WHOI-84-28

U. S. "Mussel Watch" Program: Transuranic Element Data from
Woods Hole Oceanographic Institution
1976-1983

by

Julianne Palmieri¹, Hugh Livingston¹ and John W. Farrington^{1,2}

¹Department of Chemistry
²and Coastal Research Center
Woods Hole Oceanographic Institution
Woods Hole, MA 02543

May 1984

Technical Report

Prepared for the U. S. Environmental Protection Agency under Cooperative Research Agreement No. CR-807181 between Woods Hole Oceanographic Institution and the U. S. E.P.A. Environmental Research Laboratory, Narragansett, Rhode Island, and U. S. E.P.A. Contract No. 68-03-3193.

Reproduction in whole or in part is permitted for any purpose of the United States Government. This report should be cited as: Woods Hole Oceanog. Tech. Rept. WHOI-84-28.

Approved for public release; distribution unlimited.

Approved for distribution:

Robert B. Gagosian, Chairman
Department of Chemistry

MBL/WHOI

0 0301 0040394 5

TABLE OF CONTENTS

	<u>Page</u>
List of Tables	ii
List of Figures.	iii
Abstract	iv
Acknowledgements	v
I. Introduction	1
II. Methods.	1
Shucking, Drying and Ashing.	2
Isotopic Separations and Quantification.	2
Quality Control.	3
III. Results and Discussion	5
Monthly Samples.	5
U. S. Coast Data 1976-1978	7
Transplant Data.	9
Farallon Islands, California	11
Transect of Samples in the Tidal Zone.	12
Samples From Other Countries	13
IV. Conclusions and General Discussions.	14
References	17

LIST OF TABLES

Table		Page
1	Biological Materials - Intercomparison Analyses	19
2	NBS Human Liver (dpm/kg freeze dry)	20
3	Reagent Blanks.	21
4	Duplicate Analyses on Split Samples	22
5	ERLN Mussel Homogenate II	23
6	Mussel Watch Intercomparison, ERLN Mussel Homogenate II	24
7	Monthly Samples -- <u>Mytilus edulis</u>	25
8	Monthly Samples -- <u>Mytilus edulis</u>	28
9	Monthly Samples -- <u>Mytilus californianus</u>	29
10	<u>Mytilus edulis</u> from Narragansett, RI.	32
11	<u>Mytilus californianus</u> from Bodega Head, CA.	33
12	<u>Mytilus edulis</u> from Gay Head, MA.	34
13	Station Locations	35
14	Three Year Data -- Annual Collections	45
15	<u>Mytilus edulis</u> from Sears Island, ME to Wachapreague Inlet, VA.	52
16	Oysters from Wachapreague Inlet, VA to Espiritu Santo Bay, TX.	53
17	<u>Mytilus californianus</u> from Boundary Bay, WA to San Diego Harbor, CA	54
18	1978 Data -- Annual Sites	55
19	<u>Mytilus californianus</u> Transplanted from Bodega Harbor, CA to Narragansett, RI.	58
20	<u>Mytilus edulis</u> Transplanted from Gay Head, MA to Bodega Harbor, CA	59
21	<u>Mytilus edulis</u> Transplanted from Gay Head, MA to Bodega Harbor, CA	60
22	<u>Mytilus californianus</u> Transplanted from the Farallon Islands, CA.	61
23	<u>Mytilus californianus</u> from Soberanes Point, CA.	62
24	<u>Mytilus galloprovincialis</u> , Soft Parts from Spain.	63
25	<u>Mytilus edulis</u> from Windscale Reprocessing Plant and Isle of Man.	64

LIST OF FIGURES

Figure	Page
1 U. S. Mussel Watch 1976 sampling stations.	65
2 Fresh weight to dry weight of tissue ratios for <u>Mytilus edulis</u> at the U. S. Mussel Watch Station, Narragansett Bay, R.I., 1976-1980	66
3 $^{239,240}\text{Pu}$ (dpm/kg) in <u>Mytilus edulis</u> from U. S. Mussel Watch Station, Narragansett Bay, R.I., 1976-1980	67
4 ^{241}Am (dpm/kg) in <u>Mytilus edulis</u> from U. S. Mussel Watch Station, Narragansett Bay, R.I., 1976-1980	68
5 Fresh weight to dry weight of tissue ratios for <u>Mytilus californianus</u> at the U. S. Mussel Watch Station, Bodega Head, CA, 1976-1980.	69
6 $^{239,240}\text{Pu}$ (dpm/kg) in <u>Mytilus edulis</u> from U. S. Mussel Watch Station, Bodega Head, CA, 1976-1980.	70
7 ^{241}Am (dpm/kg) in <u>Mytilus edulis</u> from U. S. Mussel Watch Station, Bodega Head, CA, 1976-1980.	71
8 Pb, Cd, $^{239,240}\text{Pu}$ concentrations in U. S. Mussel Watch east coast samples, 1976, 1977, 1978	72
9 Cd and $^{239,240}\text{Pu}$ concentrations in U. S. Mussel Watch west coast samples, 1976, 1977, 1978	73

ABSTRACT

Bivalves (Mytilus edulis, Mytilus californianus, Crassostrea virginica and Ostrea equestris) were collected once per year during 1976, 1977, and 1978 along the United States coast and analyzed for $^{239,240}\text{Pu}$, ^{241}Am and ^{137}Cs as part of the U. S. Mussel Watch program. Monthly samples were collected during 1976-1980 from Narragansett Bay, Rhode Island and Bodega Head, California and analyzed for $^{239,240}\text{Pu}$, ^{241}Am , and ^{137}Cs .

There is no evidence in the data for systematic regional or local elevated concentrations of radionuclides as a result of releases from the nuclear fuel cycle. Elevated concentrations of $^{239,240}\text{Pu}$ in mussels from the central California coast are due to uptake from upwelled water fed by North Pacific water which has elevated $^{239,240}\text{Pu}$ from input of nuclear weapons test fallout.

Monthly fluctuations in radionuclide concentrations in the Narragansett Bay mussels appear to be primarily influenced by spawning. The slight monthly fluctuations in the radionuclide concentrations for the Bodega Head mussels are less coherent from year to year compared to Narragansett Bay although $^{239,240}\text{Pu}$ may be influenced by upwelling season.

Limited data on transplants of mussels as well as mussel data from the Ebro estuary on the Spanish coast and from the Irish Sea are also reported.

ACKNOWLEDGEMENTS

Professor Edward Goldberg of Scripps Institution of Oceanography initiated the U. S. Mussel Watch program and was the principal investigator during the first three years.

We wish to thank our colleagues in the U. S. Mussel Watch program, and especially the many co-workers in our laboratories for their assistance and encouragement. Dr. Vaughan T. Bowen provided the impetus and guidance for the work in our laboratory.

This work was supported under Cooperative Research Agreement No. CR-807181 between Woods Hole Oceanographic Institution and the U. S. E.P.A. Environmental Research Laboratory, Narragansett, Rhode Island, and Contract No. 68-03-3193 from U. S. E.P.A. to Woods Hole Oceanographic Institution. The samples from Spain were provided by Dr. Robert Risebrough as part of a study sponsored by the U.S.-Spanish Joint Committee. Copies of this report for international distribution were provided by the Analyzing Biospheric Changes Program of the International Federation of Institutes for Advanced Study (ABC-IFIAS).

ACKNOWLEDGMENTS

Professor Edward Goldberg of Scripps Institution of Oceanography initiated the U. S. Mammal Watch program and was the principal investigator during the first three years.

We wish to thank our colleagues in the U. S. Mammal Watch program and especially the many co-workers in our laboratory for their advice and encouragement. Dr. Vaughan I. Brown provided the labels and guidance for the work in our laboratory.

This work was supported under Cooperative Research Agreement No. GR-50181 between Woods Hole Oceanographic Institution and the U. S. E.P.A. Environmental Research Laboratory, Narragansett, Rhode Island, and Contract No. 55-07-3195 from U. S. E.P.A. to Woods Hole Oceanographic Institution. The samples from Spain were provided by Dr. Robert Mearns as part of a study sponsored by the U.S.-Spanish Joint Committee. Copies of this report for International distribution were provided by the American Wholphin Chapter League of the International Federation of Animal Clubs for Advanced Study (450-1742).

I. INTRODUCTION

The U.S. "Mussel Watch" program began in 1976 as a prototype monitoring program to assess the status of chemical pollution of the continental U.S. coast. Mussels (Mytilus edulis, Mytilus californianus) and oysters (Crassostrea and Ostrea spp.) were chosen as sentinel organisms for reasons set forth by Goldberg (1975); Goldberg et al. (1978), and Farrington et al. (1983). A detailed description of the program and its mission as well as results for metals, hydrocarbons, chlorinated hydrocarbons and some of the transuranic radionuclides are presented in Goldberg et al. (1978); Goldberg et al. (1983); Farrington et al. (1982) and Farrington et al. (1983).

This report presents the results of analyses for $^{239,240}\text{Pu}$, ^{241}Am , ^{137}Cs , and ^{55}Fe completed at Woods Hole Oceanographic Institution during the period 1976-1983. The intent of the report is to make this unique data available to colleagues and to provide initial, first order, interpretations. We do not pretend that we have had sufficient time to fully appreciate the details of this set of data. Future publications of interpretations and discussions are contemplated, especially with regard to the monthly data set and transplant experiments. Several important interpretations of the data have been presented and discussed by Goldberg et al. (1978, 1983); and Farrington et al. (1983).

The analyses we report were carried out in the laboratory group of Dr. Vaughan T. Bowen who planned and directed this part of the "Mussel Watch" project until his recent retirement.

II. METHODS

During the six years of the program monthly collections were taken of Mytilus californianus from Bodega Head, CA. Mytilus edulis from Narragansett Bay, R.I., were collected monthly during portions of 1976 and 1977 and the entire year for 1978, 1979, and 1980; and from Gay Head, MA, in 1978, 1979, and 1981. Annual collections were made of Mytilus edulis, Crassostrea virginica, Ostrea equestris, and Mytilus californianus from

the three major coastlines of the continental United States (Figure 1) during 1976, 1977, and 1978. The animals were packed in plastic bags and frozen immediately after collection. They remained frozen during shipment to the various laboratories and were stored frozen at approximately -20°C until shucked for analysis. The sampling procedure is described in detail by Goldberg et al. (1978).

Shucking, Drying and Ashing

Frozen mussels or oysters were partially thawed and the tissue plus fluid shucked into a clean tared one liter beaker. The material was dried in an oven at 110°C for a week, weighed, then ashed in a muffle furnace at 500°C for three days, and reweighed. Dry ashing reduced the biomass and the amount of organic material as well as facilitated later digestion by acids.

Isotopic Separations and Quantification

An amount of ashed mussel material equivalent to 400 g wet tissue was digested in 400 ml hot 8N HNO_3 with carriers and yield monitors. The Cs and Fe carriers were standardized solutions of the stable elements since the recoveries were determined gravimetrically and by atomic absorption spectrophotometry, respectively. Nd was added as a holdback carrier for Am. The ^{242}Pu and ^{243}Am isotopic tracers were added in precisely known amounts as yield monitors and recoveries of $^{238,240}\text{Pu}$ and ^{241}Am , respectively, are based on the recovery of these added tracers. The acid digestion of the ashed mussel sample in the presence of suitable carriers and yield monitors facilitates isotopic equilibrium between the sample, carriers and yield monitors.

The sample was filtered through a glass fiber filter after digestion to remove any undissolved material. The Pu was separated on an anion exchange column pretreated with HNO_3 . It was retained on the column in oxidized form and was reduced with NH_4I for elution. The Pu was electrodeposited on a highly polished stainless steel disc for alpha spectrometry.

The eluate from the Pu separation (which contained Cs, Am, and Fe) was diluted, pH adjusted to 1.5 and AMP (ammonium molybdophosphate) was added to adsorb the Cs from the sample. The AMP was removed, dissolved, and the sample passed through a cation exchange column to separate the Cs from other alkaline metals. The Cs was precipitated as Cs_2PtCl_6 and the recovery was determined gravimetrically. This precipitate was then mounted for beta counting.

The supernate from the Cs-AMP separation contained Am and Fe which were precipitated as hydroxides. The Am was selectively separated from the Fe as an oxalate at low pH (1.5) and then further separated from the Nd carrier and other lanthanides present by ion exchange as the thiocyanate complex. The Am was separated from residual Pu and Th by a final nitric anion exchange column and from residual Pb, Bi, and Po by two chloride anion exchange columns in series. The Am was electrodeposited for alpha spectrometry in the same manner as Pu using the ^{243}Am added to determine the recovery.

The supernate from the Am oxalate precipitation contained Fe. The oxalic acid was destroyed by repeated evaporation with concentrated HNO_3 . The Fe was precipitated as a hydroxide, dissolved in HCl , and passed through two ion exchange columns to remove any residual heavy metals. The Fe was electroplated on a copper tube and counted by a windowless-gas-flow proportional x-ray detector and the recovery determined by atomic absorption spectrophotometry measurement of Fe.

Quality Control

The intercomparison of data between the participating laboratories has been a concern within the program. Since no standard reference material identical to mussel tissue existed at the beginning of the program our laboratory routinely analyzed IAEA and NBS standard reference materials. We also analyzed reagent blanks routinely in conjunction with the mussels and oysters. Throughout the program both W.H.O.I. (Woods Hole Oceanographic Institution) and S.I.O. (Scripps Institution of Oceanography) analyzed a series of split samples. These were Mytilus californ-

nianus from Bodega Head, CA, and Mytilus edulis from Narragansett Bay, R.I., collected each month and split between the two laboratories. Since the results of this exercise appeared to be inadequate for quality control, a large mussel homogenate was prepared by the EPA Environmental Research Laboratory at Narragansett, R.I., for this purpose.

During the time period of the Mussel Watch program we participated in IAEA and NBS intercomparison analyses. Although the materials analyzed were not identical to those being analyzed in Mussel Watch, the results of these various exercises have given us confidence in the accuracy and precision of the data we produce. A summary of our performance may be found in Tables 1 and 2.

At intervals throughout the program, blanks were analyzed on our reagents. The blanks were performed in the following manner: a clean one liter beaker was placed in a muffle furnace at 500°C for 48 hours, cooled and filled with 400 ml 8N HNO₃. This was treated exactly like an ashed mussel sample and analyzed for ^{239,240}Pu, ²⁴¹Am, and ¹³⁷Cs. As the data in Table 3 shows, the radioactivity levels in these blanks were essentially zero.

In 1976 to 1979, split-sample analyses were used for interlaboratory quality control purposes. The split-samples were mussels which were collected each month at Bodega Head, CA, and Narragansett Bay, R.I., packed, frozen, and shipped frozen to both W.H.O.I. and S.I.O. for analyses. The results of the analyses from the two laboratories indicated the possibility of interlaboratory analytical discrepancies as well as problems in the split-sample technique itself. The data from the W.H.O.I. analyses are presented in Tables 7 and 9 in the next section. In most instances, however, each laboratory has been able to reproduce results on its own split samples (Table 4).

In 1978, as another quality control exercise, alternate east coast samples were analyzed by S.I.O., and W.H.O.I. analyzed alternate west coast samples. (In 1976 and 1977 W.H.O.I. analyzed east coast samples and S.I.O. analyzed samples from the west coast.) The data are presented in Table 14. In nearly every east coast station that S.I.O. analyzed the ²⁴¹Am/^{239,240}Pu ratio is slightly high, whereas the ratios of the

W.H.O.I. analyzed samples show little change from the previous two years. This is a laboratory discrepancy which has not been resolved.

In March of 1980 the EPA Environmental Research Laboratory at Narragansett, R.I., collected a very large number of Mytilus edulis by a dredge from a single site in Narragansett Bay. These mussels were shucked, homogenized, and frozen in approximately 250 g portions. This quality control material is identified as "ERLN Mussel Homogenate II." From 1980 until 1982, twelve of these samples were analyzed for $^{239,240}\text{Pu}$, ^{238}Pu , ^{241}Am , ^{137}Cs , and eight for ^{55}Fe . There is very good interlaboratory agreement for $^{239,240}\text{Pu}$ and good agreement for ^{241}Am (Tables 5 and 6) as discussed by Galloway et al. (1983).

In a large multi-laboratory program such as Mussel Watch a good quality control program is necessary. The monthly split-samples alone proved not to be an adequate enough quality control exercise. In the Mussel Watch Intercomparison in which a mussel homogenate was analyzed, there was better agreement between W.H.O.I. and S.I.O. results. More homogenates having various concentrations of nuclides should be analyzed routinely to assure better intercomparability in these types of programs in the future.

III. RESULTS AND DISCUSSION

Monthly Samples

The Bodega Head mussels (Mytilus californianus) were collected from the same locations throughout the program. At the Narragansett Bay station, however, the collection site for Mytilus edulis was changed several times. After the severe winter of 1976 which decimated the population at the site near Newport, the collection site was changed to a sub-tidal bed off Prudence Island. From 1977 until 1981 mussels were collected either from the east or west side of Prudence Island depending on the size of the mussel populations. In 1978, 1979, and 1981 monthly samples were analyzed from another east coast location off Gay Head, MA, in about 20 m of water near the mouth of Vineyard Sound (40°24'40''N,

70°45'45''W). This site is relatively free from local pollution sources and the Mytilus edulis population is subtidal.

The nuclide concentrations vary on a month-to-month basis as shown in Tables 7, 8, and 9 and Figures 2-7. This variation is greater than was originally anticipated by the Mussel Watch participants (Goldberg et al., 1978). The data suggest that biological half-lives for the radionuclides measured are in the range of weeks under some conditions rather than months to years.

The levels of Pu and especially Am in mussels from Bodega Head, CA, are generally higher than those from the east coast. This appears to be related to seasonal upwelling of the Peru ^{239,240}Pu and ²⁴¹Am-rich deeper Pacific Ocean waters as discussed later in this report and in Goldberg et al. (1982) and Farrington et al. (1983). The east coast mussels, which are not exposed to upwelling, still show seasonal variations (Figures 3, 4). The nuclide levels are generally higher during the winter months. This may be related to pre-spawned state and a slower metabolism due to cold winter weather. Fresh weight to dry weight ratios tend to support the hypothesis that these fluctuations are related to spawning (Figure 2) and spawning is a major factor in fluctuations in body burdens of several trace metals in bivalves (Phillips, 1980).

There are no indications of seasonal spawning patterns for M. californianus at Bodega Head as indicated by the fresh weight/dry weight ratio (Figure 5). There are indications of seasonal trends in plutonium concentrations with maximum values in 1976 to 1979 occurring in the period of March through June. This is consistent with the hypothesis that elevated plutonium concentrations in the central to northern California coast samples are a result of mussels accumulating plutonium from upwelling mid-depth Pacific water containing elevated plutonium concentrations (Bowen et al., 1980; Goldberg et al., 1983; Farrington et al., 1983). The onset of upwelling in a nearby California Current area at 33°N 119°W as calculated by the Bakun Upwelling Index for 1974 to 1977 begins in March, peaks in May to June and subsides in July and August (Killingley and Berger, 1979). Jones et al. (1983) also refer to March-April as the period of the onset of upwelling in this general area. The 1980 data set indicates

a late onset of upwelling and more prolonged upwelling period but there are significant gaps in the data for that year.

^{241}Am concentrations do not have the seasonal fluctuation signal associated with upwelling (Figure 7) which is a paradox since ^{241}Am also has a mid-depth maxima in the Pacific (Bowen et al., 1984). Perhaps the upwelled water is subjected to preferential removal of Am relative to Pu as the water traverses a shelf region and is exposed to higher concentrations of suspended particles, which would tend to remove the more particle active Am.

An alternative might be that the mussel's uptake response time is more rapid for $^{239,240}\text{Pu}$ compared to ^{241}Am . Guary and Fowler (1981) have experimentally determined that the biological half-lives during the initial period of release of ^{237}Pu and ^{241}Am from Mytilus galloprovincialis are between 1-2 days to 2 weeks (^{237}Pu), and between 2 and 3 weeks (^{241}Am). If the uptake response in Mytilus californianus is similar to the release response in Mytilus galloprovincialis, then the Bodega Head mussels might better reflect the $^{239,240}\text{Pu}$ enrichment in the upwelled water compared to ^{241}Am because the response to the ^{241}Am enrichment may be slow relative to the residence time of the water plus ^{241}Am in the mussel's habitat.

U.S. Coast Data 1976-1978

Collection stations are shown in Figure 1 and described in Table 13. The 1976 and 1977 samples were divided into east coast plus eastern Gulf of Mexico samples and were analyzed at Woods Hole Oceanographic Institution in Dr. Bowen's laboratory and the western Gulf of Mexico plus west coast samples analyzed in Professor Edward Goldberg's laboratory at Scripps Institution of Oceanography. In 1978, alternate stations from all coastal areas were analyzed by these laboratories.

The results of analyses at W.H.O.I. of east and Gulf Coast samples are summarized in Table 14 and summarized in Tables 15-17. There are no significant differences in $^{239,240}\text{Pu}$, ^{241}Am , and ^{137}Cs concentrations in mussels compared to oysters (Tables 15 and 16) according to a Student's t

test (0.05 level). The results of 1978 analyses at W.H.O.I. for west coast samples are given in Table 17 and the 1978 data are given in detail in Table 18.

Comparison of the entire data set from this laboratory and the S.I.O. laboratory (Goldberg et al., 1978, 1983) shows no significant difference between $^{239,240}\text{Pu}$ for west coast and east coast mussels (Student's t test 0.05 level). However, it is clear that the central California stations have elevated $^{239,240}\text{Pu}$ concentrations relative to the southern California Oregon, Washington and east coast mussels (Figures 8 and 9). Also plotted in Figures 8 and 9 are Cd data showing the slightly elevated Cd values for the central California coast. Higher concentrations of both Cd and $^{239,240}\text{Pu}$ are attributable to upwelling in this area (Goldberg et al., 1983; Farrington et al., 1983). The $^{239,240}\text{Pu}$ maxima in the North Pacific water column is described in detail by Bowen et al. (1980).

The ^{241}Am for west coast mussels were a factor of ten higher (Student's t test significant 0.05 level) than the east coast mussels for 1976, 1977, and 1978 samples (Tables 15, 17 and Goldberg et al., 1978, 1983). These elevated ^{241}Am values are attributable to the association of ^{241}Am with fine particles and the different coastal dynamics of the U.S. west and east coasts. The ^{241}Am to $^{239,240}\text{Pu}$ ratios (Tables 14 and 18) are typical of ratios for open ocean fine (small) particles (Bowen et al., 1984; Fowler et al., 1983). The Mytilus californianus of the west coast are exposed to the open ocean fine particle load. However, Mytilus edulis on the east coast are in sheltered areas and are not as exposed to the fine particle load of the open ocean. Even the west coast Mytilus californianus in partially sheltered bays and Mytilus edulis in west coast stations had low ^{241}Am to $^{239,240}\text{Pu}$ ratios which is consistent with the theory that the relative degree of exposure to open ocean fine particles is an important influence on ^{241}Am body burdens and $^{241}\text{Am}/^{239,240}\text{Pu}$ ratios.

Concentrations of ^{137}Cs in mussels do not vary between east and west coast, nor exhibit a maximum in concentration in mussels from the central California coastal area. This is consistent with the expected biogeochemical behavior of ^{137}Cs compared to the biogeochemical behavior of ^{241}Am and $^{239,240}\text{Pu}$ (Goldberg et al., 1983; Bowen et al., 1980).

An elevated radionuclide concentration has appeared on occasion during the years of these samples. However, subsequent analyses of the same populations show no evidence of systematic local or regional elevations of radionuclides in U.S. mussels and oysters as a result of nuclear fuel cycle releases.

Transplant Data

Transplant experiments were conducted during 1982 to investigate if mussels transplanted from west coast to east coast and vice versa modified their ^{241}Am and $^{239,240}\text{Pu}$ content to reflect their new habitats; and the time required to achieve the modified radionuclide distributions. These experiments were of a trial nature and not an extensive test. Nonetheless, they yielded interesting data.

A collection of Mytilus californianus was taken at the Bodega Head sampling site on June 2, 1981. A portion of these were frozen as time zero samples and the remainder were packed in ice and air shipped to the U.S. EPA environmental Research Laboratory at Narragansett, Rhode Island, where they were placed in an aquarium tank containing flowing water from Narragansett Bay. Half of these mussels were sampled on July 28th and the other half were sampled on August 19, 1981. These samples were frozen and sent to W.H.O.I. for analyses.

The results of analyses are given in Table 19. The ^{137}Cs concentrations changed very little as expected since there are no significant differences in ^{137}Cs concentrations when comparing east and west coast indigenous populations. $^{239,240}\text{Pu}$ and ^{241}Am concentrations appeared to decrease by 30% and 60% respectively over the first eight weeks and remained constant over the remaining three weeks of the experiment. The $^{241}\text{Am}/^{239,240}\text{Pu}$ ratio also decreased (Table 19). All of these changes are in the direction expected for a transition from typical Bodega Head values (Table 11) to typical Narragansett Bay values (Table 10) for indigenous populations. However, ^{241}Am concentrations were still higher by a factor of four for transplanted mussels as compared to indigenous Narragansett Bay mussels (Table 19, Table 10). $^{239,240}\text{Pu}$ concentrations

of transplant and indigenous mussels were about the same after the eleven week period.

We cannot discount the possibility that the transplanted mussels spawned or otherwise released some of their body burden of $^{239,240}\text{Pu}$ and ^{241}Am because of physiological response to the transplantation process. This seemed to be the case for the east coast to west coast transplants discussed next.

Mytilus edulis from the Narragansett Bay sampling site were transplanted to Bodega Head, California. However, heavy surf destroyed this experiment by carrying away the bags of mussels. A second attempt using Mytilus edulis from the subtidal population at Gay Head was successful in maintaining the transplanted mussels. The results of analyses of the Gay Head mussels at the time of transplanting and subsequent time intervals are given in Table 20.

The ratio of fresh weight to dry weight over the time period of the experiment indicates a substantial physiological response by the transplanted population (Table 20) consistent with increased lipids in preparation for spawning. Such a dramatic decrease in the fresh weight to dry weight ratio did not occur for the Mytilus californianus transplanted from Bodega Head to Narragansett Bay.

All the measured radionuclides $^{239,240}\text{Pu}$, ^{241}Am , ^{137}Cs declined in concentration during the first 23 days of the transplant and slowly increased in concentration over the next month of the experiment to concentrations that were slightly lower than the starting concentrations. These increases occurred at the same time as the fresh weight to dry weight ratio continued to decline (Table 20). We interpret the declining concentrations of radionuclides as resulting from an increase in dry tissue weight of each organism for T_1 to T_3 and an initial small release of radionuclides by the transplanted mussels (T_1) followed by a substantial accumulation of radionuclides at T_2 and T_3 . The increased body burden of radionuclides at T_2 and T_3 is not clearly expressed as a dry weight concentration since the dry weight of tissue per individual is also increasing. Table 21 presents the results of this experiment recalculated as radionuclide concentrations on a wet weight basis.

It is interesting to note that the $^{241}\text{Am}/^{239,240}\text{Pu}$ ratio did not significantly change during the time course of the east to west coast transplantation experiment. If the $^{239,240}\text{Pu}$ and ^{241}Am body burdens of the transplanted mussels had been substantially influenced by the $^{239,240}\text{Pu}$ and ^{241}Am of their new Pacific outer coast habitat over the two months of transplantation, then we would have expected the $^{241}\text{Am}/^{239,240}\text{Pu}$ ratio to change to a value closer to typical outer coast mussels on the west coast (Tables 9 and 18).

These transplant experiments were preliminary in nature but did demonstrate that east to west coast and west to east coast transplants are feasible in that populations survived and remained viable for several months. The experiments indicated that longer periods of time of transplantation, perhaps six months to a year, would be required before definitive influences of change in habitat on radionuclide burdens could be discerned because of the physiological response of mussels to transplantation and the interaction of this response with radionuclide body burdens.

Farallon Islands, California

Solidified low level radioactive wastes have been disposed at a site on the continental slope off the coast of California. There has been concern over the release of radionuclides from this waste and subsequent transfer through the food chain to man. The results of the U.S. Mussel Watch program showed elevated $^{239,240}\text{Pu}$ values near the Farallon Islands and nearby California coastal areas. The data, without accompanying interpretation by the scientists participating in Mussel Watch, became available to a few people who misinterpreted the higher $^{239,240}\text{Pu}$ and ^{241}Am concentrations in this area as due to release of radionuclides from the waste disposal. As explained in an earlier section, concentrations and relative ratios of radionuclides are consistent with a source in upwelled water, and not release from the dumpsite.

However, in order to more completely convince and reassure the public and to establish a benchmark against which future measurements could be gauged in the event of a release from the waste making its way to the

surface ocean food web, additional samples from the Farallon Islands were obtained and analyzed. Results are presented in Table 22. $^{239,240}\text{Pu}$, ^{238}Pu , ^{241}Am , ^{137}Cs , ^{55}Fe concentrations and $^{241}\text{Am}/^{239,240}\text{Pu}$ ratio are in the range of values expected if the predominant source of these radionuclides is water with an origin in the mid-depth North Pacific region and upwelled along this area of the California coast as previously discussed. The fluctuations observed in concentrations over the time period of sampling are of the same order as the month to month variations observed for Narragansett Bay (Figures 3, 4) and Bodega Head (Figures 6, 7) and could be due to a combination of fluctuations in upwelling intensity and exact source of upwelled water, and spawning.

Transect of Samples in the Tidal Zone

Physiological responses of mussels to position within a population relative to height in the tidal zone have been documented (Bayne, 1976; Phillips, 1980). This influence also extends to the relationship between concentrations of certain metals in the water of a population's habitat and concentrations in mussels. Samples were obtained from the Soberanes Point, California station in August, 1981, to investigate the influence of positioning in the tidal zone on the radionuclide concentrations in mussels from the same population. Soberanes Point is the Mussel Watch station which experiences the influence of the most intense upwelling. Samples were obtained from the high, mid, and low tide zones.

Results of analyses are presented in Table 23. The $^{239,240}\text{Pu}$ concentrations are four times higher in the high tidal zone mussels when compared to mid and low tidal zone mussels. There are no significant differences between mussels in the three zones for the other radionuclides measured (^{241}Am , ^{137}Cs). There are several possible explanations for the observed concentration difference for $^{239,240}\text{Pu}$. It is possible that $^{239,240}\text{Pu}$ is enriched in sea spray relative to the other radionuclides and thus the high tidal zone mussels receive a higher exposure via this route. Alternatively, or in concert, physiological response to longer periods of subareal exposure may influence the processes responsible for

uptake or release of $^{239,240}\text{Pu}$ and may not influence the other radionuclides.

In any event, the influence of position in the tidal zone must be explicitly recognized in sampling strategy design and data interpretation. The differences observed for $^{239,240}\text{Pu}$ are within the range which could account for some of the year to year and month to month fluctuations seen in $^{239,240}\text{Pu}$ presented in earlier tables. Although there was an attempt to obtain samples at approximately the same place in the tidal zone during this Mussel Watch program, the surf did not always cooperate.

Samples from Other Countries

We stated earlier that there was no evidence of systematic local or regional elevations in radionuclide concentrations in bivalves sampled on the United States coast as a result of releases from the nuclear fuel cycle. If such releases occurred, would a bivalve sampling program detect these releases? This is a question that can be answered in the affirmative based on experimental evidence and scientific extrapolation from certain metals to $^{239,240}\text{Pu}$, ^{241}Am and ^{137}Cs .

However, there are a few areas in the world's coastal zone where deliberate releases of low levels of radionuclides from the nuclear fuel cycle do occur. Perhaps, the most intensely studied area is the Irish Sea, especially adjacent to the Windscale nuclear fuel reprocessing facility on the west coast of England. These studies have been described by Pentreath (1981, 1982).

Two collections of Mytilus edulis from the Irish Sea were analyzed in this program. One sampling site was on the Isle of Man located in the middle of the Irish Sea about 50 km (31 miles) from Windscale. The second sampling site was in the Ravenglass estuary approximately 16 km (10 miles) south of Windscale. Results of analyses are presented in Table 24 and demonstrate that mussel populations do reflect increased concentrations of $^{239,240}\text{Pu}$, ^{238}Pu , ^{241}Am , and ^{137}Cs in their habitat. Concentrations of these radionuclides are orders of magnitude higher at these two sam-

pling sites in the Irish Sea in comparison to concentrations in samples from the U.S. coast.

Other samples have been obtained by Dr. Robert Risebrough of Bodega Bay Institute of Pollution Ecology from the Ebro River estuary on the east coast of Spain as part of a joint U.S.-Spanish research program to initiate a Mussel Watch program in Spain. Five sites were sampled near to and at various distances from an operating nuclear power plant. Results of analyses are given in Table 25. Mussels from the site nearest the power plant had the highest concentrations of $^{239,240}\text{Pu}$ and ^{137}Cs . However, these concentrations were not much elevated compared to typical U.S. west coast, central California data (Tables 9 and 18; and Goldberg et al., 1983; Farrington et al., 1983).

A comparison of the $^{239,240}\text{Pu}$ concentrations of U.S. east coast samples with these samples from Spain may be more meaningful because of more similarities in coastal and estuarine geomorphology and hydrography. The results from the Ebro samples show increased concentrations compared to U.S. east coast $^{239,240}\text{Pu}$, but the increase is only about a factor of 2 to 3. A more systematic survey of radionuclides in mussels from the Spanish coast would be needed to clarify the causative factor for the increase. The Farallon Islands situation, as previously discussed, argues against blithely accepting the proximity of the Ebro estuary samples to the nuclear power plant as the causative factor.

The ^{241}Am concentrations in the Ebro estuary samples are low and consistent with the great distance of these samples from open ocean fine particles enriched with ^{241}Am , as noted in earlier sections of this report.

IV. CONCLUSIONS AND GENERAL DISCUSSIONS

The data for $^{239,240}\text{Pu}$, ^{137}Cs and ^{241}Am from the U.S. Mussel Watch program provide a basis for assessing the influence of possible future releases of radionuclides from the nuclear fuel cycle on environmental burdens in coastal areas. The data collected thus far in the program has revealed no systematic local or regional elevation of $^{239,240}\text{Pu}$, ^{241}Am ,

or ^{137}Cs in bivalve tissue from the U.S. coast as a result of releases of these radionuclides from the nuclear fuel cycle. In this regard, it must be kept in mind that several important estuaries and bays were not sampled extensively but generally only at the outer coast. Thus, this conclusion may not be true for heads of some estuaries and bays. The data reported for the Irish Sea mussels demonstrate that when $^{239,240}\text{Pu}$, ^{241}Am , and ^{137}Cs are released from the nuclear fuel cycle in substantial quantities they are detected in bivalves.

The concentrations and relative abundances of $^{239,240}\text{Pu}$, ^{241}Am , and ^{137}Cs are consistent with input from the nuclear weapons test fallout source and subsequent biogeochemistries of these radionuclides. Upwelled North Pacific water is the source of the elevated concentrations of $^{239,240}\text{Pu}$ in mussels from the mid-California coast. The geographical coincidence of this phenomena with the low level nuclear waste dump site off the Farallon Islands caused some mistaken concern when the data from the U.S. Mussel Watch program was informally distributed without accompanying interpretation and discussion. This illustrates the importance of close coupling of research and monitoring activities. The knowledge and biogeochemical research experience of the Mussel Watch participants were essential to interpretation of this data and other data from the program. Furthermore, the larger coastal data set were required to place the central California coastal data in proper perspective.

The experience with the U.S. coastal data provides the cautionary framework for interpretation of the few samples from the Ebro estuary on the Spanish Mediterranean coast. The elevated $^{239,240}\text{Pu}$ concentrations found in a few of those samples may be due to releases from a nearby nuclear power plant or they may reflect the influence of hydrological, geochemical or physiological conditions for these organisms or their habitat.

Investigations of monthly fluctuations in $^{239,240}\text{Pu}$, ^{241}Am , ^{137}Cs show changes of factors of 2 to 4 on a dry weight basis which appear to be linked with seasonality of upwelling in the case of the Bodega Head population and with spawning in the case of the Narragansett Bay population. These fluctuations are not unexpected (Phillips, 1980) but must be

considered in the design of future sampling and analysis strategies to detect geographic or temporal trends, especially if changes smaller than a factor of 2 to 4 are to be detected.

Quality assurance for the data and the essential need for intercomparison exercises have been clearly demonstrated in this program as reported in an earlier section and in Galloway et al. (1983).

The sentinel organism concept using analysis of bivalve tissues as a monitoring tool for assessing the status of chemical contamination of coastal areas has provided useful information on the present status of $^{239,240}\text{Pu}$, ^{241}Am , and ^{137}Cs levels in U.S. coastal waters. However, we emphasize that the U.S. Mussel Watch program was an investigation into the feasibility of instituting one type of monitoring strategy and we, and the other program participants, do not advocate this approach as the only strategy (Farrington et al., 1983; Farrington, 1983; NAS, 1980). Coupling of these types of monitoring data, with measurements of edible fish, and other key food web components in the route to man, and further biogeochemical research are clearly the desirable strategy to offer maximum protection to man and valuable living natural resources.

REFERENCES

- Bayne, B. L. (ed.) (1976). *Marine Mussels: Their Ecology and Physiology*. International Biological Programme 10, New York, Cambridge University Press.
- Bowen, V. T., D. R. Mann, S. A. Casso, D. L. Schneider, L. D. Surprenant and H. D. Livingston (1984). Particle and solution phase depth distributions of transuranics and ^{55}Fe in the North Pacific. To be submitted to Earth & Planet. Sci. Letts.
- Bowen, V. T., V. E. Noshkin, H. D. Livingston and H. L. Volchok (1980). Fallout radionuclides in the Pacific Ocean: Vertical and horizontal distributions, largely from GEOSECS stations. Earth & Planet. Sci. Letts., 49: 411-434.
- Dyer, R. S. (1976). Environmental surveys of two deep-sea radioactive waste disposal sites using submersibles. Management of radioactive wastes from the nuclear fuel cycle. Proc. Symp., Vienna, 1976, International Atomic Energy Agency, Vienna, 317 pp.
- Farrington, J. W., R. W. Risebrough, P. L. Parker, A. C. Davis, B. DeLappe, J. K. Winters, D. Boatwright, N. M. Frew (1982). Hydrocarbons, polychlorinated biphenyls, and DDE in mussels and oysters from the U.S. coast, 1976-1978 - The Mussel Watch. Technical Report No. 82-42, Woods Hole Oceanographic Institution, Woods Hole, MA 02540.
- Farrington, J. W., E. D. Goldberg, R. W. Risebrough, J. H. Martin, V. T. Bowen (1983a). U.S. "Mussel Watch" 1976-1978: An overview of the trace metal, DDE, PCB, hydrocarbon, and artificial radionuclide data. Environ. Sci. Tech., 17: 490-496.
- Fowler, S. W., S. Ballestra, J. La Rosa and R. Fukai (1983). Vertical transport of particulate-associated plutonium and americium in the Northeast Pacific. Deep-Sea Res., 30: 1221-1233.
- Galloway, W. B., J. L. Lake, D. K. Phelps, P. F. Rogerson, V. T. Bowen, J. W. Farrington, E. D. Goldberg, J. L. Laseter, G. C. Lawler, J. H. Martin, R. W. Risebrough (1983). The Mussel Watch: Intercomparison of trace level constituent determinations. Environ. Toxicol. and Chem., 2: 395-410.
- Goldberg, E. D. (1975). The "Mussel Watch" - a first step in global marine monitoring. Mar. Poll. Bull., 6: 111.
- Goldberg, E. D., V. T. Bowen, J. W. Farrington, R. W. Risebrough, W. Robertson, E. Schneider and E. Gamble (1978). The "Mussel Watch". Environ. Conserv., 5: 101-125.

- Goldberg, E. D., M. Koide, V. Hodge, A. R. Flegal, J. Martin (1983). U.S. Mussel Watch: 1977-1978. Results on trace metals and radionuclides. Est. Coast. and Shelf Sci., 16: 69-93.
- Guary, J. C. and S. W. Fowler (1981). Americium-241 and Plutonium-237 turnover in mussels (Mytilus galloprovincialis) living in field enclosures. Est. Coast. and Shelf Sci., 12: 193-203.
- Jones, B. H., K. H. Brink, R. C. Dugdale, D. W. Stuart, J. C. VanLeer, D. Blasco and J. C. Kelley (1983). Observations of a persistent upwelling center off Point Conception, California. In: Coastal Upwelling, Its Sediments Record. Part A. Responses of the Sedimentary Regime to Present Coastal Upwelling (E. Suess and J. Thiede, eds.). Plenum Press, New York, pp. 37-60.
- Killingley, J. S. and W. Berger (1979). Stable isotopes in a mollusc shell: detection of upwelling events. Science, 205: 186-188.
- Pentreath, R. J. (1982). Principles, practice and problems in the monitoring of radioactive wastes disposed of into the marine environment. Nuclear Energy, 21: 235-244.
- Pentreath, R. J. (1981). The biological availability to marine organisms of transuranium and other long-lived nuclides. Proc. Symp, "Impacts of Radionuclide Releases into the Marine Environment", International Atomic Energy Agency, Vienna, IAEA-SM-248, pp. 241-272.
- Phillips, D.J.H. (1980). Quantitative Biological Indicators, Their Use to Monitor Trace Metal and Organochlorine Pollution. Applied Science, London.
- Fowler, S. W., J. C. Guary, J. A. Rose and K. L. Fisher (1983). Transport of particulate-associated plutonium and americium in the Northeast Pacific. Deep-Sea Res., 30: 1231-1237.
- Calloway, W. E., J. L. Jaber, D. E. Fisher, R. V. Robertson, V. T. Brown, J. W. Farrington, E. D. Goldberg, J. L. Lancaster, G. C. Lawler, J. A. Martin, R. W. Nriagu (1981). The Mussel Watch: International comparison of trace metal contamination determinations. Environ. Toxicol. and Chem., 1: 393-410.
- Goldberg, E. D. (1975). The "Mussel Watch" - a first step in global marine monitoring. Mar. Poll. Bull., 6: 111.
- Goldberg, E. D., V. T. Brown, J. W. Farrington, R. W. Nriagu, W. Robertson, E. Schuster and E. Gamble (1978). The "Mussel Watch". Environ. Toxicol., 1: 101-112.

Table 1

BIOLOGICAL MATERIALS--INTERCOMPARISON ANALYSES

	^{90}Sr	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}\text{Pu}$	^{241}Pu	^{241}Am	^{242}Cm	^{244}Cm
	pCi/g			pCi/g					
IAEA AG-I-1 (<i>Fucus serratus</i>)									
Reference date: 1/1/72									
WHOI values	10.0 ± 0.3	10.5 ± 0.2	78.2 ± 0.3	4.8×10^3 $\pm 0.2 \times 10^3$	30.0×10^3 $\pm 0.6 \times 10^3$	800×10^3 $\pm 30 \times 10^3$	5.2×10^3 $\pm 0.2 \times 10^3$	0.08×10^3 $\pm 0.01 \times 10^3$	
IAEA values	10.0 ± 0.2	10.0 ± 0.2	75 ± 1	3.8×10^3 $\pm 0.1 \times 10^3$	27.0×10^3 $\pm 0.5 \times 10^3$				
Other laboratory values							4.4×10^3 $\pm 0.1 \times 10^3$	0.03×10^3 $\pm 0.1 \times 10^3$	
IAEA MA-B-1 (<i>Anadara granosa</i>) — clam									
Reference date: 1/1/75									
WHOI values	8.0 ± 0.4		17.7 ± 0.1	1.41 ± 0.25	38.3 ± 1.4		18.6 ± 2.5		
IAEA values	7.4 ± 0.8		16.2 ± 0.4	1.5 ± 0.1	44 ± 4				
Other laboratory values							8-35		
IAEA MA-B-2 (<i>Aplysia benedicti</i>) sea hare									
Reference date: 1/1/75									
WHOI values			5.56 ± 0.02		0.76 ± 0.12	1.05 ± 0.17			0.9 ± 0.4
IAEA values			4.2 ± 0.2	0.86 ± 0.07	1.1 ± 0.5				

Table 2
NBS HUMAN LIVER
(dpm/kg Freeze dry)

M#	Bottle #	Gm Wt of Sample	% Pu Recovery	^{239}Pu	^{238}Pu	$^{238}\text{Pu}/^{239}\text{Pu}$	% Am Recovery	^{241}Am	$^{241}\text{Am}/^{239}\text{Pu}$
6173	00093	15.1	58	122+5	2.63+0.50	0.021+0.004	68	9.27+0.89	0.076+0.008
6174	00255	8.3	72	115+5	3.14+0.60	0.027+0.005	68	8.49+1.14	0.074+0.011
6175	00360	12.9	52	122+5	2.74+0.61	0.022+0.005	74	8.49+0.87	0.069+0.008
6176	00525	12.1	65	116+5	3.61+0.63	0.031+0.005	65	8.69+0.95	0.075+0.008

STANDARDIZATION OF HUMAN LIVER SAMPLES

1976

Table 3
REAGENT BLANKS

Date	Treatment	Radionuclides: (dpm/kg dry weight)			
		239,240 Pu	238 Pu	241 Am	137 Cs
Feb. 1978	Ashed beaker	0.0021+0.0012	0.0007+0.0007	0.0176+0.0299	0.008+0.118
Mar. 1978	Ashed beaker	0.001 +0.0004	--	--	0.06 +0.15
May 1980	Ashed beaker	0.001 +0.001	0.001 +0.001	0.002 +0.002	Lost
May 1980	Ashed beaker	0.001 +0.001	0.001 +0.001	0.003 +0.004	0.13 +0.12
Nov. 1981	Ashed beaker	0.001 +0.001	0.001 +0.001	0.002 +0.002	0.15 +0.20
Jan. 1983	Ashed beaker	0.001 +0.001	0.001 +0.001	0.002 +0.002	0.17 +0.09

Table 4
DUPLICATE ANALYSES ON SPLIT SAMPLES

Mussel Watch Identification	Location	Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)				
			239,240 Pu	238 Pu	241 Am	137 Cs	239,240 Pu 241 Am
AC-761014	Atlantic City, NJ	11.4	0.80+0.23*	0.11+0.11	1.14+0.11	30+ 6	2.0 +0.8*
AC-761014	Atlantic City, NJ	11.4	5.59+0.34*	0.23+0.11	1.25+0.23	—	0.22+0.04*
BH-761202	Bodega Head, CA	7.6	1.66+0.23	0.03+0.03	7.25+0.53	28+ 3	4.4 +0.7
BH-761202	Bodega Head, CA	7.6	1.74+0.15	0.06+0.03	—	33+5	—
FAR-780820	Farallon Island, CA	7.2	4.58+0.21	0.06+0.03	14.3 +0.7	36+14	3.1 +0.2
FAR-780820	Farallon Island, CA	7.2	4.80+0.36	0.15+0.06	22.8 +1.2	39+ 4	4.8 +0.4
CM-780812	Cape Mendocino, CA	8.4	5.44+0.17	0.21+0.04	13.5 +1.0	43+ 3	2.6 +0.2
CM-780812	Cape Mendocino, CA	8.4	4.06+0.26	0.12+0.04	12.6 +0.7	28+ 5	8.1 +0.3
PLY-780926	Plymouth, MA	26.7	3.74+0.56	N.D.	0.69+0.24	154+ 6*	0.18+0.07
PLY-780926	Plymouth, MA	26.7	3.74+0.27	0.16+0.05	0.96+0.19	43+10*	0.26+0.05
NRI-790824	Narragansett, RI	9.5	5.46+0.44	0.26+0.09	0.86+0.10	24+ 3	0.15+0.02
NRI-790824	Narragansett, RI	9.5	2.63+0.38	0.09+0.08	—	22+ 2	—
NRI-791024	Narragansett, RI	14.1	5.91+0.55*	0.14+0.08	0.79+0.13	20+ 4*	0.13+0.02
NRI-791024	Narragansett, RI	14.1	3.39+0.15*	0.15+0.08	—	65+ 6*	—
BH-800310	Bodega Head, CA	6.7	1.30+0.13	0.12+0.12	4.2 +0.5	60+ 3*	3.2 +0.5
BH-800310	Bodega Head, CA	6.7	1.32+0.18	0.09+0.05	—	30+ 3*	—

* = Data questionable because one of the duplicates was a bad number.
N.D. = Not detected.

Table 5
ERLN MUSSEL HOMOGENATE II

Mussel Watch Identification	Ratio: Fresh wt. Dry wt.	Radionuclides: (dpm/kg dry weight)				
		$^{239,240}\text{Pu}$	^{238}Pu	^{137}Cs	^{241}Am	^{55}Fe
4002	6.9	1.37 ± 0.14	0.03 ± 0.02	12 ± 3	0.35 ± 0.14	83 ± 10
4018	6.8	1.87 ± 0.22	0.10 ± 0.05	27 ± 5	0.66 ± 0.17	56 ± 9
4033	6.8	1.86 ± 0.22	0.08 ± 0.05	14 ± 5	0.51 ± 0.14	69 ± 8
4049	6.8	1.45 ± 0.25	0.04 ± 0.04	15 ± 4	0.28 ± 0.12	68 ± 9
4064	6.8	1.60 ± 0.24	0.10 ± 0.06	19 ± 3	0.54 ± 0.10	117 ± 10
4066	6.9	1.95 ± 0.21	0.04 ± 0.04	15 ± 2	0.39 ± 0.39	—
4080	6.7	1.36 ± 0.19	—	13 ± 5	0.39 ± 0.09	97 ± 8
4095	6.8	1.56 ± 0.20	0.05 ± 0.03	13 ± 4	0.51 ± 0.09	70 ± 12
4111	6.7	1.58 ± 0.19	—	13 ± 3	0.46 ± 0.08	—
4126	6.8	1.69 ± 0.14	0.02 ± 0.01	20 ± 3	0.48 ± 0.14	75 ± 9
4131	6.9	2.11 ± 0.21	0.04 ± 0.04	12 ± 2	0.35 ± 0.35	—
4142	6.7	1.75 ± 0.18	0.02 ± 0.02	15 ± 4	0.49 ± 0.11	—

Table 6
MUSSEL WATCH INTERCOMPARISON
ERLN MUSSEL HOMOGENATE II

Lab	No. of Analyses	Wet Wt. Dry Wt. (110°)	Radionuclides: (dpm/kg dry weight)			
			^{239,240} Pu	²³⁸ Pu	²⁴¹ Am	¹³⁷ Cs
WHOI	12	6.8±0.1	1.68±0.23	0.05±0.03	0.45±0.16	16±4
SIO	3	6.6	1.64±0.15	0.06±0.02	0.66±0.21	N.A.

WHOI = Woods Hole Oceanographic Institution
SIO = Scripps Institution of Oceanography
N.A. = Not analyzed

Table 7
MONTHLY SAMPLES—MYTILUS EDULIS

Year	Mussel Watch No. or Date	Location (R.I.)	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)				
				239, 240 Pu	238 Pu	241 Am	137 Cs	241 Am 239, 240 Pu
1976	NRI-760609	Newport	11.9	2.86±0.36	0.13±0.07	0.83±0.12	--	0.29±0.06
1976	NRI-760720	Newport	7.9	1.98±0.24	0.03±0.03	0.32±0.08	21±5	0.16±0.04
1976	NRI-760818	Newport	8.3	1.91±0.17	0.04±0.03	0.42±0.08	26±3	0.22±0.05
1976	NRI-760909	Newport	8.3	1.08±0.17	0.04±0.03	0.42±0.12	17±3	0.38±0.12
1976	NRI-761020	Newport	11.1	1.89±0.22	0.16±0.10	0.46±0.11	27±3	0.24±0.06
1976	NRI-761111	Newport	11.8	1.54±0.35	< 0.04	0.15±0.09	27±4	0.10±0.07
1977	NRI-770623	Narragansett *	5.5	1.09±0.10	0.04±0.02	0.39±0.11	12±2	0.36±0.11
1977	NRI-770718	Narragansett	6.2	0.25±0.05	< 0.01	0.25±0.06	29±3	0.98±0.34
1977	NRI-770810	Narragansett	6.5	1.36±0.23	< 0.04	0.65±0.26	21±3	0.47±0.22
1977	NRI-770914	Narragansett	7.9	0.26±0.06	--	--	--	--
1977	NRI-771017	Narragansett	10.6	1.35±0.27	< 0.05	Lost	33±5	--
1977	NRI-771118	Narragansett	9.7	1.08±0.15	0.09±0.04	0.16±0.11	29±3	0.14±0.10
1977	NRI-771212	Narragansett	9.7	0.77±0.10	--	0.23±0.14	25±3	0.30±0.20
1978	NRI-780220	Narragansett	10.3	5.25±0.41	0.12±0.05	0.32±0.08	29±2	0.06±0.02
1978	NRI-780309	Narragansett	5.6	1.01±0.11	0.05±0.02	0.26±0.08	13±2	0.25±0.09
1978	NRI-780428	Narragansett	7.7	0.77±0.08	0.03±0.02	0.16±0.05	13±1	0.21±0.07
1978	NRI-780523	Narragansett	5.3	0.69±0.11	0.02±0.02	0.27±0.05	18±2	0.38±0.09
1978	NRI-780630	Narragansett	5.3	0.58±0.11	0.05±0.02	0.19±0.06	27±1	0.32±0.12
1978	NRI-780721	Narragansett	6.8	0.82±0.14	0.06±0.03	0.25±0.15	39±2	0.30±0.19
1978	NRI-780829	Narragansett	5.7	0.41±0.18	0.05±0.07	0.39±0.17	63±1	0.91±0.53

Table 7
MONTHLY SAMPLES--MYTILUS EDULIS

Year	Mussel Watch No. or Date	Location (R.I.)	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)				
				239,240 Pu	238 Pu	241 Am	137 Cs	241 Am 239,240 Pu
1978	NRI-781020	Narragansett	10.1	0.71+0.10	< 0.03	0.37+0.12	15+4	0.55+0.018
1978	NRI-781121	Narragansett	8.5	1.94+0.25	< 0.03	0.17+0.10	21+2	0.09+0.05
1978	NRI-781228	Narragansett	9.5	2.53+0.26	0.06 +0.04	0.46+0.10	23+4	0.18+0.05
1979	NRI-790126	Narragansett	7.1	1.10+0.06	0.04 +0.01	0.36+0.06	12+1	0.32+0.06
1979	NRI-790227	Narragansett	9.1	1.73+0.14	0.06 +0.03	0.44+0.09	21+3	0.26+0.06
1979	NRI-790327	Narragansett	8.5	2.08+0.15	0.03 +0.02	0.65+0.11	25+5	0.31+0.06
1979	NRI-790419	Narragansett	6.1	1.08+0.13	0.10 +0.04	0.25+0.06	8+3	0.24+0.03
1979	NRI-790523	Narragansett	9.6	1.66+0.15	0.03 +0.02	0.48+0.19	22+3	0.25+0.10
1979	NRI-790627	Narragansett	6.4	0.73+0.08	0.01 +0.01	0.17+0.04	10+2	0.24+0.06
1979	NRI-790725	Narragansett	6.9	0.94+0.13	0.06 +0.04	0.40+0.08	13+3	0.43+0.05
1979	NRI-790824	Narragansett**	9.5	2.63+0.38	0.09 +0.08	0.86+0.10	24+3	0.15+0.02
1979	NRI-790919	Narragansett	11.3	2.15+0.25	0.03 +0.05	0.74+0.15	29+7	0.34+0.08
1979	NRI-791024	Narragansett	14.1	3.39+0.15	0.15 +0.08	0.79+0.13	20+4	0.13+0.02
1979	NRI-791128	Narragansett	14.4	1.93+0.32	0.06 +0.04	0.75+0.14	13+7	0.39+0.10
1979	NRI-791226	Narragansett	12.5	8.31+0.75	0.34 +0.14	1.18+0.20	100+5	0.14+0.03
1980	NRI-800118	Narragansett	12.2	4.14+0.33	0.13 +0.01	1.10+0.19	37+5	0.27+0.05
1980	NRI-800228	Narragansett	7.3	0.76+0.20	0.038+0.038	0.07+0.07	18+2	0.06+0.07
1980	NRI-800318	Narragansett	3.8	0.90+0.11	0.011+0.014	0.30+0.11	17+2	0.34+0.13
1980	NRI-800424	Narragansett	6.5	0.82+0.18	0.08 +0.03	0.31+0.10	22+3	0.76+0.60
1980	NRI-800520	Narragansett	6.9	1.97+0.15	0.067+0.026	0.41+0.10	22+2	0.21+0.05
1980	NRI-800625	Narragansett	7.0	2.70+0.83	0.24 +0.24	0.51+0.11	25+2	0.19+ .07

Table 7
MONTHLY SAMPLES--MYTILUS EDULIS

Year	Mussel Watch No. or Date	Location (R.I.)	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)				
				239,240 Pu	238 Pu	241 Am	137 Cs	241 Am 239,240 Pu
1980	NRI-800721***	Narragansett	6.9	0.88+0.14	0.09 +0.05	0.17+0.07	40+2	0.19+0.08
1980	NRI-800820	Narragansett	7.7	2.19+0.23	0.05 +0.03		13+2	
1980	NRI-800922	Narragansett	10.8	1.53+0.17	0.04 +0.03	0.45+0.13	34+4	0.29+0.09
1980	NRI-801022	Narragansett	12.8	2.70+0.35	0.26 +0.10	0.94+0.39	54+3	0.32+0.13
1980	NRI-801205	Narragansett	10.3	2.39+0.19	0.07 +0.03	0.75+0.31	46+3	0.32+0.13
1981	NRI-801231	Narragansett	9.6	1.03+0.21	0.05 +0.04	---	57+2	---
1981	NRI-810325	Narragansett	5.3	2.15+0.32	0.05 +0.05		13+1	
1981	NRI-810423	Narragansett	4.8	1.02+0.15	0.02 +0.02		10+1	
1981	NRI-810521	Narragansett	4.5	1.07+0.11	0.04 +0.02	0.17+0.04	23+1	0.16+0.04
1981	NRI-810623	Narragansett	5.8	0.85+0.11	0.03 +0.02		40+2	
1981	NRI-810723	Narragansett	6.1	0.96+0.13	0.02 +0.02		30+2	

* = This collection site and the collections thereafter were changed from Newport to west of Prudence Island; the Newport population was destroyed by ice during a severe winter.

** = This collection site and the collections thereafter were changed from west of Prudence Island to east of Prudence Island.

*** = This collection site and the collections thereafter were changed from east of Prudence Island to west of Prudence Island.

Table 8
MONTHLY SAMPLES—MYTILUS EDULIS

Year	Mussel Watch No. or Date	Location (MA)	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)				
				238Pu	241Am	137Cs	239, 240Pu	241Am 239, 240Pu
1978	GH 780330	Gay Head	8.2	N.D.	0.40±0.10	24±2	1.47±0.16	0.27±0.07
1978	GH 780426	Gay Head	7.6	N.D.	0.39±0.08	19±1	1.29±0.15	0.30±0.07
1978	GH 780607	Gay Head	8.8	0.04±0.02	0.35±0.09	23±1	1.66±0.09	0.21±0.05
1978	GH 780626	Gay Head	9.1	0.15±0.05	0.75±0.20	Lost	1.45±0.18	0.51±0.15
1978	GH 780727	Gay Head	9.9	0.10±0.04	0.49±0.20	21±3	4.24±0.30	0.11±0.03
1978	GH 780906	Gay Head	9.7	0.17±0.08	0.80±0.18	18±5	2.44±0.29	0.33±0.08
1978	GH 781011	Gay Head	10.4	0.06±0.04	0.49±0.13	65±3	2.19±0.21	0.22±0.06
1978	GH 781026	Gay Head	13.2	N.D.	0.41±0.13	27±4	1.19±0.26	0.33±0.13
1978	GH 781206	Gay Head	12.5	N.D.	0.39±0.19	64±3	3.01±0.25	0.13±0.06
1979	GH 790301	Gay Head	6.9	0.07±0.02	0.74±0.11	19±3	1.99±0.11	0.37±0.06
1979	GH 790330	Gay Head	10.1	0.04±0.02	0.44±0.12	30±5	1.20±0.10	0.37±0.11
1979	GH 790424	Gay Head	8.6	< 0.01	0.94±0.16	17±3	1.38±0.11	0.69±0.13
1979	GH 790628	Gay Head	9.5	< 0.01	--	17±5	2.03±0.15	--
1979	GH 790801	Gay Head	9.4	0.06±0.03	0.69±0.10	15±3	1.40±0.14	0.49±0.09
1979	GH 790828	Gay Head	10.2	0.10±0.04	0.63±0.01	16±4	1.67±0.18	0.38±0.04
1979	GH 791026	Gay Head	10.1	0.05±0.02	0.62±0.12	10±3	1.79±0.12	0.37±0.08
1979	GH 791108	Gay Head	9.1	0.02±0.03	--	17±4	1.54±0.23	--
1980	The mussel population at this location was too small to sample from Dec. 1979 through 1980							
1981	GH 810106	Gay Head	8.5	0.29±0.17	0.80±0.27	29±6	2.79±0.82	0.29±0.13
1981	GH 810505	Gay Head	6.5	0.08±0.03	0.71±0.11	52±2	2.95±0.19	0.24±0.04
1981	GH 810707	Gay Head	6.7	0.13±0.05	--	40±1	3.57±0.27	--
1981	GH 810812	Gay Head	7.5	0.09±0.03	--	66±3	2.87±0.20	--

N.D. = Not detected.

Table 9
MONTHLY SAMPLES—MYTILUS CALIFORNIANUS

Year	Mussel Watch No. or Date	Location (CA)	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)			
				239, 240 Pu	238 Pu	241 Am	137 Cs
1976	BH 760324	Bodega Head	6.4	5.90±0.38	0.15±0.05	14.10±0.83	23±4
1976	BH 760603	Bodega Head	6.6	5.37±0.33	0.17±0.05	9.83±0.66	22±2
1976	BH 760729	Bodega Head	6.3	3.65±0.25	0.08±0.03	10.69±0.57	16±2
1976	BH 761006	Bodega Head	9.1	2.45±1.18	< 0.5	9.60±0.63	26±3
1976	BH 761202	Bodega Head	7.6	1.70±0.19	0.06±0.03	7.25±0.53	31±4
1977	BH 770104	Bodega Head	7.2	2.39±0.23	0.09±0.04	7.79±0.50	33±2
1977	BH 770202	Bodega Head	5.2	1.88±0.16	0.04±0.02	3.67±0.21	21±2
1977	BH 770303	Bodega Head	5.0	1.95±0.16	0.01±0.01	5.06±0.30	22±1
1977	BH 770408	Bodega Head	8.5	3.27±0.23	0.06±0.03	8.48±0.85	39±3
1977	BH 770506	Bodega Head	6.4	3.59±0.26	0.11±0.04	10.88±0.84	24±2
1977	BH 770607	Bodega Head	6.4	3.48±0.28	0.02	8.96±0.64	28±3
1977	BH 770705	Bodega Head	6.7	2.96±0.23	0.13±0.05	6.75±0.40	25±2
1977	BH 770803	Bodega Head	7.5	2.34±0.21	0.03±0.02	2.32±0.30	21±4
1977	BH 770831	Bodega Head	6.8	2.60±0.24	< 0.02	8.80±0.47	25±4
1977	BH 770930	Bodega Head	7.3	1.63±0.22	< 0.03	5.33±0.88	36±3
1977	BH 771108	Bodega Head	7.9	0.98±0.14	0.03±0.02	11.67±0.79	32±2
1977	BH 771208	Bodega Head	6.5	2.25±0.21	0.03±0.03	5.37±0.45	26±2
1978	BH 780124	Bodega Head	9.4	2.92±0.28	0.07±0.04	10.14±0.69	38±7
1978	BH 780222	Bodega Head	9.7	2.04±0.29	0.01±0.02	11.19±0.68	27±6
1978	BH 780317	Bodega Head	10.3	9.31±0.62	N.D.	10.04±0.71	16±5
1978	BH 780412	Bodega Head	9.4	3.02±0.28	0.06±0.04	8.02±0.57	21±2

2.64±0.29

Table 9
MONTHLY SAMPLES--MYTILUS CALIFORNIANUS

Year	Mussel Watch No. or Date	Location (CA)	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)				
				239,240 Pu	238 Pu	241 Am	137 Cs	241 Am 239,240 Pu
1978	BH 780524	Bodega Head	8.8	3.60+0.35	0.12+0.05	10.00+0.61	16+2	2.77+0.28
1978	BH 780621	Bodega Head	3.5	3.31+0.21	0.14+0.04	7.3 +1.5	19+4	1.96+0.45
1978	BH 780822	Bodega Head	14.1	4.15+0.32	0.09+0.04	13.28+0.64	11+4	3.20+0.29
1978	BH 780929	Bodega Head	8.2	3.14+0.24	0.10+0.04	11.15+0.41	16+3	3.55+0.30
1978	BH 781027	Bodega Head	8.2	3.12+0.25	0.07+0.03	10.66+0.82	31+5	2.57+0.30
1978	BH 781128	Bodega Head	7.2	3.06+0.21	0.04+0.02	9.45+0.36	17+3	3.09+0.24
1978	BH 781213	Bodega Head	7.3	2.56+0.22	0.07+0.03	6.50+0.58	28+4	3.42+0.36
1979	BH 790223	Bodega Head	8.7	2.84+0.17	0.11+0.04	10.75+0.52	27+4	3.78+0.29
1979	BH 790323	Bodega Head	7.5	1.94+0.57	0.01+0.01	4.86+0.22	39+3	2.50+0.23
1979	BH 790418	Bodega Head	6.7	3.47+0.18	0.05+0.02	10.48+0.60	15+3	3.02+0.23
1979	BH 790517	Bodega Head	8.8	7.46+0.57	0.14+0.07	10.36+0.70	55+3	1.39+0.14
1979	BH 790615	Bodega Head	8.6	3.21+0.27	0.14+0.05	7.64+0.35	47+3	2.37+0.23
1979	BH 790710	Bodega Head	8.1	2.79+0.23	0.19+0.06	8.08+0.71	29+2	2.90+0.71
1979	BH 791204	Bodega Head	5.9	1.81+0.14	0.05+0.01	5.64+0.18	17+2	3.12+0.25
1980	BH 800128	Bodega Head	6.4	1.91+0.21	0.11+0.05	8.42+0.55	56+2	0.82+0.31
1980	BH 800310	Bodega Head	6.8	1.30+0.13	0.01+0.01	4.20+0.46	60+3	3.23+0.48
1980	BH 800403	Bodega Head	6.2	3.01+0.32	0.06+0.04	7.28+0.44	40+2	1.08+0.16
1980	BH 800505	Bodega Head	6.5	1.41+0.13	0.05+0.03	3.70+0.27	29+1	2.63+0.31
1980	BH 800603	Bodega Head	6.7	3.47+0.31	0.10+0.05	8.51+0.49	41+3	0.54+0.07
1980	BH 300715	Bodega Head	7.1	4.48+0.32	0.02+0.01	6.27+0.40	29+3	1.40+0.13

Table 9
MONTHLY SAMPLES--MYTILUS CALIFORNIANUS

Year	Mussel Watch No. or Date	Location (CA)	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)				
				239,240 Pu	238 Pu	241 Am	137 Cs	241 Am 239,240 Pu
1980	BH 801120	Bodega Head	6.3	1.58+0.16	0.05+0.03	2.39+0.28	26+1	1.50+0.17
1981	BH 810219	Bodega Head	8.3	2.90+0.40	0.10+0.07		18+2	
1981	BH 810331	Bodega Head	9.5	3.88+0.48	0.35+0.05		17+2	
1981	BH 810430	Bodega Head	6.9	5.35+0.33	0.09+0.04		35+2	
1981	BH 810602	Bodega Head	7.9	2.13+0.20	0.10+0.04	5.56+0.30	27+2	2.62+0.67

N.D. = Not detected

Table 10
MYTILUS EDULIS FROM NARRAGANSETT, RI

<u>Year</u>	<u>Number of Samples</u>	<u>Mean</u>	<u>Median</u>	<u>Range</u>
$^{239,240}\text{Pu}$ in dpm/kg dry				
1977	7	0.88	1.08	0.25-1.36
1978	10	1.47	0.79	0.41-5.25
1979	12	2.31	1.83	0.73-8.31
1980	11	1.91	1.97	0.76-4.14
^{241}Am in dpm/kg dry				
1977	5	0.34	0.25	0.16+0.65
1978	10	0.28	0.26	0.16-0.46
1979	12	0.60	0.57	0.17-1.18
1980	10	0.50	0.43	0.07-1.10
^{137}Cs in dpm/kg dry				
1977	6	25	27	12-33
1978	10	26	22	13-63
1979	12	25	21	8-100
1980	11	30	25	13-54

Table 11
MYTILUS CALIFORNIANUS FROM BODEGA HEAD, CA

<u>Year</u>	<u>Number of Samples</u>	<u>Mean</u>	<u>Median</u>	<u>Range</u>
$^{239,240}\text{Pu}$ in dpm/kg dry				
1977	12	2.44	2.37	0.98- 3.59
1978	11	3.66	3.12	2.04- 9.31
1979	7	3.36	2.84	1.81- 7.46
1980	7	2.45	1.91	1.58- 4.48
^{241}Am in dpm/kg dry				
1977	12	7.09	7.27	2.32-11.67
1978	11	9.79	10.04	6.50-13.28
1979	7	8.26	8.08	4.86-10.05
1980	7	5.82	6.27	2.39- 7.28
^{137}Cs in dpm/kg dry				
1977	12	28	26	21-39
1978	11	9.79	10.04	11-38
1979	7	33	29	15-55
1980	7	40	40	26-60

Table 12
MYTILUS EDULIS FROM GAY HEAD, MA

<u>Year</u>	<u>Number of Samples</u>	<u>Mean</u>	<u>Median</u>	<u>Range</u>
<u>$^{239,240}\text{Pu}$ in dpm/kg dry</u>				
1978	9	2.10	1.66	1.19-4.24
1979	8	1.63	1.54	1.20-2.03
1981	4	3.05	3.18	2.79-3.57
<u>^{241}Am in dpm/kg dry</u>				
1978	9	0.50	0.41	0.35-0.80
1979	6	0.68	0.66	0.44-0.94
1981	2	5.82	0.76	0.71-0.80
<u>^{137}Cs in dpm/kg dry</u>				
1978	8	33	24	18-65
1979	8	18	17	10-30
1981	4	47	44	29-66

STATION LOCATIONS

Location	Station Initials ^a & Date ^b	Fix	Species	Description of Site
Bodega Head	BH 760324	38°18.4'N 123°03.8'W	<u>M. californianus</u>	Horizontal tidal ledge, upper range
Pt. La Jolla	LJ 760420	32°51'N 117°16.6'W	<u>M. californianus</u>	Horizontal tidal ledge, upper middle range
San Diego Harbor	SDH 760425	32°40.9'N	<u>M. edulis</u> (1,2,3,5)	1 & 2 from concrete bridge standards
		117°14.2'W	<u>M. californianus</u> (4) ^e	3, N. tip of Harbor Island
				4, Point Loma, just inside harbor on granite breakwater
				5, North Island on abandoned berths
Point Fermin	PF 760506	33°42.9'N 118°19'W	<u>M. californianus</u>	Horizontal tidal ledge, upper reaches of mussel range
Ricon Cliffs	RC 670507	34°21.3'N 119°26.5'W	<u>M. californianus</u> 15°C	Breakwater rocks, base of pier
Point Arguello	PTA 760508	34°34.7'N 120°38.8'W	<u>M. californianus</u>	Tip of Arguello, N. side
San Pedro Harbor	SPH 760516	33°42.8'N	<u>M. edulis</u>	1, rock and concrete landfill
		118°16.4'W		2, large granite rocks, base of pier, at entrance to Middle Harbor
				3, concrete pier pilings
				4, concrete pilings, Terminal Island side of Main Channel
				5, Terminal Island side of Main Channel, below bridge and near berth
Oceanside jetty	OS 760523	33°11.6'N 117°23.4'W	<u>M. californianus</u>	Granite beach jetty

Location	Station Initials ^a & Date ^b	Fix	Species	Description of Site
Santa Catalina Is.	SCI 760604	33°27.1'N 118°29.2'W	<u>M. californianus</u>	
San Simeon	SS 760614	35°37.2'N 121°09.2'W	<u>M. californianus</u>	Horizontal tidal ledge
Diablo Canyon	D 760616	35°12.1'N 120°50.6'W	<u>M. californianus</u>	Horizontal rock surface, upper range of mussels
Santa Cruz	SCZ 760622	37°57.1'N 122°04.9'W	<u>M. californianus</u>	Horizontal tidal ledge, eroding sedimentary rock
Soberanes Pt.	SOB 760623	36°27'N 122°55.7'W	<u>M. californianus</u>	Granite semi-horizontal ledge, upper-mid range
N. San Francisco (11 stations)	NSF 760701	38°3.8'N 122°13.5'W	<u>M. edulis</u>	Concrete pilings
	(1)	38°3.4'N 122°15.8'W	<u>M. edulis</u>	Concrete pilings
	(2)	38°3.3'N 122°18.3'W	<u>M. edulis</u>	Metal buoy
	(3)	38°2.4'N 122°20.9'W	<u>M. edulis</u>	Metal buoy
	(4)	38°0.7'N 122°24.1'W	<u>M. edulis</u>	Metal buoy
	(5)	37°57.8'N 122°25.9'W	<u>M. edulis</u>	Creosote wood pier pilings
	(6)	37°56.1'N 122°26.5'W	<u>M. edulis</u>	Creosote wood pier pilings
	(7)	37°51.8'N 122°23.7'W	<u>M. edulis</u>	Metal buoy
	(8)	37°49.9'N 122°28.7'W	<u>M. edulis</u>	Creosote pylon
	(9)	37°50.9'N 122°21.5'W	<u>M. edulis</u>	End of pier, 1 m above water level
	(10)	37°49.1'N 122°20.7'W	<u>M. edulis</u>	Concrete pilings, 1 m above water level
	(11)			

Location	Station Initials ^a & Date ^b	Fix	Species	Description of Site
San Francisco (9 stations - continuation of NSF 760701)	SSF 760701 (12)	37°45.7'N 122°22.7'W	<u>M. edulis</u>	Creosote pier piling
	(13)	37°43.6'N 122°20.4'W	<u>M. edulis</u>	Wood substrate (apparently not creosote)
	(14)		<u>M. edulis</u>	Concrete piling
	(15)		<u>M. edulis</u>	Chammel marker
	(16)		<u>M. edulis</u>	Chammel marker
	(17)		<u>M. edulis</u>	Creosote wood pylon, main channel
	(18)		<u>M. edulis</u>	Chammel marker
Farallon Islands	FAR 760705		<u>M. edulis</u>	Chammel marker
			<u>M. edulis</u>	Concrete piling
			<u>M. edulis</u>	Horizontal tidal ledge,
			<u>M. californianus</u>	natural rock, upper range
Point Arena	PA 760710	37°41.8'N 122°59.9'W	<u>M. californianus</u>	Erosional sedimentary rock, upper range
Cape Mendocino	CM 760712	38°57.4'N 123°44.4'W	<u>M. californianus</u>	Small rocky point, on soft conglomerate rock
Humboldt	H 760714	40°24.3'N 124°23.4'W	<u>M. californianus</u>	On jetty rock
		40°45.8'N 124°14.4'W	<u>M. californianus</u>	
Point St. George	PSG 760716	41°46.7'N 124°15.2'W	<u>M. californianus</u>	Natural rock (shale type), horizontal ledge, upper range
Gold Beach, Ore.	GB 760720	42°27.0'N 124°25.6'W	<u>M. californianus</u>	Semi-horizontal natural rock
Coos Bay, Ore.	CB 760723	43°19.9'N 124°22.9'W	<u>M. californianus</u>	Horizontal tidal shelf, natural rock
Yaquina Head	Y 760726	44°40.7'N 124°04.7'W	<u>M. californianus</u>	On natural rock, upper ranges from small rocky point
Tillamook Bay (5 stations)	T 760729 (1) (2)	45°31.5'N 123°53.8'W 45°32.1'N 123°53.9'W	<u>M. edulis</u> <u>M. edulis</u>	Man-made rock fill-point, near oyster processing plant Flood channel, concrete sub- strate

Location	Station Initials ^a & Date ^b	Fix	Species	Description of Site
Tillamook Bay (5 stations)	(3)	45°32.9'N 123°54.4'W	<u>M. edulis</u>	On concrete remnants
	(4)	45°33.5'N 123°55.1'W	<u>M. edulis</u>	Natural rock substrate
	(5)	45°33.9'N 123°56.2'W	<u>M. edulis</u>	Entrance channel to bay
Columbia River	CR 760802	46°14.0'N 124°03'W	<u>M. californianus</u>	Jetty rock
Willapa Bay (2 stations)	WB 760804 (1)	46°40.4'N 123°55.6'W	<u>M. edulis</u>	Natural rock substrate, mussels are underneath rock at mud line
Grays Harbor	GH 760806 (2)	46°43.7'N 124°04.0'W	<u>M. edulis</u>	Area largely mud-flats for both stations
Cape Flattery	CF 760810	46°55.7'N 124°10.5'W	<u>M. californianus</u>	Area largely mud-flats, mussels from jetty
Puget Sound	PS 760812	48°23.1'N 123°43.6'W	<u>M. californianus</u>	Horizontal tidal ledge, natural rock substrate
Boundary Bay	BB 760818	47°54.2'N 122°22.9'W	<u>M. edulis</u>	Natural rock, south end of Whidbey Island
Blue Hills Falls, Maine	BHF 760915	48°56.5'N 122°49.2'W	<u>M. edulis</u>	Natural rock
Sears Island, Maine	SI 760916	44°22.5'N 68°33.5'W	<u>M. edulis</u>	Horizontal tide-pool, upper range
Cape Newagen, Maine	CN 760917	44°25.8'N 68°53.1'W	<u>M. edulis</u>	Horizontal tide-flat, small rocky area
Bailey Island, Maine	BI 760918	43°47.2'N 69°39.2'W	<u>M. edulis</u>	Natural rock
Portland, Maine	P 760920	43°44.9'N 69°59.4'W	<u>M. edulis</u>	Rock ledges
Cape Ann, Mass.	CA 760921	43°41.2'N 70°13.9'W	<u>M. edulis</u>	Stone-boulder beach substrate
		42°39.6'W 70°37.3'W	<u>M. edulis</u>	Tide-pool rocks, adjacent to sandy beach

Location	Station Initials ^a & Date ^b	Fix	Species	Description of Site
Boston	B 760922	42°21.3'N 70°58.1'W	<u>M. edulis</u>	Small stone beach, northwest corner Deer Island
Plymouth, Mass.	PLY 760923	41°56.5'N 70°36.7'W	<u>M. edulis</u>	Rocky-stone beach
Cape Cod Canal, Mass.	CCC 760925	41°44.45'N 70°36.8'W	<u>M. edulis</u>	Granite rock along canal
Sakonnet Point, Rhode Island	SK 760927	41°27.2'N 71°11.7'W	<u>M. edulis</u>	Natural rock shelves, between sandy beaches
Block Island, Rhode Island	BLK 761001	41°11.6'N 71°35.7'W	<u>M. edulis</u>	Small stone beach
Millstone, Conn.	MIL 761004	41°18.3'N 72°09.8'W	<u>M. edulis</u>	Natural rock tidal ledges, S. of nuclear power-plant outfall (temp. 28°C near outfall)
New Haven, Conn.	NH 761006	41°11.5'N 73°03.2'W	<u>M. edulis</u>	Rock substrate, Charles Island
Manhasset Neck, New York	MN 761009	40°51.9'N 73°43.9'W	<u>M. edulis</u>	Shell-bed substrate on coarse sand to small rock beach
Herod Point, Long Island, New York	HP 761010	40°58.1'N 72°50.7'W	<u>M. edulis</u>	Stone-sand substrate beach
Fire Island, Long Island, New York	FI 761011	40°46'N 72°45.1'W	<u>M. edulis</u>	Jetty rock
Great Gull Island	GGI 761011	41°12.2'N 72°07.1'W	<u>M. edulis</u>	
Rockaway Point, New York	RK 761012	40°32.5'N 73°56.5'W	<u>M. edulis</u>	Jetty rock substrate
Atlantic City, New Jersey	AC 761014	39°22.3'N 74°24.3'W	<u>M. edulis</u>	Jetty rock substrate
Cape May, New Jersey	MAY 761015	38°55.6'N 74°57.8'W	<u>M. edulis</u>	Jetty rock substrate

Location	Station Initials ^a & Date ^b	Fix	Species	Description of Site
Cape Henlopen, Delaware	CH 761104a	38°46.8'N 75°07.7'W	<u>M. edulis</u>	Jetty rock substrate
	CH 761104b	38°46.8'N 75°07.7'W	<u>C. virginica</u>	
Assateague, Maryland	A 761106	38°19.4'N 75°05.6'W	<u>M. edulis</u>	Jetty rock
Cape Charles, Virginia	CC 761109	37°17.3'N 76°01'W	<u>C. virginica</u>	Tidal marshland, substrate is old oyster shells and mud
Lynnhaven Bay, Virginia	LH 761115	36°54.2'N 76°05.3'W	<u>C. virginica</u>	Marsh-grass habitat
Wachapreague Inlet, Virginia	W 76116a W 76116b	37°35.2'N 75°36.8'W 37°35.2'N 75°37.8'W	<u>M. edulis</u> <u>C. virginica</u>	Wood pier pilings
Hatteras Island, North Carolina	H 761119	35°12.3'N 75°43'W	<u>C. virginica</u>	Tidal marshland, mud sub- strate
Beauford, North Carolina	BU 761121	34°43'N 76°40.7'W	<u>C. virginica</u>	Tidal basin
Cape Fear, North Carolina	FR 761122	33°57'N 77°55.5'W	<u>C. virginica</u>	Tidal marshland
Sapelo Island, Georgia	SAP 761129	31°23.6'N 81°16.6'W	<u>C. virginica</u>	Tidal creek
Savannah River, Georgia	SAV 761130	32°01'N 80°52.4'W	<u>C. virginica</u>	Banks of South Channel
Charleston, South Carolina	CHR 761201	32°44.2'N 79°52.5'W	<u>C. virginica</u>	Fort Johnson
St. Augustine, Florida	STA 761204	29°41.5'N 81°13.8'W	<u>C. virginica</u>	Tidal marsh
Smithsonian Harbor Branch Laboratory	SMTH 761218		<u>O. equestris</u>	Raised in laboratory tanks
Naples, Florida	NAP 761223	26°01.3'N 81°44.1'W	<u>O. equestris</u>	Mangrove roots

Location	Station Initials ^a & Date ^b	Fix	Species	Description of Site
Anclote, Florida	AN 761230	28°11.4'N 82°47.5'W	<u>O. equestris</u>	Oyster beds north of electric power-plant
Cedar Key, Florida	KEY 761231	29°03.5'N 82°59'W	<u>C. virginica</u>	Commercial oyster-bede
Apalachicola, Florida	AP 770104	29°42.9'N 84°53.4'W	<u>C. virginica</u>	Commercial oyster-bede
Panama City, Florida	PAN 770105	30°15'N 85°45'W	<u>C. virginica</u>	West Bay of St. Andres Baye
Pensacola, Florida	PEN 770108	30°20.3'N 87°09.5'W	<u>C. virginica</u>	Sabine Point, Santa Rosa Island
Dauphin Island, Alabama	DAU 770113	30°18'N 88°08.5'W	<u>C. virginica</u>	Commercial subtidal reefe
Pass Christian, Mississippi	PAS 770115	30°18'N 89°15.8'W	<u>C. virginica</u>	Subtidal reefe
Biloxi, Mississippi	BIL 770117	30°23.4'N 88°51.5'W	<u>C. virginica</u>	Shallow waters, next to dock
Lake Borgne, Louisiana	BOR 770120	29°57.5'N 89°39.1'W	<u>C. virginica</u>	Southwest area of lakee
Lake Campo, Louisiana	CAM 770123	29°39.8'N 89°38.7'W	<u>C. virginica</u>	e
Black Bay, Louisiana	BLA 770124	29°37'N 89°37'W	<u>C. virginica</u>	West area of baye
Bastian Bay	BAS 770125	29°19.2'N 89°38.9'W	<u>C. virginica</u>	Northern area of baye
Bayou de West, Louisiana	DEW 770126	29°12'N 91°03.4'W	<u>C. virginica</u>	Between Bay Junop and Gulf of Mexico ^e
Lake Barre, Louisiana	BAR 770126	29°15.7'N 90°34.1'W	<u>C. virginica</u>	West side of lake
Bay de Illettes, Louisiana	ILE 770127	29°17.1'N 90°00.1'W	<u>C. virginica</u>	In Bay de Illettes, just west of Point Peiro; oil-drilling in area ^e
Barataria Bay, Louisiana	BRT 770128	29°21'N 89°55.9'W	<u>C. virginica</u>	Central area of bay, near Middle Bank Lighte

Location	Station Initials ^a & Date ^b	Fix	Species	Description of Site
Calcasieu Lake, Louisiana	CAL 770201	29°50.4'N 93°20.2'W	<u>C. virginica</u>	South end of lake, just east of ship chamele
Galveston Bay	GAL 770219	29°29.2'N 94°46.3'W	<u>C. virginica</u>	
East Matagordo Bay	EMB 770315	28°40.0'N 95°55.1'W	<u>C. virginica</u>	
Fulton	FUL 77036	28°08.5'N 97°02.9'W	<u>C. virginica</u>	
San Antonio Bay	ANT 770316	28°18.6'N 96°40.2'W	<u>C. virginica</u>	
Panther Point	PAN 770316	28°12.5'N 96°42.0'W	<u>C. virginica</u>	
Matagordo Bay	MAT 770316	28°38.0'N 96°02.0'W	<u>C. virginica</u>	
Espiritu Santo Bay	ESB 770310	28°18.6'N 96°36.0'W	<u>C. virginica</u>	
Lake Sabine Bay	SAB 770318	29°43.2'N 93°51.5'W	<u>C. virginica</u>	

1977 Collections
Special Notations
Location

NSF only substations 1, 2, 7, 9, 10, 11 collected
 SSF only substations 12, 13, 14, 15, 16, 17 collected
 WB only substation 2 collected

Stations Discontinued or not Collected - 1977

SMTH, BOR, CAM, BAS, DEW, BAR, ILE, BRT, FUL, PPT, ESB, GGI

Location	Station Initials ^a & Date ^b	Fix	Species	Description of Site
<u>New Stations</u>				
Fort Pierce	FORP	27°29.1'N 80°18'W	<u>C. virginica</u>	
Pumpkin Bay	PUK	29°40.2'N 89°33.1'W	"	
Quarantine Bay	QRT	29°24.4'N	"	
Junop Bay	JUN	89°32.1'W 29°12.2'N	"	
Golden Meadows	GOD	91°03.1'W 29°15.1'N	"	
Drum Bay	DRM	90°19.1'W 29°52.8'N	"	
Brownsville	BRV	89°20.0'W 26°02.1'N	"	
Mesquite Bay	MEQ	97°11.0'W 28°08.2'N	"	
Lavaca Bay	LAV	96°50.1'W 28°36.1'N	"	
Lavaca Bay North	LAVN	96°33.4'W 28°40.1'N	"	
Aransas Bay	ARN	96°35.1'W 28°02.3'N	"	
		97°01.0'W		

1978 Collections (includes 1976 and 1977 stations except as noted)

Stations Not Collected

WB, TIL substations 3 and 4, HI, GGI, PUK, JUN, GOD, DRM, EMB, BRV, ANT, MEQ,
LAV, LAVN, BIL, PEN

Location	Station Initials ^a & Date ^b	Fix	Species	Description of Site
<u>New Stations</u>				
New Bedford	NB	41°37.6'N	<u>M. edulis</u>	Rocky intertidal near hurricane dike
Tampa Bay	TAB	70°55.0'W		
		27°45'N		
California Bay	CAI	82°31'W	<u>C. virginica</u>	e.
		29°30.2'N	"	e.
Chaland Bay	CHL	89°35.6'W	"	e.
		29°14.5'N	"	
		90°38.3'W		
Terrabone Bay	TER	29°06'N	"	e.
		90°35'W		
<u>Monthly Stations</u>				
Narragansett Bay	NRI	41°31.3'N	<u>M. edulis</u>	Coddington Point; Intertidal rocks
	7606-7608	71°19.6'W		West Shore, Beavertail
	7609-7611	41°28.5'N		Neck's intertidal rocks
		71°23.9'W		West of Prudence Island;
	7706-7812	41°38.5'N		Subtidal, dredged
		71°22'W		Rocky headland
Bodega Head	BH	38°18.4'N	<u>M. californianus</u>	
		123°03.8'W		

^aInitials of the station's name.

^bDate of collection, starting with year, then month, then day. A small letter or seventh digit in some samples refers to the station sequence.

^cExplanations are given in the right-hand column.

^dDates of collections given in data tables. Change in stations largely dictated by non-availability of species at earlier station locations. New stations added to replace old stations or to increase sampling density in given region.

^eSamples and locations provided by local commercial fishermen and/or local natural resource officials.

Table 14
THREE YEAR DATA—ANNUAL COLLECTIONS

Page 1 of 7

Year	Mussel Watch No.	Location	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)				
				239, 240 Pu	238 Pu	241 Am	137 Cs	241 Am 239, 240 Pu
1976	BHF760915	Blue Hill Falls, ME ^a	7.0	1.05+0.14	< 0.01	0.22+0.08	15+2	0.21+0.08
1977	BHF770812	Blue Hill Falls, ME	11.9	1.52+0.19	0.05+0.04	0.36+0.12	18+5	0.23+0.10
1978	BHF780920*	Blue Hill Falls, ME	9.9	1.7 +0.15	N.D.	0.7 +0.08	N.M.	0.4 +0.1
1976	SI760916	Sears Island, ME ^a	10.1	3.44+0.30	0.06+0.05	0.70+0.09	29+2	0.62+0.13
1977	SI770813	Sears Island, ME	9.4	2.88+0.23	0.04+0.03	0.66+0.09	24+4	0.23+0.04
1978	SI780921	Sears Island, ME	9.4	2.08+0.28	0.05+0.04	0.60+0.18	35+3	0.29+0.10
1976	CN760917	Cape Newagen, ME ^a	12.6	3.15+0.38	0.14+0.08	1.19+0.21	28+4	0.37+0.08
1977	CN770814	Cape Newagen, ME	12.0	4.53+0.49	0.39+0.14	0.60+0.12	21+5	0.14+0.03
1978	CN780922*	Cape Newagen, ME	11.9	2.2 +0.2	N.D.	0.8 +0.1	N.M.	0.4 +0.1
1976	BI760918	Bailey Island, ME ^a	9.2	2.65+0.27	0.09+0.06	0.49+0.14	23+3	0.19+0.06
1977	BI770815	Bailey Island, ME	7.5	2.36+0.22	0.04+0.02	0.45+0.08	18+3	0.20+0.04
1978	BI780923	Bailey Island, ME	11.6	3.12+0.35	N.D.	0.45+0.19	33+3	0.14+0.06
1976	P760920	Portland, ME ^a	10.8	2.27+0.22	< 0.03	0.65+0.15	37+3	0.29+0.07
1977	P770816	Portland, ME	12.5	3.36+0.22	0.08+0.03	0.87+0.13	114+2	0.25+0.04
1978	P780924*	Portland, ME	13.7	3.0 +0.3	N.D.	1.6 +0.1	N.M.	0.5 +0.1
1976	CA760921	Cape Ann, MA ^a	10.9	1.96+0.22	< 0.02	0.27+0.18	46+3	0.14+0.09
1977	CA770817	Cape Ann, MA	13.0	1.91+0.18	< 0.03	0.26+0.13	20+6	0.16+0.06
1978	CA780924	Cape Ann, MA	14.7	2.79+0.29	0.10+0.06	0.37+0.25	35+5	0.13+0.09

Table 14

Page 2 of 7

THREE YEAR DATA—ANNUAL COLLECTIONS

Year	Mussel Watch No.	Location	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)					
				239, 240 Pu	238 Pu	241 Am	137 Cs	241 Am 239, 240 Pu	
1976	B760922	Boston, MA ^a	8.6	0.94±0.17	< 0.02	0.07±0.03	15±3	0.07	±0.04
1977	B770818	Boston, MA	9.6	1.53±0.13	0.04±0.02	0.19±0.10	20±2	0.14	±0.06
1978	B780925*	Boston, MA	11.9	1.3 ±0.1	N.D.	0.7 ±0.1	N.M.	0.5	±0.1
1976	P760923	Plymouth, MA ^a	10.0	6.69±0.90	0.23±0.15	0.03±0.07	20±2	0.004	±0.010
1977	P770818	Plymouth, MA	8.0	2.11±0.19	0.06±0.03	0.40±0.16	21±2	0.18	±0.06
1978	PLY780926	Plymouth, MA	26.7	3.73±0.53	0.16±0.05	0.83±0.29	98±12	0.22	±0.09
1978	NB781002	New Bedford, MA ^a	10.7	0.75±0.21	N.D.	0.33±0.11	43±3	0.40	±0.24
1976	CCC760925	Cape Cod Canal, MA ^a	6.9	0.89±0.14	0.08±0.04	0.14±0.06	13±2	0.16	±0.06
1977	CCC770819	Cape Cod Canal, MA	8.5	2.21±0.15	0.18±0.04	0.43±0.09	33±2	0.19	±0.05
1978	CCC780926*	Cape Cod Canal, MA	11.2	0.7 ±0.06	N.D.	1.5 ±0.2	N.M.	2.1	±0.3
1976	SK760927	Sakonnet Pt., RI ^a	12.9	1.93±0.26	< 0.06	0.17±0.08	36±3	0.09	±0.04
1977	SK770821	Sakonnet Pt., RI	9.1	2.00±0.15	0.10±0.04	0.27±0.09	18±3	0.14	±0.04
1978	SK781003*	Sakonnet Pt., RI	—	0.7 ±0.07	N.D.	0.3 ±0.07	N.M.	0.4	±0.1
1976	BLK761001	Block Island, RI ^a	11.0	2.10±0.22	0.09±0.06	0.41±0.17	56±3	0.19	±0.08
1977	BLK770825	Block Island, RI	11.6	2.08±0.23	0.09±0.05	0.46±0.23	26±3	0.22	±0.11
1978	BLK781012	Block Island, RI	12.1	1.57±0.24	< 0.04	0.19±0.16	40±4	0.12	±0.10
1976	MIL761004	Millstone Pt., CT ^a	12.1	2.18±0.24	< 0.05	0.24±0.12	50±2	0.11	±0.06
1977	MIL770824	Millstone Pt., CT	10.8	2.88±0.22	0.05±0.03	0.97±0.32	33±2	0.34	±0.12
1978	MIL781010*	Millstone Pt., CT	11.2	1.6 ±0.2	N.D.	1.7 ±0.2	N.M.	1.1	±0.8

Table 14

Page 3 of 7

THREE YEAR DATA—ANNUAL COLLECTIONS

Year	Mussel Watch No.	Location	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)				
				239,240 Pu	238 Pu	241 Am	137 Cs	241 Am 239,240 Pu
1976	NH61006	New Haven, CT ^a	14.1	3.39±0.28	0.16±0.06	0.59±0.18	Lost	0.18 ±0.06
1977	NH770827	New Haven, CT	11.0	4.33±0.46	0.31±0.12	0.77±0.22	22±7	0.18 ±0.06
1978	NH78013	New Haven, CT	5.1	1.64±0.15	0.08±0.03	0.22±0.04	17±1	0.13 ±0.03
1976	MN761009	Manhasset Neck, NY ^a	7.8	0.68±0.08	0.05±0.02	0.08±0.03	23±2	0.13 ±0.05
1977	MN770828	Manhasset Neck, NY	8.3	0.79±0.09	0.10±0.03	0.58±0.17	18±3	0.61 ±0.19
1978	MN781015*	Manhasset Neck, NY	6.4	0.4 ±0.05	N.D.	0.6 ±0.07	NM	1.5 ±0.3
1976	HP761010	Herod Pt., NY ^a	8.4	0.76±0.08	0.07±0.03	0.12±0.05	20±3	0.16 ±0.07
1977	HP770829	Herod Pt., NY	7.7	0.93±0.09	0.02±0.02	0.08	24±2	—
1976	FI761011	Fire Island, NY ^a	11.1	2.34±0.33	< 0.04	0.56±0.13	30±28	0.24 ±0.07
1977	FI770829	Fire Island, NY	8.2	1.01±0.11	0.04±0.02	Lost	28±3	—
1978	FI781014*	Fire Island, NY	9.9	1.6 ±0.1	N.D.	0.6 ±0.09	NM	0.4 ±0.1
1976	GGI761011	Great Gull Island, NY ^a	12.6	1.38±0.25	< 0.04	0.30±0.09	25±4	0.07 ±0.02
1976	RK761012	Rockaway Pt., NY ^a	9.2	2.8 ±1.3	< 0.05	0.29±0.10	25±4	0.10 ±0.06
1977	RK770830	Rockaway Pt., NY	7.3	1.54±0.16	0.04±0.02	0.25±0.11	21±2	0.16 ±0.07
1978	RK781015	Rockaway Pt., NY	8.3	2.40±0.25	0.06±0.03	0.43±0.25	18±4	0.18 ±0.11
1976	AC761014	Atlantic City, NJ ^a	11.4	3.20±0.31	0.17±0.09	1.17±0.18	42±8	0.22 ±0.04
1977	AC770901	Atlantic City, NJ	7.8	1.96±0.16	0.02±0.02	0.55±0.08	29±4	0.28 ±0.05
1978	AC781017	Atlantic City, NJ	11.0	0.97±0.10	0.03±0.02	0.56±0.19	34±4	0.57 ±0.21

Table 14
THREE YEAR DATA—ANNUAL COLLECTIONS

Year	Mussel Watch No.	Location	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)				
				239, 240 Pu	238 Pu	241 Am	137 Cs	$\frac{241 \text{ Am}}{239, 240 \text{ Pu}}$
1976	MAY761015	Cape May, NJ ^a	11.1	1.88±0.22	< 0.02	0.30±0.11	Lost	0.16 ±0.06
1977	MAY770902	Cape May, NJ	8.6	1.14±0.30	0.10±0.10	0.10±0.08	16±3	0.09 ±0.07
1978	MAY781018*	Cape May, NJ	13.5	1.0 ±0.1	N.D.	0.4 ±0.08	NM	0.4 ±0.1
1976	CH761104	Cape Henlopen, DE ^a	11.2	2.90±0.34	0.11±0.07	0.76±0.16	34±3	0.26±0.06
1977	CH770904	Cape Henlopen, DE	8.5	1.10±0.19	0.19±0.08	0.14±0.09	19±2	0.19±0.14
1978	CH781019	Cape Henlopen, DE	11.0	1.54±0.22	< 0.02	0.57±0.22	24±5	0.37±0.15
1976	A761106	Assateague, MD ^a	10.5	2.73±0.32	0.08±0.06	0.82±0.16	28±3	0.26±0.03
1977	A770907	Assateague, MD	8.0	1.27±0.16	0.02±0.02	0.40±0.09	28±3	0.31±0.08
1978	A781020*	Assateague, MD	11.9	1.1 ±0.1	N.D.	0.4 ±0.06	NM	0.4 ±0.1
1976	CC761109	Cape Charles, VA ^b	11.4	1.25±0.23	0.13±0.07	0.41±0.14	51±5	0.33±0.12
1977	CC770911	Cape Charles, VA	11.8	1.39±0.18	0.05±0.04	0.12±0.12	36±5	0.08±0.08
1978	CC781021*	Cape Charles, VA	9.0	1.5 ±0.1	N.D.	1.5 ±0.2	NM	1 ±0.2
1976	LH761115	Lynnhaven, VA ^b	11.2	0.89±0.11	< 0.02	0.39±0.20	34±3	0.45±0.24
1977	LH770910	Lynnhaven, VA	11.3	1.65±0.20	0.02±0.02	0.30±0.23	37±3	0.18±0.14
1978	LH781022	Lynnhaven, VA	9.8	0.59±0.10	< 0.03	0.27±0.10	19±4	0.42±0.19
1976	W761116A	Wachapreague, VA ^a	6.8	1.56±0.27	< 0.04	0.22±0.14	27±7	0.14±0.10
1977	W770909B	Wachapreague, VA	7.7	0.99±0.13	0.07±0.03	0.44±0.11	16±4	0.45±0.12
1976	W761116B	Wachapreague, VA ^b	10.1	2.9 ±1.0	0.2 ±0.4	0.06±0.08	20±3	0.02±0.03
1977	W770909A	Wachapreague, VA	9.9	2.98±0.22	0.14±0.05	Lost	35±2	—
1978	W781023	Wachapreague, VA	8.3	0.67±0.08	< 0.02	0.06±0.07	21±2	0.08±0.10

Table 14
THREE YEAR DATA—ANNUAL COLLECTIONS

Year	Mussel Watch No.	Location	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)				
				238Pu	241Am	137Cs	241Am	
							239, 240Pu	239, 240Pu
1976	H761119	Hatteras Island, NC ^b	11.7	0.06±0.05	0.61±0.15	36±4	0.27±0.07	
1977	CH770915	Hatteras Island, NC	19.1	0.08±0.06	0.19±0.21	29±5	0.08±0.08	
1978	HAT781027 [*]	Hatteras Island, NC	9.6	N.D.	N.M.	N.M.	—	
1976	BU761121	Beaufort, NC ^b	9.7	0.07±0.04	0.65±0.19	20±3	0.32±0.10	
1977	BU770914	Beaufort, NC	12.6	0.05±0.04	1.01±0.25	12±3	0.43±0.46	
1978	BU781029	Beaufort, NC	10.1	0.16±0.05	0.17±0.08	10±1	0.09±0.04	
1976	FR761122	Cape Fear, NC ^b	10.9	0.11±0.10	0.52±0.12	32±3	0.18±0.05	
1977	FR770917	Cape Fear, NC	12.2	0.13±0.05	1.95±0.37	54±6	0.39±0.08	
1978	FR781029 [*]	Cape Fear, NC	12.8	N.D.	1.7 ±0.2	N.M.	1±0.1	
1976	SAP761129	Sapelo Island, GA ^b	17.6	0.34±0.11	0.37±0.19	34±7	0.09±0.05	
1977	SAP770921	Sapelo Island, GA	13.5	< 0.10	0.27±0.12	28±5	0.16±0.09	
1978	SAP781101	Sapelo Island, GA	12.1	0.42±0.23	0.80±0.33	Lost	0.32±0.15	
1976	SAV761130	Savannah River, GA ^b	13.4	< 0.44	0.17±0.08	28±5	0.10±0.07	
1977	SAV770920	Savannah River, GA	13.3	0.05±0.04	0.16±0.05	146±3	0.18±0.07	
1978	SAV781030 [*]	Savannah River, GA	14.5	N.D.	0.7 ±0.1	N.M.	0.9 ±0.2	
1976	CHR761201	Charleston, SC ^b	12.1	< 0.07	—	29±4	0.16±0.10	
1977	CHR770918	Charleston, SC	11.5	0.07±0.03	0.35±0.12	39±3	0.23±0.08	
1978	CHR781030	Charleston, SC	11.7	N.D.	1.01±0.41	Lost	—	

Table 14
THREE YEAR DATA—ANNUAL COLLECTIONS

Year	Mussel Watch No.	Location	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)				
				239, 240 Pu	238 Pu	241 Am	137 Cs	241 Am 239, 240 Pu
1976	STA761204	St. Augustine, FL ^b	11.1	2.02±0.30	0.10±0.06	0.31±0.10	20±3	0.16±0.06
1977	STA770923	St. Augustine, FL	5.9	1.66±0.21	0.16±0.06	0.42±0.12	21±3	0.25±0.08
1978	STA781102*	St. Augustine, FL	11.3	1.9 ±0.2	N.D.	1.5 ±0.2	N.M.	0.79±0.13
1977	FORP770924	Fort Pierce, FL ^b	10.7	1.29±0.22	0.05±0.05	0.18±0.10	27±3	0.17±0.09
1978	FORP781104	Fort Pierce, FL	9.3	0.58±0.14	< 0.03	0.33±0.08	13±3	0.56±0.20
1976	NAP761223	Naples, FL ^c	11.9	1.19±0.24	< 0.04	Lost	21±4	0.51±0.17
1977	NAP771001	Naples, FL	13.1	3.29±0.42	0.34±0.14	1.46±0.27	52±8	0.44±0.10
1978	NAP781107*	Naples, FL	12.6	1.2 ±0.1	N.D.	0.7 ±0.1	N.M.	0.58±0.10
1976	AN761230	Anclothe, FL ^c	13.7	0.82±0.14	< 0.04	Lost	30±4	—
1977	AN771003	Anclothe, FL	9.9	1.20±0.17	0.05±0.03	0.24±0.11	24±4	0.20±0.09
1978	AN781109*	Anclothe, FL	15.3	0.7 ±0.1	N.D.	0.7 ±0.1	N.M.	1±0.2
1976	KEY761231	Cedar Key, FL ^b	9.5	2.85±0.19	0.31±0.08	0.10±0.02	35±3	0.35±0.06
1977	KEY771004	Cedar Key, FL	10.2	5.23±0.36	0.41±0.10	0.20±0.20	48±4	0.04±0.04
1978	KEY781110	Cedar Key, FL	8.0	1.92±0.16	0.15±0.05	0.42±0.10	30±2	0.22±0.05
1976	AP770104	Apalachicola, FL ^b	12.5	2.62±0.25	< 0.03	0.44±0.11	38±4	0.17±0.05
1977	AP771005	Apalachicola, FL	17.4	2.39±0.28	N.D.	0.45±0.24	32±4	0.20±0.11
1978	AP781109*	Apalachicola, FL	13.1	2.3 ±0.2	N.D.	0.4 ±0.08	N.M.	0.17±0.04

Table 14
THREE YEAR DATA—ANNUAL COLLECTIONS

Year	Mussel Watch No.	Location	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)					
				239, 240 Pu	238 Pu	241 Am	137 Cs	241 Am 239, 240 Pu	
1976	PAN770105	Panama City, FL ^b	6.4	1.73+0.19	0.10+0.05	0.03+0.02	21+2	0.12+0.07	
1977	PAN771005	Panama City, FL	17.8	4.38+0.46	0.36+0.13	0.89+0.36	35+8	0.20+0.08	
1978	PAN781111	Panama City, FL	12.5	7.10+1.18	1.10+0.36	1.00+0.31	Lost	0.14+0.05	
1976	PEN770108	Pensacola, FL ^b	6.6	1.52+0.13	< 0.01	0.20+0.05	38+2	0.14+0.04	
1977	PEN771007	Pensacola, FL	14.9	2.99+0.30	0.12+0.09	0.75+0.30	17+4	0.35+0.15	
1976	DAU770113	Dauphin Island, AL ^b	8.2	0.74+0.08	< 0.02	—	15+3	—	
1977	DAU771008	Dauphin Island, AL	11.4	2.15+0.22	0.07+0.03	0.45+0.23	47+3	0.20+0.20	
1978	DAU781113*	Dauphin Island, AL	9.3	0.7 +0.06	N.D.	0.2 +0.04	N.M.	0.3 +0.1	
1976	PAS770115	Pass Christian, MS ^b	7.0	0.70+0.14	0.07+0.04	0.25+0.08	17+2	0.36+0.12	
1977	PAS771008	Pass Christian, MS	12.01	1.48+0.18	0.04+0.02	1.32+0.36	36+6	0.92+0.29	
1978	PAS781113	Pass Christian, MS	11.0	1.10+0.22	0.04+0.03	0.32+0.09	50+4	0.28+0.09	
1976	BIL770117	Biloxi, MS ^b	12.4	1.12+0.25	< 0.04	Lost	25+4	0.23+0.10	
1977	BIL771007	Biloxi, MS	12.0	0.81+0.37	< 0.18	0.60+0.24	39+4	0.75+0.46	

a = *Mytilus edulis*b = *Crassostrea virginica*c = *Ostrea equistris*

N.D. = Not detected

N.M. = Not measured

* = S.I.O. data

Table 15
MYTILUS EDULIS FROM SEARS ISLAND, ME TO WACHAPREAGUE INLET, VA

<u>Year</u>	<u>Number of Samples</u>	<u>Mean</u>	<u>Median</u>	<u>Range</u>
239,240Pu in dpm/kg dry				
Sept.-Nov. 1976	23	2.30	2.18	0.68- 6.69
Aug.-Sept. 1977	22	2.10	1.93	0.79- 4.53
Sept.-Oct. 1978	22	1.7	1.6	0.4- 3.7
241Am in dpm/kg dry				
Sept.-Nov. 1976	23	0.43	0.30	0.03- 1.19
Aug.-Sept. 1977	22	0.46	0.44	0.10- 0.97
Sept.-Oct. 1978	22	0.65	0.56	0.19- 1.7
137Cs in dpm/kg dry				
Sept.-Nov. 1976	21	30	28	13- 56
Aug.-Sept. 1977	22	27	21	16-114
Sept.-Oct. 1978	10	38	35	17-98

Table 16
OYSTERS FROM WACHAPREAGUE INLET, VA TO ESPIRITU SANTO BAY, TX

<u>Year</u>	<u>Number of Samples</u>	<u>Mean</u>	<u>Median</u>	<u>Range</u>
239,240Pu in dpm/kg dry				
Sept.-Nov. 1976	19	1.82	1.74	0.70- 4.23
Aug.-Sept. 1977	20	2.33	1.91	0.81- 5.23
Sept.-Oct. 1978	31	1.24	0.70	0.25- 7.10
241Am in dpm/kg dry				
Sept.-Nov. 1976	14	0.32	0.34	0.03- 0.65
Aug.-Sept. 1977	20	0.60	0.42	0.12- 1.95
Sept.-Oct. 1978	29	0.52	0.33	0.06- 1.5
137Cs in dpm/kg dry				
Sept.-Nov. 1976	19	29	30	15- 51
Aug.-Sept. 1977	20	40	36	12-149
Sept.-Oct. 1978	14	28	26	10-50

Table 17
MYTILUS CALIFORNIANUS FROM BOUNDARY BAY, WA TO SAN DIEGO HARBOR, CA

<u>Year</u>	<u>Number of Samples</u>	<u>Mean</u>	<u>Median</u>	<u>Range</u>
$^{239,240}\text{Pu}$ in dpm/kg wet				
Apr.-Aug. 1978	27	2.2	1.9	0.3 - 4.7
^{241}Am in dpm/kg wet				
Apr.-Aug. 1978	27	4.9	2.9	0.14-18.5
^{137}Cs in dpm/kg wet				
Apr.-Aug. 1978	14	31	29	13-66

1978 DATA—ANNUAL SITES

Year	Mussel Watch No.	Location	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)				
				238Pu	241Am	137Cs	241Am 239,240Pu	
				239,240Pu	241Am	137Cs	241Am 239,240Pu	
1978	TAB781109	Tampa Bay, FL ^a	8.1	0.47+0.08	< 0.02	0.11+0.05	32+4	0.14+0.06
1978	BLA781114	Black Bay, LA ^a	6.5	0.28+0.07	0.08+0.04	0.12+0.05	23+2	0.42+0.20
1978	BUR781115	Lake Borgne, LA ^a	9.6	0.67+0.11	0.03+0.03	0.23+0.11	40+2	0.34+0.17
1978	CHL781116	Bay Chaland, LA ^a	10.3	0.47+0.09	< 0.02	0.14+0.08	28+3	0.30+0.18
1978	CAL781118	Calcasieu Lake, LA ^a	11.4	0.25+0.08	< 0.02	0.07	23+3	—
1978	CAL781115*	Calcasieu Lake, LA	12.3	0.7 +0.07	N.D.	0.2 +0.04	N.M.	0.3 +0.1
1978	GAL780815	Galveston, TX ^a	13.0	0.48+0.13	< 0.04	0.07+0.09	27+4	0.14+0.19
1978	GAL780922*	Galveston, TX	21.1	0.4 +0.04	N.D.	0.4 +0.08	N.M.	1 + .22
1978	ARS781121	Aransas Bay, TX ^a	12.3	1.31+0.14	0.06+0.03	0.33+0.14	44+2	0.25+0.01
1978	ESP781122*	Espiritu Santo Bay, TX ^a	11.1	0.57+0.15	< 0.03	0.32+0.10	25+3	0.56+0.23
1978	QRT781114*	Quarantine Bay, LA ^a	11.1	0.5 +0.05		0.3 +0.05	N.M.	0.6 +0.1
1978	TER781116*	Terrabonne Bay, LA ^a	12.7	0.5 +0.07		0.5 +0.07	N.M.	1+0.2
1978	SAB781120*	Lake Sabine, TX ^a	14.2	1.5 +0.14		0.6 +0.1	N.M.	0.4 +0.2
1978	MAG781122*	Matagorda Bay, TX ^a	10.6	0.5 +0.07				
1978	LJ780425	Point La Jolla, CA ^b	8.0	0.72+0.16	N.D.	2.00+0.32	28+5	2.85+0.63
1978	SC780626	Santa Catalina, CA ^b	11.4	0.91+0.23	N.D.	2.73+0.45	29+5	3.20+0.87

Table 18
1978 DATA--ANNUAL SITES

Year	Mussel Watch No.	Location	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)				
				239,240Pu	238Pu	241Am	137Cs	241Am 239,240Pu
1978	SPH780428	San Pedro Harbor, CA ^c	9.6	0.87+0.10	0.02+0.05	0.19+0.10	36+ 2	0.22+0.11
1978	PTA780725	Point Arguello, CA ^b	7.5	2.53+0.22	0.05+0.04	6.63+0.52	24+ 4	2.64+0.33
1978	SS780727	San Simeon, CA ^b	4.9	1.86+0.15	0.03+0.02	6.94+0.39	16+ 1	3.75+0.38
1978	SC780729	Santa Cruz, CA ^b	10.2	3.15+0.20	0.10+0.04	5.79+0.51	13+ 2	1.80+0.20
1978	FAR780820	Farallon Island, CA ^b	7.2	4.65+0.43	0.11+0.06	18.54+1.36	38+15	3.95+0.47
1978	A780810	Point Arenas, CA ^b	8.6	3.37+0.26	0.07+0.03	12.77+0.86	60+ 3	3.79+0.36
1978	CM780812	Cape Mendocino, CA ^b	8.4	4.60+0.33	0.16+0.06	12.62+1.17	34+ 6	2.82+0.36
1978	GB780815	Gold Beach, OR ^b	6.2	2.29+0.19	0.05+0.03	3.96+0.31	22+ 3	1.75+0.20
1978	Y780818	Yaquina Bay, OR ^b	9.1	1.92+0.18	0.03+0.02	4.94+0.46	22+ 4	2.57+0.33
1978	CR780821	Columbia River, OR ^b	8.3	0.99+0.17	0.07+0.03	0.91+0.08	16+ 4	0.92+0.17
1978	CF780824	Cape Flattery, WA ^b	7.6	3.36+0.23	0.03+0.02	8.47+0.46	32+ 4	2.53+0.22
1978	BB780828	Boundary Bay, WA ^b	9.9	2.37+0.30	0.02+0.03	0.50+0.10	66+ 3	0.21+0.05
1978	SDH780426*	San Diego Harbor, CA ^b	10.2	0.8 +0.2		0.3 +0.03		0.4 +0.1
1978	OS780526*	Oceanside, CA ^b	8.1	0.5 +0.08		2.9 +0.4		5.8 +1.3
1978	PF780608*	Point Fermin, CA ^b	10.8	0.8 +0.1		2.2 +0.2		2.8 +0.4
1978	RC780724*	Rincon Cliffs, CA ^b	8.1	0.5 +0.05		0.9 +0.1		0.1 +0.01

Radionuclides:
(dpm/kg dry weight)

Year	Mussel Watch No.	Location	Ratio:		Radionuclides:				
			Fresh Wt.	Dry wt.	238Pu	241Am	137Cs	241Am 239,240Pu	
1978	D780726*	Diablo, CA ^b	9.0		2.1 +0.17	7.5 +0.3		3.6+0.3	
1978	SOB780728*	Soberanes Pt., CA ^b	9.0		3.9 +0.24	16.9 +1.3		4.3+0.4	
1978	SSF780805*	S. San Francisco, CA ^c	7.4		0.4 +0.05	0.14+0.04		0.4+0.1	
1978	NSF780813*	N. San Francisco, CA ^c	6.5		0.5+0.05			—	
1978	H780811*	Humboldt, CA ^b	7.0		2.4+0.2	2.9 +0.2		1.2+0.1	
1978	PSG780814*	Point St. George, CA ^b	3.3		1.8+0.1	1.5 +0.1		0.8+0.1	
1978	CB780817*	Coos Bay, OR ^b	10.3		3.2+0.2	6.4 +0.4		2.0+0.2	
1978	T780820*	Tillamook Bay, OR ^c	13.7		1.1+0.1	0.3 +0.08		0.3+0.1	
1978	GH780822*	Grays Harbor, WA ^b	6.9		0.7+0.06	0.5 +0.1		0.7+0.1	
1978	PS780827*	Puget Sound, WAC	7.7		0.3+0.05	0.3 +0.05		1 +0.2	

a = Crassostrea virginica

b = Mytilus californianus

c = Mytilus edulis

* = Scripps Institution of Oceanography data

N.D. = Not detected

N.M. = Not measured

Table 19
MYTILUS CALIFORNIANUS TRANSPLANTED FROM BODEGA HARBOR, CA TO NARRAGANSETT, RI

Mussel Watch Identification	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)				
		239,240 Pu	238 Pu	241 Am	137 Cs	241 Am 239,240 Pu
T ₀ BH-810602	7.9	2.13±0.20	0.10 ±0.04	5.57±0.30	27±2	5.57±0.30
T ₁ 6/05/81 to 7/28/81	7.0	1.46±0.18	0.07 ±0.04	2.17±0.21	24±2	1.49±0.23
T ₂ 6/05/81 to 8/19/81	6.0	1.59±0.18	0.05 ±0.04	2.14±0.13	21±1	1.35±0.17

(values are averages)
standard deviation:

Table 19B - Mussel Watch
Page 19

Page 2 of 3

Table 20
MYTILUS EDULIS TRANSPLANTED FROM GAY HEAD, MA TO BODEGA HARBOR, CA

Mussel Watch Identification	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg dry weight)				
		239,240 Pu	238 Pu	241 Am	137 Cs	241 Am 239,240 Pu
T ₀ GH-810812	7.5	2.87±0.20	0.09 ±0.03	0.59±0.11	69±4*	0.20±0.04
T ₁ 8/18/81 to 9/10/81	5.2	0.77±0.09	0.015±0.012	0.19±0.04	13±1	0.24±0.05
T ₂ 8/18/81 to 10/3/81	3.5	1.15±0.11	0.12 ±0.04	0.31±0.05	18±2	0.27±0.05
T ₃ 8/18/81 to 10/23/81	3.0	1.70±0.16	0.09 ±0.04	0.44±0.09	20±4	0.26±0.06

* = Average of two counts.

Table 21
MYTILUS EDULIS TRANSPLANTED FROM GAY HEAD, MA TO BODEGA HARBOR, CA

Mussel Watch Identification	Ratio: Fresh Wt. Dry wt.	Radionuclides: (dpm/kg wet weight)				
		239,240 Pu	238 Pu	241 Am	137 Cs	241 Am 239,240 Pu
T ₀ GH-810812	7.5	0.39±0.03	0.012±0.004	0.079±0.015	9.3±0.5	0.20±0.04
T ₁ 8/18/81 to 9/10/81	5.2	0.15±0.02	0.003±0.002	0.036±0.008	2.5±0.2	0.24±0.05
T ₂ 8/18/81 to 10/3/81	3.5	0.33±0.03	0.034±0.011	0.089±0.014	5.2±0.6	0.27±0.05
T ₃ 8/18/81 to 10/23/81	3.0	0.58±0.05	0.031±0.014	0.149±0.066	6.8±1.4	0.26±0.06

2 - 100% of 100 counts

2¹ 8/18/81 to 10/12/81
2² 8/18/81 to 10/12/81
2³ 8/18/81 to 10/12/81
2⁴ 8/18/81 to 10/12/81

Translocation
Mussel Watch

QIA 22
Lamp 22

328 340

328 340

328 340

328 340

(dpm/kg wet weight)
1000 counts

MYTILUS EDULIS TRANSPLANTED FROM GAY HEAD, MA TO BODEGA HARBOR, CA
10/18/81

Table 22
MYTILUS CALIFORNIANUS FROM THE FARALLON ISLANDS, CA

Collection Date	Ratio: Fresh Wt. Dry Wt.	Radionuclides: (dpm/kg dry weight)					
		239,240 Pu	238 Pu	241 Am	137 Cs	241 Am 239,240 Pu	55 Fe *
20 Aug. 78 **	6.7	4.03+0.39	0.11+0.06	14.64+1.23	38+15	3.63+0.46	
16 Jan. 80	11.2	14.50+2.25	0.70+0.29	12.43+1.23	64+5	0.86+0.16	
21 Jul. 80	8.0	10.09+0.77	0.29+0.09	12.86+0.56	33+3	1.27+0.11	14.5+4.8
25 May. 81	5.6	6.08+0.76	0.19+0.13	10.83+0.54	42+4	1.78+0.24	
31 May. 81	7.2	4.41+0.34	0.07+0.04	11.33+0.56	29+3	2.57+0.23	
24 Jul. 81	3.4	5.85+0.38	0.29+0.08	10.03+0.46	36+2	1.71+0.14	7.5+4.2
29 Aug. 81	7.6	2.92+0.26	0.04+0.03	12.26+0.64	31+3	4.20+0.43	

* = Decay corrected to date of collection

** = Average of three analyses

Table 23
MYTILUS CALIFORNIANUS FROM SOBERANES POINT, CA

Collection Date	Radionuclides: (dpm/kg dry weight)					
	Ratio:					
	Fresh Wt. Dry Wt.	239,240 Pu	238 Pu	241 Am	137 Cs	241 Am 239,240 Pu
High tide 15 Aug. 81	10.8	17.76±1.79	0.39±0.23	14.51±0.87	41±3	0.82±0.33
Mid tide 15 Aug. 81	10.9	4.76±0.45	0.18±0.08	16.51±1.19	49±5	3.46±0.42
Low tide 15 Aug. 81	8.2	4.34±0.46	0.14±0.08	—	30±9	—
28 July 78 SOB-78 0728*	9.9	10±1	0.09±0.09	16.9 ±1.3**	37±6	1.6 ±0.5

* - Mussel Watch number

** - Scripps Institution of Oceanography data

Table 24
MYTILUS GALLOPROVINCIALIS, SOFT PARTS FROM SPAIN

Location and Collection Date	Ratio: Fresh Wt. Dry Wt.	Radionuclides: (dpm/kg dry weight)				
		239,240 Pu	238 Pu	241 Am	137 Cs	241 Am 239,240 Pu
Vandellos 2 VII 80	7.3	11.7+0.9	0.60+0.18	0.88+0.16	85+5	0.08+0.02
Fondeadero del Fangal 1 VII 80	11.7	8.2+0.9	0.37+0.19		34+8	
Ampolla 30 VI 80	7.5	5.6+0.5	0.35+0.12		26+3	
San Carlos de la Rapita 28 VI 80	9.1	6.5+0.5	0.22+0.10		37+8	
Peniscola 29 VI 80	7.1	6.7+0.6	0.24+0.10	0.52+0.13	25+4	0.08+0.02

Table 25
MYTILUS EDULIS FROM WINDSCALE REPROCESSING PLANT AND ISLE OF MAN

Location and Collection Date	Ratio: Fresh wt. Dry wt.	Radionuclides: (dpm/kg dry weight)			
		238Pu	241Am	137Cs	241Am 239,240Pu
Ravenglass Estuary August 1977	9.8	56400+4400	15410+1240	63900+6390	1921+10
					1.1+0.1
Isle of Man August 1977	5.5	154+44	39+11	550+55	7030+150
					4+1

* see text for change of collection site

Figure 2

* see text for change of collection site

Figure 3

* see text for change of collection site

Figure 4

Figure 5

Figure 6

Figure 7

U.S. EAST COAST "MUSSEL WATCH"

Figure 8

U.S. WEST COAST "MUSSEL WATCH"

Figure 9

REPORT DOCUMENTATION PAGE	1. REPORT NO. WHOI-84-28	2.	3. Recipient's Accession No.
4. Title and Subtitle U.S. "Mussel Watch" Program: Transuranic Element Data from Woods Hole Oceanographic Institution 1976-1983		5. Report Date May 1984	
7. Author(s) Julianne Palmieri, Hugh Livingston and John W. Farrington		8. Performing Organization Rept. No. WHOI-84-28	
9. Performing Organization Name and Address Woods Hole Oceanographic Institution Woods Hole, Massachusetts 02543		10. Project/Task/Work Unit No.	
12. Sponsoring Organization Name and Address U.S. Environmental Protection Agency		11. Contract(C) or Grant(G) No. (C) CR-807181 (G) 68-03-3193	
		13. Type of Report & Period Covered Technical	
		14.	
15. Supplementary Notes This report should be cited as: Woods Hole Oceanog. Inst. Tech Rept. WHOI-84-28.			
16. Abstract (Limit: 200 words) <p>Bivalves (<u>Mytilus edulis</u>, <u>Mytilus californianus</u>, <u>Crassostrea virginica</u> and <u>Ostrea equestris</u>) were collected once per year during 1976, 1977, and 1978 along the United States coast and analyzed for $^{239,240}\text{Pu}$, ^{241}Am and ^{137}Cs as part of the U.S. Mussel Watch program. Monthly samples were collected during 1976-1980 from Narragansett Bay, Rhode Island and Bodega Head, California and analyzed for $^{239,240}\text{Pu}$, ^{241}Am, and ^{137}Cs.</p> <p>There is no evidence in the data for systematic regional or local elevated concentrations of radionuclides as a result of releases from the nuclear fuel cycle. Elevated concentrations of $^{239,240}\text{Pu}$ in mussels from the central California coast are due to uptake from upwelled water fed by North Pacific water which has elevated $^{239,240}\text{Pu}$ may be influenced by upwelling season.</p> <p>Monthly fluctuations in radionuclide concentrations in the Narragansett Bay mussels appear to be primarily influenced by spawning. The slight monthly fluctuations in the radionuclide concentrations for the Bodega Head mussels are less coherent from year to year compared to Narragansett Bay although $^{239,240}\text{Pu}$ may be influenced by upwelling season.</p> <p>Limited data on transplants of mussels from the Ebro estuary on the Spanish coast and from the Irish Sea are also reported.</p>			
17. Document Analysis a. Descriptors <ol style="list-style-type: none"> 1. Radionuclides 2. Bivalves 3. Coast <p>b. Identifiers/Open-Ended Terms</p> <p>c. COSATI Field/Group</p>			
18. Availability Statement: Approved for publication; distribution unlimited.		19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 73
		20. Security Class (This Page)	22. Price