M298NC

**History of the Gulf of the Farallones Low-level Radioactive Waste Disposal Site and EPA/NOAA Sponsored Surveys**

Approximately 47,750 barrels of low-level radioactive waste and solvents of numerous and unknown quantities were disposed in the vicinity of the Farallon Islands between 1946-1964. About 14,500 curies of radioactivity with half lives of a few hundred years to about 25,000 years were among the barrels disposed. Following is a brief summary of the history and status of the Gulf of the Farallones low-level radioactive waste disposal sites known as the 100 meter, 900 meter and 1800 meter sites.

**Table 1.** Location and summary of the Gulf of the Farallones Low-level Radioactive Waste Disposal Sites

| Site/ Location | Depth (m) | Distance from shore (km) | Years Used | Estimated Number of 55-Gallon Barrels | Estimated Activity (Curies)* |
|---|---|---|---|---|---|
| 1-37°37'N 123°00'W | 90 (295 ft) | 45 (28 mi) | 1946 | 150 | unknown |
| 2-37°38'N 123°8.5'W | 900 (2953 ft) | 60 (37 mi) | 1951-1953 | 3,600 | 1,100 |
| 3-37°37'N 123°17'W to 123°20'W | 1700 (5578 ft) | 77 (48 mi) | 1946-1950 1954-1964 | 44,000 | 13,400 |

* One Curie= 37 billion disintegrations per second

**Table 2.** Chronological record of known dumping at the Farallon Island Nuclear Waste Dump.

| YEAR | COORDINATES | COMMENTS |
|---|---|---|
| 1946 | 37° 37'N 123° 00'W | 3 tugboats dumped 150 barrels of waste at the shallow (91m) site |
| 1946-1958 | | 14,061 Ci in 24,305 barrels dumped |
| 1951-1953 | 37° 38'N 123° 8.5'W | 3,600 barrels dumped at the intermediate depth site (914m) |

| YEAR | COORDINATES | COMMENTS |
|---|---|---|
| 1945-1950& 1954-1965 | 37° 37'N ~123° 20'W | 44,000 barrels dumped at the deep site (1829m) |
| 1959-1960 | | 156 Ci in 14,311 barrels dumped |
| 1961-1962 | | 235 Ci in 8,913 barrels dumped |
| 1963-1964 | | 16 Ci in 8 barrels dumped |
| 1965 | | 0.4 Ci in 4 barrels dumped |
| 1966 | | 15.4 Ci in 3 barrels dumped |

**SURVEYS**

Since EPA was formed in 1970, the following surveys occurred at or in the vicinity of the Farallon Islands' radioactive waste disposal sites:

**I.** 1957 (Gulf of the Farallones): First preliminary survey of dumpsite. Reference - Faughn, et al., 1957.

**II.** 1960 (1800 meter site): Second survey. Reference - Pneumodynamics, 1961.
-No detectable radioactivity in sediments, water and biota near deep site. Damaged barrel spotted at 2550m depth.

**III.** 1970-1971 Current studies in Gulf of Farallones:
Reference: Conomos, et al., 1971, 1975, 1977

**IV.** 1974 (900 meters site): Ref: EPA, 1975; Dyer 1976
-Photographic Survey of the Site, cable-controlled underwater vehicle (CURVIII)
-Location of Barrels

**V.** 1975 (1700 meters site): Dyer, 1976; Bowden & Livingston, 1981
-Photographic Survey of the Site (CURVIII)
-Location of Barrels

**VI.** 1976 Current Studies: Reference - Lindberg (unpub)

**VII.** 1977 (900 and 1700 meters sites): PISCES VI
-Photographic Survey of the Sites
-RECOVERY of one (1) BARREL from the 900 meters site

1977 Sample Collection: References - Schell & Sugai, 1980; Noshkin et al., 1978.
-Sediment, water column and biota assays (10 invert and 14 fish spp.)

**VIII.** 1976-1978 Sample Collection: References - Goldberg et al., 1978, 1983; Farrington et al., 1983.
-Mussels collected from Southeast Farallon Island for Mussel Watch program.

**IX.** 1984 Analysis: December cruise. Reference - Kizer, 1985.
-DHS lab analyzed 137Cs on 3 spp. Fo fish (1 individual each) caught in Ocean Block 467 from depths of 530-695 meters.

**X.** 1985 (900 meters site): U.S. Navy's Deep Submergence Rescue Vehicle, AVALON (DSRV-2), June 20-26. Reference - Kizer, 1985.
-Photographic and videotape survey of the site
-Positively identified 1 barrel of radioactive waste and noted bioturbation.
-Observed sablefish, Dover sole and Thornyheads
-Two sediment cores were taken:
*Analysis for 137Cs was performed - none detected (minimum detection limit = 16 fCi/g dry wt).
*Analysis for 241Am, 238 & 239Pu will be done
*Distribution coefficients in sediment for cesium, cobalt and nickel will be determined by the Brookhaven National Laboratory, N.Y.

**XI.** 1985 (900 and 1700 meters sites): David Starr Jordan,
-Sediment, fish, and invertebrate samples collected during the cruise of the DAVID STARR JORDAN
-in 1987, Melzian et al. published a paper in MARINE POLLUTION BULLETIN describing the concentrations of DDTs and PCBs detected in the LIVERS of a sablefish and Dover sole. These concentrations were as high, or higher, than those recently reported for southern California.
-Please see below for the results of EPA's recently completed RADIONUCLIDE analyses (sediments and animals) and GEOCHEMICAL and GEOTECHNICAL analyses (sediments)

**XII.** 1986 (Southeast Farallon Island & Point Arena Lighthouse): November, collected mussels for CA Mussel Watch

Program

**XIII.** 1986-1987 Farallon Island & Point Arena: Reference Suchanek et al., unpub. December, 1986, and January, 1987. Fish sample collection.

**XIV.** 1989 (South of the Farallon Islands): David Starr Jordan
- Region IX/ORD (Newport) cruise on DAVID STARR JORDAN to collect midwater fish and invertebrates for DDT/PCB analyses.
- Because of funding limitations at the ORD laboratory, very few of these analyses have been completed.

**XV.** 1989-1991 (Gulf of the Farallones):
- EPA REGION IX/CALIFORNIA MARINE MAMMAL CENTER project
- PCB/DDT analyses of BEAKED WHALES and PYGMY SPERM WHALE that washed ashore (e.g., Ocean Beach) and were kept alive for a few weeks before dying
- Analyses indicate that these baby whales received high concentrations of DDTs, PCBs, and Chlordane from their mothers' milk.

**XVI.** 1990 (South and Within the Gulf of the Farallones Marine Sanctuary):
- Region IX/ORD (Newport) cruise on DAVID STARR JORDAN to collect midwater fish and invertebrates for DDT/PCB analyses
- Because of funding limitations at the ORD laboratory, analysis of the tissue samples has not started.

**XVII.** 1990 (Gulf of the Farallones): R/V HMS Farnella, 30kHz Side-scan sonar survey of the 900 meter disposal site. References - Karl, et al., 1990a, 1990b, 1990c; Karl, et al., 1992; Karl, et al., 1994; Chavez, et al., 1995.

**XVIII.** 1991 (Reference Site): NOAA R/V MacArthur. Farallon Islands Dumpsite Contamination Study Cruise was designed to establish a reference area at 37.10833N 122.80000W.
- Collected 13 fish and 2 sediment samples, which were analyzed for 137Cs, 238Pu & 239Pu, 90Sr, and 241Am.

**XIX.** 1992 (Gulf of the Farallones): NOAA R/V MacArthur. Farallon Islands Radioactive Waste Dumpsite Contamination Study. Objectives of the cruise were to sample benthic commercial fish and sediment samples in the general area of known barrel concentration, 37° 37' 57"N and 123° 08' 00"W. Sediment samples were to be taken in the same aser as the fish samples in the area of 37° 40.53'N and 123° 12.35'W.

- Collected 108 fish and 3 sediment samples, which were analyzed for 137Cs, 238Pu & 239Pu, 90Sr, and 241Am.

**XX.** 1994 (Gulf of the Farallones): Navy R/V Laney Chouest, DSV Sea Cliff and the Advanced Tethered Vehicle (ATV).
-Submersible, photographic and videotape survey of the 900 meter site during August of 1994

**RESULTS**

**IV.** 1974 - Study sponsored by the EPA, Dyer examined sediments collected within a cluster of intact and imploded canisters at the 900m Farallon disposal site. The concentration of 239,240Pu in the 0-5cm sediment sections was reported to be 2-25 times the expected maximum concentration from fallout debris, and ranged from 0.5 to 532 pCi/g dry weight.

**VII.** 1977, January - Noshkin sampled water, sediment and benthic biota from three disposal sites near the Farallon Islands. Noshkin found 239,240Pu and 137Cs of the water to be within global fallout levels. Fish and benthic invertebrates had concentrations of 239,240Pu and 137Cs similar to species exposed to only global fallout. The concentrations of 239,240Pu in surface sediments ranged from 0.026 to 0.042 pCi/g dry weight.

1977, August/September - Schell and Sugai collected 6 sediment cores and occupied 2 water sampling stations within the vicinity of the disposal site.

1977, October - Eight cores were collected in the immediate vicinity of radioactive waste canisters. Sediment samples were collected using the coring mechanism on the submersible, Pisces VI. Biological samples were collected from mid- and deep-water trawls.

**Table 3.** Sample collection sites. Exact location of the 6 cores collected by Pieces VI is unknown.

| Station | Latitude | Longitude | Depth(m) | 239,240Pu mCi/km2// pCi/kg dry |
|---|---|---|---|---|
| **Dyer** 13A | 37 38.0' | 123 08.0' | 920 | |
| 15 | 37 36.0' | 123 06.0' | 929 | |
| 6 | 37 36.0' | 123 05.0' | 945 | |

| Station | Latitude | Longitude | Depth (m) | 239,240Pu mCi/km2// pCi/kg dry |
|---|---|---|---|---|
| **Noshkin** N-1 | 37 38.5'N | 123 18.0'W | 2000 | W/S 1.78/40 |
| N-2 | 37 38.0'N | 123 08.0'W | 920 | 1.40/35.7 |
| N-3 | 37 36.0'N | 123 06.0'W | 750 | 1.21/NA |
| N-4 | | | | NA/26.3 |
| N-5 | 37 39.0'N | 123 08.0'W | 650 | 1.23/NA |
| N-6 | 37 38.5'N | 122 58.0'W | 99 | 0.41/29.0 |
| N-7 | 37 42.6'N | 122 44.0'W | Surface | 0.19/NA |
| N-8 | 37 49'12" | 122 28'37" | Surface | 0.25/NA |
| N-9 | 37 31.0'N | 123 8.5'W | Surface | 0.38/NA |
| N-10 | 37 31.0'N | 123 18.5'W | Surface | 0.11/NA |
| **Shell&Sugai** 2A | 37 38.8'N | 123 07.1'W | 878 | 7.0 |
| 13A | 37 38.1'N | 123 08.0'W | 1043 | 4.3 |
| 39 | 37 38.0'N | 123 17.0'W | 1469 | 1.3 |
| 47 | 37 38.3'N | 123 14.0'W | 1400 | 0.9 |
| 48 | 37 36.6'N | 123 12.7'W | 1216 | 2.2 2.1 (2 sub-cores analyzed separately) |
| **Pisces Submersible** 1 | | | | 11.0 |
| 2 | | | | 7.5 |
| 3 | | | | 8.4 |
| 4 | | | | 4.1 |
| 6 | | | | 20.6 |
| 9 | | | | 5.0 |

| Station | Latitude | Longitude | Depth (m) | 239,240Pu mCi/km2// pCi/kg dry |
|---|---|---|---|---|
| **NOAA** 1991 | 37.10833 | 122.80000 | | |
| 1992a | 37 37'57" | 123 08'00" | | |
| 1992b | 37 40.53' | 123 12.35' | | |

Results of the radionuclides measurements at the deep water disposal site off the Farallon Isalnds indicate 239,240Pu and 137Cs were present in the sediment and in some biological samples collected. Plutonium 239,240 was found in sediment cores as deep as 16cm indicating rapid vertical transport, possibly by burrowing organisms. The sediment concentrations of 239,240Pu in cores collected by submersible from the immediate vicinity of the radioactive canisters are approximately 10 times higher than the box cores taken nearby and actual concentrations of 239,240Pu in the submersible-collected cores may be even higher because of probable loss of surface layers during collection. The tital 239,240Pu activities per surface area for submersible-collected cores are 2-20 times greater than expected fallout levels of 1.8+/-0.6mCi/km² for the 30-40°N latitude band. Some pelagic fish and benthic organisms contain measureable quantities of 137Cs and 239,240Pu, but 239,240Pu concentrations in edible muscle tissue were less than 0.006pCi/g dry weight for all species analyzed.

**IV.** 1985 - Results from the radionuclide data for sediments and animals collected during the December 1985 cruise:

- -Sediment samples were analyzed for Plutonium-238 & 239, Cesium-137, Lead-214, Potassium-40, Uranium-238, Bismuth-214, Radium-226, and Thorium-232.
- -Animal samples (whole organism or tissues) were analyzed for Plutonium-238 & 239, Cesium-137, and Strontium-89 & 90
- -The following animals were analyzed by EPA's National Air and Radiation Environmental Laboratory (Montgomery, Alabama):
  - *Sablefish (muscle and livers)
  - *Dover sole (muscle and livers)
  - *Red starfish (whole)
  - *Holothurians (sea cucumbers: whole)
  - *Long-Spined and Short-Spined Thornyhead Fish
  - *Tanner Crabs (exoskeleton, muscle, gonads, eggs)

Preliminary analyses of the radionuclide data obtained from the 1985 sediment and animal samples indicated that the radioactivity

found in these samples was at or below "background levels." Hence, there is no indication of wide-spread contamination in the vicinity of the Farallon Islands.

Geochemical analyses (e.g., pH, Eh, Total Organic Carbon, Clay Types) and geotechnical analyses (e.g., water content, shear strength, plasticity) on the 1985 sediment samples indicated the following:

1) Barrels disposed at the 1700 meters site probably became partially or completely buried by the surrounding mud after they hit the bottom;
2) The mud (clay) surrounding the barrels acts as a very effective barrier to any radionuclides that may have been released from the barrels; and
3) The muds (clays) found at the deeper sites (i.e., 900 & 1700 meters sites) contain a high percentage of clay types (e.g., smectite + illite) known to have high radionuclide retention properties.

**V.** 1986-1987 - Results from California's Mussel Watch Program.

The chemistry data from this study for fish and mussel tissue is of questionable value. The laboratory was unable to recovery a known spike at an adequate level.

**VI.** 1990 - Results of the 30kHz sidescan sonar survey.

**Table 4.** Location of Clusters of Barrels (Karl, et al., 1994). Geographic coordinates are the center point of probable areas of drum concentrations. Locations (1-6) of probable concentrations of 55-gallon drums based on interpretation of 1-km swath sidescan sonar mosaic around the 900 meter dumpsite.

| Area | Latitude | Longitude |
|---|---|---|
| 1a | 37° 37.33'N | 123° 07.18'W |
| 1b | 37° 37.38'N | 123° 08.24'W |
| 2 | 37° 39.94'N | 123° 12.56'W |
| 3 | 37° 41.33'N | 123° 14.24'W |
| 4 | 37° 40.53'N | 123° 12.35'W |
| 5 | 37° 39.14'N | 123° 11.40'W |
| 6 | 37° 38.31'N | 123° 11.52'W |

| Area | Latitude | Longitude |
|---|---|---|
| A | 37° 37' 57.2"N | 123° 08' 00.8"W ( 2 clusters) |
| B | 37° 38' 02.4"N | 123° 07' 32.9"W (1 cluster) |

**IV.** 1992 - Results of the MacArthur Cruise

| Station | Samples | Location of Deployment | Depth (fathoms) | Date | Comments |
|---|---|---|---|---|---|
| 1 | fish | 37 37.455'N 123 07.711'W | 530 | 6/29/92 | lines broke, traps not retrieved |
| 2 | fish | 37 38.453'N 123 07.461'W | 560 | 6/30/92 | collected |
| 3 | sediment | 37 38.2'N 123 08.0'W | 341 | 6/30/92 | pinger dropped off, grab did not reach bottom |
| 4 | fish | 37 37.95'N 123 07.43'W | 415 | 7/1/92 | collected |
| 5 | sediment | 37 38.93'N 123 08.35'W | 480 | 7/1/92 | collected, 300 count on FIDLER |
| 6 | fish | 37 37.40'N 123 06.70'W | 420 | 7/2/92 | collected |
| 7 | sediment | 37 37.806'N 123 06.235'W | 410 | 7/2/92 | grab did not close, nothing collected |
| 8 | sediment | 37 38.2'N 123 05.9'W | 372 | 7/2/92 | grab partially closed, nothing collected |
| 9 | sediment | 37 38.4'N 123 07.3'W | 342 | 7/2/92 | medium rock collected |
| 10 | sediment | not recorded | - | 7/2/92 | drifted too deep |

| Station | Samples | Location of Deployment | Depth (fathoms) | Date | Comments |
|---|---|---|---|---|---|
| 11 | sediment | 37 36.971'N 123 06009'W | 404 | 7/3/92 | 1/3 full collected |
| 12 | sediment | 37 37.620'N 123 05.633'W | 415 | 7/3/92 | collected |

Preliminary analyses of the radionuclide data from the 1992 sediment and animal samples indicates no siginificant radioactivity. Samples were at or below "background levels."

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