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DRAFT REPORT

DISTRIBUTION AND CONCENTRATION OF POLYCHLORINATED BIPHENYLS IN LOBSTER, WINTER FLOUNDER, AND QUAHOGS FROM BUZZARDS BAY, MASSACHUSETTS

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ABSTRACT

American lobster, Homarus americanus, winter flounder, Pseudopleuronectes, and quahogs, Mercenaria mercenaria, were analyzed to determine the distribution and tissue concentrations of polychlorinated biphenyls (PCBs) in Buzzards Bay. PCBs were extracted according to U.S. Food and Drug Administration protocol and quantified as Aroclor 1254 by gas chromatography. PCB concentrations for Buzzards Bay species were compared to samples collected in New Bedford Harbor and other coastal areas.

PCBs were detected in all three species. Average tissue concentrations between species decreased in the following order: lobster (0.96 ppm)> flounder (0.45 ppm)> quahog (0.03 ppm). All three species in Buzzards Bay contained less PCBs than New Bedford Harbor, however lobster and flounder PCB concentrations in Buzzards Bay were similar to levels detected in Boston Harbor. PCB concentrations in quahogs were extremely low, except in the vicinity of New Bedford Harbor which suggests that PCBs are dispersing from New Bedford Harbor into Buzzards Bay.

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Field collections and chemical analyses were accomplished with the help of several Division of Marine Fisheries personnel. Bruce Estrella and Daniel McKiernan collected lobster samples with the kind assistance of several commercial lobstermen, whose cooperation is greatfully acknowledged. J. Michael Hickey and Frank Germano collected quahog samples and coordinated DMF collection efforts with the Massachusetts Division of Water Pollution Control. Arnold B. Howe supervised winter flounder sampling in conjunction with the Division's resouce assessment survey. Laboratory analyses were conducted by Eileen Cox, Selina J. Makofsky, and Matthew Pride. Leigh Bridges (principal investigator), Bruce Estrella, J. Michael Hickey, and Arnold B. Howe provided their critical reviews and improvements to the manuscript, and Dr. John W. Farrington (Woods Hole Oceanographic Institution) kindly provided PCB analyses for the interlaboratory comparison. This project was made possible through financial support from the U.S. Environmental Protection Agency Buzzards Bay Program, grant no. CX 812852-01.

INTRODUCTION

Ever since New Bedford Harbor was identified as being severely contaminated with PCBs (polychlorinated biphenyls) there has been increasing concern about the extent and concentration of PCBs in the fishery resources of adjacent Buzzards Bay. Large quantities of PCBs were discharged into New Bedford Harbor over several decades as the byproduct of the manufacture of electrical components (Weaver 1984), and despite the discontinuation of PCB manufacturing and use the harbor sediments and biota still contain relatively large concentrations of PCBs which serve as a long-term source of contamination for Buzzards Bay (Deubert et al. 1981; Hatch et al. 1981; Kolek and Ceurvels 1981; Boehm 1983; Farrington et al. 1985; Brownawell and Farrington 1986; Farrington et al. 1986). PCBs can be acutely toxic to fish (Hansen et al. 1971). In New Bedford Harbor, chronic exposure to PCBs reduces the physiological condition of the mussel, Mytilis edulis, (Capuzzo et al. 1986), and potentially reduces the viability of larval winter flounder, Pseudopleuronectes americanus, (Black et al. 1988).

The discharge of municipal sewage from New Bedford into Buzzards Bay has also been identified as a potential source of contaminants that cause black gill and shell disease in the american lobster, Homarus americanus. Black gill and shell disease has been used as an indicator of ocean dumping of dredge-spoils as well as municipal waste (Young and Pearce 1975). In a coastwide survey of black gill and shell disease in lobster, Estrella (1984) found that all five Buzzards Bay sampling locations had elevated levels of disease. The lowest incidence of black gill disease was 21.7% and increased to 54.2% in the vicinity of the New Bedford Harbor sewage outfall. Various external and internal pathological lesions and infections were also reported in Quincy Bay fish and shellfish, including

lobster, resulting from the discharge of municipal waste from a sewage treatment plant (Gardner and Pruell 1988). Both PCBs and municipal sewage from New Bedford Harbor represent chronic sources of contamination to all of Buzzards Bay, which could have harmful effects to valuable fishery resources.

This report presents PCB analyses on marine fish and shellfish collected in Buzzards Bay as part of the U.S. Environmental Protection Agency (EPA) Buzzards Bay Program. The objective of this survey was to measure the concentration and distribution of PCBs in edible portions of selected fish and shellfish species that are important commercial fishery resources. The three representative species analyzed were the quahog, Mercenaria mercenaria, winter flounder, Pseudopleuronectes americanus, and american lobster, Homarus americanus. The report also includes PCB concentrations from other areas in Massachusetts to compare the PCB body burdens in Buzzards Bay species with other contaminated and relatively clean coastal areas. A subsequent report will include results of pathological examinations for disease.

MATERIALS AND METHODS

Field Sampling

Field sampling for lobsters began in May, 1985, and concluded in May, 1986. Lobsters were acquired by Division of Marine Fisheries (DMF) personnel aboard fishing vessels directly from the commercial lobster fishery in Buzzards Bay. Five legal-size lobsters (>81 cm carapace length) from 8 locations (total of 40 lobsters) were obtained on the basis of their occurrence in the fishery. Lobsters were collected using commercial lobster pots. Winter flounder were collected in May, 1986, as part of DMF

resource assessment cruise #8691. Legal-size flounder (>25 cm total length) were collected by DMF personnel at three randomly selected stations near the middle of Buzzards Bay (total of 35 fish). Flounder were sampled with a 3/4 size North Atlantic type 2 seam otter trawl towed at 2.5 knots for 20 min aboard the NOAA fishery research vessel Gloria Michelle. The otter trawl configurations were 11.9 m headrope - 15.5 m footrope rigged with a 7.6 cm rubber disk sweep; 19.2 m, 9.5 mm chain bottom legs; 18.3 m, 9.5 mm wire top legs; and 1.8 x 1.0 m, 147 kg wooden trawl doors. The net contained a 6.4 mm codend liner to retain small fish. Quahogs were collected in May and June, 1986, by DMF biologists from 32 nearshore areas around the perimeter of Buzzards Bay. Quahog rakes (scratchers) and bull rakes were used to collect the clams. Sample locations were determined in conjunction with the Division of Water Pollution Control (Dept. of Environmental Quality Engineering) to coordinate PCB analysis with DWPCs analysis for trace metals. A minimum of ten legal-size quahogs (>2 inches dia.) were composited from each location (total of 32 samples) with additional quahogs collected to provide DWPC with sample material from the composite. All sampling locations were outside sampling areas in New Bedford Harbor used by DMF to monitor PCBs in lobster, flounder, and quahog. Samples were frozen in polyethylene bags and remained frozen until shipment to Cat Cove Marine Laboratory for PCB analysis.

Labaoratory Analysis and Quality Control

All samples were thawed in a stainless steel trough and the edible portion from each sample was removed for PCB analysis. The edible portion was defined as the skinless filet of flounder, combined meat and tomalley (hepatopancreas) of lobster, and shucked meat of quahogs. Samples were extracted according to the high moisture method of the U.S. Food and Drug Administration (method 212, Pesticide Analytical Manual, Volume 1; see Appendix

A). PCBs were quantified using a Hewlett-Packard model 5880A gas chromatograph equipped with an electron capture detector and a 2 m packed column of 1.5% SP2250/1.95% SP2401 on 100/120 Supelcoport. Injection volume = 1 ul, 95% argon/5% methane flowrate = 40 ml/min, isothermal oven temperature = 205 ^{o}C, injector temperature = 225 ^{o}C, detector temperature = 300 ^{o}C. Total PCBs were identified by comparison to the chromatographic pattern of Aroclor 1254, and quantified based on the average area of four peaks from the aroclor moiety (Schwartz 1987).

Routine quality control included tracking all samples as they proceeded through each step of the analysis. Logbooks were maintained for all samples received, stored in freezers, extracted on the bench, and released as analytical reports. Final data is also stored on computer files. A logbook of calculations was maintained for samples used as quality control spikes for percent recovery. Percent recovery was determined by adding a known amount of Aroclor 1254 to a sample, with duplicates of that sample for background correction. Alternate batches of samples (approximately every 10 samples) were accompanied by a set of spike and recovery analyses. Every batch included a reagent blank. Triplicate analyses were also performed on 10% of all samples. The gas chromatograph was calibrated daily prior to the start of a batch run at five concentrations ranging from 0.01 ppm (parts per million) to 20.0 ppm. Each sample was injected twice to ensure precision within +/- 10%. The laboratory also participates in a semi-annual interlaboratory calibration survey for PCBs and trace metals sponsored by the U. S. EPA. Three lobster samples were also sent to the Woods Hole Oceanographic Institution (WHOI) for interlaboratory comparison (J. Farrington, personal communication). Results indicated that DMF's PCB analyses were approximately 10% higher than the analyses conducted at WHOI which identified separate PCB congeners.

RESULTS

Lobster

Table 1 lists individual lobster PCB concentrations at each station. Station locations and average PCB levels in Buzzards Bay lobster are indicated on Figure 1. Lobsters were collected from the extreme Northeast area of the bay near Tobey's Island (station #3), to as far Southeast as Westport (station #6). The range of PCB concentrations varied from 0.26 ppm (+/- 0.07 ppm, n = 5) at station #3 to 1.66 ppm (+/- 0.30 ppm, n = 5) at station #1. The average PCB concentration for all lobsters was 0.96 ppm (+/- 0.11 ppm, n = 40). Water temperature varied from 5.5 ^{o}C to 23 ^{o}C, and depth varied from 3 m to 15 m among stations (Appendix B). There was no correlation between PCB concentrations in lobster with station, water temperature, or depth. Calculation of the coefficient of intraclass correlation (Sokal and Rohlf 1969) indicated that the majority of variation in lobster PCB concentrations was within station samples. Figure 1 also includes the average PCB concentration in lobster collected from outer New Bedford Harbor (area 3; see map in Kolek and Ceurvels 1981) in September and October, 1985, by DMF (ave. = 3.96 +/- 0.15, n = 11). There was a highly significant difference in PCB concentrations between lobsters from Buzzards Bay and New Bedford Harbor by analysis of variance ($F_{[1,49]} = 7.779$; $p < 0.01$).

Flounder

Table 2 lists individual flounder PCB concentrations at each station. Station locations and average PCB levels for flounder samples are indicated on Figure 2. Water temperature, and salinity were similar between stations (Appendix C). The

Table 1. PCB concentrations (ug/g) for Lobster, H. Americanus, collected at each station in Buzzards Bay, 1985-1986.

Date	Station	ppm (ug/g)
5/22/85	1	1.50
		1.40
		1.70
		0.90
		2.80
8/13/85	2	1.20
		1.20
		3.30
		1.10
		0.90
11/26/85	3	0.20
		0.20
		0.50
		0.10
		0.30
12/13/85	4	0.60
		0.30
		0.30
		1.00
		0.30
4/2/86	5	0.92
		1.14
		1.08
		0.75
		1.50
4/4/86	6	0.32
		0.58
		0.68
		0.40
		0.79
5/15/86	7	0.80
		0.43
		0.40
		2.28
		1.28
5/22/86	8	1.57
		0.53
		1.14
		0.92
		0.79

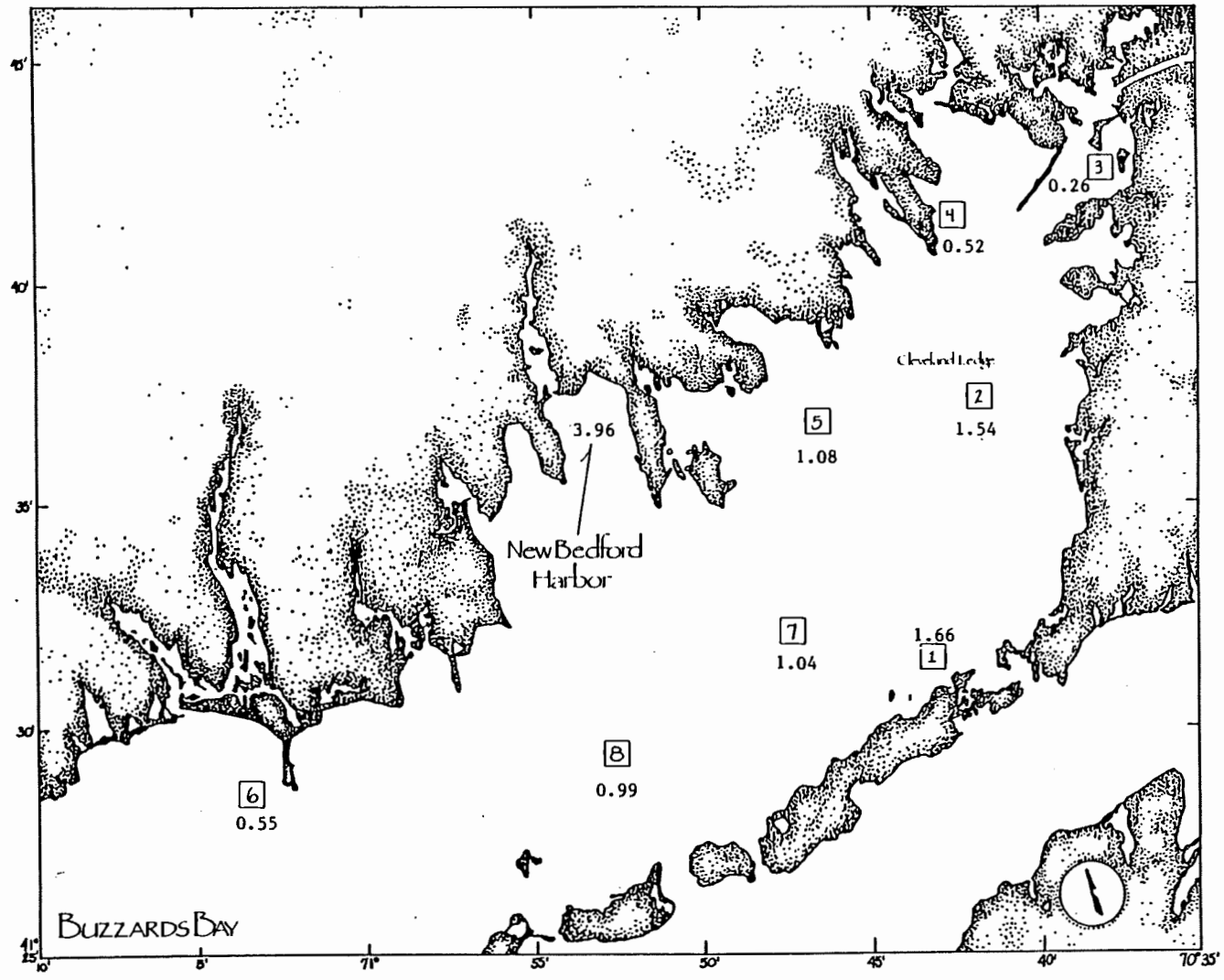

Figure 1. Station locations and average PCB concentrations (ppm) for Lobster, H. americanus, in Buzzards Bay, and New Bedford Harbor from DMF field survey.

Table 2. PCB concentrations (ug/g) for flounder, P. americanus, collected at each station in Buzzards Bay, 1986.

Date	Station	ppm (ug/g)
5/12/86	33	0.59
		0.17
		0.14
		0.91
		0.58
		0.37
		0.68
		0.71
		0.13
		0.16
		0.41
		0.20
		0.08
		0.19
		0.41
		0.54
5/12/86	34	0.24
		0.31
		1.18
		0.33
		0.39
		0.18
		1.12
		0.46
		0.76
		0.32
		0.33
		0.88
		0.30
		0.19
		0.31
		0.96
5/13/86	41	0.35
		0.75
		0.13

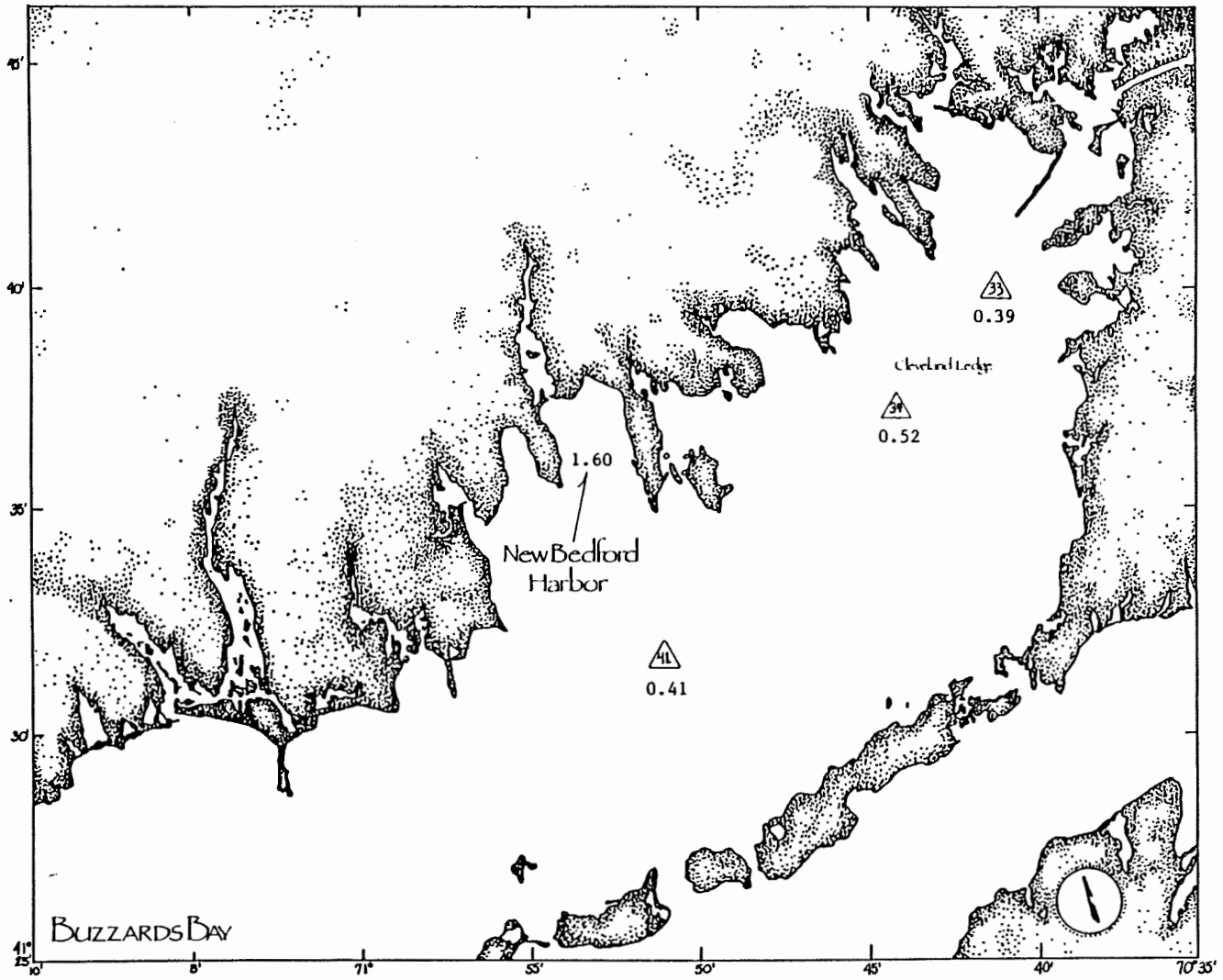

Figure 2. Station locations and average PCB concentrations (ppm) for winter flounder, P. americanus, in Buzzards Bay, and New Bedford Harbor (Kolek and Ceurvels 1981).

average PCB concentration for all flounder was 0.45 ppm (+/- 0.05 ppm, n = 35). Figure 2 includes the average PCB concentration in flounder (ave. = 1.6 ppm +/- 0.5 ppm, n = 15) collected between 1976 and 1980 in outer New Bedford Harbor (area 3; see map in Kolek and Ceurvels 1981). There was a highly significant difference in PCB concentrations between flounder from Buzzards Bay and New Bedford Harbor by analysis of variance ($F [1,52] = 13.678$; $p < 0.001$).

Quahog

Table 3 lists individual composite PCB concentrations at each station. Quahogs were collected from 32 areas encompassing all of Buzzards Bay (Appendix D). PCBs in two samples (stations 15 & 16) were not determined because of interfering compounds that persisted after florisil column cleanup. Figure 3 gives station locations and PCB levels for Buzzards Bay quahogs, and includes the average PCB concentration for quahogs collected in area 2 of New Bedford Harbor (see map in Kolek and Ceurvels 1981) by DMF in May, 1984. PCB concentrations in quahogs were extemely low in comparison to lobster and flounder. The average PCB concentration for all samples analyzed from Buzzards Bay was 0.03 ppm (+/- 0.01 ppm, n = 30), and concentrations in 24 samples were less than 0.05 ppm. One sample (station #31) contained 0.10 ppm, and another sample (station #32) contained 0.20 ppm. Both of these stations were in closest proximity to outer New Bedford Harbor than all other stations. In contrast, quahogs collected near the hurricane barrier of New Bedford Harbor (area 2) contained an average of 0.70 ppm (+/- 0.09 ppm, n = 6) PCBs (Figure 3). There was a highly significant difference in PCB concentration between Buzzards Bay and New Bedford Harbor quahogs by analysis of variance ($F [1,34] = 261.96$; $p < 0.001$).

Table 3. PCB concentrations (ug/g) for quahogs, M. mercenaria, collected at each station in Buzzards Bay, 1986.

Date	Station	ppm (ug/g)
5/6/86	4	0.01
5/6/86	5A	0.01
5/7/86	6	0.01
5/7/86	7	0.02
5/7/86	8	0.01
5/7/86	9	0.01
5/7/86	11	0.02
5/21/86	15	ND
5/21/86	16	ND
5/22/86	18	0.03
5/22/86	19	0.02
5/22/86	20	<0.01
5/22/86	21	<0.01
5/28/86	22	0.04
5/28/86	23	0.03
5/28/86	24	0.02
5/28/86	25	0.06
5/29/86	26	0.01
5/29/86	27	0.01
5/29/86	28	0.01
5/29/86	29	0.01
5/30/86	30	0.10
5/30/86	31	0.20
5/30/86	32	0.08
5/30/86	33	0.07
5/30/86	34	0.05
6/4/86	35	0.01
6/4/86	36	0.01
6/4/86	37	0.03
6/4/86	38	0.01
6/6/86	39	0.01
6/6/86	40	0.08

ND = no determination

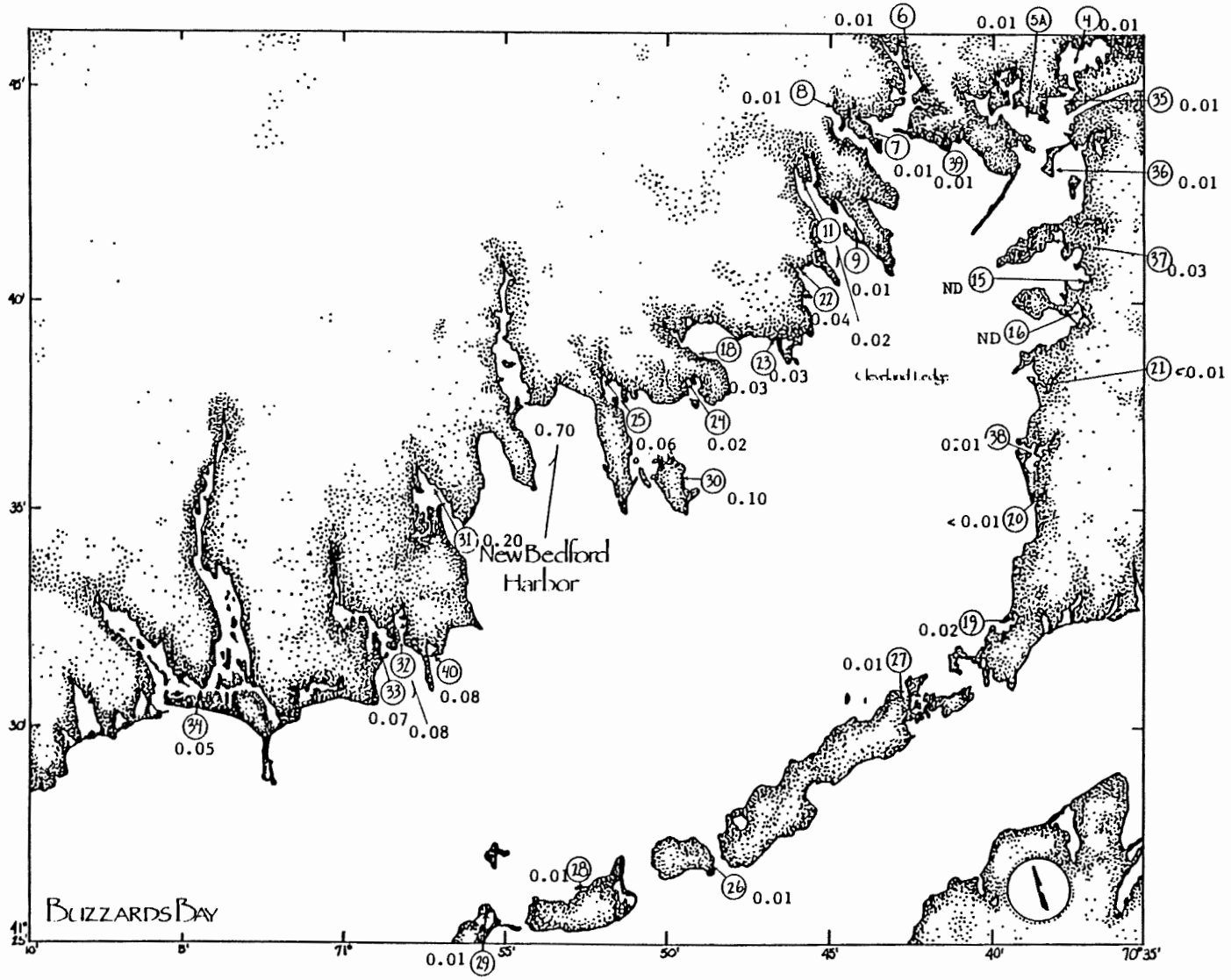

Figure 3. Station locations and PCB concentrations (ppm) for quahogs, M. mercenaria, in Buzzards Bay, and New Bedford Harbor from DMF field survey.

DISCUSSION

PCB levels among the three species analyzed decreased in the following order: lobster > flounder > quahog, and this same pattern of PCB body burdens was also observed for lobster, flounder, and the soft shell clam, Mya arenaria, in Boston Harbor (Schwartz 1987). Several studies have demonstrated that the edible hepatopancreas (tomalley) of the lobster accumulates substantially more PCBs than edible muscle tissue (Farrington et al. 1986; Gardner and Pruell 1988; Division of Marine Fisheries unpublished data), and inclusion of the tomalley with muscle tissue presumably increased the reported total PCB body burden in the present study, even though the tomalley constitutes only 17% of the edible portion by wet weight (Division of Marine Fisheries unpublished data). For example, Gardner and Pruell (1988) reported PCB concentrations in lobster muscle samples from Quincy Bay that were below one ppm, and PCB concentrations in the tomalley that were in excess of 40 ppm. Boehm (1983) found PCB concentrations in Buzzards Bay lobster muscle in the range of 0.1 ppm to 0.02 ppm. The Division of Marine Fisheries (unpublished data) also detected PCBs in Salem Harbor lobster muscle between 0.02 and 0.06 ppm, and tomalleys with an average PCB concentration of approximately 6 ppm.

Despite differences in PCB concentrations between species and tissue types, the levels in Buzzards Bay lobster and flounder from areas as far away from New Bedford Harbor as seven miles (Figure 2, station 1; Figure 2, station 34) were similar to PCB concentrations in samples from Boston Harbor, and indicate widespread occurrence of PCBs in these fishery resources. Figure 4 presents average PCB concentrations in lobster, flounder, and quahog compiled by DMF for Buzzards Bay and New Bedford Harbor, and lobster and flounder PCB levels from Boston Harbor, Salem Harbor, and stations further offshore of coastal Massachusetts (Schwartz 1987). PCB levels in Buzzards Bay lobster appear

PCB distributions in Massachusetts marine fisheries

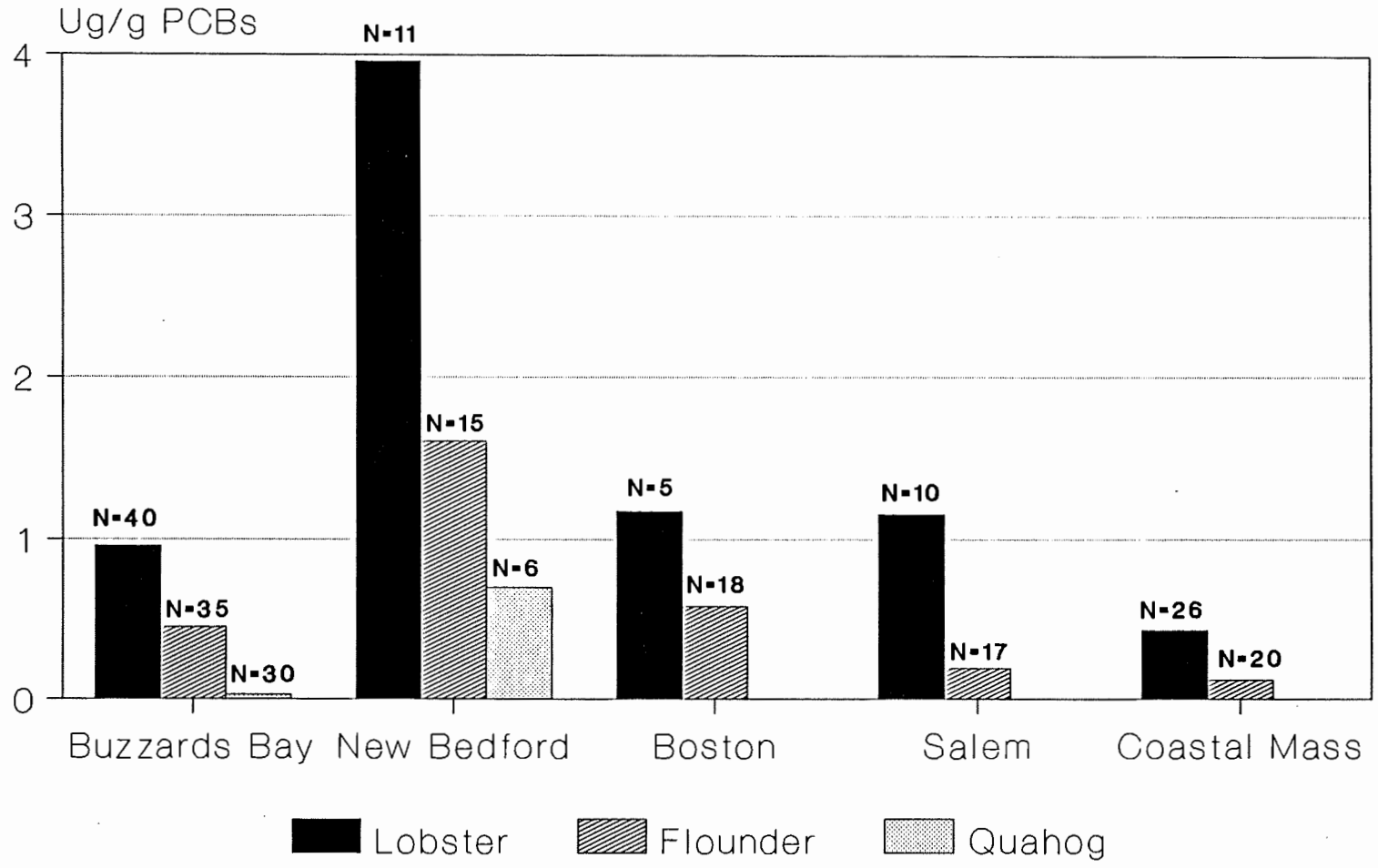

Figure 4. Average PCB concentrations (ppm) and sample size (N) in Lobster, H. americanus, winter flounder, P. americanus, and quahog, M. mercenaria, from Buzzards Bay and New Bedford Harbor, with lobster and flounder from Boston and Salem Harbors, and Coastal Massachusetts (Schwartz 1987).

similar to levels in Boston and Salem Harbor lobster ($F [2,52] = 0.319$; $p < 0.75$), higher than concentrations in coastal lobster ($F [1,59] = 16.63$; $p < 0.001$), and considerably lower than New Bedford lobster as previously described. PCB levels in Buzzards Bay flounder also appear similar to Boston Harbor flounder ($F [1,51] = 2.339$; $p < 0.25$), higher than Salem Harbor ($F [1,50] = 12.885$; $p < 0.001$) and Coastal flounder ($F [1,64] = 12.618$; $p < 0.001$), and lower than New bedford Harbor flounder as previously described. Both lobster and flounder are migratory and demersal species, and forage on benthic prey organisms inhabiting their niche. Since New Bedford Harbor is the only known source of PCBs in Buzzards Bay, both species presumably acquired their PCB body burden through direct contact with PCBs in sediments by migrating to the contaminated area, and/or consumed PCB-contaminated benthic food organisms which were already exposed to PCBs. Laboratory investigations have demonstrated that fish and invertebrates can accumulate PCBs through contact with contaminated sediments or ingestion of prey organisms (Fowler et al. 1978; Rubinstein et al. 1984).

Quahogs in Buzzards Bay contained some of the lowest detectable levels of PCBs. The clams were in pre-spawning condition when sampled in the Spring, and were expected to have higher PCB levels than were detected because of increased fat content at this time of the year. However, quahog samples from the numerous nearshore clambeds around the bay suggest that PCB contamination in nearshore embayments is not widespread, with the exception of quahog samples from the vicinity near outer New Bedford Harbor. For example, the highest PCB concentration in quahogs (0.20 ppm) detected at station 31 (Figure 3) is the same area where 0.177 ppm PCBs in quahogs was previously detected (Hatch et al. 1981).

Unlike lobster and flounder which migrate and forage for prey species, quahogs are sedentary filter feeders. The presence of PCBs in quahogs outside but near New Bedford Harbor, therefore,

is probably the result of the clams filtering and ingesting PCBs contained in food organisms, such as phytoplankton, or PCBs adsorbed onto suspended sediments originating from New Bedford Harbor.

If PCBs are dispersing from New Bedford Harbor into Buzzards Bay it appears to be occurring at a slow rate. Farrington et al. (1986) reported a plume and isolated locations of sediments containing as much as 50 ppm PCBs extending from New Bedford Harbor into Buzzards Bay, and DMF found quahogs containing 0.70 ppm PCBs near this area (Figure 3). All five of the highest quahog samples (exceeding 0.05 ppm PCBs) in the present study were from coastal areas around and West of New Bedford Harbor. In contrast, sediment samples from the middle of Buzzards Bay contained between 0.1 ppm and 0.0003 ppm PCBs, and the range of PCBs in the clam, Pitar morrhauna, was 0.021 ppm to 0.045 ppm (Boehm 1983). Signell (1987) determined that the inferred freshwater inflow from the Acushnet River through New Bedford Harbor into Buzzards Bay is very low (0.8 m^3/sec), and tidal currents in Buzzards Bay are propagated in the along-bay axis from Northeast to Southwest. Fine-grained sediments (silt/clay) transported from New Bedford Harbor to Buzzards Bay would therefore be dispersed at a relatively slow rate by tidal currents. This may explain why PCB levels are so low in quahogs collected several miles away from New Bedford Harbor, compared to lobster and flounder collected at similar distances from New Bedford Harbor.

Both lobster and flounder contained substantially more PCBs than quahogs in this study, which indicates that active migration and predation at higher trophic levels are responsible for greater bioaccumulation and distribution of PCBs among these fishery resources than by the physical mixing and dispersion of PCBs through the water column. However, regardless of the mode of exposure, transfer, and accumulation among the three species in

this study, the large quantities of PCBs sequestered in New Bedford Harbor sediments provide a continuous source of PCBs to fishery resources in Buzzards Bay.

SUMMARY

1. Lobster, winter flounder, and quahogs were collected from Buzzards Bay and analyzed for PCBs. Samples were obtained from different areas of the bay outside New Bedford Harbor.

2. PCBs were detected in all three species. Average tissue concentrations between species decreased in the following order: lobster (0.96 ppm)> flounder (0.45 ppm)> quahog (0.03 ppm). Previous studies indicate that inclusion of the edible hepatopancreas (tomalley) with lobster muscle tissue contributed the majority of PCBs to the total concentration in lobster samples.

3. Buzzards Bay lobster had PCB concentrations similar to levels in Boston and Salem Harbor, lower than New Bedford Harbor, but higher than samples from coastal Massachusetts.

4. Buzzards Bay flounder had PCB concentrations similar to levels in Boston Harbor, lower than New Bedford Harbor, but higher than samples from Salem Harbor and Coastal Massachusetts.

5. Buzzards Bay quahogs contained less PCBs than quahogs in New Bedford Harbor.

6. Quahogs contained extremely low levels of PCBs, except near New Bedford Harbor. Since these are sedentary organisms, it is assumed that the clams are acquiring PCBs by filter-feeding contaminated food organisms and/or suspended sediments dispersing from New Bedford Harbor into the surrounding water column at a

relatively slow rate. In contrast to quahogs, lobster and flounder are migratory and prey upon benthic organisms, and therefore accumulated more PCBs directly from contaminated sediments and/or food organisms.

7. High Concentrations of PCBs sequestered in New Bedford Harbor sediments provide a continuous source of PCBs to fishery resources in Buzzards Bay regardless of the different specific pathways of exposure and accumulation for the three species analyzed in this study.

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EXTRACTION PROCEDURE

FOR PCBs (according to P.A.M. 212.13a)

Reagents:

Acetonitrile
Petroleum Ether
Saturated Salt Solution
Distilled Water
Florisil: 60-100 mesh; activated @ 650C stored at 130°C
Sodium Sulfate (anhydrous)

1. Add homogenized biota sample to blender jar. Approximate wet weight for different organisms is as follows:

lobster	25g
flounder	50-70g
striped bass	25-30g
bivalves	50-70g

2. Measure 200 ml acetonitrile in graduated cylinder and add to blender. Graduated cylinder remains with sample through extraction procedure.

   Note: When preparing spiked sample, add known standard to sample prior to blending using hexane rinsed pipette. Blanks receive identical treatment at all times.

3. Start blending at low speed for a few seconds, then set blender at high speed for one minute. Stop after one minute and scrape caked sample material on the sides of blender jar into the acetonitrile using a stainless steel spatula. Stir any caked material on the bottom of the blender with the stainless steel spatula. Resume blending for 1 minute, first at low speed for a few seconds, then at high speed.

   Note: Use individual stainless steel spatulas for each sample.

4. Pour entire contents of blender cup through a buchner funnel (containing no. 614 VWR filter paper, placed in buchner using clean tweezers) into a 500ml filter flask attached to an operating suction pump. Collect as much extract and sample material as possible from the blender jar using the stainless steel spatula. Allow sample to drip through the filter paper until dripping stops. Do not allow the sample to sit more than one minute.

   Note: Both the filter flask and the graduated cylinder remain with the sample throughout the extraction procedure.

5. Pour the extract into the graduated cylinder and record the volume. This volume is "F" in the adjusted wet weight calculations.

6. Pour extract into a 1L separatory funnel. Measure 100ml petroleum ether in a separate graduated cylinder. Pour the 100ml petroleum ether into the graduated cyclinder assigned to the sample to rinse any remaining sample residue. Add the 100ml petroleum ether to the 1L separatory funnel.

7. Vigorously shake the 1L separatory funnel for 90 seconds.

   Caution: Vent the separatory funnel once or twice after 1 or 2 initial shakes to relieve vapor pressure and repeat periodically while shaking.

8. Add 10ml of saturated salt solution to the 1L separatory funnel, followed by approximately 600ml distilled water. Distilled water is added by measuring approximately 350ml in the filter flask and 250ml in the graduated cylinder to rinse both pieces of glassware.

9. Hold separatory funnal horizontally and shake for 35 seconds. Remember to vent funnel periodically.

10. Allow phases to separate. Drain lower phase and watch for an emulsion. If an emulsion (foam) is present between phases, attempt breaking up the emulsion with a glass rod (use a separate glass rod for each sample). If emulsion still persists, proceed as follows:

    a. Add another 10ml saturated salt solution, after draining as much of the lower phase as possible without losing any emulsified material. Allow some time for the emulsion to disperse.
    b. Drain any water that has been released.
    c. Wash 4X with 100ml distilled water, draining lower phase each time.

11. Add 100ml distilled water to separatory funnel. Invert the separatory funnel, open stop cock (carefully!) and gently swirl for 5 seconds. Drain lower phase then repeat procedure with a second 100ml distilled water.

12. Drain lower phase from separatory funnel. Collect upper phase in a glass stoppered graduated cylinder. Record this volume, which is called "P" in the adjusted wet weight calculation.

    Note: Samples can be stored in a refrigerator at this step.

Column Chromatography Cleanup

1. Wearing dry disposable gloves, construct column by placing a glass wool plug, (handling the glass wool with tweezers and a glass rod) at the bottom of the column. Add 20g Florisil (cool to the touch) and approximately 1/2" of sodium sulfate. Rinse column with petroleum ether. Drain off excess petroleum ether but always leave 1/2" of petroleum ether covering the top of the column. (Do not let column go dry)

2. Connect a 10ml concentrator tube containing 4 glassbeads to a 500ml Kuderna-Danish (K-D) flask, and place under the column.

3. Before putting extract on the column, add sodium sulfate up to the 3-5ml mark of the glass-stoppered graduated cylinder. Invert the cylinder (keep your thumb on the stopper) and watch to see if all the sodium sulfate forms clumps. If so, add more sodium sulfate up to the 5-7ml mark and invert the cylinder. If all the sodium sulfate forms clumps, add more but do not exceed the 10ml mark on the graduated cylinder. Let the extract and sodium sulfate stand no less than 10 minutes but no more than 30 minutes before putting the extract on the column.

4. Adjust the flow rate on the column to approximately 5ml/min (or 1ml/12 seconds). As petroleum ether drains from top of column, carefully pour extract onto column. Do not let the column go dry. Adjust flow rate to approximately 5ml/min. (1ml/12 seconds).

5. Add 10ml of petroleum ether to the empty glass-stoppered graduated cylinder. When the last of the extract disappears from the top of the column, add the 10ml petroleum ether rinse

6. Repeat the 10ml graduated cylinder rinse 2X adding the rinse each time to the column.

7. After the last 10ml petroleum ether rinse disappears from the top of the column, rinse the column with petroleum ether using the teflon squeeze bottle, and add 170ml petroleum ether to the column. Collect all petroleum ether from the column in the K-D flask.

Sample Concentration

1. Remove the K-D flask concentrator tube from the column. Place a three ball snyder column on top of the K-D flask. Rinse the snyder column with a small amount of petroleum ether. Place the entire K-D flask assembly on a steambath. Steam-bath should be set at #7 or 80-85C. Strap down the K-D assembly with rubber bands. As the petroleum ether begins to boil, watch to see if the vapors are passing freely around the balls while the petroleum ether heats up in the snyder column. If not, tap the side of the snyder column to loosen the balls, otherwise vapor pressure will build up in the K-D flask and it could violently rupture (bump).

2. Concentrate the sample to 5-6ml. Remove the K-D assembly from the steam bath and rinse the snyder column with 1-2ml petroleum ether.

3. Disconnect the concentrator tube from the K-D flask when it is cool to the touch. Absorb moisture around the outer joint with a kimwipe. Allow the concentrator tubes to air dry.

   Note: Leaving the concentrator tube joined to the K-D flask for prolonged periods can result in frozen ground glass joints.

4. Bring total volume of sample in concentrator tube to 10ml with hexane. Cap the concentrator tube with a ground glass stopper and mix contents.

5. Transfer 1-2ml aliquots to autosampler vials using disposable pipettes that have been hexane rinsed and are dry. Make up 2 sample vials for each sample. Crimp and seal the vials. Store one in refrigerator in back up file. Store second vial in small beaker in refrigerator until G.C. analysis.

APPENDIX B

Buzzards Bay PCB Monitoring - Lobster

Date	Station #	Field #	Lab#	Carapace Length (cm)	Weight (gm)	PCB (ppm)
5/22/85	1	A-5	P903	87	530	1.50
	Lat. 41° 31.6'	A-17	P907	86	511	1.40
	Long. 70° 43.3'	A-19 [a]	P901	88	449	1.70
	Depth 8m	A-21	P902	89	569	0.90
	Temp. (btm) 13.0°C	A-22	P908	87	530	2.80
8/13/85	2	A-40	P909	93	568	1.20
	Lat. 41° 37.8'	A-41	P910	84	482	1.20
	Long. 70° 42.0'	A-42	P906	81	426	3.30
	Depth 14m	A-43	P904	85	482	1.10
	Temp.(btm) 23°c	A-44	P905	81	426	0.90
11/26/85	3	A-45	P934	88	511	0.20
	Lat. 41° 41.5'	A-46	P935	97	794	0.20
	Long. 70° 37.9'	A-47	P936	97	709	0.50
	Depth 3m	A-48	P937	98	766	0.10
	Temp.(sfc) 8.5°C	A-49	P938	89	539	0.30
	(btm) 8.5°C					
12/13/85	4	A-50	P959	83	454	0.60
	Lat. 41° 42.5'	A-51	P960	85	482	0.30
	Long. 70° 42.8'	A-52	P961	82	454	0.30
	Depth 5m	A-53	P962	88	511	1.00
	Temp.(btm) 5.7°C	A-54	P958	83	454	0.40
4/2/86	5	A-55	P986	84	482	0.92
	Lat. 41° 36.4'	A-56	P987	91	653	1.14
	Long. 70° 47.2'	A-57	P988	84	482	1.08
	Depth 8m	A-58	P989	83	482	0.75
	Temp.(btm) 7.0°C	A-59	P990	84	511	1.50
4/4/86	6	A-60	P991	83	482	0.32
	Lat. 41° 27.6'	A-61	P992	84	454	0.58
	Long. 71° 3.4'	A-62	P993	84	454	0.68
	Depth 8m	A-63	P994	85	482	0.40
	Temp.(sfc) 6.1°C	A-64	P995	82	454	0.79
	(btm) 5.5°C					
5/15/86	7	A-65	P1089	86	624	0.80
	Lat. 41° 32.1'	A-66	P1090	85	568	0.43
	Long. 70° 46.3'	A-67	P1091	93	794	0.40
	Depth 15m	A-68	P1092	82	511	2.28
	Temp.(sfc) 10.8°C	A-69	P1093	91	766	1.28
	(btm) 10.0°C					
5/22/86	8	A-70	P1094	87	596	1.57
	Lat. 41° 29.6'	A-71	P1095	93	681	0.53
	Long. 70° 52.6'	A-72	P1096	82	482	1.14
	Depth 14m	A-73	P1097	83	454	0.92
	Temp.(sfc) 15.6°C	A-74	P1098	87	482	0.79
	(btm) 12.5°C					

(sfc) = surface
(btm) = bottom
a. cull

APPENDIX C

Buzzards Bay PCB Monitoring - Winter Flounder

Date	Station #	Field #	Lab#	Length (cm)	Weight (gm)	PCB (ppm)
5/12/86	33	8691 BB33-1	P1132	35	487	0.59
	Lat. 41° 39'	8691 BB33-2	P1133	33	534	0.17
	Long. 70° 42'	8691 BB33-3	P1134	35	597	0.14
	Depth 8m	8691 BB33-4	P1135	38	690	0.91
	Temp.(sfc) 10.3°C	8691 BB33-5	P1149	41	944	0.58
	(btm) 10.2°C	8691 BB33-6	P1136	30	341	0.37
	[a]Sal. 29 o/oo	8691 BB33-7	P1137	34	450	0.68
		8691 BB33-8	P1138	35	499	0.71
		8691 BB33-9	P1150	37	709	0.13
		8691 BB33-10	P1139	32	462	0.16
		8691 BB33-11	P1151	31	401	0.41
		8691 BB33-12	P1140	32	385	0.20
		8691 BB33-13	P1141	31	427	0.08
		8691 BB33-14	P1142	29	337	0.19
		8691 BB33-15	P1152	26	235	0.41
		8691 BB33-16	P1131	31	363	0.54
5/12/86	34	8691 BB34-1	P1153	40	966	0.24
	Lat. 41° 45'	8691 BB34-2	P1154	29	297	0.31
	Long. 70° 43'	8691 BB34-3	P1155	33	481	1.18
	Depth 8m	8691 BB34-4	P1156	34	520	0.33
	Temp.(sfc) 10.4°C	8691 BB34-5	P1126	-	-	0.39
	(btm) 10.5°C	8691 BB34-6	P1157	31	480	0.18
	Sal. 29 o/oo	8691 BB34-7	P1158	31	414	1.12
		8691 BB34-8	P1127	37	653	0.46
		8691 BB34-9	P1159	37	716	0.76
		8691 BB34-10	P1160	35	645	0.32
		8691 BB34-11	P1143	33	427	0.33
		8691 BB34-12	P1144	35	576	0.88
		8691 BB34-13	P1145	31	380	0.30
		8691 BB34-14	P1146	30	361	0.19
		8691 BB34-15	P1147	36	522	0.31
		8691 BB34-16	P1148	31	363	0.96
5/13/86	41	8691 BB41-1	P1128	34	617	0.35
	Lat. 41° 31'	8691 BB41-2	P1129	33	520	0.75
	Long. 70° 51'	8691 BB41-3	P1130	37	742	0.13
	Depth 14m					
	Temp.(sfc) 10.5°C					
	(btm) 9.7°C					
	Sal. 30 o/oo					

- = field data not determined
(sfc) = surface
(btm) = bottom
a. All salinity data are surface measurements

APPENDIX D

Buzzards Bay PCB Monitoring - Quahog

Station & Field #	Lab #	Date	Location	Lat./Long.	[a] Temp. °C	Sal. o/oo	# In Composite	Size (mm) Range/Mean	PCB (ppm)
4	P1030	5/6/86	Ctr. Buttermilk Bay	41° 45.5'/70° 37'	10.0	-	14	50-80/62	0.01
5A	P1031	5/6/86	Onset Bay	41° 44' /70° 39'	-	-	21	53-90/72	0.01
6	P1032	5/7/86	Wareham Crab Cove	41° 45' /70° 42.5'	12.0	-	14	50-80/61	0.01
7	P1033	5/7/86	Wareham River	41° 44' /70° 43.5'	11.0	-	19	50-81/61	0.02
8	P1034	5/7/86	Weweantic River	41° 44' /70° 45'	12.0	-	11	50-76/61	0.01
9	P1035	5/7/86	Plant Is. Cove	41° 41.7'/70° 44'	-	-	20	52-94/71	0.01
11	P1036	5/7/86	Sippican Harbor	41° 42.7'/70° 45'	12.0	-	13	58-95/72	0.02
15	P1038	5/21/86	Red Brook Harbor	41° 40.5'/70° 37'	19.4	-	11	58-100/84	ND
16	P1039	5/21/86	Squeteague Harbor	41° 39.7'/70° 37'	21.1	-	27	56-90/72	ND
18	P1040	5/22/86	Mattapoisett Harbor	41° 38.8'/70° 49'	14.5	-	13	55-90/76	0.03
19	P1041	5/22/86	Quisett Harbor	41° 32.5'/70° 39.5'	14.5	-	24	50-88/65	0.02
20	P1042	5/22/86	Sippewissett Marsh	41° 35' /70° 39'	17.5	-	18	47-82/61	<0.01
21	P1043	5/22/86	Wild Hbr River	41° 38' /70° 39'	-	-	19	57-88/68	<0.01
22	P1107	5/28/86	Aucoot Cove	41° 40.5'/70° 45.2'	16.1	28	13	65-82/73	0.04
23	P1108	5/28/86	Pine Is. Pond	41° 39' /70° 47'	16.1	29	21	61-80/69	0.03
24	P1109	5/28/86	Brant Is. Cove	41° 38' /70° 49'	18.9	27	17	47-80/64	0.02
25	P1110	5/28/86	Little Bay	41° 38' /70° 51.8'	18.9	29	10	70-90/77	0.06
26	P1111	5/29/86	Pasque Island	41° 27' /70° 48.9'	15.0	30	10	52-94/75	0.01
27	P1112	5/29/86	Naushon Island	41° 31.8'/70° 42.7'	19.4	29	21	46-69/55	0.01
28	P1113	5/29/86	Nashawena Island	41° 26.2'/70° 53'	18.9	31	16	49-90/71	0.01
29	P1114	5/29/86	Cuttyhunk Pond	41° 25.5'/70° 55.5'	16.7	31	27	50-82/66	0.01
30	P1115	5/30/86	East Cove, West Is.	41° 35.7'/70° 49.5'	15.0	30	12	58-75/67	0.10
31	P1116	5/30/86	Apponagansett River	41° 35.5'/70° 57.2'	19.4	25	16	58-80/67	0.20
32	P1117	5/30/86	Little River	41° 35.5'/70° 58.3'	17.8	28	16	55-89/71	0.08
33	P1118	5/30/86	Slocums River	41° 32' /70° 59'	18.9	26	11	65-100/77	0.07
34	P1119	5/30/86	Westport River	41° 31' /71° 4.5'	17.8	29	12	54-103/72	0.05
35	P1120	6/4/86	Taylor Point	41° 44.3'/70° 37.8'	16.1	30	12	50-80/63	0.01
36	P1121	6/4/86	Phinney's Harbor	41° 43' /70° 37.8'	17.8	30	15	53-105/69	0.01
37	P1122	6/4/86	Barlow's Landing	41° 41.5'/70° 37.8'	17.8	28	20	53-72/64	0.03
38	P1123	6/4/86	W. Falmouth Harbor	41° 36.4'/70° 38.8'	17.2	27	15	46-67/56	0.01
39	P1124	6/6/86	Bourne Cove	41° 43.8'/70° 41.3'	19.4	27	10	59-85/75	0.01
40	P1125	6/6/86	Salter's Pond	41° 31.8'/70° 57.4'	17.2	31	12	56-92/64	0.08

ND = not determined
- = field data not determined
a. All temperature and salinity data are surface measurements