Grammatorcynus billineatus	1	1879	565	1	0

Table A-4. 1978 Concentrations of radionuclides in fish tissue - Bikini Atoll.

Sample ID	Island locator	Tissue[b]	Dry/wet weight	pCi/kg dry weight[a] ^{40}K ($\times 10^3$)	$^{239+240}Pu$	^{241}Am	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu	Other
Name: Mullet - Crenimugil											
9133	B-1	Muscle	0.245	14.2 (2)	2.6 (5)		1620 (1)	3660 (1)	16 (21)	0.045 (25)	
9134		Bone	0.648	0.6 (18)	93 (3)	20.9 (4)	37 (22)	1360 (2)	<6	1.20 (4)	
9135		Stomach cont.	0.654	1.4 (22)	8000 (20)	5400 (29)	910 (4)	730 (5)	190 (11)	44 (4)	
9136		Viscera	0.413	3.8 (3)		1220 (2)	1000 (2)	4510 (1)	130 (11)		
9137		Skin	0.569	4.0 (5)	33 (2)	10.3 (3)	390 (4)	3450 (1)	<6	0.36 (12)	
9138		Liver	0.253	16.2 (6)			1450 (8)	79200 (1)	460 (15)		^{108m}Ag 340 (14)
7245	B-5	Muscle	0.257	13.9 (1)	1.09 (7)		1450 (1)	947 (1)	<3	0.031 (30)	
7246		Bone	0.611	1.2 (14)	42 (6)		80 (12)	440 (5)	<7	1.0 (13)	
7247		Stomach cont.	0.598	1.7 (23)	10000 (3)	5150 (3)	3400 (2)	760 (5)	40 (33)	210 (1)	
7248		Viscera	0.431	3.8 (6)	4000 (20)	930 (4)	2310 (1)	1920 (2)	40 (15)	148 (1)	
7249		Skin	0.575	4.4 (4)	15.0 (6)	4.2 (7)	400 (4)	890 (3)	<5	0.41 (30)	
7250		Liver	0.291	10.6 (8)	1810 (2)	740 (4)	720 (12)	33400 (1)	<60	39.5 (3)	
7212	B-13	Muscle	0.232		0.36 (7)					0.032 (35)	
7213		Bone	0.593		8.90 (4)					0.22 (21)	
7214		Stomach cont.	0.639		1260 (3)	610 (3)	<20	155 (26)	60 (32)	23.9 (6)	
7215		Viscera	0.404	4.5 (4)	740 (3)	98 (2)	50 (16)	630 (3)	35 (13)	13.6 (2)	
7216		Skin	0.552	4.9 (4)	4.2 (6)		19 (30)	250 (6)	<5	0.08 (40)	
7217		Liver	0.241	17.8 (8)	840 (2)	333 (2)	<90	20000 (1)	<70	20 (16)	
7293	B-17	Muscle	0.222	16.3 (1)	1.25 (6)	0.3 (80)	400 (2)	640 (2)	<3	0.08 (22)	
7294		Bone	0.616	1.4 (11)	23 (5)	5.5 (4)	<9	120 (28)	<6	2.1 (11)	^{244}Cm 0.07 (33)
7295		Stomach cont.	0.305		210 (4)		<200	<500	<300	9.4 (20)	
7296		Viscera	0.212	14.3 (2)	147 (3)		360 (6)	5060 (1)	50 (21)	11.2 (13)	
7297		Skin	0.539	4.9 (4)	11.0 (6)		100 (10)	590 (3)	<6	1.1 (15)	
7298		Liver	0.228	21.0 (7)			560 (22)	29300 (2)	360 (20)		^{108m}Ag 210 (21)
Name: Mullet - Neomyxus											
9127	B-1	Muscle	0.244	11.9 (2)	2.2 (6)	0.50 (12)	810 (2)	1760 (1)	<5	<0.03	^{90}Sr 2.0 (35)
9128		Bone	0.584		27 (4)	9.7 (7)	<20	450 (5)	<13	0.47 (26)	^{90}Sr 211 (4)
9129		Stomach cont.	0.567		7130 (3)	5700 (4)	610 (16)	800 (14)	180 (28)	56.3 (8)	^{90}Sr 4470 (3)
9130		Viscera	0.457	3.2 (4)	3350 (3)	2130 (4)	660 (2)	2220 (2)	150 (6)	22.6 (4)	^{90}Sr 2320 (3)
9131		Skin	0.551	5.3 (4)	11.3 (7)	3.6 (13)	350 (5)	1440 (2)	<7	<0.04	^{90}Sr 164 (2)
9132		Liver	0.266	11.4 (6)	11.4 (7)		690 (13)	43800 (1)	180 (25)		

Table A-4. (Continued)

Sample ID	Island locator	Tissue[b]	Dry/wet weight	pCi/kg dry weight[a]							
				^{40}K (x10^3)	$^{239+240}Pu$	^{241}Am	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu	Other
Name: Mullet - Neomyxus (continued)											
7224	B-5	Muscle	0.243	10.3 (2)	1.1 (12)	0.34 (12)	247 (3)	1000 (1)	<4	0.07 (80)	^{90}Sr 2.2 (25)
7225		Bone	0.572	21.5 (4)	10.8 (5)					0.47 (24)	^{90}Sr 304 (3)
7226		Stomach cont.	0.492		5800 (2)	14700 (6)	1270 (7)	1160 (8)	<60	143 (4)	^{90}Sr 12500 (3)
7227		Viscera	0.441	3.2 (4)	6200 (5)	8800 (5)	410 (3)	1690 (1)	30 (21)	150 (6)	^{90}Sr 5400 (2)
7228		Skin	0.558	12.8 (4)	8.8 (7)	4.5 (7)	150 (12)	2100 (2)	<7	<0.1	^{90}Sr 180 (2)
7229		Liver	0.278	11.3 (5)	1030 (5)	230 (4)	170 (25)	26600 (1)	<40	26.7 (17)	^{90}Sr 80 (31)
7194	B-12	Muscle	0.247	11.9 (1)			36 (11)	403 (2)	<3		
7195		Bone	0.548	0.6 (23)			<9	50 (22)	<5		
7196		Stomach cont.	0.493	4.4 (16)			<40	430 (11)	<30		
7197		Viscera	0.466	3.0 (3)			20 (22)	380 (2)	24 (11)		
7198		Skin	0.540	4.5 (3)			<8	320 (3)	<5		
7199		Liver	0.293								
7299	B-17	Muscle	0.241	8.9 (9)			<50	5160 (2)	<40		
7300		Bone	0.566	0.8 (19)			<9	210 (6)	<7		
7301		Stomach cont.	0.551	3 (36)			380 (19)	1100 (11)	190 (25)		
7302		Viscera	0.465	4.3 (4)			116 (10)	1420 (1)	99 (9)		^{102m}Rh 24 (34)
7303		Skin	0.526	5.1 (4)			50 (22)	600 (3)	<6		
7304		Liver	0.246	12.3 (9)			<70	10600 (2)	190 (26)		
7305	B-23	Muscle	0.232	10.9 (2)	4.7 (3)	4.7 (3)	95 (7)	1770 (1)	19 (20)	0.14 (13)	
7306		Bone	0.569	0.4 (21)	61 (4)	6.7 (4)	<6	700 (2)	18 (22)	2.3 (8)	
7307		Stomach cont.	0.709	1.3 (22)	5000 (20)	2950 (3)	190 (11)	740 (4)	490 (4)	155 (4)	
7308		Viscera	0.426	3.3 (4)	4100 (2)	630 (3)	160 (11)	2680 (1)	540 (2)	140 (2)	
7309		Skin	0.559	4.6 (4)	22 (5)	4.6 (5)	<8	1780 (2)	25 (20)	0.7 (18)	
7310		Liver	0.291	11.4 (6)	4110 (2)	530 (7)	<50	35400 (1)	570 (7)	129 (2)	^{108m}Ag 80 (26)
Name: Surgeonfish - Acanthurus											
9159	B-1	Muscle	0.222	14.3 (3)	5 (20)	2.4 (28)	600 (1)	1050 (2)	<10	<0.5	^{90}Sr 26 (53)
9160		Bone	0.642		48 (7)	11 (11)	<50	<70	<40	1.1 (67)	^{90}Sr 950 (3)
9161		Stomach cont.	0.220				6400 (19)	4000 (63)	<900		
9162		Viscera	0.206	17 (7)	1580 (3)	310 (6)	6750 (2)	4700 (3)	240 (21)	10 (20)	^{90}Sr 850 (4)
9163		Skin	0.393	6 (30)			4600 (5)	650 (19)	<80		
9164		Liver	0.231				1400 (37)	7200 (11)	<500		

Table A-4. (Continued)

Sample ID	Island locator	Tissue[b]	Dry/wet weight	pCi/kg dry weight[a] ^{40}K (x10^3)	$^{239+240}Pu$	^{241}Am	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu	Other
Name: Surgeonfish - Acanthurus (continued)											
7257	B-5	Muscle	0.211	18.0 (1)	0.6 (30)	0.5 (27)	1070 (1)	260 (5)	<4	0.3 (50)	^{90}Sr 6 (27)
7258		Bone	0.471		30 (7)	7.3 (8)	160 (13)	8 (24)	<10	<0.3	^{90}Sr 710 (3)
7259		Stomach cont.	0.125	21 (18)	4810 (4)	2840 (4)	<300	<900	<200	140 (14)	^{90}Sr 1590 (5)
7260		Viscera	0.143	16.4 (4)			790 (7)	4270 (2)	70 (42)		
7261		Skin	0.394	8 (8)	25 (11)	6 (16)	780 (6)	470 (9)	<20	<0.5	^{90}Sr 184 (4)
7262		Liver	0.231	14 (24)	320 (7)	150 (9)	<200	8100 (5)	<200	11 (50)	^{90}Sr <60
7352	B-6	Muscle	0.219	14.1 (2)			760 (2)	90 (7)	<3		
7353		Bone	0.601	0.4 (32)			<7	<10	<6		
7354		Stomach cont.	0.128	25 (4)			1220 (5)	1700 (6)	150 (23)		
7355		Viscera	0.141	19 (3)			1050 (2)	2320 (2)	101 (7)		
7356		Skin	0.410	8.1 (5)			690 (3)	160 (9)	<9		
7357		Liver	0.259	15.2 (5)	103 (4)	13 (60)	370 (11)	3200 (4)	400 (7)	1.7 (27)	^{108m}Ag 63 (19)
7269	B-10	Muscle	0.214	13.9 (2)	0.5 (20)	0.1 (56)	220 (4)	120 (14)	<3	0.12 (50)	^{90}Sr 2.9 (27)
7270		Bone	0.592		33 (4)	3.7 (9)	<7	60 (17)	<7	0.34 (43)	^{90}Sr 222 (3)
7271		Stomach cont.	0.188	16 (9)	800 (5)	404 (5)	260 (35)	1350 (7)	<60	14 (34)	^{90}Sr 230 (17)
7272		Viscera	0.173	6.0 (3)	2080 (3)	890 (3)	76 (8)	690 (2)	38 (12)	14 (7)	^{90}Sr 700 (4)
7273		Skin	0.395	6.9 (3)	20 (7)	5.1 (11)	138 (6)	193 (6)	<5	<0.2	^{90}Sr 48 (5)
7274		Liver	0.245	12 (15)	310 (7)	78 (10)	<100	3300 (5)	440 (17)	8 (50)	^{90}Sr <30
7188	B-12	Muscle	0.220	13.4 (1)			283 (2)	104 (6)	<3		
7189		Bone	0.596								
7190		Stomach cont.	0.189	0.5 (22)			<7	<11	<5		
7191		Viscera	0.177	17.3 (3)			390 (3)	960 (2)	67 (9)		
7192		Skin	0.381	7.0 (2)			177 (6)	135 (5)	<9		
7193		Liver	0.229	12 (11)			<70	2100 (5)	<60		
7218	B-13	Muscle	0.215		0.27 (8)	<1					
7219		Bone	0.593		11.5 (4)					0.25 (22)	
7220		Stomach cont.	0.176	7.4 (30)	890 (2)	360 (3)	<100	1000 (15)	<100	20 (12)	
7221		Viscera	0.198	10.2 (3)	560 (4)	770 (3)	93 (13)	1450 (2)	108 (9)	10.6 (5)	
7222		Skin	0.410	8.2 (3)	8.8 (7)	<3	123 (8)	180 (7)	<7	0.2 (70)	
7223		Liver	0.249	9.3 (14)	181 (3)	40 (24)	<60	2750 (4)	550 (10)	2.5 (22)	

Table A-4. (Continued)

Sample ID	Island locator	Tissue[b]	Dry/wet weight	pCi/kg dry weight[a]							
				^{40}K ($\times 10^3$)	$^{239+240}Pu$	^{241}Am	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu	Other
Name:	Goatfish - Mulloidichthys										
9121	B-1	Muscle	0.220	18.2 (2)	0.84 (24)	0.34 (21)	673 (3)	2600 (1)	6180 (2)	<0.1	^{90}Sr 15.6 (5)
9122		Bone	0.517		13.7 (7)	9.9 (9)	128 (16)	930 (3)	780 (4)	0.4 (83)	^{90}Sr 2030 (3)
9123	B-1	Stomach cont.	0.195				<700	18500 (1)	5500 (11)		
9124		Viscera	0.251	4.9 (11)	293 (3)	197 (4)	430 (13)	22300 (4)	820 (2)	7.5 (13)	^{90}Sr 47 (13)
9125		Skin	0.551	5.7 (4)	8.5 (9)	4.9 (9)	200 (13)	3030 (2)	1740 (2)	<0.06	^{90}Sr 1350 (2)
9126		Liver	0.240	21.8 (3)	730 (5)	450 (18)	450 (18)	107000 (1)	12800 (2)	27 (20)	^{90}Sr 90 (46)
7251	B-5	Muscle	0.225				230 (4)	1650 (2)	400 (8)		
7252		Bone	0.544				<20	490 (4)	60 (28)		
7253		Stomach cont.	0.278								
7254		Viscera	0.244	14.8 (6)			400 (33)	51700 (1)	960 (9)		
7255		Skin	0.531	7.1 (3)			60 (26)	2680 (1)	153 (6)		
7256		Liver	0.269	20.6 (7)			<200	71300 (1)	750 (13)		
7370	B-6	Muscle	0.219	18.9 (1)			95 (6)	300 (3)	81 (4)		
7371		Bone	0.505	0.7 (26)			90 (12)	100 (13)	<9		
7372		Stomach cont.	0.177				<400	<500	<400		
7373		Viscera	0.251	15.1 (4)			140 (23)	6890 (2)	200 (11)		
7374		Skin	0.547	6.9 (3)			27 (26)	460 (3)	40 (15)		
7375		Liver	0.257	14.3 (8)			<70	11300 (2)	210 (25)		
7263	B-10	Muscle	0.213	17.6 (1)			65 (6)	192 (3)	103 (3)		
7264		Bone	0.514	0.7 (19)			<7	<10	18 (27)		
7265		Stomach cont.	0.208				<400	<600	<300		
7266		Viscera	0.214	16.8 (4)			<30	2770 (2)	150 (14)		
7267		Skin	0.513				<7	<10	30 (41)		
7268		Liver	0.241	17.7 (9)			<70	6940 (2)	200 (28)		
7200	B-12	Muscle	0.222	16.6 (1)	<0.03	0.05 (43)	86 (6)	430 (2)	195 (2)	<0.06	^{90}Sr 1.9 (18)
7201		Bone	0.521	0.8 (20)	3.3 (12)	1.5 (11)	<10	70 (28)	30 (24)	<0.06	^{90}Sr 240 (3)
7202		Stomach cont.	0.203		150 (30)	55 (41)	<500	<800	<400	<1	^{90}Sr 700 (57)
7203		Viscera	0.291	12.1 (5)	264 (4)	143 (5)	100 (34)	3880 (2)	410 (6)	4 (25)	^{90}Sr 79 (8)
7204		Skin	0.512	7.2 (3)	1.5 (10)	1.5 (10)	30 (27)	520 (3)	68 (9)	<0.1	^{90}Sr 107 (3)
7205		Liver	0.249	20 (16)			<200	8620 (5)	370 (30)		

Table A-4. (Continued)

Sample ID	Island locator	Tissue[b]	Dry/wet weight	pCi/kg dry weight[a]							
				^{40}K ($\times 10^3$)	$^{239+240}Pu$	^{241}Am	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu	Other
Name: Goatfish - Mulloidichthys (continued)											
7206	B-13	Muscle	0.219								
7207		Bone	0.505		3.2 (7)					0.09 (75)	
7208		Stomach cont.	0.187	25 (37)	9 (40)	25 (30)	<500	3500 (29)	<400		
7209		Viscera	0.210	18.7 (4)	28 (4)	12 (70)	<40	6930 (2)	1010 (4)	1.1 (20)	
7210		Skin	0.537	6.9 (2)	1.90 (3)		20 (37)	540 (3)	220 (6)	0.07 (15)	
7211		Liver	0.230	22 (9)	171 (3)	56 (8)	<100	14200 (4)	1080 (9)	8.2 (16)	
7281	B-17	Muscle	0.229	15.1 (2)	0.32 (23)	0.13 (31)	211 (4)	1150 (2)	990 (2)	0.17 (46)	^{90}Sr 14 (7)
7282		Bone	0.548	0.5 (32)	7.3 (8)	4.4 (7)	<9	230 (19)	230 (5)	0.7 (30)	^{90}Sr 1000 (2)
7283		Stomach cont.	0.364		178 (16)	80 (16)	<400	5000 (24)	<400	<10	^{90}Sr <300
7284		Viscera	0.361	8.4 (4)	1690 (4)	530 (4)	346 (10)	6900 (1)	980 (3)	226 (4)	^{90}Sr 1000 (3)
7285		Skin	0.448	5.1 (11)	7.6 (8)	2.7 (8)	60 (31)	1080 (3)	440 (5)	0.8 (30)	^{90}Sr 610 (3)
7286		Liver	0.220	17.6 (17)	400 (6)	137 (8)	<200	27400 (1)	2930 (6)	30 (21)	^{90}Sr 60 (90)
7311	B-23	Muscle	0.214	18.3 (1)			225 (6)	1800 (1)	2800 (1)		
7312		Bone	0.485	0.5 (27)			<10	710 (3)	480 (3)		
7313		Stomach cont.	0.214				<700	12200 (8)	<700		
7314		Viscera	0.217	16.4 (4)			110 (42)	31300 (1)	5690 (2)		
7315		Skin	0.545	6.9 (3)			50 (23)	2640 (2)	1070 (2)		
7316		Liver	0.282								
Name: Parrotfish - Scarus											
7287	B-17	Muscle	0.209	17.6 (1)			670 (2)	91 (9)	<4		
7288		Bone	0.589	1.42 (9)			<8	<10	<5		
7289		Stomach cont.	0.541				<200	400 (26)	<90		
7290		Viscera	0.524	3.4 (5)			186 (6)	290 (8)	18 (27)		
7291		Skin	0.467	5.6 (5)			163 (7)	340 (5)	<9		
7292		Liver	0.491	3.8 (7)			120 (16)	500 (4)	<10		
Name: Snapper - Aprion											
7328	Bravo	Muscle	0.233		0.47 (10)	0.15 (15)				0.04 (75)	^{90}Sr 1.0 (20)
7329	Crater	Bone	0.653	1.3 (8)	8.9 (6)	4.9 (5)	46 (17)	23 (65)	730 (2)	<0.04	^{90}Sr 205 (3)
7330		Stomach cont.	0.153	14 (42)	130 (18)	90 (11)	<300	8830 (6)	1300 (22)	<10	^{90}Sr <100
7331		Viscera	0.346	3.2 (4)	19.3 (5)	9.1 (7)	160 (8)	5460 (1)	1520 (2)	0.4 (45)	^{90}Sr <3

Table A-4. (Continued)

Sample ID	Island locator	Tissue[b]	Dry/wet weight	pCi/kg dry weight[a] ^{40}K (x10^3)	$^{239+240}Pu$	^{241}Am	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu	Other
Name: Snapper - Aprion (continued)											
7332		Skin	0.547	6.8 (5)	19.7 (5)	12.4 (6)	390 (5)	590 (4)	1640 (2)	<0.1	^{90}Sr 127 (3)
7333		Liver	0.277	13.4 (9)	162 (4)	148 (6)	700 (22)	127000 (1)	9370 (2)	2.6 (41)	^{90}Sr <20
7340	W of	Muscle	0.217	18.5 (1)	0.3 (25)	<0.3	230 (4)	380 (4)	50 (10)		
7341	B-6	Bone	0.671	1.0 (19)	11.9 (5)		<10	100 (11)	<9	0.14 (55)	
7342		Stomach cont.	0.0747		<20	<20	<600	4000 (24)	<600		
7343		Viscera	0.257	7.8 (4)	92 (4)	60 (16)	60 (27)	4270 (1)	80 (16)	1.8 (25)	^{113m}Cd 90000 (29)
7344		Skin	0.568		60 (8)		50 (42)	<10	<9	2 (50)	
7345		Liver	0.247	16 (10)	140 (12)	480 (20)	<100	32200 (1)	680 (17)	6 (90)	^{113m}Cd 1.2x10^6(17)
7346	Off	Muscle	0.204	20.7 (2)			720 (3)	1010 (2)	1620 (2)		
7347	B-23	Bone	0.647		1.7 (22)		<6	<6	<7		
7348		Stomach cont.	0.0945				<450	5600 (11)	<400		
7349		Viscera	0.237	6.4 (5)	182 (3)	78 (5)	200 (10)	8670 (1)	950 (2)	5.7 (12)	^{90}Sr 120 (7)
7350	Off	Skin	0.559	3.0 (12)	2.2 (15)	2.4 (25)	100 (16)	870 (3)	180 (6)	1.0 (30)	^{90}Sr 180 (4)
7351	B-23	Liver	0.238	10 (24)			<200	68300 (1)	4800 (5)		
Name: Jack - Caranx											
7322	Near	Muscle	0.242	18.0 (2)			1060 (2)	1340 (2)	500 (2)		
7323	Bravo	Bone	0.638		1.8 (12)	1.6 (38)	<10	<20	30 (36)	1.0 (23)	^{90}Sr 98 (3)
7324	Crater	Stomach cont.	0.123	45 (28)			<700	11300 (8)	<500		
7325		Viscera	0.209	16.2 (6)	54 (9)	34 (14)	780 (10)	11800 (2)	570 (11)	2.7 (50)	^{90}Sr <8
7326		Skin	0.517		0.6 (65)	1.3 (33)				<0.2	^{90}Sr 122 (7)
7327		Liver	0.228	14 (26)			<200	9460 (4)	850 (20)		
Name: Mackerel - Grammatorcynus											
7334	4 miles	Muscle	0.236	19.9 (1)			334 (3)	227 (5)	17 (25)		
7335	W of	Bone	0.572	1.2 (20)	0.6 (50)	0.8 (31)	<10	40 (30)	<10	<0.2	^{90}Sr 36 (10)
7336	B-6	Stomach cont.	0.168				<600	<500	<500		
7337		Viscera	0.243	15.5 (6)			170 (24)	2580 (3)	3900 (3)		^{108m}Ag 160 (16)
7338		Skin	0.364	11.6 (4)	3.8 (21)	4 (29)	230 (13)	530 (6)	<17	<0.5	^{90}Sr <9
7339		Liver	0.285	18			<200	6000 (7)	1500 (12)		

[a] Number in parenthesis is the 1-σ counting error expressed as percent of the value listed.
[b] Viscera sample for all of the 1978 collection includes the stomach but does not include: the stomach contents, intestines or reproductive organs.

Table A-5. 1980 Fish collections - Bikini Atoll.

Island locator	Month collected	Common name	Scientific name	Number of individuals pooled/sample	Average whole body wet wt (gm)	Average standard length (mm)	Male	Female
B-6	September	Mullet	Crenimugil crenilabis	14	634	286	4	7
B-6	September	Mullet	Crenimugil crenilabis	7	923	331	4	3
B-6	September	Goatfish	Mulloidichthys samoensis	39	157	198	15	11
B-6	September	Snapper	Letherinus kallopterus	1	2767	500		1

Table A-6. 1980 Concentrations of radionuclides in fish tissue - Bikini Atoll.

Sample ID	Island locator	Tissue	Dry/wet weight	pCi/kg dry weight[a] ^{40}K ($\times 10^3$)	$^{239+240}Pu$	^{241}Am	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu	Other
Name: Mullet - Crenimugil											
MSA 372	B-6	Muscle	0.261	13.1 (2)	0.43 (14)		200 (3)	670 (1)	<3		
373		Bone	0.503								
374		Gizzard Cont.	0.592	4.1 (30)							
375		Gizzard	0.231								
376		Liver	0.281								
377		Intest. Cont.	0.487	3.5 (12)			530 (7)	760 (2)	<20		
379		Scales	0.611								
380		Skin	0.413								
MSA 848	B-6	Muscle	0.256	14.6 (2)			414 (4)	873 (3)	<5		
849		Bone	0.393								
850		Gizzard Cont.	0.632		4000 (4)		314 (27)	380 (16)	<60	22 (4)	^{155}Eu 600 (18)
851		Gizzard	0.212	11.2 (11)			240 (23)	2080 (6)	<60		
852		Liver	0.265	13.5 (19)	720 (2)		290 (40)	10840 (3)	<100	11 (7)	
853		Viscera	0.368	5.9 (6)	2000 (5)		352 (8)	1840 (2)	37 (30)	10 (5)	^{155}Eu 430 (15)
854		Intest. Cont.	0.558	2.5 (20)			418 (13)	699 (5)	<25		^{155}Eu 570 (14)
855		Scales	0.670	2.5 (9)			50 (34)	557 (3)	<12		
856		Skin	0.412	5.4 (15)			140 (27)	2425 (15)	<33		
Name: Goatfish - Mulloidichthys											
MSA 841	B-6	Muscle	0.234	17.0(2)			52 (14)	134 (8)	80 (7)		
842		Bone	0.325	0.8 (40)			<25	91 (25)			
843		Intest. Cont.	0.586	5.1 (35)	213 (2)		<140	340 (37)	<115	1.1 (13)	
844		Viscera	0.278	7.1 (2)	66 (2)		<19	850 (4)	94 (14)	0.5 (15)	
845		Liver	0.254	15 (17)	138 (3)		<180	3118 (8)		1.5 (30)	
846		Scales	0.606	3.7 (7)			<15	99 (15)			
847		Skin	0.343	10.2 (10)			<50	352 (16)			

Table A-6. (Continued)

Sample ID	Island locator	Tissue	Dry/wet weight	pCi/kg dry weight[a]							
				^{40}K ($\times 10^3$)	$^{239+240}Pu$	^{241}Am	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu	Other
Name: Snapper - Letherinus											
MSA 164	B-6	Muscle	0.234								
165		Bone	0.540	1.1 (20)			<20	<20	<20		
166		St. contents									
167		Viscera	0.262	7.1 (9)			89 (37)	2080 (3)	160 (18)		
168		Skin	0.518	7.6 (22)			<80	132 (40)	<60		
169		Liver	0.338								
182		Muscle	0.234	19.7 (2)	<0.02		300 (8)	160 (12)	130 (9)		
183		Muscle		19.4 (3)	<0.05	0.14 (50)	270 (10)	150 (26)	150 (10)		

[a] Numbers in parenthesis are the 1-σ counting error expressed as percent of listed value.

Table A-7. 1981 Fish collections - Bikini Atoll.

Island locator	Month collected	Common name	Scientific name	Number of individuals pooled/sample	Average whole body wet wt (gm)	Average standard length (mm)	Male	Female
B-1	February	Mullet	Crenimugil crenilabis	14	714	320	6	7
B-5	February	Mullet	Crenimugil crenilabis	7	911	336	1	6
B-6	February	Mullet	Crenimugil crenilabis	8	1314	391	0	8
B-6	February	Mullet	Neomyxus chaptalii	38	176	217	25	11
B-13	February	Mullet	Neomyxus chaptalii	23		231		
B-5	February	Surgeonfish	Acanthurus triostegus	33	76	114	16	12
B-5	February	Goatfish	Mulloidichthys samoensis	44	126	189	22	18
B-5	February	Parrotfish	Scarus sordidus	3	695	267	1	2
Lagoon	February	Mackerel	Grammatorcynus billineatus	1	1113	490	0	1

Table A-8. 1981 Concentrations of radionuclides in fish tissue - Bikini Atoll.

Sample ID	Island locator	Tissue	Dry/wet weight	pCi/kg dry weight[a] ^{40}K ($\times 10^3$)	$^{239+240}Pu$	^{241}Am	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu
Name: Mullet - Crenimugil										
MSA 356	B-1	Muscle	0.253	13.7 (2)	2.8 (6)		900 (3)	877 (2)	<4	0.045 (40)
357		Bone	0.573							
358		Gizzard cont.	0.305		6200 (20)		<3000	5300 (48)	<2100	37 (25)
359		Gizzard	0.217							
360		Liver	0.246							
361		Viscera cont.	0.191							
362		Viscera	0.242							
363		Scales	0.598							
364		Skin	0.365							
MSA 186	B-5	Muscle	0.284	12.3 (2)			1200 (2)	610 (2)	<5	
187		Bone	0.681	0.8 (37)			<3	150 (13)	<20	
188		Viscera	0.364	5.4 (4)			1450 (2)	2490 (2)	120 (9)	
189		Scales	0.650	3.7 (6)			300 (6)	290 (5)	<9	
190		Skin	0.333	6.0 (13)			990 (6)	1800 (4)	<30	
191		Liver	0.249	9 (34)			1200 (23)	25900 (2)	<200	
MSA 253	B-6	Muscle	0.255	14.2 (2)	0.86 (10)	0.14 (10)	234 (4)	510 (2)	<4	0.02 (75)
254		Bone	0.561	0.8 (34)			<20	230 (9)	<20	
255		Stomach cont.	0.617	1.5 (24)	4430 (3)		230 (16)	230 (13)	70 (26)	25.7 (2)
256		Viscera	0.379	2.5 (5)			131 (6)	570 (2)	30 (13)	
257		Skin	0.337	8.2 (6)			120 (21)	1110 (4)	<20	
258		Scales	0.662	1.5 (4)			20 (20)	199 (3)	<4	
259		Liver	0.257	12.4 (13)			700 (15)	15700 (3)	200 (33)	
260		Gizzard	0.220	9.0 (11)			220 (20)	1460 (3)	<30	
Name: Mullet - Neomyxus										
MSA 401	B-6	Muscle	0.238	11.3 (6)	0.97 (4)		127 (10)	370 (8)	<6	
402		Bone	0.535	0.9 (30)			<15	80 (21)		
409		Liver	0.218		850 (2)					14 (16)
406		Viscera	0.367		940 (3)					7.3 (4)
MSA 530	B-13	Muscle	0.265	11.5 (2)			43 (14)	171 (8)	<5	
403		Gizzard cont.	0.563		2200 (1)					19 (4)
405		Gizzard	0.494		1800 (1)					14 (4)

Table A-8. (Continued)

Sample ID	Island locator	Tissue	Dry/wet weight	pCi/kg dry weight[a] ^{40}K ($\times 10^3$)	$^{239+240}Pu$	^{241}Am	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu
Name: Surgeonfish - Acanthurus										
MSA 224	B-5	Muscle	0.222	14.1 (4)	0.97 (8)	0.68 (18)	1440 (3)	460 (7)	<20	0.02 (90)
225		Bone	0.570				<30	150 (16)	<20	
226		Stomach cont.	0.188	12 (35)	4050(2)	2640 (2)	<400	5780 (13)	<200	154 (3)
227		Viscera	0.159	17.2 (7)			1560 (10)	7780 (2)	130 (36)	
228		Skin	0.464	7.3 (10)			500 (12)	470 (4)	<30	
229		Liver	0.306				<500	11900 (5)	1200 (24)	
Name: Goatfish - Mulloidichthys										
MSA 233	B-5	Muscle	0.232	16.5 (2)	1.22 (5)	0.55 (6)	360 (5)	1860 (2)	240 (4)	0.07 (32)
234		Bone	0.491				<20	870 (5)	45 (3)	
235		St. content	0.484	4 (37)	12000 (6)		750 (20)	9200 (3)	500 (18)	648 (2)
236		Viscera	0.269	13 (9)			600 (19)	21800 (1)	540 (12)	
237		Scale	0.599	3.2 (10)			<20	970 (3)	40 (28)	
238		Skin	0.312	9.6 (8)			240 (22)	3870 (2)	120 (25)	
239		Liver	0.264	12 (22)			<200	30900 (2)	<200	
Name: Parrotfish - Scarus										
MSA 240	B-5	Muscle	0.216	19.3 (3)	1.38 (7)	0.37 (16)	1080 (4)	190 (14)	<20	0.04 (45)
241		Bone	0.465	1.8 (29)			<30	140 (21)	<30	
242		Stomach cont.	0.429	3.4 (24)	13200 (3)		960 (6)	1570 (4)	120 (23)	471 (1)
243		Viscera	0.491	9.7 (27)			1620 (10)	3200 (6)	<100	
244		Skin	0.252	15 (16)			800 (15)	560 (20)	<90	
245		Scales	0.532	3.0 (15)			260 (13)	270 (18)	<20	
246		Liver	0.515				<200	1140 (22)	<100	
Name: Mackerel - Grammatorcynus										
MSA 247	Lagoon	Muscle	0.236	20.4 (2)	0.09 (35)		420 (5)	270 (7)	30 (32)	
248		Bone	0.465				<90	<90	<70	
250		Viscera	0.253				<400	4500 (9)	<300	
251		Skin	0.353	10 (23)			<200	620 (19)	<100	

[a] Numbers in parenthesis are the 1-σ counting error expressed as percent of listed value.

Table A-9. 1982 Fish collections - Bikini Atoll.

Island locator	Month collected	Common name	Scientific name	Number of individuals pooled/sample	Average whole body wet wt (gm)	Average standard length (mm)	Male	Female
B-6	March	Mullet	Neomyxus chaptalii	31	199	223	12	14
B-5	June	Mullet	Neomyxus chaptalii	33	243	232	17	14
B-22	June	Ulua	Caranx melanpygus	1		1070	1	
B-22	September	Ulua	Caranx melanpygus	2	2020	454		

Table A-10. 1982 Concentrations of radionuclides in fish tissue - Bikini Atoll.

Sample ID	Island locator	Tissue	Dry/wet weight	pCi/kg dry weight[a] ^{40}K ($\times 10^3$)	$^{239+240}Pu$	^{241}Am	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu	^{210}Po
Name: Mullet - Neomyxus											
MSG 363	B-6	Muscle	0.222	13.6 (2)	1.40 (2)		94 (8)	231 (6)	<4		1370 (3)
364		Bone	0.514		8.7 (3)			99 (17)		0.13 (30)	3800 (3)
365		Gizzard cont.	0.535		1620 (2)		600 (20)			11 (11)	1500 (4)
366		Gizzard	0.222	9.2 (13)			<90	340 (19)			
367		Viscera cont.	0.362	3.0 (8)	1440 (2)	600 (13)	720 (14)	240 (9)	40(25)	10.8 (8)	5900 (3)
368		Viscera	0.278		740 (2)			240 (9)		4.9 (7)	750 (2)
369		Scale	0.633								
370		Skin	0.359								
371		Liver	0.234		480 (3)					7.7 (7)	44000 (3)
MSG 372	B-5	Muscle	0.226	13.2 (2)			300 (3)	590 (2)	<4		
373		Bone	0.513				<20	122 (16)			
374		Gizzard cont.	0.338			14 (5)	810 (24)	1120 (14)			
375		Gizzard	0.224	3.4 (37)		8.2 (10)	510 (15)	1490 (5)			
376		Viscera cont.	0.248								
377		Viscera	0.241								
378		Scales	0.619								
379		Skin	0.334	5.4 (15)			120 (20)	870(6)			
380		Liver	0.248								
Name: Ulua - Caranx											
MSA 967	B-22	Muscle	0.227	20.4 (3)			1670 (4)	215 (4)	490 (10)		
968		Skin	0.452	4.3 (12)			330 (12)	330 (10)	230 (11)		
969		Stomach lin.	0.215	6.8 (7)			420 (7)	1560 (2)	526 (4)		
970		Liver	0.265	8.9 (16)			240 (40)	36520 (1)	4120 (3)		
971		Spleen	0.260	12 (41)			<400	4000 (9)	8150 (4)		
972		Pyloric caeca	0.213	8.7 (11)			400 (15)	1700 (4)	870 (5)		
973		Gonad	0.190	7 (40)			473 (28)	2710 (8)	1610 (10)		
974		Viscera cont.	0.168					2220 (17)	<400		
975		Viscera wall	0.236	4.6 (30)			300 (25)	1740 (12)	1240 (6)		
MSA 421	B-22	Muscle	0.22	13.8 (2)			1640 (2)	246 (5)	166 (5)		
422		Viscera	0.24								
426		Skin	0.29	7.1 (12)			970 (8)	326 (15)	435 (10)		

[illegible]

Table A-11. 1983 Fish collections - Bikini Atoll.

Island locator	Month collected	Common name	Scientific name	Number of individuals pooled/sample	Average whole body wet wt (gm)[a]	Average standard length (mm)	Male[a]	Female[a]
B-1	August	Mullet	Crenimugil crenilabis	11	189	203	4	7
B-5	August	Mullet	Crenimugil crenilabis	5		216		
B-1	August	Mullet	Neomyxus chaptalii	5		225		
B-1	August	Surgeonfish	Acanthurus triostegus	36	116	134	22	14
B-1	August	Surgeonfish	Acanthurus triostegus	37	74	118	17	20
B-5	August	Surgeonfish	Acanthurus triostegus	6		143		
B-12	August	Surgeonfish	Acanthurus triostegus	6		123		
B-17	August	Surgeonfish	Acanthurus triostegus	5		142		
B-1	August	Goatfish	Mulloidichthys samoensis	70	45	96	23	47
B-6	August	Goatfish	Mulloidichthys samoensis	11	175	221	3	8
B-6	August	Goatfish	Mulloidichthys samoensis	7		149		
B-6	August	Goatfish	Mulloidichthys samoensis	5		181		
B-12	August	Goatfish	Mulloidichthys samoensis	5		203		
				6		103	5	1

[a] Not determined for all samples.

Sample ID	Island locator	Tissue	Dry/wet weight	^{40}K ($\times 10^3$)	$^{239+240}Pu$	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu	^{210}Pb	^{210}Bi	^{210}Po
						pCi/kg dry weight						
						Average						
Name: Mullet - Crenimugil												
MSG 561 B-1		Muscle	0.220	14.9 (3)	0.27 (19)	540 (2)	310 (26)			<3		160 (3)
569		Viscera	0.230	12.9 (6)		660 (8)	780 (5)					
MSH 117 B-1		Liver								150 (13)	950 (7)	3800 (3)
MSH 115 B-5		Muscle								<3		156 (3)
118		Liver								140 (20)		5200 (3)
Name: Mullet - Neomyxus												
MSH 113 B-1		Muscle								36 (6)	200 (8)	280 (3)
116		Liver								1330 (3)	7500 (4)	10400 (1)
Name: Surgeonfish - Acanthurus												
MSG 515 B-1		Muscle	0.224	16.0 (2)		2060 (1)	150 (6)	17 (31)				
517		Skin	0.348	8.2 (7)		840 (5)	340 (8)	<30				
518		Viscera	0.182	12.4 (5)		1210 (3)	2000 (2)	240 (9)				
519		Liver	0.205	<10		800 (35)	4200 (8)	1700 (17)				
520		Stomach cont.	0.146	<20		2200 (3)						
MSG 521 B-1		Muscle	0.222	14.9 (2)	0.68 (5)	1830 (2)	200 (7)	<10	0.006 (42)			
524		Viscera	0.192	13.8 (7)	396 (1)	1400 (5)	2170 (3)	180 (18)	3.6 (6)			
526		Stomach cont.	0.147		1280 (2)				8 (32)			
527		Intest. cont.	0.154	<30	1840 (1)	2800 (35)	3600 (22)		17 (12)			
522		Bone	0.499			<30	110 (20)					
523		Skin	0.340	6.8 (12)		980 (5)	230 (24)					
MSH 124 B-1		Muscle								7 (20)	70 (30)	26 (3)
121		Liver								1220 (6)	9800 (9)	2150 (3)
MSG 666		Bone								2420 (3)		3020 (1)
MSH 123 B-5		Muscle								<42 (8)	120 (20)	208 (3)
120		Liver								3550 (3)	16000 (7)	23800 (1)
MSG 665		Bone								3180 (3)		4260 (1)
MSH 126 B-12		Muscle								10 (5)	50 (15)	34 (3)
MSG 661		Bone								1590 (3)		4170 (1)
483		Stomach Cont.								179 (3)		4600 (1)

Table A-12. (Continued)

Sample ID	Island locator	Tissue	Dry/wet weight	pCi/kg dry weight[a] ^{40}K ($\times 10^3$)	$^{239+240}Pu$	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu	^{210}Pb	^{210}Bi	^{210}Po
Name: Surgeonfish - Acanthurus (continued)												
MSG-621	B-17	Muscle	0.207	16.6 (2)		210 (5)	31 (25)					
615		Liver	0.209	16 (30)		<300	900 (31)					
616		Viscera	0.174	11 (17)		230 (40)	500 (20)					
Name: Goatfish - Mulloidichthys												
MSG 576	B-1	Muscle	0.226	21.1 (4)		720 (6)	800 (4)	4300 (4)				
581		Viscera	0.210	12 (36)		<300	14700 (3)	5200 (4)				
MSH 135		Liver								340 (3)		24100 (1)
MSH 136	B-6	Muscle										
MSG 801		Bone								4 (45)		720 (8)
802		Bone										1730 (3)
												2460 (3)
MSH 136	B-6	Muscle										
MSG 803		Bone								4 (45)		720 (8)
804		Bone										1480 (3)
												4430 (3)
MSH 138	B-6	Muscle										
MSG 805		Bone								6 (30)		290 (3)
806		Bone										3450 (3)
												5160 (3)
MSH 130	B-12	Muscle										
MSG 490		Liver								9 (30)		600 (5)
603		Bone										25000 (1)
488		Intest. cont.								1200 (3)		1410 (3)
489		Intest. cont.							870 (3)			59000 (1)
487		Intestine							790 (3)			145000 (1)
										80 (25)		5000 (3)

[a] Numbers in parenthesis are the 1-σ counting error expressed as percent of listed value.

Table A-13. 1984 Fish collections - Bikini Atoll.

Island locator	Month collected	Common name	Scientific name	Number of individuals pooled/sample	Average whole body wet wt (gm)	Average standard length (mm)	Male	Female
B-6	September	Mullet	Crenimugil crenilabis	12	800	326	11	1
B-12	September	Mullet	Neomyxus chaptalii	35	252	231	9	25
B-17	September	Mullet	Neomyxus chaptalii	31	194	218		
B-6	September	Goatfish	Mulloidichthys samoensis	26	92	167	15	11
B-6	September	Goatfish	Mulloidichthys samoensis	58	49	138	24	29
B-1	September	Goatfish	Mulloidichthys samoensis	22	134	187	4	18
B-12	September	Goatfish	Mulloidichthys samoensis	13	134	189	10	3
B-1	September	Rainbow Runner	Elagatis sp.	1	1616	551		
B-1	September	Snapper	Lethrinus kallopterus	1	2523	529		
B-1	September	Bonito	Euthynnus affinus	1	1729	455		
B-1	September	Ulua	Caranx sp.	8	1582	430		

Table A-14. 1984 Concentrations of radionuclides in fish tissue - Bikini Atoll.

Sample ID	Island locator	Tissue	Dry/wet weight	pCi/kg dry weight[a] ^{40}K ($\times 10^3$)	$^{239+240}Pu$	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu	^{210}Po
Name: Mullet - Crenimugil										
MSJ 734	B-6	Muscle	0.246	15.0 (1)		216 (2)	371 (1)			
Name: Mullet - Neomyxus										
MSJ 708	B-12	Muscle	0.214							
709		Stomach cont.	0.392	1.8 (35)		<30	80 (36)			
MSJ 730	B-17	Muscle	0.242	12.3 (2)		52 (13)	158 (7)			
731		Stomach cont.	0.465			280 (21)	130 (26)			
Name: Goatfish - Mulloidichthys										
MSJ 420	B-6	Muscle	0.226	19.1 (2)	0.30 (12)	87 (16)	150 (10)	190 (6)	0.02 (70)	2300 (5)
MSJ 422	B-6	Muscle	0.232	18.2 (2)	0.15 (17)	51 (24)	130 (14)	140 (7)		4100 (3)
MSJ 706	B-1	Muscle	0.229							
707		Stomach cont.	0.545			1500 (22)	14000 (3)	21600 (2)		
MSJ 415	B-12	Muscle	0.218	20.9 (2)	0.14 (17)	92 (18)	110 (18)	220 (7)		4300 (3)
416		Stomach cont.	0.395							
Name: Rainbow Runner - Elagatis										
MSJ 291	B-1	Muscle	0.226	19.7 (2)	0.09 (16)	280 (8)	190 (11)	<20		3500 (3)
Name: Snapper - Lethrinus										
MSJ 292	B-1	Muscle	0.253	19.4 (2)	0.06 (33)	680 (3)	170 (8)	130 (8)		332 (1)
Name: Bonito - Euthynnus										
MSJ 293	B-1	Muscle	0.302	13.1 (4)	0.29 (8)	580 (3)	660 (3)	590 (2)		3100 (4)
Name: Ulua - Caranx										
MSJ 294	B-1	Muscle	0.242	14.8 (1)	0.23 (15)	790 (2)	400 (2)	460 (2)		4300 (2)

[a] Numbers in parenthesis are the 1-σ counting error expressed as percent of listed value.

Table A-15. Invertebrate collections - Bikini Atoll.

Island locator	Month/year collected	Common name	Scientific name	Number of individuals pooled/sample	Average standard length (mm)
B-1	11/72	Rock oyster	Chama iostoma	6	80
B-4	11/72	Rock oyster	Chama iostoma	6	87
B-6	11/72	Limpets	Lambis lambis	71	
B-10	11/72	Tridacna	Tridacna crocea	5	57
B-10	11/78	Tridacna	Tridacna crocea	8	140
B-6	6/79	Tridacna	Tridacna crocea	2	168
B-6	9/80	Tridacna	Tridacna crocea	8	
B-10	11/78	Hippopus	Hippopus hippopus	1	329
B-6	9/80	Tridacna	Tridacna squamosa	2	

Table A-16. Concentrations of radionuclides in invertebrate tissue - Bikini Atoll.

Sample ID	Island locator/ year	Tissue	Dry/wet weight	pCi/kg dry weight[a] ^{40}K ($\times 10^3$)	$^{239+240}Pu$	^{241}Am	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu	Other
Name: Chama iostoma											
6350	B-1/72	Mantle/muscle	0.185		280 (3)	170 (5)	<300	98000 (3)	2800 (12)	12 (12)	
6351		Viscera	0.222		3300 (2)	1330 (4)	<500	340000 (1)	24000 (5)	53 (7)	^{113m}Cd 50400 (2)
Name: Chama iostoma											
6348	B-4/72	Mantle/muscle	0.230	9 (26)	175 (2)	84 (5)	<200	15500 (3)	<100	12 (8)	
6349		Viscera	0.192		1100 (3)		<200	89000 (3)	<400	68 (5)	^{113m}Cd 16000 (3)
Name: Lambis lambis											
6345	B-6/72	Soft parts	0.256	4.4 (15)	111 (2)	9 (53)	<40	2850 (5)	190 (20)	4.9 (7)	
Name: Tridacna crocea											
6346	B-10/72	Mantle/muscle	0.276	6 (30)	146 (3)	70 (8)	<200	30000 (4)	<160	4.5 (16)	
6347		Viscera	0.274	7 (30)	840 (2)	360 (4)	<200	280000 (1)	2700 (8)	12.6 (7)	^{113m}Cd 80600 (2)
6341	B-10/78	Mantle	0.181	7.7 (5)	274 (2)		<30	9660 (2)	50 (30)	10.4 (4)	^{108m}Ag 63 (33)
6342		Muscle	0.240	9.0 (5)	28 (3)	18 (8)	<20	4630 (1)	<19	0.9 (13)	
6343		Viscera	0.206	6.9 (3)	500 (2)	128 (2)	<30	16000 (1)	180 (8)	6.8 (3)	^{108m}Ag 100 (10); ^{113m}Cd 19200 (2)
7006	B-6/79	Muscle	0.224	11.3 (7)	22 (13)	27 (9)	<40	3850 (3)	<30	2 (60)	^{90}Sr <10
7007		Mantle	0.159		141 (4)	83 (6)				0.8 (30)	^{90}Sr <10
7008		Kidney	0.313		117 (3)	500 (3)	<300	460000 (1)	<230	1.6 (25)	
7009		Viscera	0.191	6.9 (7)	432 (2)	187 (2)	<30	9400 (1)	155 (17)	5.3 (7)	^{108m}Ag 70 (25)
G383	B-6/80	Mantle/muscle	0.179	6.8 (1)			<30	8400 (2)	<25		
G384		Viscera	0.209	5.5 (9)			<55	56000 (1)	190 (25)		

Table A-16. (Continued)

Sample ID	Island locator/ year	Tissue	Dry/wet weight	pCi/kg dry weight[a]							
				^{40}K ($\times 10^3$)	$^{239+240}Pu$	^{241}Am	^{137}Cs	^{60}Co	^{207}Bi	^{238}Pu	Other
Name: Hippopus hippopus											
6337	B-10/78	Mantle	0.103	7.5 (6)	53 (5)	<2	<30	4410 (1)	82 (34)	2.1 (23)	
6338		Muscle	0.216	10.3 (5)	8.9 (7)	2.2 (40)	<20	920 (10)	<15	<1	
6339		Viscera	0.170	5.8 (8)	2400 (3)	350 (2)	<40	11700 (1)	420 (5)	34 (4)	^{113m}Cd 15200 (2)
6340		Kidnev	0.288	4 (23)	130 (2)	190 (2)	<200	289000 (1)	1230 (11)	1.8 (11)	^{113m}Cd 24900 (2)
Name: Tridacna squamosa											
6385	B-6/80	Muscle	9.9 (8)				<40	1120 (6)	<30		
6386		Mantle	6.6 (5)				<20	5130 (1)	<20		
6387		Viscera	6.4 (3)				<40	58200 (1)	250 (13)		

a Numbers in parentheses are the 1-σ counting error expressed as percent of the listed value.