United States
Environmental Protection
Agency

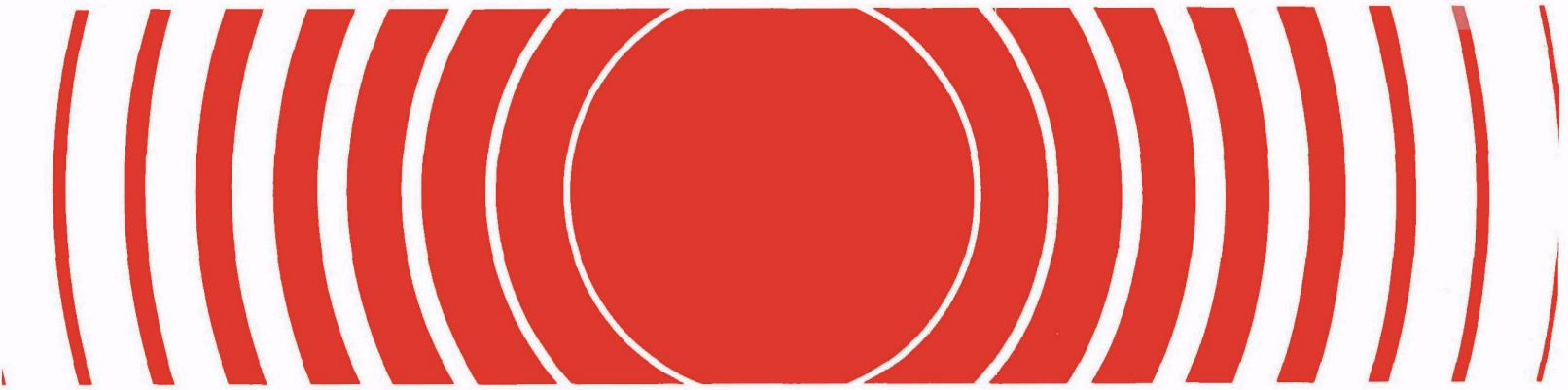
Office of
Radiation Programs
Washington, DC 20460

EPA 520/1-88-010
June 1988

Radiation

EPA

A Monitoring Program for Radionuclides in Marketplace Seafoods



EPA 520/1-88-010

A MONITORING PROGRAM FOR RADIONUCLIDES IN MARKETPLACE SEAFOODS

Conducted by the Environmental Protection Agency and the Food and Drug Administration, 1981-1982

William R. Curtis

Office of Radiation Programs

U.S. ENVIRONMENTAL PROTECTION AGENCY

Washington, D.C. 20460

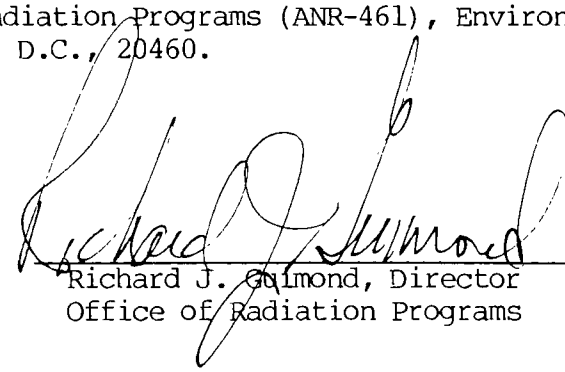
FOREWORD

In response to the Marine Protection, Research and Sanctuaries Act of 1972, as amended (Public Law 92-532), the Environmental Protection Agency (EPA) developed regulations and criteria to control ocean disposal of waste materials, including low-level radioactive wastes (LLW). In 1981, the EPA Office of Radiation Programs and the Food and Drug Administration (FDA) began monitoring the concentrations of radioactivity in seafoods commercially available from marketplaces that are near previously used LLW disposal sites.

Between 1946 and 1970, the United States authorized ocean disposal for LLW. The EPA has determined that approximately 112,000 LLW containers were disposed off the Atlantic and Pacific coasts, primarily at the following locations: (1) near the Farallon Islands off the coast of California; (2) at two deep-ocean sites east of the Delaware, Maryland, and Virginia (DELMARVA) peninsula; and (3) in Massachusetts Bay. Accordingly, for this EPA/FDA radionuclide monitoring study, seafood samples were collected from San Francisco, Atlantic City and Boston, each of which is near one of the major U.S. ocean disposal locations for LLW.

This report presents the results of EPA and FDA radionuclide analyses for all seafood samples collected. The data show that the radioactivity levels for man-made nuclides in the samples were found to be within normally expected environmental background (ambient) ranges. There is no indication that previous U.S. ocean disposals of LLW have resulted in contamination of commercially available seafoods.

The Agency invites all readers of this report to send any comments or suggestions to Mr. David E. Janes, Director, Analysis and Support Division, Office of Radiation Programs (ANR-461), Environmental Protection Agency, Washington, D.C., 20460.



Richard J. Guimond, Director
Office of Radiation Programs

PREFACE

This report presents the results of a monitoring program, conducted in 1981 and 1982, by the Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA). Its purpose was to measure concentrations of man-made radionuclides in seafoods to determine effects from previous U.S. ocean disposals of low-level radioactive wastes (LLW). Commercially-marketed seafood samples were collected from Boston, Massachusetts, Atlantic City, New Jersey and San Francisco, California. Each of these cities is near a previously-used U.S. ocean disposal site for LLW.

Seafood samples were collected from commercial fishing boats in Boston between September 1981 and November 1982, in Atlantic City between September 1981 and May 1982, and in San Francisco between October 1981 and May 1982. Samples were obtained as the boats returned from fishing trips near the previously-used LLW disposal sites. Fish samples collected from Boston included Atlantic cod, Winter flounder, Haddock, Red hake and Pollock. Cusk eels were also collected. Conger eels and Tilefishes were collected from Atlantic City. Fish samples from San Francisco included Dover sole, Lingcod, Pacific hake, Pacific red snapper, Sablefish, and Thornyhead.

All samples were analyzed for radioactivity by the EPA Eastern Environmental Radiation Facility (EERF) in Montgomery, Alabama, and by the FDA Winchester Engineering and Analytical Center in Winchester, Massachusetts. This report presents the radioanalytical data from EERF and WEAC. Tables 6, 7 and 8 show the results from EERF for cesium-137, plutonium-238 and -239, and strontium-90. The WEAC data for cesium, plutonium and strontium are contained in Tables 9, 10 and 11. Appendices A, B and C provide a listing for all analytical results, both man-made and natural radionuclides, completed by EERF.

All EERF analytical results for plutonium-239 and strontium-90 yielded values below the minimum detectable level (MDL) for each radionuclide, as given in Table 5. Two analyses for cesium-137 provided results equal to or above the MDL, but are consistent with previously reported ambient data. Two analyses for plutonium-238 provided data above both the MDL and ambient levels, but a large error term associated with each of these analyses discounts their validity.

The WEAC reported no detectable activity for plutonium-239 or strontium-90 in the samples analyzed. Measureable levels were reported in twelve of thirty-seven samples analyzed for cesium -137, and are consistent with cesium values in fish reported previously.

The data obtained during this monitoring program shows that the concentrations of man-made radioactivity in seafoods sampled are below levels of public health concern. The data is considered to be of normal background level, attributable to global fallout over the oceans.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (Continued)

I. HISTORICAL AND REGULATORY PERSPECTIVE

Since World War II, the increased use of radioactive materials in the United States has created substantial volumes of low-level radioactive waste (LLW) materials. LLW are routinely generated by nuclear power facilities, commercial manufacturing processes, military and civilian research programs, university laboratories and medical facilities. LLW are generally defined as all radioactive waste materials not directly resulting from the reprocessing of spent nuclear reactor fuel, and usually contain such radionuclides as cobalt, strontium, plutonium and cesium. Small quantities of source materials, such as uranium, may also be included. Additionally, LLW frequently include laboratory equipment, tools, clothing or other items that became contaminated by contact with radioactive substances.

The United States began disposing of LLW in 1946 at ocean locations authorized by the Atomic Energy Commission (AEC), as well as by shallow burial on government-owned land. For ocean disposal, the AEC licensed private companies to package, transport and dispose of LLW. Packaging was normally accomplished by placing the LLW in containers for insertion into steel drums that were to be capped on both ends with concrete or by mixing the LLW directly into concrete used to fill steel drums. In most cases, 55-gallon drums were used. After waste encasement and concrete solidification were completed, the drums were transported to designated ocean disposal sites where the drums were then allowed to free-fall through the water column onto the sea floor. By 1963, most LLW disposals in the oceans ended because the AEC began to issue licenses for the use of newly authorized, commercially-operated land disposal sites, which were found to be more economically attractive to contract disposers. Some at-sea LLW disposal licenses did remain in effect through the late 1960's, but in 1970 the United States terminated all ocean disposals of radioactive waste materials.

In 1972, the U.S. Congress enacted the Marine Protection, Research, and Sanctuaries Act (Public Law 92-532) which authorized the Environmental Protection Agency (EPA) to regulate all ocean disposal of waste materials, including any radioactive wastes. The Act directed the EPA to determine that any type of waste disposals will not unreasonably degrade or endanger human health or the marine environment. The EPA was also directed to establish and apply criteria to review and evaluate waste disposal permit applications. The Act further directed that comprehensive, continuing monitoring for effects from waste disposals in the oceans be coordinated between the Department of Commerce's, National Oceanic and Atmospheric Administration (NOAA) and the EPA.

In 1973, the United States ratified the 1972 London Dumping Convention (LDC) which prohibited, as does U.S. Public Law 92-532, any ocean disposal of high-level radioactive wastes (HLW), as defined by the International Atomic Energy Agency (IAEA). Future ocean disposals of LLW were permitted, but only under the controlled conditions stipulated by the LDC.

The EPA Office of Radiation Programs began a series of environmental studies at formerly used LLW disposal sites in 1974. Four of the known U.S. ocean disposal locations were surveyed to obtain data to support the development of regulations and criteria to control any future disposals. Pacific Ocean studies, at 900 meter and 1700 meter sites within the AEC-designated Farallon Islands LLW disposal area, were conducted in 1974 and 1975 (DYER, 1976) and in 1977 (SCHELL, 1980). Atlantic Ocean studies, at 2800 meter and 3800 meter LLW disposal sites, were carried out in 1974 and 1975 (DYER, 1976), 1976 and 1978 (REISH, 1983) and (HANSELMAN, 1983).

The EPA issued regulations and criteria for ocean disposal of waste materials in 1977, stipulating that radioactive materials be containerized to prevent dispersion of radionuclides into ocean waters, and that the containers remain intact in the environment until the radioactivity within them decays to innocuous levels.

During the late 1970's and early 1980's, public and Congressional interest about effects from previous U.S. ocean disposals of LLW increased. Specific public health concerns were expressed because of the potential for LLW leakage from containers that were disposed previously off the coasts of California and the DELMARVA (Delaware, Maryland and Virginia) peninsula, and in Massachusetts Bay. In response to these concerns, the EPA initiated additional projects to determine the potential for public health and environmental effects from previous U.S. ocean disposals of LLW.

In 1981, the EPA reviewed available LLW ocean disposal records to more precisely determine the total extent of actual disposals. The records that EPA obtained consisted primarily of licenses issued by the AEC to private contractors, and log books from contractor-operated national laboratories supported by the AEC. From these licenses and log books, the EPA identified intended or actual dates of disposal, approximate quantities of LLW materials prepared for disposal, quantities of waste transported to disposal sites, and planned or actual navigational disposal coordinates. The general nature of LLW materials for disposal and the estimated radioactivity at the time of packaging were usually, but not always, provided. The records did not contain specific information about the types of isotopes or other items that were within each individual container. In designating ocean LLW disposal areas, the AEC had sometimes provided a single set of navigational coordinates; thereby potentially concentrating disposals within a relatively specific sea floor area. In other instances, however, the AEC had designated boundary limits for LLW disposal areas, allowing for potentially broader sea floor disposal areas.

In 1981, EPA determined that approximately 112,000 LLW containers were disposed at sea off the U.S. coasts between 1946 and 1970, and that the total radioactivity amounted to approximately 120,000 curies at the times of disposal. Twenty-nine ocean locations were identified as having received LLW. Four of these areas received the majority of wastes and are identified in Figure 1 as one area near the Farallon Islands in the Pacific Ocean, two nearby areas in the Atlantic Ocean, and one in Massachusetts Bay. The Farallon Islands LLW disposal area, which includes two disposal sites at depths of 900 meters and 1700 meters, received approximately 14,700 curies (98 percent) of the total radioactivity disposed of by the U.S. in the Pacific Ocean. In the Atlantic Ocean, LLW dispoals occurred at both a 2800 meter and a 3800 meter site. These sites together received approximately 102,500 curies (97 percent) of all the radioactivity disposed off the U.S. east coast. The Massachusetts Bay LLW disposal area received about 2 percent of the Atlantic Ocean total (CURTIS, 1984).

Also in 1981, at the request of EPA and in response to Congressional interest in ocean monitoring activities, NOAA began to collect samples of biota and sediment for EPA from Massachusetts Bay during routine NOAA monitoring program surveys. NOAA also conducted a side scan sonar survey at three sites in the Bay during 1981, as preliminary support to an EPA radiological monitoring survey in the Bay in 1982 (LOCKWOOD, 1982) and (CURTIS, 1984). These sites had been designated by the AEC for disposal of LLW in the 1940's and 1950's.

During 1981 the EPA also requested assistance from the Food and Drug Administration (FDA), specifically to conduct public health monitoring as outlined in an EPA/NOAA draft programmatic monitoring plan. A portion of that plan pertained to measuring radioactivity in seafoods commercially available from marketplaces in cities near the major U.S. ocean LLW disposal areas, since the contamination of seafoods is the only significant pathway by which humans could be affected by previous U.S. ocean disposals of LLW. The FDA has, for many years, maintained a national Total Diet Studies Compliance Program to monitor levels of radioactivity in a variety of foods. Samples are routinely collected by FDA scientists throughout the country and sent to the Winchester Engineering and Analytical Center (WEAC) in Winchester, Massachusetts for radionuclide analyses. In response to the EPA's request, the FDA began collecting commercially-marketed fish samples from San Francisco, Atlantic City, and Boston during the fall of 1981 for analysis by both the WEAC and the EPA Eastern Environmental Radiation Facility (EERF) in Montgomery, Alabama.

The remainder of this report describes the EPA/FDA Marketplace Seafood Sampling and Analysis Program, conducted during 1981 and 1982. The collection of samples, the results of radionuclide analyses, and conclusions from the study are presented in Sections II, III and IV, respectively. Appendices A, B and C contain complete computerized data results from EERF radionuclide analyses of samples collected in Boston, Atlantic City, and San Francisco.

FIGURE 1

LOCATIONS OF MAJOR U.S. OCEAN DISPOSAL AREAS
FOR LLW, 1946 - 1970

II. MARKETPLACE SEAFOOD SAMPLING

During the summer of 1981, EPA and FDA scientists and program managers met to discuss potential cooperative efforts related to public health monitoring. The EPA was specifically concerned with determining whether the levels of radioactivity in seafoods routinely consumed by the public, from fish catches near the previously-used U.S. LLW ocean disposal sites, posed any real or potential public health problems.

The FDA had previously conducted a study in which twelve commercial fish samples were analyzed for radioactivity (see Table 1). These samples were collected for the FDA near the Farallon Islands LLW disposal site by fishermen from Point St. George, California in 1978 and 1980. The FDA, based upon the data from their analyses of those fish samples and the results of previous EPA studies at major U.S. LLW disposal sites, concluded that previous U.S. ocean disposals of LLW were not giving rise to radiation levels in commercial fish that are above background levels of radioactivity in the oceans and, thus, of no public health significance. The FDA did, however, recognize that the available data on radioactivity levels in commercial fish species were limited and believed that additional sampling was therefore warranted (STROUBE, 1984). Accordingly, the FDA agreed to begin a limited Marketplace Seafood Sampling and Analysis Program for EPA in the fall of 1981 to analyze commercially-marketed seafoods for selected radionuclides.

In August 1981, three of the FDA district offices (Boston, Newark and San Francisco) set up a program to collect twelve samples of edible fish; six samples from each district during the fall of 1981 and six more samples during the spring of 1982. Samples of marketable fish, those most likely to be eaten by the public and caught by commercial fishermen near the major U.S. sites for ocean disaposal of LLW, were to be collected from Boston, Atlantic City and San Francisco. FDA personnel were to determine which commercial fishing boats would be harvesting near the disposal sites during the Marketplace Seafood Monitoring Program, and to obtain representative samples from these boats when they returned to port. Collectors were to particularly ensure that the dockside collections were made from only those species of fish collected near LLW disposal sites.

The FDA collection procedures from the fishing boats were designed to provide standardized sampling within each district. The seafoods collected provided no less than twenty (20) pounds of edible portions per species. Bottom-feeding fish were designated as the samples of choice since these would most likely provide any evidence of radioactivity migrating into the marine environment from the LLW containers in the disposal sites. Three different bottom-feeding species were to be acquired from each district collection. When bottom-feeders were not be a part of the fishing boat harvests, samples of pelagic feeders (nonmigratory and/or migratory) or shellfish were to be collected.

TABLE 1. FDA ANALYSES OF FISH COLLECTED FROM THE FARALLON ISLANDS LLW DISPOSAL AREA PRIOR TO THE EPA/FDA MARKETPLACE SEAFOOD PROGRAM

DATE COLLECTED	TYPE OF FISH	(Scientific Name)	FDA SAMPLE NUMBER	ANALYSIS RESULTS (pCi/kg) I-131	Ru-106	Cs-137	Sr-90	Pu-239
6/20/78	Thornyhead	Sebastolobus sp.	78-146-002	ND	ND	ND	ND	*
6/20/78	Sablefish	Anoplopoma fimbria	78-146-003	ND	ND	ND	ND	*
6/20/78	Dover Sole	Microstomus pacificus	78-146-004	ND	ND	ND	ND	*
10/6/80	Thornyhead	Schastolobus sp.	81-220-534	ND	ND	ND	ND	ND
10/6/80	Rockfish	Sebastes sp.	81-220-535	ND	ND	ND	ND	ND
10/6/80	Sablefish	Anoplopoma fimbria	81-220-536	ND	ND	ND	ND	ND
11/21/80	Sablefish	Anoplopoma fimbria	81-253-564	ND	ND	ND	ND	ND
11/21/80	Sablefish	Anoplopoma fimbria	81-253-565	ND	ND	ND	ND	ND
11/21/80	Sablefish	Anoplopoma fimbria	81-253-566	ND	ND	ND	ND	ND
11/21/80	Sablefish	Anoplopoma fimbria	81-253-567	ND	ND	ND	ND	ND
11/21/80	Sablefish	Anoplopoma fimbria	81-253-568	ND	ND	ND	ND	ND
11/21/80	Sablefish and Dover Sole	Anoplopoma fimbria Microstomus pacificus	81-253-569	ND	ND	ND	ND	ND

ND = Not Detectable
* = No Analysis Completed

Detection Limits
I-131 = 10 pCi/kg
Ru-106 = 20 pCi/kg
Cs-137 = 10 pCi/kg
Sr-90 = 2 pCi/kg
Pu-239 = 0.1 pCi/kg

Thirty-seven seafood samples were actually collected from Boston, Atlantic City and San Francisco fishermen. The species obtained are listed and briefly discussed below. Common name identifications were provided by the FDA district personnel collecting the samples. The brief summary about each type of sample collected was compiled from information contained in (GATES, 1974), (GOTSHALL, 1987), (McCLANE, 1978), (MILLER, 1972), (MUSICK, 1979), and (RAY, 1956) and from ichthyologists at the California Academy of Sciences Aquarium in San Francisco.

2.1 Samples Collected from Boston

Atlantic Cod (Gadus morhua) is a common commercial catch and popular sport fishery species that is generally abundant in New England waters from mid-October to April. These cod are known to either migrate extensively or remain fairly constant in a given area. Adults are commonly caught from 60 to 1,500 feet, and feed primarily on bottom-dwelling invertebrates and smaller demersal fishes. The younger specimens are normally found bottom-feeding in shallower waters than adults, after an early portion of the life cycle is spent feeding on copepods and small crustaceans in surface waters. Most commercial New England catches are in the six to twelve pound range.

Cusk eels (family Ophidiidae) bear a resemblance to true eels and to eelpount fishes (family Zoarcidae). These are basically small (commonlly about one-foot long at maturity), burrowing-type marine animals, but they can attain lengths to approximately five feet. They are generally caught in bottom-trawls, as were the samples collected during this monitoring program.

Haddock (Melanogrammus aeglefinus) is an important commercial species from the cod family of fishes. It is commonly caught at depths ranging from 150 to 450 feet where it feeds primarily on bottom-dwelling invertebrates. Average catch sizes are one to two feet and one to five pounds. Some seasonal migration occurs northward in the spring and to the south during the fall.

Pollock/Boston Blackfish (Pollachius virens) is another member of the cod fish family. It feeds more in surface waters than does the Atlantic Cod or Haddock, but not exclusively. Typical catch sizes are one to two feet, four to fifteen pounds. It is a popular sport fishery catch.

Red Hake (Urophycis chuss) is an important commercial, bottom-feeding fish that is generally caught by line-trawl fishing at night. It ranges from the shallower waters to depths of 1,800 feet, feeding on shrimps, amphipods, squids and other fish. Spawning usually occurs in the Massachusetts Bay area during June and July. Normal catch sizes are two to five pounds.

Winter Flounder (Pseudopleuronectes americanus) is a very common, right-eyed, shallow-water flounder ranging to depths of 400 feet. They generally move in groups, searching for food, from deeper to shallower waters during the fall and offshore in spring, but do not usually migrate very far from spawning areas. Average sizes are one to one and one-half feet, and one to two pounds.

2.2 Samples Collected from Atlantic City

Tilefish (Lopholatilus chamaeleonticeps) is a benthic fish, normally found at depths from 250 to 1,000 feet in outer continental shelf and upper continental slope waters. It is primarily a sport fishery catch, that is especially fished for in the Hudson Canyon area by New York and New Jersey party boats. These fish can attain sizes to about fifty pounds, although the average catch is approximately three feet long and weighs about thirty pounds. They feed on invertebrates and smaller fish.

Conger eels (Conger oceanicus) are true eels that range in size from four to six feet and are commonly found in the shallower depths on the continental shelf from Cape Cod to North Carolina.

2.3 Samples Collected from San Francisco

Dover Sole (Microstomus pacificus) is a very common, benthic fish in the waters off central California. They are an important commercial catch. These right-eyed flounders are normally caught by trawling the bottom at depths between 100 and 3,000 feet. Some specimens attain lengths of two and one-half feet, weighing ten pounds. They feed upon brittle stars, molluscs, polychaetes and crustaceans. Short migrations along the coastline are common; but there are no indications of extensive seasonal inshore/offshore migrations.

Lingcods (Ophiodon elongatus) are bottom-feeders fished by commercial and sport fishermen. They are found at depths to approximately 400 feet. Commercial catches frequently range up to fifty and sixty pound sizes, sometimes to seventy pounds. Common catches are about three feet and thirty pounds.

Pacific Hake/Butterfish (Merluccius productus) is very abundant in sport and commercial fish catches. They are generally larger (sizes to three feet are common) than the Atlantic Ocean cod family of fishes and are commonly found in the waters off central California to depths of 3,000 feet. They normally feed on smaller fishes and squids.

Pacific Red Snapper (Sebastes sp.) is a bottom-dwelling, invertebrate and fish-eating member of the Scorpaenidae (Rockfish) family that attains lengths to about two feet. They are commonly found to depths of approximately 600 feet, and sought after by sport and commercial fishermen.

Sablefish/Black Cod (Anoplopoma fimbria) is an important commercial catch in central California waters to approximately 600 feet deep. Commonly about three feet in length when caught, they feed on various fishes, crustaceans and tunicates. They are often consumed as a smoked delicacy.

Thornyhead/Hard Head (Sebastolobus sp.) is another ery important commercial catch in central California waters. Primarily benthic, they feed upon crustaceans and other fishes. The short-spined species (Sebastolobus alascanus) is common at depths from approximately 100 to over 5,000 feet. Common lengths are approximately two and one-half feet. The long-spined species (Sebastolobus altivelis) is not commonly harvested, as most catches are at depths between 1,000 and 5,000 feet. Common sizes are one to one and one-half feet.

All thirty-seven samples were forwarded to the FDA's Winchester Engineering and Analytical Center (WEAC) in Massachusetts, where a twenty-pound blended homogenate was prepared from the edible portion of each sample. One-half of this homogenate was retained by WEAC; the other half was sent to the EPA Eastern Environmental Radiation Facility (EERF) in Alabama. Thus, independent radionuclide analyses were performed on each half of the prepared samples.

The information in Tables 2, 3, and 4 shows when and approximately where each sample was collected. Sample identification numbers used by each radiation laboratory are also listed.

TABLE 2. MARKETPLACE SEAFOOD SAMPLES COLLECTED BY FDA FROM BOSTON FISHERMEN

DATE	WEAC SAMPLE NUMBER	SAMPLE COLLECTED	(Scientific Name)	APPROX. COLLECTION DEPTH (ft.)	APPROX. DISTANCE* FROM DISPOSAL SITE (nm)	EERF SAMPLE NUMBER
1981						
2 September	81-254-306	Winter Flounder	*Pseudopleuronectes americanus*	300	12	15991/15992
2 September	81-254-307	Atlantic Cod	*Gadus morhua*	DNP	14	15993/15994
10 September	81-254-308	Red Hake	*Urophycis chuss*	165	18	16842
10 September	81-254-309	Cusk eel	family *Ophidiidae*	450	13	16843
21 September	81-254-310	Winter Flounder	*Pseudopleuronectes americanus*	DNP	13	16844
21 September	81-254-311	Atlantic Cod	*Gadus morhua*	DNP	13	16845
1982						
10 June	82-255-511	Winter Flounder	*Pseudopleuronectes americanus*	BC	13 (SE)	26958
13 September	82-255-892	Red Hake	*Urophycis chuss*	180	15	26959
13 September	82-255-893	Atlantic Cod	*Gadus morhua*	180	15	26960
2 November	83-255-842	Haddock	*Melanogrammus aeglefinus*	190	15	26961
2 November	83-255-843	Atlantic Cod	*Gadus morhua*	190	15	26962
2 November	83-255-844	Pollock (Boston Blackfish)	*Pollachius virens*	190	15	26963

EERF samples 15991 and 15992 are splits of FDA/WEAC sample 81-254-306.
EERF samples 15993 and 15994 are splits of FDA/WEAC sample 81-254-307.

DNP = Collection depth not provided.
BC = Bottom Catch - depth not provided.
* = Distance from central coordinates (42° 25'N, 70° 35'W) of disposal site.
(SE) = Direction from disposal site coordinates. Direction not provided for other samples.

TABLE 3. MARKETPLACE SEAFOOD SAMPLES COLLECTED BY FDA FROM ATLANTIC CITY FISHERMEN

DATE	WEAC SAMPLE NUMBER	SAMPLE COLLECTED	(Scientific Name)	APPROX. COLLECTION DEPTH (ft.)	APPROX. DISTANCE* FROM DISPOSAL SITE (nm)	EERF SAMPLE NUMBER
1981						
3 September	81-311-205	Tilefish	Lopholatilus chamaeleonticeps	500	53	16846
13 September	81-311-206	Conger eel	Conger oceanicus	500	53	16847
24 September	81-274-181	Conger eel	Conger oceanicus	460	56	17633
24 September	81-274-182	Tilefish	Lopholatilus chamaeleonticeps	460	56	17634
30 September	81-311-281	Tilefish	Lopholatilus chamaeleonticeps	510	72	17635
7 October	81-311-284	Tilefish	Lopholatilus chamaeleonticeps	540	55	17636
1982						
3 April	82-311-381	Tilefish	Lopholatilus chamaeleonticeps	720	104	23031
3 April	82-311-382	Tilefish	Lopholatilus chamaeleonticeps	780	87	23032
2 May	82-311-300	Tilefish	Lopholatilus chamaeleonticeps	720	104	23036
7 May	82-311-383	Tilefish	Lopholatilus chamaeleonticeps	450	59	23033
10 May	82-311-384	Tilefish	Lopholatilus chamaeleonticeps	520	55	23034
10 May	82-311-385	Tilefish	Lopholatilus chamaeleonticeps	420	55	23035

* = Distance from Central Coordinates of nearest disposal site.

SITE COORDINATES
2800m Site (approximately 140nm SE of Sandy Hook, NJ) 38° 30'N, 72° 06'W.
3800m Site (approximately 220nm SE of Sandy Hook, NJ) 37° 50'N, 70° 35'W.

TABLE 4. MARKETPLACE SEAFOOD SAMPLES COLLECTED BY FDA FROM SAN FRANCISCO FISHERMEN

DATE	WEAC SAMPLE NUMBER	SAMPLE COLLECTED	(Scientific Name)	APPROX. COLLECTION DEPTH (ft.)	APPROX. DISTANCE* FROM DISPOSAL SITE (nm)	EERF SAMPLE NUMBER
1981						
6 October	82-247-356	Dover Sole	Microstomus pacificus	1,800	20 (NW)	17639
7 October	82-345-697	Thornyhead (Hard Head)	Sebastolobus sp.	1,500	8 (NW)	17637
7 October	82-345-698	Pacific Hake (Butterfish)	Merluccius productus	1,500	8 (NW)	17638
16 October	82-247-357	Sablefish (Black Cod)	Anoplopoma fimbria	720	20 (NW)	17640/17640x
12 November	82-180-258	Lingcod	Ophiodon elongatus	375	6 (NE)	18620/18620x
12 November	82-247-983	Sablefish (Black Cod)	Anoplopoma fimbria	1,600	20 (SW)	18621
12 November	82-247-984	Thornyhead (Hard Head)	Sebastolobus sp.	1,600	20 (SW)	18622
1982						
26 May	82-247-995	Pacific Red Snapper	Sebastes sp.	480	7 (S)	23041
26 May	82-247-996	Lingcod	Ophiodon elongatus	480	7 (S)	23042
27 May	82-247-991	Lingcod	Ophiodon elongatus	DNP	15 (N)	23037
27 May	82-247-992	Sablefish (Black Cod)	Anoplopoma fimbria	DNP	15 (N)	23038
27 May	82-247-993	Pacific Red Snapper	Sebastes sp.	DNP	15 (N)	23039
27 May	82-247-994	Sablefish (Black Cod)	Anoplopoma fimbria	480	7 (S)	23040

DNP = Collection depth not provided.
* = Distance (and direction) from Central Coordinates (37° 38'N, 123° 08'W) of disposal site located WSW of San Francisco, California.
EERF samples 17640 and 17640x are splits of FDA/WEAC sample 82-247-357.
EERF samples 18620 and 18620x are splits of FDA/WEAC sample 82-180-258.

III. MARKETPLACE SEAFOOD ANALYSES

3.1 Analytical Procedures

The WEAC retained one-half (ten pounds) of the blended homogenate prepared from the edible fish portion of each seafood sample collected by the three FDA districts. WEAC analyzed each sample for gross gamma activity, cesium-137, iodine-131, barium-140, and strontium-90. Six of the twelve samples received from each FDA district were also analyzed for plutonium-239. The analytical methods used are described in references to this report (BARATTA, 1969 and 1977) and (PHS, 1967). These well-established, analytical methods have been routinely used by WEAC for several thousand samples in the FDA Radionuclides in Foods Compliance Program. WEAC detection limits are 10.0 pCi/kg for cesium-137, iodine-131 and barium-140; 2.0 pCi/kg for strontium-90; and 0.1 pCi/kg for plutonium-239. The FDA routinely reports an analysis as non-detectable when the two-sigma error is greater than the measured value of activity.

The EERF received a ten-pound portion of the blended homogenate from WEAC for each of the samples collected during this Marketplace Seafood Sampling and Analysis Program. All samples were analyzed for gross gamma, alpha and beta activity. In addition, individual analyses were conducted for the following radionuclides: plutonium-238, plutonium-239, strontium-90, lead-210, polonium-210, radium-226, thorium-227, thorium-228, thorium-230, thorium-232, uranium-234, uranium-235 and uranium-238. Standard sample preparation and specific analytical procedures were used by EERF (LIEBERMAN, 1984). Measured values were reported on a wet-weight basis.

NOTE: The minimum detectable level (MDL) used by EERF is defined as the minimum value of environmental radioactivity that may be confidently detected, and its reliability is less than a five percent chance for errors of the first kind (determining that activity is present when it is not) and of the second kind (failing to determine that activity is present when it is). The MDL estimates the minimum activity that will yield a large enough signal to enable analysts to confidently state that something other than ambient variations were detected. At EERF, the MDL is typically and predominately due to the instrumental counting error and is set equal to the two-sigma counting error for specific analyses. The MDL is in no way used to adjust measurement values. Table 5 provides the EERF MDL for each radionuclide identified in the seafood samples collected during this Marketplace Seafood Sampling and Analysis Program

TABLE 5. RADIONUCLIDES IDENTIFIED BY EERF IN SAMPLES FROM THE EPA/FDA MARKETPLACE SEAFOOD MONITORING PROGRAM

RADIONUCLIDES	HALF-LIFE	DETECTION PROCEDURE USED	MDL pCi/kg	OCCURRENCE MAN-MADE	OCCURRENCE NATURAL
Gamma Scan*	NA	§	NA	X	X
Gross Alpha	NA	#	200	X	X
Gross Beta	NA	ß	100	X	X
Bi-214	19.7 minutes	§	25		X
Pb-214	26.8 minutes	§	25		X
Th-227	18.2 days	#	1.5		X
Po-210	138.4 days	#	100		X
Th-228	1.9 years	#	1.5		X
Pb-210	20.4 years	ß	200		X
Sr-90	27.7 years	ß	20	X	
Cs-137	30.0 years	§	25	X	
Pu-238	86.4 years	#	1.5	X	
Ra-226	1,602.0 years	#	10		X
Pu-239	24,390.0 years	#	1.5	X	
Th-230	8.00×10^4 years	#	1.5		X
U-234	2.47×10^5 years	#	1.5		X
U-235	7.10×10^8 years	#	1.5		X
K-40	1.26×10^9 years	§	25		X
U-238	4.51×10^9 years	#	1.5		X
Th-232	1.41×10^{10} years	#	1.5		X

*The computer program used by EERF for gamma scan analysis can identify more than 500 radionuclides. Only those radionuclides observed in the samples from this study are included here.

§ = gamma
# = alpha
ß = beta
MDL = minimum detectable level
pCi/kg = picocuries per kilogram
NA = Not applicable

3.2 Analytical Results

A complete listing of radionuclide analytical data is presented in the Appendix to this report for all samples received by EERF during the Marketplace Seafood Monitoring Program. Appendices A, B, and C contain the data for those samples collected by the FDA from Boston, Atlantic City and San Francisco, respectively. The EERF data includes specific analyses for indicated radionuclides, as well as gross alpha and gross beta activity. Data are presented for both natural and man-made radionuclides. The discussion of analytical results in Section IV is, however, limited to the activity levels observed for man-made radionuclides measured in the seafoods collected during this monitoring program, because the purpose of the study was to determine potential effects from ocean disposal of man-made radionuclides associated with LLW. The natural radionuclide data are presented for information only.

A careful examination of the data in the Appendices shows that many of the specific analyses performed by EERF are reported at levels below the MDL's listed in Table 5. This is in keeping with guidelines established by the EERF quality assurance program to provide both accurate and usable environmental radiation data, and to allow for statistical evaluation of the analytical results. Thus, except for gamma spectrometry data, all EERF radionuclide analytical results are reported as the counting results indicate, whether the numbers are negative, zero, positive, above or below the MDL. When analyzing for specific radionuclides in environmental samples, activity levels are frequently found to be close to zero. When the actual concentration of a radionuclide in a sample is determined to be zero, the net counting statistics should statistically show a distribution of negative and positive numbers about zero. This occurs when background detection counts are subtracted from a sample that only contains very low levels of radiation, resulting in the observation of negative number or zero values by the analyst. Reporting data in this format allows all the data to be presented and evaluated statistically without an arbitrary cutoff of small or negative numbers. This reporting approach facilitates estimates of bias in the nuclide analyses and allows for better evaluation of distribution and trends in environmental data. Thus, when reviewing the data presented in this report, caution should be exercised in the interpretation of individual negative or zero values. Obviously a negative value has no individual significance, but such numbers are significant when examined together with other observations of radionuclide concentrations indicating that the real distribution of values is near zero. Accordingly, activity values for the radionuclides analyzed by EERF during the Marketplace Seafood Monitoring Program are presented as follows:

Gross Alpha and Beta Analyses -- Data are reported in Appendices A, B and C as actual values of gross radioactivity. When measured concentrations are below the MDL for these analyses, at the 2-sigma confidence level, the MDL is reported.

Specific Analyses -- Activity levels are reported in the Tables and Appendices as negative, zero or positive numbers (except for gamma spectrum analyses which are essentially qualitative rather than quantitative measurements). Numerical values account for radioactive decay subsequent to the sample collection date. Activity levels that are below the MDL represent background counting data and the activity is reported less confidently than for those levels of activity that are equal to or greater than the MDL, as can be seen when comparing the 2-sigma counting error to the reported activity.

Error Terms -- Are provided for each analysis and refer to the counting term error at the 2-sigma (95 %) confidence level. Thus, error terms are reported as counting errors.

Tables 6, 7A-C, and 8A-C summarize the EERF man-made radionuclide analytical results that are contained in the Appendices. Tables 9, 10, and 11 provide the results for WEAC radionuclide analyses. A generalized comparison between the EERF and WEAC analytical results can be made by referring to the data in Tables 6, 7A-C, 8A-C, 9, 10 and 11, which also contain cross-referenced sample numbers.

An actual comparison of specific numerical results from the EERF and WEAC radionuclide analyses is not routinely possible, however. This is primarily due to the distinct differences in the sensitivity levels (MDLs) that exists between each laboratory for analyzing the same radionuclides in samples. At EERF, for example, the MDL for cesium-137 is 25 pCi/kg, 1.5 pCi/kg for plutonium-239 and 20 pCi/kg for strontium-90. At WEAC the MDLs are: 10 pCi/kg for cesium-137, 0.1 pCi/kg for plutonium-239 and 2 pCi/kg for strontium-90. These differences in sensitivity of analysis result in opposite approaches to the reporting of data by EERF and WEAC, as follows:

o EERF provided numerical results for every plutonium-239 and strontium-90 analysis, whether or not the activity level for that radionuclide in the sample was below, equal to or above the stated MDL. Thus, the EERF data includes negative, zero and positive activity levels as explained in the preceeding pages of this report. EERF also reported positive cesium-137 activity levels (below, equal to or above the MDL) obtained from gamma spectroscopy analyses of the samples. No analytical results were reported by EERF when the gamma analysis did not detect Cs-137, or other gamma nuclides, as can be seen by reviewing the Appendices.

o WEAC, in reporting its data, provided numerical analytical results only when the activity level of a radionuclide in a sample exceeded (was above) the MDL. Thus, in comparing data, note that most of the WEAC analyses for cesium-137, and those that were actually performed for plutonium-239 and strontium-90, are reported here as "ND" (not detected) values. Note also that WEAC did not analyze for Pu-239 and/or Sr-90 in twenty-eight of the thirty-seven samples collected.

TABLE 6. EERF ANALYTICAL RESULTS (1) FOR CESIUM-137

EERF SAMPLE NUMBER	BIOTA ANALYZED COMMON AND SCIENTIFIC NAMES	ACTIVITY pCi/kg WET WGT.	± 2 SIGMA COUNTING ERROR	MARKETPLACE SAMPLING LOCATION	WEAC SAMPLE NUMBER
15993	Atlantic Cod, Gadus morhua	17	13	Boston	81-254-307
15994(3)	Atlantic Cod, Gadus morhua	13	9	Boston	81-254-307
16843	Cusk eel, Ophidiidae	31 (2)	11	Boston	81-254-309
26959	Red Hake, Urophycis chuss	14	10	Boston	82-255-892
26960	Atlantic Cod, Gadus morhua	25 (2)	14	Boston	82-255-893
26962	Atlantic Cod, Gadus morhua	5	3	Boston	83-255-843
26963	Pollock (Boston Blackfish), Pollachius virens	15	11	Boston	83-255-844
17633	Conger eel, Conger oceanicus	14	10	Atlantic City	81-274-181
23031	Tilefish, Lopholatilus chamaeleonticeps	10	8	Atlantic City	82-311-381
23035	Tilefish, Lopholatilus chamaeleonticeps	17	13	Atlantic City	82-311-385
23036	Tilefish, Lopholatilus chamaeleonticeps	16	11	Atlantic City	82-311-300
18620	Lingcod, Ophiodon elongatus	7	2	San Francisco	82-180-258
18621	Sablefish (Blackcod), Anoplopoma fimbria	7	2	San Francisco	82-247-983
18622	Thornyhead, Sebastolobus sp.	12	2	San Francisco	82-247-984
23038	Sablefish (Blackcod), Anoplopoma fimbria	10	9	San Francisco	82-247-992
23040	Sablefish (Blackcod), Anoplopoma fimbria	9	8	San Francisco	82-247-994

(1) Data shows only those 16 positive values detected from the gamma spectroscopy analysis for cesium-137. A total of 41 samples were analyzed. Samples yielding non-detectable results are not listed in this table.

(2) Detection level is above or equal to the EERF minimum detectable level (25 pCi/kg)

(3) EERF samples 15993/15994 are splits of WEAC sample 81-254-307

TABLE 7A. EERF ANALYTICAL RESULTS FOR PLUTONIUM-238 AND PLUTONIUM-239 (BOSTON MARKETPLACE SAMPLES)

EERF SAMPLE NUMBER	BIOTA ANALYZED COMMON AND SCIENTIFIC NAMES	Pu-238 ACTIVITY (pCi/kg wet wgt.)	± 2 SIGMA COUNTING ERROR	Pu-239 ACTIVITY (pCi/kg wet wgt.)	± 2 SIGMA COUNTING ERROR	FDA/WEAC SAMPLE NUMBER
15991	Winter Flounder *Pseudopleuronectes americanus*	0.07	0.2	0.03	0.07	81-254-306(2)
15992	Winter Flounder *Pseudopleuronectes americanus*	0.3	0.1	0.1	0.07	81-254-306(2)
15993	Atlantic Cod *Gadus morhua*	-0.01(1)	0.09	0.02	0.04	81-254-307(3)
15994	Atlantic Cod *Gadus morhua*	0.08	0.1	0.09	0.08	81-254-307(3)
16842	Red Hake *Urophycis chuss*	0.0(1)	0.0	0.02	0.09	81-254-308
16843	Cusk Eel family Ophidiidae	0.6	0.7	0.08	0.2	81-254-309
16844	Winter Flounder *Pseudopleuronectes americanus*	1.7*	1.0	0.5	1.0	81-254-310
16845	Atlantic Cod *Gadus morhua*	0.8	0.7	-0.3(1)	0.3	81-254-311
26958	Winter Flounder *Pseudopleuronectes americanus*	0.06	0.1	-0.02(1)	0.09	82-255-511
26959	Red Hake *Urophycis chuss*	0.3	0.2	0.1	0.09	82-255-892
26960	Atlantic Cod *Gadus morhua*	0.02	0.1	0.005	0.02	82-255-893
26961	Haddock *Melanogrammus aeglefinus*	0.1	0.2	0.02	0.05	83-255-842
26962	Atlantic Cod *Gadus morhua*	0.3	0.2	-0.04(1)	0.08	83-255-843
26963	Pollock (Boston Blackfish) *Pollachius virens*	0.2	0.2	0.2	0.1	83-255-844

(1) See pages 15 and 16 for discussion of negative/zero activity values.
(2) EERF samples 15991/15992 are splits of WEAC sample 81-254-306
(3) EERF samples 15993/15994 are splits of WEAC sample 81-254-307
* Activity reported is greater than EERF MDL (1.5 pCi/kg)

TABLE 7B. EERF ANALYTICAL RESULTS FOR PLUTONIUM-238 AND PLUTONIUM-239 (ATLANTIC CITY MARKETPLACE SAMPLES)

EERF SAMPLE NUMBER	BIOTA ANALYZED COMMON AND SCIENTIFIC NAMES	Pu-238 ACTIVITY (pCi/kg wet wgt.)	± 2 SIGMA COUNTING ERROR	Pu-239 ACTIVITY (pCi/kg wet wgt.)	± 2 SIGMA COUNTING ERROR	WEAC SAMPLE NUMBER
16846	Tilefish *Lopholatilus chamaeleonticeps*	0.1	0.2	-0.03(1)	0.1	81-311-205
16847	Conger eel *Conger oceanicus*	0.0(1)	0.0	-0.02(1)	0.1	81-311-206
17633	Conger eel *Conger oceanicus*	-0.08(1)	0.4	-0.04(1)	0.3	81-274-181
17634	Tilefish *Lopholatilus chamaeleonticeps*	-0.3(1)	0.4	0.04	0.2	81-274-182
17635	Tilefish *Lopholatilus chamaeleonticeps*	-0.2(1)	0.4	-0.04(1)	0.1	81-311-281
17636	Tilefish *Lopholatilus chamaeleonticeps*	0.3	0.4	0.2	0.2	81-311-284
23031	Tilefish *Lopholatilus chamaeleonticeps*	0.03	0.05	0.0(1)	0.0	82-311-381
23032	Tilefish *Lopholatilus chamaeleonticeps*	0.06	0.2	0.04	0.08	82-311-382
23033	Tilefish *Lopholatilus chamaeleonticeps*	0.2	0.2	0.06	0.07	82-311-383
23034	Tilefish *Lopholatilus chamaeleonticeps*	0.08	0.1	-0.02(1)	0.08	82-311-384
23035	Tilefish *Lopholatilus chamaeleonticeps*	0.03	0.2	0.02	0.04	82-311-385
23036	Tilefish *Lopholatilus chamaeleonticeps*	0.2	0.1	-0.008(1)	0.06	82-311-300

(1) See pages 15 and 16 for discussion of negative/zero activity values.

TABLE 7C. EERF ANALYTICAL RESULTS FOR PLUTONIUM-238 AND PLUTONIUM-239 (SAN FRANCISCO MARKETPLACE SAMPLES)

EERF SAMPLE NUMBER	BIOTA ANALYZED COMMON AND SCIENTIFIC NAMES	Pu-238 ACTIVITY (pCi/kg wet wgt.)	± 2 SIGMA COUNTING ERROR	Pu-239 ACTIVITY (pCi/kg wet wgt.)	± 2 SIGMA COUNTING ERROR	WEAC SAMPLE NUMBER
17637	Thornyhead (Hard Head) *Sebastolobus* sp.	0.0(1)	0.2	0.03	0.07	82-345-697
17638	Pacific Hake (Butterfish) *Merluccius productus*	8.2*	10.8	-1.2(1)	2.3	82-345-698
17639	Dover Sole *Microstomus pacificus*	-0.04(1)	0.3	0.08	0.1	82-247-356
17640	Sablefish (Black Cod) *Anoplopoma fimbria*	-1.7(1)	17.2	-13.7(1)	11.0	82-247-357(2)
17640X	Sablefish (Black Cod) *Anoplopoma fimbria*	0.0(1)	0.0	0.0(1)	0.0	82-247-357(2)
18620	Lingcod *Ophiodon elongatus*	0.1	0.3	-0.1(1)	0.1	82-180-258(3)
18620X	Lingcod *Ophiodon elongatus*	0.0(1)	0.3	-0.08(1)	0.09	82-180-258(3)
18621	Sablefish (Black Cod) *Anoplopoma fimbria*	0.1	0.2	0.06	0.1	82-247-983
18622	Thornyhead (Hard Head) *Sebastolobus* sp.	0.2	0.2	0.0(1)	0.07	82-247-984
23037	Lingcod *Ophiodon elongatus*	-0.1(1)	0.2	0.0(1)	0.6	82-247-991
23038	Sablefish (Black Cod) *Anoplopoma fimbria*	0.2	0.2	0.0(1)	0.0	82-247-992
23039	Pacific Red Snapper *Sebastes* sp.	0.1	0.2	0.0(1)	0.0	82-247-993
23040	Sablefish (Black Cod) *Anoplopoma fimbria*	-0.04(1)	0.1	0.06	0.07	82-247-994
23041	Pacific Red Snapper *Sebastes* sp.	0.0(1)	0.2	0.0(1)	0.08	82-247-995
23042	Lingcod *Ophiodon elongatus*	0.09	0.1	0.03	0.04	82-247-996

(1) See pages 15 and 16 for discussion of negative/zero activity values.
(2) EERF samples 17640/17640X are splits of WEAC sample 82-247-357.
(3) EERF samples 18620/18620X are splits of WEAC sample 82-180-258.
* Activity reported is greater than EERF MDL (1.5 pCi/kg)

TABLE 8A. EERF ANALYTICAL RESULTS FOR STRONTIUM-90
(BOSTON MARKETPLACE SAMPLES)

EERF SAMPLE NUMBER	BIOTA ANALYZED COMMON AND SCIENTIFIC NAMES	Sr-90 ACTIVITY (pCi/kg wet wgt.)	± 2 SIGMA COUNTING ERROR	WEAC SAMPLE NUMBER
15991	Winter Flounder *Pseudopleuronectes americanus*	0.4	1.3	81-254-306(2)
15992	Winter Flounder *Pseudopleuronectes americanus*	0.3	0.3	81-254-306(2)
15993	Atlantic Cod *Gadus morhua*	2.6	6.0	81-254-307(3)
15994	Atlantic Cod *Gadus morhua*	-0.2(1)	0.6	81-254-307(3)
16842	Red Hake *Urophycis chuss*	-0.3(1)	0.3	81-254-308
16843	Cusk Eel family Ophidiidae	0.2	0.4	81-254-309
16844	Winter Flounder *Pseudopleuronectes americanus*	0.2	0.4	81-254-310
16845	Atlantic Cod *Gadus morhua*	-0.2(1)	0.4	81-254-311
26958	Winter Flounder *Pseudopleuronectes americanus*	-2.1(1)	0.7	82-255-511
26959	Red Hake *Urophycis chuss*	-1.0(1)	0.2	82-255-892
26960	Atlantic Cod *Gadus morhua*	-0.6(1)	0.9	82-255-893
26961	Haddock *Melanogrammus aeglefinus*	-1.0(1)	1.2	83-255-842
26962	Atlantic Cod *Gadus morhua*	-1.0(1)	1.3	83-255-843
26963	Pollock (Boston Blackfish) *Pollachius virens*	1.0	1.8	83-255-844

(1) See pages 15 and 16 for discussion of negative/zero activity values.
(2) EERF samples 15991/15992 are splits of WEAC sample 81-254-306
(3) EERF samples 15993/15994 are splits of WEAC sample 81-254-307

TABLE 8B. EERF ANALYTICAL RESULTS FOR STRONTIUM-90
(ATLANTIC CITY MARKETPLACE SAMPLES)

EERF SAMPLE NUMBER	BIOTA ANALYZED COMMON AND SCIENTIFIC NAMES	Sr-90 ACTIVITY (pCi/kg wet wgt.)	± 2 SIGMA COUNTING ERROR	WEAC SAMPLE NUMBER
16846	Tilefish *Lopholatilus chamaeleonticeps*	0.5	0.8	81-311-205
16847	Conger eel *Conger oceanicus*	1.0	1.2	81-311-206
17633	Conger eel *Conger oceanicus*	-0.4(1)	0.5	81-274-181
17634	Tilefish *Lopholatilus chamaeleonticeps*	0.1	0.1	81-274-182
17635	Tilefish *Lopholatilus chamaeleonticeps*	-20.0(1)	27.2	81-311-281
17636	Tilefish *Lopholatilus chamaeleonticeps*	-0.9(1)	1.4	81-311-284
23031	Tilefish *Lopholatilus chamaeleonticeps*	0.7	1.9	82-311-381
23032	Tilefish *Lopholatilus chamaeleonticeps*	-0.4(1)	1.9	82-311-382
23033	Tilefish *Lopholatilus chamaeleonticeps*	-0.2(1)	1.8	82-311-383
23034	Tilefish *Lopholatilus chamaeleonticeps*	-0.5(1)	2.0	82-311-384
23035	Tilefish *Lopholatilus chamaeleonticeps*	0.1	2.2	82-311-385
23036	Tilefish *Lopholatilus chamaeleonticeps*	0.7	2.0	82-311-300

(1) See pages 15 and 16 for discussion of negative/zero activity values.

TABLE 8C. EERF ANALYTICAL RESULTS FOR STRONTIUM-90
(SAN FRANCISCO MARKETPLACE SAMPLES)

EERF SAMPLE NUMBER	BIOTA ANALYZED COMMON AND SCIENTIFIC NAMES	Sr-90 ACTIVITY (pCi/kg wet wgt.)	± 2 SIGMA COUNTING ERROR	WEAC SAMPLE NUMBER
17637	Thornyhead (Hard Head) *Sebastolobus* sp.	0.0(1)	0.0	82-345-697
17638	Pacific Hake (Butterfish) *Merluccius productus*	-5.0(1)	15.0	82-345-698
17639	Dover Sole *Microstomus pacificus*	-0.03(1)	1.0	82-247-356
17640	Sablefish (Black Cod) *Anoplopoma fimbria*	-40.0(1)	151.2	82-247-357(2)
17640X	Sablefish (Black Cod) *Anoplopoma fimbria*	0.0(1)	0.0	82-247-357(2)
18620	Lingcod *Ophiodon elongatus*	0.6	2.4	82-180-258(3)
18620X	Lingcod *Ophiodon elongatus*	0.1	0.1	82-180-258(3)
18621	Sablefish (Black Cod) *Anoplopoma fimbria*	0.0(1)	0.0	82-247-983
18622	Thornyhead (Hard Head) *Sebastolobus* sp.	0.0(1)	0.0	82-247-984
23037	Lingcod *Ophiodon elongatus*	0.7	2.2	82-247-991
23038	Sablefish (Black Cod) *Anoplopoma fimbria*	0.1	0.4	82-247-992
23039	Pacific Red Snapper *Sebastes* sp.	0.1	1.7	82-247-993
23040	Sablefish (Black Cod) *Anoplopoma fimbria*	0.0(1)	1.9	82-247-994
23041	Pacific Red Snapper *Sebastes* sp.	0.3	2.3	82-247-995
23042	Lingcod *Ophiodon elongatus*	0.2	2.1	82-247-996

(1) See pages 15 and 16 for discussion of negative/zero activity values.
(2) EERF samples 17640/17640X are splits of WEAC sample 82-247-357.
(3) EERF samples 18620/18620X are splits of WEAC sample 82-180-258.

TABLE 9. WEAC ANALYTICAL RESULTS[1] FOR SEAFOOD SAMPLES COLLECTED FROM BOSTON

WEAC SAMPLE NUMBER	Cs-137[2]	Pu-239[3]	Sr-90[4]	Ba-140	I-131	EERF SAMPLE NUMBER
81-254-306	ND	ND	ND	ND	ND	15991/15992
81-254-307	18 ± 10	*	ND	ND	ND	15993/15994
81-254-308	45 ± 10	*	ND	ND	ND	16842
81-254-309	ND	ND	ND	ND	ND	16843
81-254-310	13 ± 10	*	ND	ND	ND	16844
81-254-311	ND	ND	ND	ND	ND	16845
82-255-511	ND	ND	*	ND	ND	26958
82-255-892	ND	*	*	ND	ND	26959
82-255-893	17 ± 10	ND	*	ND	ND	26960
83-255-842	ND	ND	*	ND	ND	26961
83-255-843	12 ± 10	*	*	ND	ND	26962
83-255-844	ND	*	*	ND	ND	26963

(1) Units are pCi/kg.
ND = Not Detected
* = No Analysis Performed
(2) See Table 6 for comparable EERF Cs-137 Analytical Results.
(3) See Table 7A for comparable EERF Pu-239 Analytical Results.
(4) See Table 8A for comparable EERF Sr-90 Analytical Results.

WEAC DETECTION LIMITS

10.0 pCi/kg. for Cs-137, Ba-140, I-131
2.0 pCi/kg. for Sr-90
0.1 pCi/kg. for Pu-239

TABLE 10. WEAC ANALYTICAL RESULTS FOR SEAFOOD SAMPLES COLLECTED FROM ATLANTIC CITY

WEAC SAMPLE NUMBER	Cs-137[1]	Pu-239[2]	Sr-90[3]	Ba-140	I-131	EERF SAMPLE NUMBER
81-311-205	ND	*	ND	ND	ND	16846
81-311-206	ND	ND	ND	ND	ND	16847
81-274-181	ND	*	ND	ND	ND	17633
81-274-182	ND	ND	ND	ND	ND	17634
81-311-281	ND	ND	ND	ND	ND	17635
81-311-284	ND	*	ND	ND	ND	17636
82-311-300	ND	ND	*	ND	ND	23036
82-311-381	ND	ND	*	ND	ND	23031
82-311-382	ND	*	*	ND	ND	23032
83-311-383	ND	ND	*	ND	ND	23033
83-311-384	ND	*	*	ND	ND	23034
83-311-385	ND	ND	*	ND	ND	23035

ND = Not Detected
* = No Analysis Performed

(1) See Table 6 for comparable EERF Cs-137 Analytical Results.
(2) See Table 7B for comparable EERF Pu-239 Analytical Results.
(3) See Table 8B for comparable EERF Sr-90 Analytical Results.

WEAC DETECTION LIMITS

10.0 pCi/kg. for Cs-137, Ba-140, I-131
2.0 pCi/kg. for Sr-90
0.1 pCi/kg. for Pu-239

TABLE 11. WEAC ANALYTICAL RESULTS(1) FOR SEAFOOD SAMPLES COLLECTED FROM SAN FRANCISCO

WEAC SAMPLE NUMBER	Cs-137(2)	Pu-239(3)	Sr-90(4)	Ba-140	I-131	EERF SAMPLE NUMBER
82-247-356	ND	ND	ND	ND	ND	17639
82-247-357	15 ± 10	*	ND	ND	ND	17640/17640X
82-180-258	23 ± 10	ND	ND	ND	ND	18620/18620X
82-247-983	17 ± 10	*	ND	ND	ND	18621
82-247-984	ND	*	ND	ND	ND	18622
82-345-697	ND	*	ND	ND	ND	17637
82-345-698	ND	ND	ND	ND	ND	17638
82-247-991	21 ± 10	ND	*	ND	ND	23037
82-247-992	ND	ND	*	ND	ND	23038
82-247-993	30 ± 10	ND	*	ND	ND	23039
82-247-994	ND	*	*	ND	ND	23040
82-247-995	28 ± 10	*	*	ND	ND	23041
82-247-996	21 ± 10	*	*	ND	ND	23042

(1) Units are pCi/kg.
ND = Not Detected
* = No Analysis Performed
(2) See Table 6 for comparable EERF Cs-137 Analytical Results.
(3) See Table 7C for comparable EERF Pu-239 Analytical Results.
(4) See Table 8C for comparable EERF Sr-90 Analytical Results.

WEAC DETECTION LIMITS

10.0 pCi/kg. for Cs-137, Ba-140, I-131
2.0 pCi/kg. for Sr-90
0.1 pCi/kg. for Pu-239

IV. SUMMARY AND CONCLUSIONS

4.1 Discussion of Analytical Results

A total of thirty-seven seafood samples were collected during the 1981-1982 Environmental Protection Agency (EPA) and Food & Drug Administration (FDA) Marketplace Seafood Monitoring Program. The FDA Winchester Analytical and Engineering Center (WEAC) prepared a twenty-pound blended homogenate from the edible portions of each seafood sample collected by the FDA from Atlantic City, Boston and San Francisco fishermen. Each sample consisted of a sufficient number of seafood samples to prepare the twenty-pound homogenate. One-half of the blended homogenate sample was retained by the WEAC; the other half was shipped, frozen, to the EPA Eastern Environmental Radiation Facility (EERF). The WEAC analyzed all thirty-seven of its homogenate samples for cesium-137, barium-140, and iodine-131. Nineteen of the samples were also analyzed for plutonium-239 and strontium-90. The EERF, having split four of the homogenates obtained from the WEAC, completed forty-one analyses each for cesium-137, plutonium-238, plutonium-239, and strontium-90. In addition, the EERF also completed forty-one analyses for each of the natural radionuclides identified in the Appendices. Tables 6-11, in Section III of this report, list the results from the EERF analyses for man-made radionuclides, and all of the analyses completed by the WEAC. Tables 12 and 13, in this Section, provide a summary of the data presented in Tables 6-11.

Table 12 pertains only to the data from Tables 6, 7A-C, and 8A-C. The results from the EERF for cesium, plutonium, and strontium are grouped into activity-level categories. It is noteworthy that only four of the 164 analyses (less than 2.5%) yielded results equal to or exceeding the EERF minimum detectable levels (MDL); two each for cesium-137 and plutonium-238. All analyses for plutonium-239 and strontium-90 provided results less than MDL.

As shown in Table 12, the EERF detected cesium-137 at a level equal to or greater than MDL (25 pCi/kg wet weight) in only two of forty-one analyses. Both were from samples collected from Boston fishermen. In Table 6 the cesium-137 activity in a Cusk eel sample is reported as 31 ($\pm$ 11) pCi/kg, exceeding the MDL. In an Atlantic cod sample the activity reported is 25 ($\pm$ 14) pCi/kg, equalling the MDL. One could add the error-range to the reported activity levels and obtain a maximum possible activity for each sample, which would be 42 and 39 pCi/kg respectively. This worst case approach to reporting data would put the activity levels from these two samples in or below the lower portion of the range (40 to 80 pCi/kg wet weight) for cesium-137 in marine fishes from all oceans (IAEA, 1976). Specific analytical data for cesium-137 in Atlantic ocean fishes, collected in deeper waters (2100 meters), shows activity levels ranging to a maximum of 34 pCi/kg wet weight (NEA, 1983).

TABLE 12. EERF DATA SUMMARY, NUMBER OF ANALYSES FOR MAN-MADE RADIONUCLIDES BY ACTIVITY LEVEL CATEGORIES

BOSTON SAMPLES (56 Analyses)	Cs-137	Pu-238	Pu-239	Sr-90	TOTAL
No Activity Detected	7	0	0	0	7
Negative Activity Value	0	1	3	8	12
Zero Activity Value	0	1	0	0	1
Positive Activity, less than MDL	5	11	11	6	33
Positive Activity, equal to MDL	1	0	0	0	1
Postive Activity, greater than MDL	1	1	0	0	2
					56

ATLANTIC CITY SAMPLES (48 Analyses)	Cs-137	Pu-238	Pu-239	Sr-90	TOTAL
No Activity Detected	8	0	0	0	8
Negative Activity Value	0	3	6	6	15
Zero Activity Value	0	1	1	0	2
Positive Activity, less than MDL	4	8	5	6	23
Positive Activity, equal to MDL	0	0	0	0	0
Positive Activity, greater than MDL	0	0	0	0	0
					48

TABLE 12. EERF DATA SUMMARY, NUMBER OF ANALYSES FOR MAN-MADE RADIONUCLIDES BY ACTIVITY LEVEL CATEGORIES
(Continued)

SAN FRANCISCO SAMPLES (60 Analyses)	Cs-137	Pu-238	Pu-239	Sr-90	TOTAL
No Activity Detected	10	0	0	0	10
Negative Activity Value	0	4	4	3	11
Zero Activity Value	0	4	6	5	15
Positive Activity, less than MDL	5	6	5	7	23
Positive Activity, equal to MDL	0	0	0	0	0
Postive Activity, greater than MDL	0	1	0	0	1
					60

ALL SAMPLES (164 Analyses)	Cs-137	Pu-238	Pu-239	Sr-90	TOTAL
No Activity Detected	25	0	0	0	25
Negative Activity Value	0	8	13	17	38
Zero Activity Value	0	6	7	5	18
Positive Activity, less than MDL	14	25	21	19	79
Positive Activity, equal to MDL	1	0	0	0	1
Positive Activity, greater than MDL	1	2	0	0	3
					164

NOTES TO TABLE

EERF MDL for Cs-137 = 25 pCi/kg.
EERF MDL for Pu-238 = 1.5 pCi/kg.
EERF MDL for Pu-239 = 1.5 pCi/kg.
EERF MDL for Sr-90 = 20 pCi/kg.

TABLE 13. WEAC DATA SUMMARY, NUMBER OF ANALYSES FOR RADIONUCLIDES (1) BY ACTIVITY LEVEL CATEGORIES

BOSTON SAMPLES (36)	Cs-137	Pu-239	Sr-90	TOTAL
No Analysis Performed	0	6	6	12
Activity less than dectectable limit	7	6	6	19
Activity equal to dectectable limit	0	0	0	0
Activity greater than detectable limit	5	0	0	5
				36

ATLANTIC CITY SAMPLES (36)	Cs-137	Pu-239	Sr-90	TOTAL
No Analysis Performed	0	5	6	11
Activity less than dectectable limit	12	7	6	25
Activity equal to dectectable limit	0	0	0	0
Activity greater than dectectable limit	0	0	0	0
				36

SAN FRANCISCO SAMPLES (39)	Cs-137	Pu-239	Sr-90	TOTAL
No Analysis Performed	0	7	6	13
Activity less than dectectable limit	6	6	7	19
Activity equal to dectectable limit	0	0	0	0
Activity greater than dectectable limit	7	0	0	7
				39

TABLE 13. WEAC DATA SUMMARY, NUMBER OF ANALYSES FOR RADIONUCLIDES (1) BY ACTIVITY LEVEL CATEGORIES (Continued)

ALL SAMPLES (111)	Cs-137	Pu-239	Sr-90	TOTAL
No Analysis Performed	0	18	18	36
Activity less than dectectable limit	25	19	19	63
Activity equal to dectectable limit	0	0	0	0
Activity greater than dectectable limit	12	0	0	12
				111

(1) Data presented here includes only those nuclides comparable to EERF analytical data. Sixty-one WEAC Analyses were performed for both Ba-140 and I-131 but are not included in this Table since all yielded non-detectable results.

WEAC Detection

CS-137 = 10.0 pCi/kg.
Pu-239 = 0.1 pCi/kg.
Sr-90 = 2.0 pCi/kg.

When comparing the analytical results from these two Boston samples to Atlantic ocean data only, their reported cesium-137 activites fall into the upper portion of the range given by NEA. Using the worst case data reporting approach in this instance would find the activity from the two Boston samples exceeding the ranges for cesium-137 reported by the NEA. It is important to note here, however, that the above comparisons of the Boston samples to the IAEA and NEA data are made for analyses between different fish species samples collected from disparate environmental regimes. Furthermore, the sample preparations for radionuclide analyses are not analagous. The IAEA and NEA data sets pertain to analyses of eviscerated whole fish, muscle and viscera samples. In this study the EERF analyses were performed on blended homogenates of the edible portions of seafoods collected. The levels of cesium-137 found in these two Boston samples from the EPA/FDA study do, however, appear to be reasonably consistent with the baseline data available.

Table 12 also shows that the EERF detected plutonium-238 at a level exceeding the MDL (1.5 pCi/kg wet weight) in two of forty-one analyses. One analysis was from a Boston sample, the other from a San Francisco sample. In Table 7A the activity for plutonium-238 in Winter flounder is reported as 1.7 ($\pm$ 1.0) pCi/kg wet weight, which definitely exceeds the range for plutonium-238 that was found in other Boston Winter flounder samples, and also exceeds the range for plutonium-238 observed in other Massachusetts Bay flounder samples. Plutonium-238 activity in the three other samples of Winter flounder collected from Boston during this study ranged from 0.06 to 0.3 pCi/kg wet weight (mean = 0.14), corresponding closely to data from the analyses of eight flounder collected one year later, September 1982, in Massachusetts Bay. The plutonium-238 activity in those samples ranged from 0.04 to 0.5 pCi/kg wet weight, with a mean of 0.24 (CURTIS, 1984). The validity of this 1.7 pCi/kg analytical result must, therefore, be questioned. It appears likely that the reported plutonium-238 activity in this sample may not represent true plutonium-238 activity. This statement can be supported by the large 2-sigma counting error value of $\pm$ 1.0 pCi/kg for this analysis, and the corresponding analysis for plutonium-239 in the same sample (0.5 pCi/kg activity with a large error term of 1.0 pCi/kg). The questionable validity of plutonium-238 activity in this sample can probably be attributed to laboratory error during the sample preparation and analysis procedure and/or contaimination of the sample itself (LIVINGSTON, 1987). In Table 7C the activity for plutonium-238 in Pacific hake is reported as 8.2 ($\pm$ 10.8) pCi/kg wet weight which far exeeds baseline plutonium-238 activity levels in marine fishes. Again, due to the extremely large 2-sigma counting error reported with this analysis and the corresponding data for analysis of plutonium-239 in the same sample (minus 1.2 pCi/kg activity and a large error term of 2.3 pCi/kg), the validity of this analytical result is also questionable.

Repeat analyses by EERF on the homogenate samples yielded essentially the same results, indicating that the homogenates were contaminated. As the original fish samples are not available for reprocessing, additional samples will be obtained for verification.

From the data summarized in Table 12, and from the above discussions about the four EERF analytical results for cesium-137 and plutonium-238 that were at or above MDL, it is clear that 162 of the 164 analyses show radioactivity in the thirty-seven samples to be below or within expected environmental background (ambient) radiation levels, due primarily from global fallout, as previously reported (DYER, 1976), (IAEA, 1976), (NOSHKIN, 1978), (SCHELL, 1980), (NEA, 1983 and 1985), and (CURTIS, 1984).

Table 13 pertains only to data contained in Tables 9, 10, and 11. Analytical results from the 111 WEAC analyses for barium, cesium, iodine, plutonium, and strontium are grouped into the same activity-level categories as given for the EERF data in Table 12. The WEAC reported measureable activity, above detection limits, for cesium-137 only. The data listed in Tables 9, 10, and 11 shows the twelve measurable quantities for cesium-137 from the thirty-seven analyses performed by the WEAC. Five of the twelve samples from Boston are listed with cesium-137 activity, as are seven of the thirteen samples from San Francisco. The WEAC reports no measureable quantities of cesium-137 in any of the twelve samples collected from Atlantic City. The WEAC further reports that no detectable activity for barium-140, iodine-131, plutonium-239, or strontium-90 was found in any of the thirty-seven samples analyzed during this study.

Measureable quantities of cesium-137, reported by the WEAC, range in the Boston samples from 12 to 45 pCi/kg (mean = 21) and from 15 to 30 pCi/kg (mean = 22) in the San Francisco samples. These activity levels are reasonably consistent with the ranges of cesium-137 previously reported for Pacific ocean fish (NOSHKIN, 1978) and (SCHELL, 1980). The activity levels for these twelve cesium-137 analyses are also within the range of values observed during the past twelve years of the FDA Total Diet Studies and Radionuclides in Foods monitoring programs. The cesium-137 analytical results presented by WEAC in this report are below levels considered by the FDA to be of public health concern. The data presented is also considered to be of normal background levels in seafood and attributable to global fallout over the oceans (STROUBE, 1984).

4.2 Conclusions

Direct numerical comparisons between the EERF and WEAC analysis data were difficult due to differences in each laboratory's analytical sensitivities and reporting procedures, and because of the number of WEAC samples for which no numerical data was reported. Analysis of the overall Marketplace Seafood Monitoring Program data clearly shows, however, that the levels of man-made radionuclides in the samples were at or below those levels normally found in foods (STROUBE, 1984). All results were found to be in the lower portion of Range I of the Federal Radiation Council guidelines for radioactivity and similar to previous findings from FDA analyses of imported fish obtained from retail outlets (JELINEK, 1982). Based upon the analytical data presented in this report, the EPA therefore concludes that:

(1) The analyses for man-made radionuclides in the seafood samples collected show that radioactivity levels are at or below those normally found in food samples.

(2) Measureable levels of cesium-137 and plutonium-238 activity were detected in 16 of the 239 analyses (6.7%) completed by EERF and WEAC during this monitoring program. The activity levels observed in those 16 samples are, however, well below activity levels considered to be of public health significance or concern.

(3) The data show no evidence that previous LLW disposals in Massachusetts Bay, at the Atlantic Ocean disposal sites, or at the Farallon Islands disposal site have resulted in contamination of local seafood populations with waste-related radionuclides.

These conclusions are in accord with data previously reported from FDA food study programs and in previous EPA reports of studies conducted at the major U.S. ocean disposal sites for LLW.

REFERENCES

BARATTA, E.J. and Reavy, T.C., "Rapid Determination of Strontium-90 in Tissue, Food, Biota and other Environmental Media by Tributyl Phosphate," Journal of Agriculture and Food Chemistry, Vol. 17, 1969.

BARATTA, E.J. and Lumsden, E.M., "Isotopic Analysis of Plutonium in Food Ash," Food and Drug Administration (FDA) Library Information Bulletin, No. 2015, 1977.

CURTIS, W.R. and Mardis, H.M., "Data From Studies of Previous Radioactive Waste Disposal in Massachusetts Bay," Environmental Protection Agency (EPA) Report, No. 520/1-84-031, December 1984.

DYER, R.S., "Environmental Surveys of Two Deepsea Radioactive Waste Disposal Sites Using Submersibles," Management of Radioactive Wastes From the Nuclear Fuel Cycle, Vol. II, International Atomic Energy Agency, Vienna 1976.

GATES, D.E. and Frey, H.W., "Designated Common Names of Certain Marine Organisms of California," State of California Department of Fish and Game Bulletin, No. 161, 1974.

GOTSHALL, D.W. and Dyer, R.S., "Deepwater Demersal Fishes Observed From the Submersible AVALON Off the Farallon Islands in June 1985," State of California Department of Fish and Game Marine Resources Technical Report, No. 55, 1987.

HANSELMAN, D.H. and Ryan, W., "1978 Atlantic 3800 Meter Radioactive Waste Disposal Site Survey," Environmental Protection Agency (EPA) Report, No. 520/1-83-017, June 1983.

IAEA, "Effects of Ionizing Radiation on Aquatic Organisms and Ecosystems," International Atomic Energy Agency (IAEA) Technical Report Series, No. 172, 1976.

JELINEK, C.F., Correspondence with R.H. Johnson, Environmental Protection Agency (EPA), Office of Radiation Programs (ORP), December 1982.

LIEBERMAN, R., Eastern Environmental Radiation Facility (EERF) Radiochemistry Procedures Manual, Environmental Protection Agency (EPA) Report, No. 520/5-84-006, August 1984.

LIVINGSTON, H., Woods Hole Oceanographic Institution, Personal Communication, September 1987.

LOCKWOOD, M., Grunthal, M. and Curtis, W.R., "Side Scan Sonar Survey of the Massachusetts Bay LLW Disposal Sites," OCEANS'82, Marine Technology Society Conference, Washington DC, September 1982.

REFERENCES (Continued)

McCLANE, A.J., (Ed.), Field Guide to Saltwater Fishes of North America, Holt, Rinehart and Winston, New York, 1978.

MILLER, D.J. and Lea, R.N., "Guide to the Coastal Marine Fishes of California," State of California Department of Fish and Game Bulletin, Fishery Bulletin No. 157, 1972.

MUSICK, J.A. and Sulak, K.J., "Characterization of the Demersal Fish Community of a Deepsea Radioactive Waste Disposal Site," Environmental Protection Agency (EPA) Draft Contract Report, 1979.

NEA, Interim Oceanographic Description of the Northeast Atlantic Site for the Disposal of Low-Level Radioactive Waste, Nuclear Energy Agency (NEA) Organization for Economic Cooperation and Development, Paris, January 1983.

NEA, Review of the Continued Suitability of the Dumping Site for Radioactive Waste in the Northeast Atlantic, Nuclear Energy Agency (NEA) Organization for Economic Cooperation and Development, Paris, 1985.

NOSHKIN, V.E. et al, "Radionuclides in The Marine Environment Near the Farallon Islands," University of California, Lawrence Livermore Laboratory Report, No. UCRL-52381, January 1978.

PHS, "Radioassay Procedures for Environmental Samples," Public Health Service (PHS) Publication, Section 4-22, January 1967.

RAY, C. and Ciampi, E., The Underwater Guide to Marine Life, A.S. Barnes and Company, New York, 1956.

REISH, D.J., "Survey of the Benthic Invertebrates Collected From the U.S. 2800 Meter Radioactive Waste Disposal Site in the Atlantic Ocean," Environmental Protection Agency (EPA) Report, No.520/1-82-003, 1983.

SCHELL, W.R. and Sugai, S., "Radionuclides At the U.S. Radioactive Waste Disposal Site Near The Farallon Islands," Health Physics, Vol. 39, No. 3, September 1980.

STROUBE, W.B., Correspondence with W.R. Curtis, Environmental Protection Agency (EPA), Office of Radiation Programs (ORP), August 1984 (Food and Drug Administration 1981 Compliance Program Assignment Memorandum).

ACKNOWLEDGMENTS

Sincere gratitude is expressed to Charles Jelinek, of the Food and Drug Administration (FDA), for his assistance in planning this monitoring program and helping to get it started. Gratitude is also expressed to William Stroube and William Cunningham, of the FDA, for assisting in the evaluation of Winchester Engineering and Analytical Center (WEAC) radioanalytical data, and for reviewing the preliminary drafts of this report. Recognition is also accorded to Patrick Lombardo, Edmond Baretta and the staff at WEAC for preparing the collected samples for analysis, shipping duplicate homogenates to the EPA radiation laboratory, and conducting radionuclide analyses.

The cooperation provided to the author by Charles Porter and the staff of the EPA Eastern Environmental Radiation Facility (EERF) during this monitoring program was significant to its success. Two members of the EERF staff, Jon Broadway and Geraldine Luster, were particularly helpful in providing and evaluating the data, answering and responding to numerous questions and requests from the author, and reviewing draft and final versions of the report.

Special thanks also are extended to Victor Noshkin, of Lawrence Livermore Laboratories, and Hugh Livingston, of the Woods Hole Oceanographic Institution, for their critical reviews of the report and for their helpful suggestions to me in presenting the data from this monitoring program. Critical reviews of the report by Robert Dyer, William Gunter and Michael Mardis, of the EPA Office of Radiation Programs, are also gratefully appreciated.

In addition, I wish to thank Raymond Clark and Bonnie Wyvill, of the EPA Office of Radiation Programs, for their assistance. Ray provided the graphic art expertise displayed in Figure 1; Bonnie spent countless hours typing and retyping text and tables.

APPENDICES

COMPLETE LISTING OF ALL EERF ANALYTICAL RESULTS (MAN-MADE AND NATURAL RADIONUCLIDES) FOR MARKETPLACE SEAFOOD SAMPLES COLLECTED BY THE FDA FROM:

Radionuclide Analyses of Marketplace Seafood Samples Collected by FDA Boston District, 1981 and 1982

Sample Number	Date Collected	Sample Type	Analysis	Nuclide	Activity Pci/g (Wet)	2-Sigma Error
	MAN-MADE NUCLIDES					
15993	9/ 2/81	Cod	GAMMA	CS-137	1.7000E-02	1.2920E-02
15994	9/ 2/81	Cod	GAMMA	CS-137	1.3000E-02	8.8400E-03
16843	9/10/81	Cusk Eels	GAMMA	CS-137	3.1000E-02	1.1160E-02
26959	9/13/82	Hake	GAMMA	CS-137	1.4000E-02	1.0080E-02
26960	9/13/82	Cod	GAMMA	CS-137	2.5000E-02	1.4500E-02
26962	11/ 2/82	Cod	GAMMA	CS-137	5.0000E-03	3.3000E-03
26963	11/ 2/82	Pollock	GAMMA	CS-137	1.5000E-02	1.1250E-02
15991	9/ 2/81	Flounder	PU	PU-238	7.0000E-05	1.7150E-04
15991	9/ 2/81	Flounder	PU	PU-239	3.0000E-05	7.3500E-05
15992	9/ 2/81	Flounder	PU	PU-239	1.0000E-04	6.7000E-05
15992	9/ 2/81	Flounder	PU	PU-238	3.0000E-04	1.4400E-04
15993	9/ 2/81	Cod	PU	PU-238	-1.0000E-05	9.1700E-05
15993	9/ 2/81	Cod	PU	PU-239	2.0000E-05	4.0000E-05
15994	9/ 2/81	Cod	PU	PU-238	8.0000E-05	1.1360E-04
15994	9/ 2/81	Cod	PU	PU-239	9.0000E-05	7.7400E-05
16842	9/10/81	Hake	PU	PU-239	2.0000E-05	8.9400E-05
16842	9/10/81	Hake	PU	PU-238	0.0000E+00	0.0000E+00
16843	9/10/81	Cusk Eels	PU	PU-239	8.2232E-05	1.6491E-04
16843	9/10/81	Cusk Eels	PU	PU-238	5.7566E-04	7.2211E-04
16844	9/21/81	Flounder	PU	PU-238	1.7000E-03	1.0370E-03
16844	9/21/81	Flounder	PU	PU-239	5.1860E-04	1.0410E-03
16844	9/21/81	Flounder	PU	PU-238	8.8170E-03	5.3710E-03
16844	9/21/81	Flounder	PU	PU-239	1.0000E-04	2.0100E-04
16845	9/21/81	Cod	PU	PU-239	-3.0000E-04	2.7300E-04
16845	9/21/81	Cod	PU	PU-238	8.0000E-04	7.4400E-04
26958	6/10/82	Flounder	PU	PU-239	-1.9060E-05	8.5260E-05
26958	6/10/82	Flounder	PU	PU-238	5.7180E-05	1.3760E-04
26959	9/13/82	Hake	PU	PU-239	1.0160E-04	9.1700E-05
26959	9/13/82	Hake	PU	PU-238	2.8460E-04	1.5580E-04
26960	9/13/82	Cod	PU	PU-238	2.1120E-05	1.0970E-04
26960	9/13/82	Cod	PU	PU-239	4.8180E-06	1.7750E-05
26960X	9/13/82	Cod	PU	PU-239	-4.2850E-05	8.5950E-05
26960X	9/13/82	Cod	PU	PU-238	7.0140E-05	3.1660E-04
26961	11/ 2/82	Haddock	PU	PU-239	2.1370E-05	4.5930E-05
26961	11/ 2/82	Haddock	PU	PU-238	1.0800E-04	1.8710E-04
26962	11/ 2/82	Cod	PU	PU-238	2.5950E-04	2.0600E-04
26962	11/ 2/82	Cod	PU	PU-239	-3.9520E-05	7.9250E-05
26963	11/ 2/82	Pollock	PU	PU-239	1.6970E-04	1.2490E-04
26963	11/ 2/82	Pollock	PU	PU-238	2.4510E-04	1.5090E-04
15991	9/ 2/81	Flounder	SR	SR-90	4.0000E-04	1.2920E-03
15992	9/ 2/81	Flounder	SR	SR-90	3.0000E-04	3.0000E-04
15993	9/ 2/81	Cod	SR	SR-90	2.6000E-03	5.9800E-03
15994	9/ 2/81	Cod	SR	SR-90	-2.0000E-04	6.0000E-04
16842	9/10/81	Hake	SR	SR-90	-2.5680E-04	3.4239E-04
16843	9/10/81	Cusk Eels	SR	SR-90	2.2084E-04	4.4168E-04
16844	9/21/81	Flounder	SR	SR-90	2.1484E-04	4.2968E-04
16845	9/21/81	Cod	SR	SR-90	-2.0715E-04	4.1430E-04
26958	6/10/82	Flounder	SR	SR-90	-2.1000E-03	7.3500E-04
26959	9/13/82	Hake	SR	SR-90	-1.0000E-03	2.0000E-04
26960	9/13/82	Cod	SR	SR-90	-6.0000E-04	9.0000E-04
26960X	9/13/82	Cod	SR	SR-90	1.0000E-03	1.0000E-03
26961	11/ 2/82	Haddock	SR	SR-90	-1.0000E-03	1.2000E-03

26962	11/ 2/82	Cod	SR	SR-90	-1.0000E-03	1.2700E-03
26963	11/ 2/82	Pollock	SR	SR-90	1.0000E-03	1.7500E-03

NATURAL NUCLIDES

15991	9/ 2/81	Flounder	GAMMA	K-40	2.9000E+00	3.7700E-01
15992	9/ 2/81	Flounder	GAMMA	K-40	3.2000E+00	2.5600E-01
15993	9/ 2/81	Cod	GAMMA	K-40	3.1000E+00	2.7900E-01
15994	9/ 2/81	Cod	GAMMA	K-40	3.0000E+00	2.1000E-01
16842	9/10/81	Hake	GAMMA	K-40	2.8000E+00	3.6400E-01
16843	9/10/81	Cusk Eels	GAMMA	K-40	3.1000E+00	2.4800E-01
16844	9/21/81	Flounder	GAMMA	K-40	2.7000E+00	2.1600E-01
16845	9/21/81	Cod	GAMMA	K-40	3.4000E+00	2.0400E-01
26958	6/10/82	Flounder	GAMMA	K-40	3.4000E+00	4.4200E-01
26959	9/13/82	Hake	GAMMA	K-40	3.6000E+00	2.8800E-01
26960	9/13/82	Cod	GAMMA	K-40	3.0000E+00	3.0000E-01
26960X	9/13/82	Cod	GAMMA	K-40	3.2000E+00	2.8800E-01
26961	11/ 2/82	Haddock	GAMMA	K-40	3.5000E+00	4.9000E-01
26962	11/ 2/82	Cod	GAMMA	K-40	3.8000E+00	2.2800E-01
26963	11/ 2/82	Pollock	GAMMA	K-40	3.9000E+00	3.1200E-01
15991	9/ 2/81	Flounder	PB	PB-210	1.9600E-01	3.2405E-01
15992	9/ 2/81	Flounder	PB	PB-210	1.0600E+00	7.1624E-01
15993	9/ 2/81	Cod	PB	PB-210	3.4600E-01	4.1032E-01
15994	9/ 2/81	Cod	PB	PB-210	3.5350E-01	5.2880E-01
16842	9/10/81	Hake	PB	PB-210	2.5800E-01	4.5408E-01
16843	9/10/81	Cusk Eels	PB	PB-210	1.0690E-01	4.1021E-01
16844	9/21/81	Flounder	PB	PB-210	1.1255E-03	2.9518E-01
16845	9/21/81	Cod	PB	PB-210	4.2463E-01	4.6463E-01
26958	6/10/82	Flounder	PB	PB-210	-7.5977E-03	1.9284E-01
26959	9/13/82	Hake	PB	PB-210	-6.8101E-02	1.2003E-01
26960	9/13/82	Cod	PB	PB-210	-3.3857E-02	1.0053E-01
26960X	9/13/82	Cod	PB	PB-210	5.9297E-02	1.4097E-01
26961	11/ 2/82	Haddock	PB	PB-210	2.1966E-01	2.7060E-01
26962	11/ 2/82	Cod	PB	PB-210	7.2815E-02	1.7233E-01
26963	11/ 2/82	Pollock	PB	PB-210	-5.6450E-02	1.4744E-01
26963	11/ 2/82	Pollock	PB	PB-210	-2.7124E-01	7.0845E-01
15991	9/ 2/81	Flounder	PO	PO-210	2.2000E-02	1.2817E-02
15992	9/ 2/81	Flounder	PO	PO-210	9.5000E-03	1.0275E-02
15993	9/ 2/81	Cod	PO	PO-210	1.5000E-03	1.1220E-03
15994	9/ 2/81	Cod	PO	PO-210	4.0000E-04	5.5459E-03
16842	9/10/81	Hake	PO	PO-210	2.4450E-03	5.6646E-03
16843	9/10/81	Cusk Eels	PO	PO-210	1.0800E-02	9.2880E-03
16844	9/21/81	Flounder	PO	PO-210	5.5000E-03	5.4450E-03
16845	9/21/81	Cod	PO	PO-210	1.6150E-03	5.3926E-03
26958	6/10/82	Flounder	PO	PO-210	1.1164E-02	6.5512E-03
26959	9/13/82	Hake	PO	PO-210	5.3392E-03	3.4434E-03
26960	9/13/82	Cod	PO	PO-210	5.9960E-03	3.8234E-03
26960X	9/13/82	Cod	PO	PO-210	5.3739E-03	3.6929E-03
26961	11/ 2/82	Haddock	PO	PO-210	6.0917E-03	5.3091E-03
26962	11/ 2/82	Cod	PO	PO-210	1.2251E-03	2.7398E-03
26963	11/ 2/82	Pollock	PO	PO-210	3.2341E-02	2.2647E-02
26963	11/ 2/82	Pollock	PO	PO-210	6.7306E-03	4.7131E-03
15991	9/ 2/81	Flounder	RA	RA-226	1.3000E-03	3.1200E-04
15992	9/ 2/81	Flounder	RA	RA-226	2.0000E-03	4.0000E-04
15993	9/ 2/81	Cod	RA	RA-226	1.2000E-03	2.6400E-04
15994	9/ 2/81	Cod	RA	RA-226	2.4000E-03	3.1200E-04
16842	9/10/81	Hake	RA	RA-226	2.0000E-03	2.2000E-04
16843	9/10/81	Cusk Eels	RA	RA-226	3.0000E-03	3.3000E-04
16844	9/21/81	Flounder	RA	RA-226	1.5000E-03	3.3000E-04
16845	9/21/81	Cod	RA	RA-226	1.1000E-03	2.9700E-04

26958	6/10/82	Flounder	RA226	RA-226	3.0000E-03	3.6000E-04
26959	9/13/82	Hake	RA226	RA-226	2.0000E-03	3.0000E-04
26960	9/13/82	Cod	RA226	RA-226	2.0000E-03	3.2000E-04
26960X	9/13/82	Cod	RA226	RA-226	2.0000E-03	3.4000E-04
26961	11/ 2/82	Haddock	RA226	RA-226	2.0000E-03	3.0000E-04
26962	11/ 2/82	Cod	RA226	RA-226	2.0000E-03	3.4000E-04
26963	11/ 2/82	Pollock	RA226	RA-226	3.0000E-03	4.5000E-04
15991	9/ 2/81	Flounder	TH	TH-228	2.0000E-05	2.7080E-04
15991	9/ 2/81	Flounder	TH	TH-227	2.5000E-04	1.6750E-04
15991	9/ 2/81	Flounder	TH	TH-232	1.0000E-04	6.9000E-05
15991	9/ 2/81	Flounder	TH	TH-230	4.0000E-04	1.6000E-04
15992	9/ 2/81	Flounder	TH	TH-228	4.0000E-05	3.7480E-04
15992	9/ 2/81	Flounder	TH	TH-227	1.8000E-04	1.8900E-04
15992	9/ 2/81	Flounder	TH	TH-232	3.0000E-04	1.4400E-04
15992	9/ 2/81	Flounder	TH	TH-230	5.0000E-04	2.0000E-04
15993	9/ 2/81	Cod	TH	TH-227	2.0000E-04	1.4200E-04
15993	9/ 2/81	Cod	TH	TH-228	-1.0000E-04	2.4600E-04
15993	9/ 2/81	Cod	TH	TH-230	5.0000E-04	1.7500E-04
15993	9/ 2/81	Cod	TH	TH-232	1.0000E-04	6.7000E-05
15994	9/ 2/81	Cod	TH	TH-232	2.0000E-04	2.0000E-04
15994	9/ 2/81	Cod	TH	TH-230	2.0000E-04	2.6600E-04
15994	9/ 2/81	Cod	TH	TH-228	-8.0000E-04	5.0400E-04
15994	9/ 2/81	Cod	TH	TH-227	-8.0000E-05	4.2320E-04
16842	9/10/81	Hake	TH	TH-232	2.0000E-04	1.2400E-04
16842	9/10/81	Hake	TH	TH-228	-1.0000E-04	3.5000E-04
16842	9/10/81	Hake	TH	TH-230	7.0000E-04	2.3100E-04
16842	9/10/81	Hake	TH	TH-227	5.0000E-04	2.7000E-04
16843	9/10/81	Cusk Eels	TH	TH-228	-4.0000E-04	3.3600E-04
16843	9/10/81	Cusk Eels	TH	TH-227	3.0000E-04	2.5800E-04
16843	9/10/81	Cusk Eels	TH	TH-230	2.0000E-04	1.3400E-04
16843	9/10/81	Cusk Eels	TH	TH-232	2.0000E-04	1.3400E-04
16844	9/21/81	Flounder	TH	TH-227	1.0000E-04	1.4100E-04
16844	9/21/81	Flounder	TH	TH-228	-4.0000E-04	4.3200E-04
16844	9/21/81	Flounder	TH	TH-232	2.0000E-04	1.5800E-04
16844	9/21/81	Flounder	TH	TH-230	6.0000E-04	2.5200E-04
16845	9/21/81	Cod	TH	TH-228	-3.0000E-04	5.1900E-04
16845	9/21/81	Cod	TH	TH-232	2.0000E-04	1.7800E-04
16845	9/21/81	Cod	TH	TH-230	7.0000E-04	3.2900E-04
16845	9/21/81	Cod	TH	TH-227	4.0000E-04	3.6000E-04
26958	6/10/82	Flounder	TH	TH-230	4.1940E-04	2.3010E-04
26958	6/10/82	Flounder	TH	TH-228	-1.0060E-03	2.9650E-04
26958	6/10/82	Flounder	TH	TH-227	6.9900E-04	3.5010E-04
26958	6/10/82	Flounder	TH	TH-232	2.7260E-04	1.8300E-04
26959	9/13/82	Hake	TH	TH-227	3.3870E-04	2.5630E-04
26959	9/13/82	Hake	TH	TH-230	3.0190E-04	2.1310E-04
26959	9/13/82	Hake	TH	TH-232	1.6260E-04	1.3940E-04
26959	9/13/82	Hake	TH	TH-228	-5.2310E-04	3.9820E-04
26960	9/13/82	Cod	TH	TH-230	1.9470E-04	1.5590E-04
26960	9/13/82	Cod	TH	TH-232	9.7350E-05	1.0310E-04
26960	9/13/82	Cod	TH	TH-227	1.2170E-04	2.1470E-04
26960	9/13/82	Cod	TH	TH-228	6.0200E-05	3.5940E-04
26961	11/ 2/82	Haddock	TH	TH-230	3.7840E-04	1.8390E-04
26961	11/ 2/82	Haddock	TH	TH-227	9.2740E-05	2.2720E-04
26961	11/ 2/82	Haddock	TH	TH-232	8.9030E-05	8.9070E-05
26961	11/ 2/82	Haddock	TH	TH-228	-1.2190E-04	3.7820E-04
26962	11/ 2/82	Cod	TH	TH-232	2.0920E-04	2.2060E-04
26962	11/ 2/82	Cod	TH	TH-227	7.2630E-05	2.5160E-04
26962	11/ 2/82	Cod	TH	TH-230	3.4860E-04	2.6110E-04
26962	11/ 2/82	Cod	TH	TH-228	-1.2120E-04	5.0350E-04
26963	11/ 2/82	Pollock	TH	TH-230	4.1170E-04	1.9440E-04

26963	11/ 2/82	Pollock	TH	TH-228	4.5580E-04	4.3570E-04
26963	11/ 2/82	Pollock	TH	TH-227	9.5290E-05	1.3480E-04
26963	11/ 2/82	Pollock	TH	TH-232	1.1430E-04	1.0230E-04
15991	9/ 2/81	Flounder	U	U-235	2.0000E-04	1.2000E-04
15991	9/ 2/81	Flounder	U	U-234	9.0000E-04	2.3400E-04
15991	9/ 2/81	Flounder	U	U-238	6.0000E-04	1.8600E-04
15992	9/ 2/81	Flounder	U	U-235	1.4000E-04	9.2400E-05
15992	9/ 2/81	Flounder	U	U-238	6.0000E-04	1.8600E-04
15992	9/ 2/81	Flounder	U	U-234	9.9000E-04	2.4750E-04
15993	9/ 2/81	Cod	U	U-234	4.6230E-03	1.2950E-03
15993	9/ 2/81	Cod	U	U-238	1.3110E-03	6.7220E-04
15993	9/ 2/81	Cod	U	U-235	1.3100E-02	7.8862E-03
15994	9/ 2/81	Cod	U	U-235	2.0000E-04	1.1600E-04
15994	9/ 2/81	Cod	U	U-238	3.0000E-04	1.2900E-04
15994	9/ 2/81	Cod	U	U-234	6.0000E-04	1.9800E-04
16842	9/10/81	Hake	U	U-238	4.0000E-04	1.7600E-04
16842	9/10/81	Hake	U	U-235	7.0000E-05	7.0700E-05
16842	9/10/81	Hake	U	U-234	5.0000E-04	1.9500E-04
16843	9/10/81	Cusk Eels	U	U-238	4.5800E-04	3.9860E-04
16843	9/10/81	Cusk Eels	U	U-235	6.2000E-05	2.1498E-04
16843	9/10/81	Cusk Eels	U	U-234	1.1700E-03	5.7903E-04
16844	9/21/81	Flounder	U	U-234	1.8770E-03	1.0120E-03
16844	9/21/81	Flounder	U	U-238	8.4480E-04	6.9280E-04
16844	9/21/81	Flounder	U	U-235	-3.7550E-04	4.6450E-04
16845	9/21/81	Cod	U	U-234	1.1930E-03	6.8140E-04
16845	9/21/81	Cod	U	U-235	0.0000E+00	0.0000E+00
16845	9/21/81	Cod	U	U-238	1.1930E-03	6.8140E-04
26958	6/10/82	Flounder	U	U-238	4.9930E-04	2.3610E-04
26958	6/10/82	Flounder	U	U-235	2.7200E-05	9.2740E-05
26958	6/10/82	Flounder	U	U-234	1.0890E-03	3.5790E-04
26959	9/13/82	Hake	U	U-235	6.5560E-06	2.7520E-05
26959	9/13/82	Hake	U	U-234	7.9800E-04	3.2380E-04
26959	9/13/82	Hake	U	U-238	7.9920E-04	3.2400E-04
26960	9/13/82	Cod	U	U-235	4.7800E-05	6.7460E-05
26960	9/13/82	Cod	U	U-234	4.8190E-04	2.1930E-04
26960	9/13/82	Cod	U	U-238	3.6780E-04	1.9040E-04
26961	11/ 2/82	Haddock	U	U-235	8.9410E-05	1.0180E-04
26961	11/ 2/82	Haddock	U	U-238	2.9500E-04	1.8660E-04
26961	11/ 2/82	Haddock	U	U-234	4.4890E-04	2.3180E-04
26962	11/ 2/82	Cod	U	U-235	-5.0780E-05	1.0170E-04
26962	11/ 2/82	Cod	U	U-234	6.6060E-04	4.0110E-04
26962	11/ 2/82	Cod	U	U-238	6.8560E-04	3.8180E-04
26963	11/ 2/82	Pollock	U	U-234	4.4630E-04	2.4890E-04
26963	11/ 2/82	Pollock	U	U-238	2.3680E-04	1.8900E-04
26963	11/ 2/82	Pollock	U	U-235	0.0000E+00	0.0000E+00

GROSS ALPHA

26958	6/10/82	Flounder	ALPHA	ALPHA	-2.0000E-02	2.0000E-01
26959	9/13/82	Hake	ALPHA	ALPHA	-2.0000E-02	1.9180E-01
26960	9/13/82	Cod	ALPHA	ALPHA	-3.0000E-02	1.0380E-01
26960X	9/13/82	Cod	ALPHA	ALPHA	-3.0000E-02	1.1220E-01
26961	11/ 2/82	Haddock	ALPHA	ALPHA	-2.0000E-02	1.4420E-01
26962	11/ 2/82	Cod	ALPHA	ALPHA	-1.3000E-01	1.9370E-01
26963	11/ 2/82	Pollock	ALPHA	ALPHA	-1.5000E-01	2.1150E-01

GROSS BETA

26958	6/10/82	Flounder	BETA	BETA	4.0000E+00	3.2000E-01
26959	9/13/82	Hake	BETA	BETA	4.2000E+00	2.9400E-01
26960	9/13/82	Cod	BETA	BETA	4.1000E+00	2.8700E-01
26960X	9/13/82	Cod	BETA	BETA	4.0000E+00	2.8000E-01
26961	11/ 2/82	Haddock	BETA	BETA	3.1000E+00	2.4800E-01
26962	11/ 2/82	Cod	BETA	BETA	3.8000E+00	2.6600E-01
26963	11/ 2/82	Pollock	BETA	BETA	3.7000E+00	2.9600E-01

Radionuclide Analyses of Marketplace Seafood Samples Collected by FDA New Jersey District, 1981 and 1982

Sample Number	Date Collected	Sample Type	Analysis	Nuclide	Activity Pci/g (Wet)	2-Sigma Error
	MAN-MADE NUCLIDES					
17633	9/24/81	Eels	GAMMA	CS-137	1.4000E-02	9.8000E-03
23031	4/ 3/82	Tilefish	GAMMA	CS-137	1.0000E-02	8.2000E-03
23035	5/10/82	Tilefish	GAMMA	CS-137	1.7000E-02	1.3090E-02
23036	5/ 2/82	Tilefish	GAMMA	CS-137	1.6000E-02	1.0880E-02
16846	9/13/81	Tilefish	PU	PU-239	-3.0000E-05	1.0410E-04
16846	9/13/81	Tilefish	PU	PU-238	1.0000E-04	1.8800E-04
16847	9/13/81	Eels	PU	PU-238	0.0000E+00	0.0000E+00
16847	9/13/81	Eels	PU	PU-239	-2.0000E-05	1.0600E-04
17633	9/24/81	Eels	PU	PU-238	-8.0000E-05	4.3840E-04
17633	9/24/81	Eels	PU	PU-239	-4.0000E-05	2.6520E-04
17634	9/24/81	Tilefish	PU	PU-238	-3.0420E-04	3.6030E-04
17634	9/24/81	Tilefish	PU	PU-239	4.3460E-05	1.5060E-04
17635	9/30/81	Tilefish	PU	PU-239	-4.2360E-05	1.4680E-04
17635	9/30/81	Tilefish	PU	PU-238	-2.1180E-04	4.0710E-04
17636	10/ 7/81	Tilefish	PU	PU-239	1.7510E-04	2.1550E-04
17636	10/ 7/81	Tilefish	PU	PU-238	2.6260E-04	3.5160E-04
23031	4/ 3/82	Tilefish	PU	PU-239	0.0000E+00	0.0000E+00
23031	4/ 3/82	Tilefish	PU	PU-238	3.1670E-05	4.9230E-05
23032	4/ 3/82	Tilefish	PU	PU-239	3.5280E-05	8.0580E-05
23032	4/ 3/82	Tilefish	PU	PU-238	6.4250E-05	1.8330E-04
23033	5/ 7/82	Tilefish	PU	PU-238	1.8290E-04	1.9490E-04
23033	5/ 7/82	Tilefish	PU	PU-239	6.1100E-05	7.2610E-05
23034	5/10/82	Tilefish	PU	PU-239	-2.1460E-05	8.3930E-05
23034	5/10/82	Tilefish	PU	PU-238	7.5660E-05	1.2800E-04
23035	5/10/82	Tilefish	PU	PU-239	1.8600E-05	4.3230E-05
23035	5/10/82	Tilefish	PU	PU-238	3.1950E-05	1.5260E-04
23036	5/ 2/82	Tilefish	PU	PU-239	-7.6330E-06	5.8810E-05
23036	5/ 2/82	Tilefish	PU	PU-238	1.8320E-04	1.4600E-04
16846	9/13/81	Tilefish	SR	SR-90	5.0000E-04	7.5000E-04
16847	9/13/81	Eels	SR	SR-90	1.0000E-03	1.1500E-03
17633	9/24/81	Eels	SR	SR-90	-4.0000E-04	5.0000E-04
17634	9/24/81	Tilefish	SR	SR-90	1.0000E-04	1.0000E-04
17635	9/30/81	Tilefish	SR	SR-90	-2.0000E-02	2.7200E-02
17636	10/ 7/81	Tilefish	SR	SR-90	-9.0000E-04	1.3950E-03
23031	4/ 3/82	Tilefish	SR	SR-90	6.7000E-04	1.8961E-03
23032	4/ 3/82	Tilefish	SR	SR-90	-3.8000E-04	1.9000E-03
23033	5/ 7/82	Tilefish	SR	SR-90	-2.3000E-04	1.8400E-03
23034	5/10/82	Tilefish	SR	SR-90	-4.9000E-04	1.9600E-03
23035	5/10/82	Tilefish	SR	SR-90	1.2000E-04	2.1600E-03
23036	5/ 2/82	Tilefish	SR	SR-90	7.2000E-04	2.0376E-03
	NATURAL NUCLIDES					
16846	9/13/81	Tilefish	GAMMA	K-40	2.6000E+00	3.3800E-01
16847	9/13/81	Eels	GAMMA	K-40	2.4000E+00	2.1600E-01
17633	9/24/81	Eels	GAMMA	K-40	2.1000E+00	3.1500E-01
17634	9/24/81	Tilefish	GAMMA	K-40	3.1000E+00	2.4800E-01
17635	9/30/81	Tilefish	GAMMA	K-40	2.9000E+00	2.3200E-01
17636	10/ 7/81	Tilefish	GAMMA	K-40	2.8000E+00	3.3600E-01
23031	4/ 3/82	Tilefish	GAMMA	K-40	3.0000E+00	2.4000E-01
23032	4/ 3/82	Tilefish	GAMMA	K-40	3.3000E+00	1.9800E-01
23033	5/ 7/82	Tilefish	GAMMA	K-40	2.8000E+00	2.2400E-01

23034	5/10/82	Tilefish	GAMMA	K-40	3.2000E+00	2.2400E-01
23035	5/10/82	Tilefish	GAMMA	K-40	3.2000E+00	3.8400E-01
23036	5/ 2/82	Tilefish	GAMMA	K-40	3.0000E+00	3.9000E-01
16846	9/13/81	Tilefish	PB	PB-210	1.2088E-01	3.0764E-01
16847	9/13/81	Eels	PB	PB-210	1.7119E-01	6.3751E-01
17633	9/24/81	Eels	PB	PB-210	2.5168E-01	4.5481E-01
17634	9/24/81	Tilefish	PB	PB-210	5.2489E-01	5.2694E-01
17635	9/30/81	Tilefish	PB	PB-210	8.0800E-02	3.8989E-01
17636	10/ 7/81	Tilefish	PB	PB-210	7.1190E-02	3.9954E-01
23031	4/ 3/82	Tilefish	PB	PB-210	1.1311E+00	2.2131E+00
23032	4/ 3/82	Tilefish	PB	PB-210	-5.8883E-02	4.5813E-01
23033	5/ 7/82	Tilefish	PB	PB-210	-8.5048E-02	4.3489E-01
23034	5/10/82	Tilefish	PB	PB-210	3.0731E-01	6.7932E-01
23035	5/10/82	Tilefish	PB	PB-210	5.4563E-01	1.8927E+00
23036	5/ 2/82	Tilefish	PB	PB-210	1.8332E+00	9.9883E-01
16846	9/13/81	Tilefish	PO	PO-210	8.0000E-03	6.1592E-03
16847	9/13/81	Eels	PO	PO-210	4.6000E-03	5.3820E-03
17633	9/24/81	Eels	PO	PO-210	-1.6100E-03	2.9094E-03
17634	9/24/81	Tilefish	PO	PO-210	5.0386E-04	5.6183E-03
17635	9/30/81	Tilefish	PO	PO-210	1.1000E-02	6.7540E-03
17636	10/ 7/81	Tilefish	PO	PO-210	7.7400E-03	7.2106E-03
23031	4/ 3/82	Tilefish	PO	PO-210	-2.7448E-02	5.9972E-02
23032	4/ 3/82	Tilefish	PO	PO-210	1.0615E-02	6.8833E-03
23033	5/ 7/82	Tilefish	PO	PO-210	6.9963E-03	5.3099E-03
23034	5/10/82	Tilefish	PO	PO-210	3.7971E-03	6.4027E-03
23035	5/10/82	Tilefish	PO	PO-210	6.2020E-03	1.4175E-02
23036	5/ 2/82	Tilefish	PO	PO-210	-6.5777E-03	8.0292E-03
16846	9/13/81	Tilefish	RA	RA-226	1.2000E-03	2.8800E-04
16847	9/13/81	Eels	RA	RA-226	2.9000E-03	2.6100E-04
17633	9/24/81	Eels	RA	RA-226	2.1000E-03	2.9400E-04
17634	9/24/81	Tilefish	RA	RA-226	2.6000E-03	3.1200E-04
17635	9/30/81	Tilefish	RA	RA-226	2.2000E-03	3.3000E-04
17636	10/ 7/81	Tilefish	RA	RA-226	2.1000E-03	2.9400E-04
23031	4/ 3/82	Tilefish	RA	RA-226	2.0000E-03	3.8000E-04
23032	4/ 3/82	Tilefish	RA	RA-226	2.0000E-03	1.0000E-04
23033	5/ 7/82	Tilefish	RA	RA-226	1.0000E-03	2.0000E-04
23034	5/10/82	Tilefish	RA	RA-226	2.0000E-03	3.6000E-04
23035	5/10/82	Tilefish	RA	RA-226	2.0000E-03	3.8000E-04
23036	5/ 2/82	Tilefish	RA	RA-226	2.0000E-03	3.2000E-04
16846	9/13/81	Tilefish	TH	TH-232	3.3652E-05	4.7597E-05
16846	9/13/81	Tilefish	TH	TH-227	1.0000E-04	1.4905E-04
16846	9/13/81	Tilefish	TH	TH-230	1.0000E-04	8.6680E-05
16846	9/13/81	Tilefish	TH	TH-228	-4.2252E-06	2.3315E-06
16847	9/13/81	Eels	TH	TH-227	4.0000E-05	2.4000E-04
16847	9/13/81	Eels	TH	TH-230	2.0000E-04	1.7000E-04
16847	9/13/81	Eels	TH	TH-228	-6.0000E-04	3.7200E-04
16847	9/13/81	Eels	TH	TH-232	-8.0000E-05	1.4640E-04
17633	9/24/81	Eels	TH	TH-232	2.5799E-04	2.1101E-04
17633	9/24/81	Eels	TH	TH-228	-6.4078E+00	8.0347E+01
17633	9/24/81	Eels	TH	TH-227	0.0000E+00	0.0000E+00
17633	9/24/81	Eels	TH	TH-230	1.2900E-02	5.3393E-03
17634	9/24/81	Tilefish	TH	TH-227	0.0000E+00	3.0980E-04
17634	9/24/81	Tilefish	TH	TH-232	3.1550E-04	2.5820E-04
17634	9/24/81	Tilefish	TH	TH-228	-1.8790E-04	8.6970E-04
17634	9/24/81	Tilefish	TH	TH-230	4.7320E-04	3.8010E-04
17635	9/30/81	Tilefish	TH	TH-230	5.1690E-04	3.8210E-04
17635	9/30/81	Tilefish	TH	TH-228	3.5470E-04	9.1230E-04
17635	9/30/81	Tilefish	TH	TH-232	1.1490E-04	1.6260E-04
17635	9/30/81	Tilefish	TH	TH-227	0.0000E+00	4.7860E-04
17636	10/ 7/81	Tilefish	TH	TH-228	6.0090E-04	7.8770E-04

17636	10/ 7/81	Tilefish	TH	TH-230	8.1580E-04	3.9610E-04
17636	10/ 7/81	Tilefish	TH	TH-232	1.7170E-04	1.7200E-04
17636	10/ 7/81	Tilefish	TH	TH-227	2.6830E-04	4.7360E-04
23031	4/ 3/82	Tilefish	TH	TH-228	-7.8240E-05	1.8390E-04
23031	4/ 3/82	Tilefish	TH	TH-232	3.2420E-05	6.4850E-05
23031	4/ 3/82	Tilefish	TH	TH-227	1.5760E-04	1.1930E-04
23031	4/ 3/82	Tilefish	TH	TH-230	2.1610E-04	1.0170E-04
23032	4/ 3/82	Tilefish	TH	TH-228	-5.2400E-04	4.0770E-04
23032	4/ 3/82	Tilefish	TH	TH-227	1.6820E-04	2.5080E-04
23032	4/ 3/82	Tilefish	TH	TH-230	1.3450E-04	1.7850E-04
23032	4/ 3/82	Tilefish	TH	TH-232	1.6140E-04	1.5230E-04
23033	5/ 7/82	Tilefish	TH	TH-230	6.4670E-04	2.6440E-04
23033	5/ 7/82	Tilefish	TH	TH-230	2.3450E-05	1.4070E-04
23033	5/ 7/82	Tilefish	TH	TH-232	2.3450E-05	1.0490E-04
23033	5/ 7/82	Tilefish	TH	TH-228	-4.0770E-04	3.7630E-04
23033	5/ 7/82	Tilefish	TH	TH-227	0.0000E+00	3.0900E-04
23033	5/ 7/82	Tilefish	TH	TH-232	1.4920E-04	1.2200E-04
23033	5/ 7/82	Tilefish	TH	TH-228	-8.5100E-04	2.7600E-04
23033	5/ 7/82	Tilefish	TH	TH-227	2.0730E-04	2.0740E-04
23035	5/10/82	Tilefish	TH	TH-228	-2.9590E-04	3.9490E-04
23035	5/10/82	Tilefish	TH	TH-232	1.5260E-04	1.7630E-04
23035	5/10/82	Tilefish	TH	TH-227	2.6500E-04	2.3720E-04
23035	5/10/82	Tilefish	TH	TH-230	2.7980E-04	2.1000E-04
23036	5/ 2/82	Tilefish	TH	TH-227	2.0650E-04	2.5300E-04
23036	5/ 2/82	Tilefish	TH	TH-230	3.9650E-04	2.1090E-04
23036	5/ 2/82	Tilefish	TH	TH-228	-5.7800E-04	4.1290E-04
23036	5/ 2/82	Tilefish	TH	TH-232	1.2390E-04	1.1090E-04
16846	9/13/81	Tilefish	U	U-234	7.5322E-04	3.0694E-04
16846	9/13/81	Tilefish	U	U-235	1.5977E-04	1.2312E-04
16846	9/13/81	Tilefish	U	U-238	4.7927E-04	2.3053E-04
16847	9/13/81	Eels	U	U-238	2.0000E-04	1.4000E-04
16847	9/13/81	Eels	U	U-235	4.0000E-05	5.6800E-05
16847	9/13/81	Eels	U	U-234	5.0000E-04	2.1500E-04
17633	9/24/81	Eels	U	U-234	1.6650E-03	5.6070E-04
17633	9/24/81	Eels	U	U-235	1.5130E-04	1.8620E-04
17633	9/24/81	Eels	U	U-238	7.9450E-04	3.5950E-04
17634	9/24/81	Tilefish	U	U-238	8.3900E-04	4.3280E-04
17634	9/24/81	Tilefish	U	U-235	1.5730E-04	2.3540E-04
17634	9/24/81	Tilefish	U	U-234	1.1540E-03	5.5450E-04
17635	9/30/81	Tilefish	U	U-234	6.7840E-04	3.3970E-04
17635	9/30/81	Tilefish	U	U-238	4.7890E-04	2.8280E-04
17635	9/30/81	Tilefish	U	U-235	3.9910E-05	7.9970E-05
17636	10/ 7/81	Tilefish	U	U-238	5.9610E-04	4.0580E-04
17636	10/ 7/81	Tilefish	U	U-234	5.4640E-04	4.1650E-04
17636	10/ 7/81	Tilefish	U	U-235	9.9350E-05	1.4120E-04
23031	4/ 3/82	Tilefish	U	U-234	4.5190E-04	1.6570E-04
23031	4/ 3/82	Tilefish	U	U-235	2.5820E-05	3.6650E-05
23031	4/ 3/82	Tilefish	U	U-238	4.3900E-04	1.5910E-04
23032	4/ 3/82	Tilefish	U	U-238	4.1310E-04	2.3270E-04
23032	4/ 3/82	Tilefish	U	U-235	-1.5660E-06	8.7530E-05
23032	4/ 3/82	Tilefish	U	U-234	1.1290E-03	3.9920E-04
23033	5/ 7/82	Tilefish	U	U-235	4.5690E-05	6.6560E-05
23033	5/ 7/82	Tilefish	U	U-234	4.5190E-04	2.1500E-04
23033	5/ 7/82	Tilefish	U	U-238	3.5390E-04	1.8910E-04
23034	5/10/82	Tilefish	U	U-238	2.2330E-04	1.8590E-04
23034	5/10/82	Tilefish	U	U-234	2.8100E-04	2.3490E-04
23034	5/10/82	Tilefish	U	U-235	7.5970E-05	1.0760E-04
23035	5/10/82	Tilefish	U	U-234	4.4860E-04	2.5100E-04
23035	5/10/82	Tilefish	U	U-238	1.7680E-04	1.4620E-04
23035	5/10/82	Tilefish	U	U-235	6.3570E-05	8.7070E-05

23036	5/ 2/82	Tilefish	U	U-238	3.9590E-04	2.0980E-04
23036	5/ 2/82	Tilefish	U	U-235	1.0800E-04	1.0760E-04
23036	5/ 2/82	Tilefish	U	U-234	4.9270E-04	2.3530E-04

GROSS ALPHA

23031	4/ 3/82	Tilefish	ALPHA	ALPHA	-4.0000E-02	1.6000E-01
23032	4/ 3/82	Tilefish	ALPHA	ALPHA	-1.0000E-01	1.5600E-01
23033	5/ 7/82	Tilefish	ALPHA	ALPHA	-2.0000E-02	1.3260E-01
23034	5/10/82	Tilefish	ALPHA	ALPHA	-4.0000E-02	1.3840E-01
23035	5/10/82	Tilefish	ALPHA	ALPHA	-1.0000E-01	2.0000E-01
23036	5/ 2/82	Tilefish	ALPHA	ALPHA	-2.0000E-02	1.6480E-01

GROSS BETA

23031	4/ 3/82	Tilefish	BETA	BETA	5.3000E+00	3.1800E-01
23032	4/ 3/82	Tilefish	BETA	BETA	3.8000E+00	3.0400E-01
23033	5/ 7/82	Tilefish	BETA	BETA	3.3000E+00	2.6400E-01
23034	5/10/82	Tilefish	BETA	BETA	4.0000E+00	2.8000E-01
23035	5/10/82	Tilefish	BETA	BETA	4.8000E+00	3.3600E-01
23036	5/ 2/82	Tilefish	BETA	BETA	3.6000E+00	2.8800E-01

Radionuclide Analyses of Marketplace Seafood Samples Collected by FDA San Francisco District, 1981 and 1982

Sample Number	Date Collected	Sample Type	Analysis	Nuclide	Activity Pci/g (Wet)	2-Sigma Error
	MAN-MADE NUCLIDES					
18620	11/12/81	Ling Cod	GAMMA	CS-137	6.5572E-03	1.7049E-03
18621	11/12/81	Black Cod	GAMMA	CS-137	8.5773E-03	1.9728E-03
23038	5/27/82	Black Cod	GAMMA	CS-137	1.0000E-02	8.9000E-03
23040	5/27/82	Black Cod	GAMMA	CS-137	9.0000E-03	8.1900E-03
17637	10/ 7/81	Hardheads	PU	PU-238	0.0000E+00	1.6800E-04
17637	10/ 7/81	Hardheads	PU	PU-239	3.4300E-05	6.8730E-05
17638	10/ 7/81	Butterfish	PU	PU-238	8.1890E-03	1.0770E-02
17638	10/ 7/81	Butterfish	PU	PU-239	-1.1700E-03	2.3440E-03
17639	10/16/81	Dover Sole	PU	PU-239	7.8220E-05	1.1110E-04
17639	10/16/81	Dover Sole	PU	PU-238	-3.9110E-05	3.2260E-04
17640	10/16/81	Black Cod	PU	PU-239	-1.3730E-02	1.0970E-02
17640	10/16/81	Black Cod	PU	PU-238	-1.7160E-03	1.7160E-02
18620	11/12/81	Ling Cod	PU	PU-238	9.7160E-05	2.9170E-04
18620	11/12/81	Ling Cod	PU	PU-239	-9.7160E-05	1.3790E-04
18620X	11/12/81	Ling Cod	PU	PU-239	-7.8920E-05	9.1630E-05
18620X	11/12/81	Ling Cod	PU	PU-238	0.0000E+00	2.6830E-04
18621	11/12/81	Black Cod	PU	PU-238	1.1780E-04	2.1550E-04
18621	11/12/81	Black Cod	PU	PU-239	5.8890E-05	1.0410E-04
23037	5/27/82	Ling Cod	PU	PU-238	-9.6950E-05	2.1470E-04
23037	5/27/82	Ling Cod	PU	PU-239	0.0000E+00	1.5830E-04
23038	5/27/82	Black Cod	PU	PU-238	1.8070E-04	1.8540E-04
23038	5/27/82	Black Cod	PU	PU-239	0.0000E+00	0.0000E+00
23040	5/27/82	Black Cod	PU	PU-239	5.7670E-05	7.2770E-05
23040	5/27/82	Black Cod	PU	PU-238	-4.2030E-05	1.3010E-04
23042	5/26/82	Ling Cod	PU	PU-238	8.9330E-05	1.1000E-04
23042	5/26/82	Ling Cod	PU	PU-239	3.0980E-05	4.0950E-05
17637	10/ 7/81	Hardheads	SR	SR-90	0.0000E+00	0.0000E+00
17638	10/ 7/81	Butterfish	SR	SR-90	-5.0000E-03	1.5000E-02
17639	10/16/81	Dover Sole	SR	SR-90	-3.0000E-04	9.9900E-04
17640	10/16/81	Black Cod	SR	SR-90	-4.0000E-02	1.5120E-01
18620	11/12/81	Ling Cod	SR	SR-90	6.0000E-04	2.4000E-03
18620X	11/12/81	Ling Cod	SR	SR-90	1.0000E-04	1.0000E-04
18621	11/12/81	Black Cod	SR	SR-90	0.0000E+00	0.0000E+00
23037	5/27/82	Ling Cod	SR	SR-90	6.9000E-04	2.2080E-03
23038	5/27/82	Black Cod	SR	SR-90	1.1000E-04	4.4000E-04
23040	5/27/82	Black Cod	SR	SR-90	0.0000E+00	1.9000E-03
23042	5/26/82	Ling Cod	SR	SR-90	2.5000E-04	2.1250E-03
23039	5/27/82	Red Snapper	PU	PU-238	1.3480E-04	1.8940E-04
23039	5/27/82	Red Snapper	PU	PU-239	0.0000E+00	0.0000E+00
23041	5/26/82	Red Snapper	PU	PU-239	0.0000E+00	8.3650E-05
23041	5/26/82	Red Snapper	PU	PU-238	0.0000E+00	2.0490E-04
23039	5/27/82	Red Snapper	SR	SR-90	1.2000E-04	1.6800E-03
23041	5/26/82	Red Snapper	SR	SR-90	2.6000E-04	2.3400E-03
18622	11/12/81	Thornyheads	GAMMA	CS-137	1.1700E-02	1.8720E-03
18622	11/12/81	Thornyheads	PU	PU-238	2.3700E-04	1.8750E-04
18622	11/12/81	Thornyheads	PU	PU-239	0.0000E+00	6.7730E-05
18622	11/12/81	Thornyheads	SR	SR-90	2.0000E-04	4.0000E-04

NATURAL NUCLIDES

17637	10/ 7/81	Hardheads	GAMMA	BI-214	6.1000E-02	2.0740E-02
17640	10/16/81	Black Cod	GAMMA	BI-214	9.4000E-02	2.6320E-02
17637	10/ 7/81	Hardheads	GAMMA	K-40	2.3000E+00	2.0700E-01
17638	10/ 7/81	Butterfish	GAMMA	K-40	1.9000E+00	1.7100E-01
17639	10/16/81	Dover Sole	GAMMA	K-40	2.3000E+00	2.3000E-01
17640	10/16/81	Black Cod	GAMMA	K-40	2.8000E+00	2.5200E-01
17640X	10/16/81	Black Cod	GAMMA	K-40	2.8000E+00	2.5200E-01
18620	11/12/81	Ling Cod	GAMMA	K-40	4.2874E+00	8.5748E-02
18621	11/12/81	Black Cod	GAMMA	K-40	3.0790E+00	9.2370E-02
23037	5/27/82	Ling Cod	GAMMA	K-40	3.6000E+00	2.1600E-01
23038	5/27/82	Black Cod	GAMMA	K-40	2.6000E+00	2.3400E-01
23040	5/27/82	Black Cod	GAMMA	K-40	3.2000E+00	3.8400E-01
23042	5/26/82	Ling Cod	GAMMA	K-40	3.4000E+00	2.0400E-01
17637	10/ 7/81	Hardheads	GAMMA	PB-214	5.2000E-02	1.9760E-02
17640	10/16/81	Black Cod	GAMMA	PB-214	8.7000E-02	2.3490E-02
18620	11/12/81	Ling Cod	GAMMA	TH-232	7.5660E-03	5.5988E-03
17637	10/ 7/81	Hardheads	PB	PB-210	5.2290E-01	4.7594E-01
17638	10/ 7/81	Butterfish	PB	PB-210	8.9190E-02	4.7339E-01
17639	10/16/81	Dover Sole	PB	PB-210	1.6350E-01	4.1954E-01
17640	10/16/81	Black Cod	PB	PB-210	3.8760E-01	2.2732E+00
18620	11/12/81	Ling Cod	PB	PB-210	6.7596E-04	9.1593E-03
18621	11/12/81	Black Cod	PB	PB-210	-1.3251E-04	1.5144E-02
23037	5/27/82	Ling Cod	PB	PB-210	4.4703E-01	1.0699E+00
23038	5/27/82	Black Cod	PB	PB-210	-3.2206E-01	2.3738E+00
23040	5/27/82	Black Cod	PB	PB-210	2.1296E-01	7.6318E-01
23040X	5/27/82	Black Cod	PB	PB-210	1.9979E-01	9.5904E-01
23042	5/26/82	Ling Cod	PB	PB-210	1.0205E-01	1.7196E-01
17637	10/ 7/81	Hardheads	PO	PO-210	1.7700E-04	5.6644E-03
17638	10/ 7/81	Butterfish	PO	PO-210	1.0400E-02	1.0444E-02
17639	10/16/81	Dover Sole	PO	PO-210	1.4900E-02	8.2099E-03
17640	10/16/81	Black Cod	PO	PO-210	5.3070E-02	3.7425E-02
18620	11/12/81	Ling Cod	PO	PO-210	8.9265E-04	4.1035E-04
18621	11/12/81	Black Cod	PO	PO-210	3.5203E-02	1.4461E-02
23037	5/27/82	Ling Cod	PO	PO-210	6.1089E-03	9.1220E-03
23038	5/27/82	Black Cod	PO	PO-210	4.9556E-03	1.6747E-02
23040	5/27/82	Black Cod	PO	PO-210	3.5271E-02	1.2050E-02
23040X	5/27/82	Black Cod	PO	PO-210	2.7049E-02	1.1723E-02
23042	5/26/82	Ling Cod	PO	PO-210	9.2788E-04	2.2313E-03
17637	10/ 7/81	Hardheads	RA	RA-226	2.0000E-03	2.6000E-04
17638	10/ 7/81	Butterfish	RA	RA-226	1.8000E-03	2.5200E-04
17639	10/16/81	Dover Sole	RA	RA-226	2.3000E-03	2.5300E-04
17640	10/16/81	Black Cod	RA	RA-226	3.0000E-03	4.8000E-04
18620	11/12/81	Ling Cod	RA	RA-226	2.6000E-03	3.3800E-04
18621	11/12/81	Black Cod	RA	RA-226	2.4000E-03	3.6000E-04
23037	5/27/82	Ling Cod	RA	RA-226	3.0000E-03	4.5000E-04
23038	5/27/82	Black Cod	RA	RA-226	1.3000E-03	2.8600E-04
23040	5/27/82	Black Cod	RA	RA-226	2.4000E-03	3.3600E-04
23042	5/26/82	Ling Cod	RA	RA-226	1.8000E-03	3.6000E-04
17637	10/ 7/81	Hardheads	TH	TH-230	2.4610E-04	2.9560E-04
17637	10/ 7/81	Hardheads	TH	TH-228	-4.7050E-04	7.5520E-04
17637	10/ 7/81	Hardheads	TH	TH-232	2.9530E-04	2.4160E-04
17637	10/ 7/81	Hardheads	TH	TH-227	-1.0250E-04	4.5850E-04
17638	10/ 7/81	Butterfish	TH	TH-232	4.2830E-03	4.9510E-03
17638	10/ 7/81	Butterfish	TH	TH-227	0.0000E+00	1.1900E-02
17638	10/ 7/81	Butterfish	TH	TH-230	1.2850E-02	1.1790E-02
17638	10/ 7/81	Butterfish	TH	TH-228	3.2370E-04	2.2880E-02
17639	10/16/81	Dover Sole	TH	TH-227	0.0000E+00	3.3130E-04

17639	10/16/81	Dover Sole	TH	TH-228	3.7190E-04	7.0950E-04
17639	10/16/81	Dover Sole	TH	TH-230	7.5530E-04	3.9960E-04
17639	10/16/81	Dover Sole	TH	TH-232	0.0000E+00	1.5900E-04
17640	10/16/81	Black Cod	TH	TH-232	2.3650E-03	8.1950E-03
17640	10/16/81	Black Cod	TH	TH-228	2.7770E-02	3.9270E-02
17640	10/16/81	Black Cod	TH	TH-227	1.9710E-02	1.9740E-02
17640	10/16/81	Black Cod	TH	TH-230	9.4610E-03	1.3390E-02
18620	11/12/81	Ling Cod	TH	TH-230	3.8780E-04	2.3530E-04
18620	11/12/81	Ling Cod	TH	TH-227	7.3440E-04	4.6720E-04
18620	11/12/81	Ling Cod	TH	TH-228	6.6900E-05	7.3230E-04
18620	11/12/81	Ling Cod	TH	TH-232	2.8200E-04	2.2380E-04
18620X	11/12/81	Ling Cod	TH	TH-227	5.8570E-04	4.0759E-04
18620X	11/12/81	Ling Cod	TH	TH-232	1.4060E-04	1.4908E-04
18620X	11/12/81	Ling Cod	TH	TH-230	3.0933E-04	2.3277E-04
18620X	11/12/81	Ling Cod	TH	TH-228	-8.0150E-05	6.8815E-04
18621	11/12/81	Black Cod	TH	TH-227	3.9620E-04	2.9350E-04
18621	11/12/81	Black Cod	TH	TH-230	2.3250E-04	1.4120E-04
18621	11/12/81	Black Cod	TH	TH-228	3.1140E-06	5.5430E-04
18621	11/12/81	Black Cod	TH	TH-232	1.0570E-04	1.1210E-04
23037	5/27/82	Ling Cod	TH	TH-230	3.7820E-04	2.0100E-04
23037	5/27/82	Ling Cod	TH	TH-228	-5.6850E-04	3.9130E-04
23037	5/27/82	Ling Cod	TH	TH-227	9.8500E-05	2.4130E-04
23037	5/27/82	Ling Cod	TH	TH-232	9.4560E-05	1.1590E-04
23038	5/27/82	Black Cod	TH	TH-228	-4.0470E-04	3.7870E-04
23038	5/27/82	Black Cod	TH	TH-230	1.0230E-04	1.4480E-04
23038	5/27/82	Black Cod	TH	TH-232	5.1170E-05	1.4470E-04
23038	5/27/82	Black Cod	TH	TH-227	2.1320E-04	3.0160E-04
23040	5/27/82	Black Cod	TH	TH-227	1.8680E-04	1.8690E-04
23040	5/27/82	Black Cod	TH	TH-232	1.1210E-04	1.0030E-04
23040	5/27/82	Black Cod	TH	TH-228	-4.1360E-04	3.7130E-04
23040	5/27/82	Black Cod	TH	TH-230	2.6900E-04	1.6810E-04
23042	5/26/82	Ling Cod	TH	TH-227	5.7340E-05	1.4050E-04
23042	5/26/82	Ling Cod	TH	TH-232	5.5050E-05	5.5090E-05
23042	5/26/82	Ling Cod	TH	TH-228	-2.9230E-04	2.1850E-04
23042	5/26/82	Ling Cod	TH	TH-230	1.5140E-04	1.1360E-04
17637	10/ 7/81	Hardheads	U	U-234	9.6070E-04	4.1960E-04
17637	10/ 7/81	Hardheads	U	U-238	5.3800E-04	2.9650E-04
17637	10/ 7/81	Hardheads	U	U-235	2.3060E-04	1.9080E-04
17637	10/ 7/81	Hardheads	U	U-234	9.6070E-04	4.1960E-04
17637	10/ 7/81	Hardheads	U	U-238	5.3800E-04	2.9650E-04
17637	10/ 7/81	Hardheads	U	U-235	2.3060E-04	1.9080E-04
17638	10/ 7/81	Butterfish	U	U-234	2.0630E-02	1.1440E-02
17638	10/ 7/81	Butterfish	U	U-238	1.0920E-02	7.4180E-03
17638	10/ 7/81	Butterfish	U	U-235	3.6410E-03	5.4490E-03
17639	10/16/81	Dover Sole	U	U-234	6.9120E-04	4.8150E-04
17639	10/16/81	Dover Sole	U	U-234	6.9120E-04	4.8150E-04
17639	10/16/81	Dover Sole	U	U-235	0.0000E+00	1.5360E-04
17639	10/16/81	Dover Sole	U	U-238	4.9920E-04	3.2290E-04
17639	10/16/81	Dover Sole	U	U-238	4.9920E-04	3.2290E-04
17639	10/16/81	Dover Sole	U	U-235	0.0000E+00	1.5360E-04
17640	10/16/81	Black Cod	U	U-234	2.9220E-02	1.6880E-02
17640	10/16/81	Black Cod	U	U-235	5.1570E-03	5.9890E-03
17640	10/16/81	Black Cod	U	U-238	3.4380E-03	1.0880E-02
18620	11/12/81	Ling Cod	U	U-238	5.3320E-04	2.7540E-04
18620	11/12/81	Ling Cod	U	U-234	1.4030E-04	2.5770E-04
18620	11/12/81	Ling Cod	U	U-235	2.8060E-05	9.7260E-05
18620X	11/12/81	Ling Cod	U	U-235	7.4740E-05	8.6660E-05
18620X	11/12/81	Ling Cod	U	U-238	3.7370E-04	2.0920E-04
18620X	11/12/81	Ling Cod	U	U-234	6.9750E-04	2.9150E-04
18621	11/12/81	Black Cod	U	U-234	5.3160E-04	3.2430E-04

18621	11/12/81	Black Cod	U	U-238	4.0890E-04	2.6410E-04
18621	11/12/81	Black Cod	U	U-235	1.6360E-04	1.6500E-04
23037	5/27/82	Ling Cod	U	U-235	0.0000E+00	0.0000E+00
23037	5/27/82	Ling Cod	U	U-234	3.4420E-04	2.2720E-04
23037	5/27/82	Ling Cod	U	U-238	3.0550E-04	1.8680E-04
23038	5/27/82	Black Cod	U	U-238	3.0360E-04	1.5990E-04
23038	5/27/82	Black Cod	U	U-234	2.6820E-04	1.4980E-04
23038	5/27/82	Black Cod	U	U-235	8.0100E-05	9.8710E-05
23040	5/27/82	Black Cod	U	U-234	3.6160E-04	2.1640E-04
23040	5/27/82	Black Cod	U	U-235	3.4430E-05	1.0930E-04
23040	5/27/82	Black Cod	U	U-238	5.8320E-04	2.9200E-04
23042	5/26/82	Ling Cod	U	U-238	2.2960E-04	1.3740E-04
23042	5/26/82	Ling Cod	U	U-234	3.6430E-04	1.8410E-04
23042	5/26/82	Ling Cod	U	U-235	3.0360E-05	7.3910E-05
23039	5/27/82	Red Snapper	GAMMA	K-40	3.1000E+00	2.1700E-01
23041	5/26/82	Red Snapper	GAMMA	K-40	2.7000E+00	1.8900E-01
23039	5/27/82	Red Snapper	PB	PB-210	7.8136E-03	2.7304E-01
23041	5/26/82	Red Snapper	PB	PB-210	4.8231E-02	5.7483E-01
23039	5/27/82	Red Snapper	PO	PO-210	1.9846E-02	7.8917E-03
23041	5/26/82	Red Snapper	PO	PO-210	1.0463E-02	7.0006E-03
23039	5/27/82	Red Snapper	RA	RA-226	1.6000E-03	3.0400E-04
23041	5/26/82	Red Snapper	RA	RA-226	1.2000E-03	2.8800E-04
23039	5/27/82	Red Snapper	TH	TH-227	5.6210E-04	3.2530E-04
23039	5/27/82	Red Snapper	TH	TH-232	1.3490E-04	1.1030E-04
23039	5/27/82	Red Snapper	TH	TH-230	2.9230E-04	1.8580E-04
23039	5/27/82	Red Snapper	TH	TH-228	-2.0980E-04	4.0820E-04
23041	5/26/82	Red Snapper	TH	TH-227	2.2380E-04	2.5850E-04
23041	5/26/82	Red Snapper	TH	TH-230	2.1480E-04	2.6810E-04
23041	5/26/82	Red Snapper	TH	TH-232	7.1610E-05	1.0130E-04
23041	5/26/82	Red Snapper	TH	TH-228	-5.4230E-04	4.3120E-04
23039	5/27/82	Red Snapper	U	U-238	3.2440E-04	1.8210E-04
23039	5/27/82	Red Snapper	U	U-234	5.6620E-04	2.5410E-04
23039	5/27/82	Red Snapper	U	U-235	1.5740E-05	3.9290E-05
23041	5/26/82	Red Snapper	U	U-235	0.0000E+00	0.0000E+00
23041	5/26/82	Red Snapper	U	U-234	2.7780E-04	1.7410E-04
23041	5/26/82	Red Snapper	U	U-238	4.0160E-04	2.1090E-04
18622	11/12/81	Thornyheads	GAMMA	K-40	2.7730E+00	8.3190E-02
18622	11/12/81	Thornyheads	PB	PB-210	9.8292E-04	2.4670E-03
18622	11/12/81	Thornyheads	PO	PO-210	8.6105E-04	3.1454E-04
18622	11/12/81	Thornyheads	RA	RA-226	1.8000E-03	2.5200E-04
18622	11/12/81	Thornyheads	TH	TH-227	9.1340E-04	5.0100E-04
18622	11/12/81	Thornyheads	TH	TH-228	3.4780E-06	5.4800E-04
18622	11/12/81	Thornyheads	TH	TH-232	2.4360E-04	1.6960E-04
18622	11/12/81	Thornyheads	TH	TH-230	3.4100E-04	1.9620E-04
18622	11/12/81	Thornyheads	U	U-238	3.9360E-04	1.5960E-04
18622	11/12/81	Thornyheads	U	U-234	4.6930E-04	1.8560E-04
18622	11/12/81	Thornyheads	U	U-235	4.5420E-05	6.7870E-05

GROSS ALPHA

23037	5/27/82	Ling Cod	ALPHA	ALPHA	-4.0000E-02	1.9600E-01
23038	5/27/82	Black Cod	ALPHA	ALPHA	-1.0000E-01	3.4600E-01
23040	5/27/82	Black Cod	ALPHA	ALPHA	-1.0000E-01	1.4100E-01
23040X	5/27/82	Black Cod	ALPHA	ALPHA	-1.0000E-01	1.4100E-01
23042	5/26/82	Ling Cod	ALPHA	ALPHA	-2.0000E-01	2.2400E-01
23039	5/27/82	Red Snapper	ALPHA	ALPHA	-1.0000E-01	3.1600E-01
23041	5/26/82	Red Snapper	ALPHA	ALPHA	-1.0000E-01	4.0000E-01

GROSS BETA

23037	5/27/82	Ling Cod	BETA	BETA	4.4000E+00	3.0800E-01
23038	5/27/82	Black Cod	BETA	BETA	4.5000E+00	3.6000E-01
23040	5/27/82	Black Cod	BETA	BETA	4.2000E+00	2.9400E-01
23040X	5/27/82	Black Cod	BETA	BETA	4.3000E+00	3.0100E-01
23042	5/26/82	Ling Cod	BETA	BETA	4.4000E+00	3.0800E-01
23039	5/27/82	Red Snapper	BETA	BETA	2.9000E+00	2.3200E-01
23041	5/26/82	Red Snapper	BETA	BETA	2.2000E+00	2.2000E-01

☆U.S. Government Printing Office 1988 516-002,80205