RETURN TO 1998 ROD AR INDEX

Superfund Records Center
SITE: [illegible]
BREAK: 17.7.5
OTHER: 274582

SDMS DocID 274582

WALL
P.C.B's

17.7.5

missing pgs:
2, 4, 8

POLYCHLORINATED BIPHENYL (PCB) ANALYSES OF MARINE ORGANISMS IN THE NEW BEDFORD AREA, 1976-1980

By

Andrew Kolek
Marine Fisheries Biologist

and

Russell Ceurvels
Chief of Laboratory

January, 1981

Commonwealth of Massachusetts
Division of Marine Fisheries
100 Cambridge Street
Boston, MA 02202

PUBLICATION: #12265 - 36 - 100 - 1 - 81 - CR

APPROVED BY: John Manton, Acting State Purchasing Agent

ACKNOWLEDGEMENTS

This report is the compilation of many people's work. John DerHovanesian and DMF staff at Cat Cove Marine Laboratory analyzed samples for PCB content and coordinated analyses' reports from other laboratories. Most field samples were collected by DMF's South Shore Area Team. Past and present members include: Thomas Currier, Ray Heintz, Lawrence Furrer, Patricia Rule, Kenneth Reback, Napoleon Holmes, Deborah Udall, and James Emerald. Numerous other staff members of DMF and area fishermen collected samples during the study. Finished tables and figures were prepared by Thomas Currier. Bruce Estrella provided computer assemblage of the lobster data. Eleanor Bois and Marie Callahan typed the manuscript. Shirley Mitchell and Lewis Emerald operated the R/V F.C. WILBOUR during field sampling operations. We extend special thanks to Robert Lawton for his constructive comments and criticisms in revising the manuscript to its present form.

INTRODUCTION

Polychlorinated biphenyls (PCB's) are highly stable compounds which have been found to be toxic to man and other animals (Weimer et al. 1976). In recent years, their presence in the environment has elicited the concern of several government regulatory and health agencies. PCB's are known to have been utilized by three companies in Massachusetts. The General Electric Corporation, located in Pittsfield, has discharged PCB's into the Housatonic River. Aerovox Corporation and Cornell-Dubilier Corporation, both located in New Bedford, discharged PCB's into the Acushnet River from 1947-1976 and 1942-1976, respectively (E. Wong pers. comm.)[1].

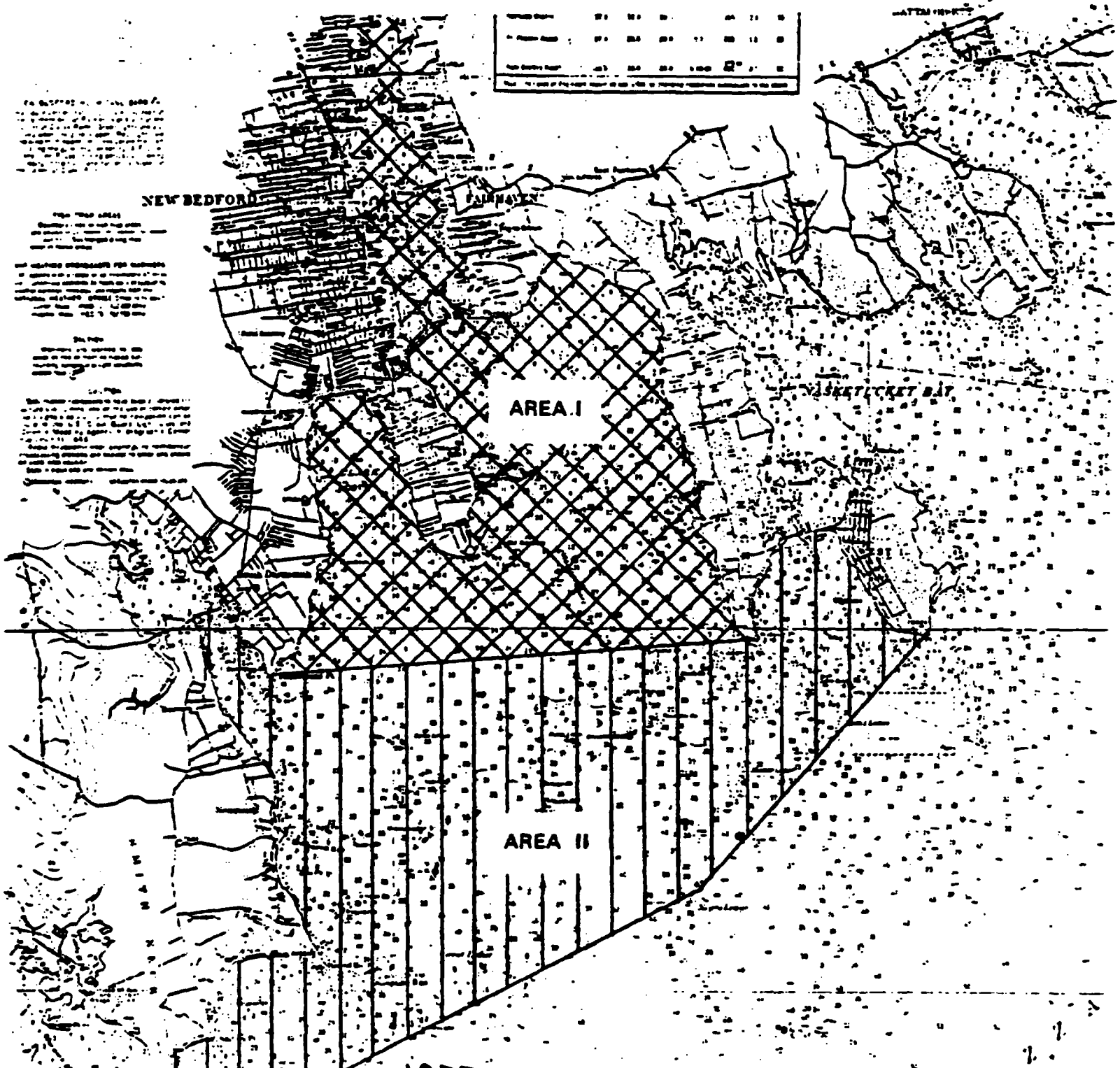
In September, 1976, the Massachusetts Division of Marine Fisheries (DMF) began to analyze finfish, shellfish and crustaceans in New Bedford area waters for PCB content. Sampling was not part of a pre-designed program but was activated as a response to requests from other government agencies for information on PCB levels in edible fish from the area.

On March 8, 1977, the Massachusetts Department of Public Health (DPH) issued a warning that bottom feeding finfish from a portion of Buzzards Bay adjacent to the Acushnet River (Figure 1), should not be consumed as they contain PCB's in excess of the 5 ppm Federal Action Level (FAL). On June 2, 1977, a second warning was issued relative to consuming lobsters. Analysis of additional samples taken from 1977-1979 resulted in a DPH closure of this area on September 25, 1979 (Figure 2). The closed area was divided into three sections. Area 1 was closed to the taking of all finfish, shellfish, and lobsters; Area 2 to the taking of bottom feeding finfish (eels, scup, flounder

[1]Edward Wong, Malacologist, U.S. Environmental Protection Agency, Lexington, MA 02173.

Figure 1.

MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH



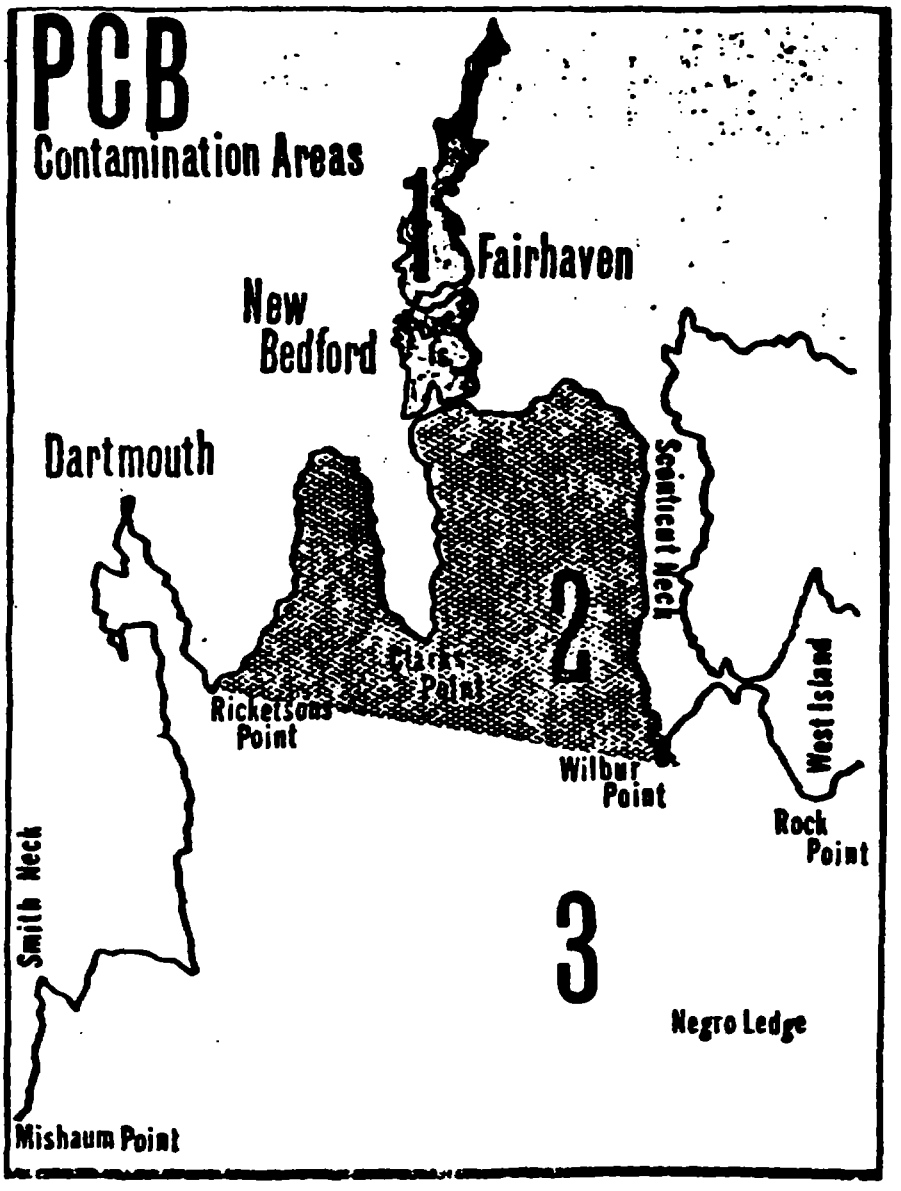
1977

HEALTH WARNING KEY For Recreational Fishermen

AREA I — Bottom feeding fish, shellfish and eels not to be eaten from these waters because of PCB contamination.

AREA II — Bottom feeding fish not to be eaten from these waters because of PCB contamination.

2/26



Areas subject to PCB closures include (1) waters closed to all fishing activities, (2) waters closed to lobstering and fishing for bottom feeding finfish, and (3) waters closed to lobstering only.

New Bedford Standard Times 9/26/79.

Figure 2.
1979 Closure

graph analysis. The DMF's Cat Cove Laboratory employed a Tracor MT 220 gas chromatograph, the Lawrence Experimental Station of the Department of Environmental Quality Engineering employed a Perkin Elmer gas chromatograph, and the United States Food and Drug Administration's Boston Laboratory utilized a Tracor 560 gas chromatograph. Analyses were performed following the FDA procedure found in Pesticide Analytical Manual, Volume 1, Section 212.13a. This procedure has a sensitivity of <0.1 ppm.

The three laboratories also split and analyzed six samples as a means of comparing instruments and techniques. The mean of all the samples was 5.0 with a standard error of 0.7.

STUDY AREA

Study area boundaries and site locations are shown in Figure 3. Areas 1, 2, and 3 are described in the DPH closure notice (Appendix 1). For the purposes of this report, the region outside of the closure has been designated Area 4. Sites A and M are adjacent to the Aerovox and Cornell-Dubilier discharges, respectively. Site V is the New Bedford sewage outfall. The presence of PCB's in the sewage effluent and sediment adjacent to the outfall pipe indicate that this is also a source of contamination (Camp Dresser and McKee, Inc., 1979). The spoil area depicted in Figure 3 was utilized in 1953 for the deposit of spoil taken from New Bedford inner harbor and in 1962 and 1966 for spoil dredged from the outer harbor.

RESULTS AND DISCUSSION

PCB levels by species are listed in Tables 1 and 2. In general, organisms

Table 1. Concentrations in ppm, of PCB's in the New Bedford area finfish and shellfish species (except lobster) at all sites.

Species	Area	Site	Date	PCB (ppm)
Winter flounder, *Pseudopleuronectes americanus*	1	G	9/23/76	6.0
	2	LL	9/23/76	5.6
	3	EE	9/23/76	2.6
	2	BB	9/23/76	11.0
	4	FF	9/23/76	11.0
	3	GG	9/23/76	5.6
	1	I	9/23/76	13.0
	2	LL	7/10/79	7.5[a]
	1	MM	8/23/79	8.1[b]
	3	BBB	10/16/79	0.2
	3	CCC	10/16/79	1.6
	3	CCC	10/16/79	0.9
	3	DDD	10/16/79	0.8
	3	EEE	10/16/79	0.6
	3	FFF	10/16/79	0.5
	3	FFF	10/16/79	0.5
	3	GGG	10/16/79	0.8
	3	HHH	10/16/79	1.0
	3	HHH	10/16/79	0.2
	2	Q	6/10/80	3.8
	3	AAA	6/10/80	1.1
	3	AAA	6/10/80	1.0
	2	LL	6/10/80	0.0
	3	FFF	6/10/80	5.9
Striped bass, *Morone saxatilis*	2	KK	4/28/77	0.4
	2	KK	5/ 5/77	0.5
	2	KK	5/ 6/77	3.0
	2	S	5/20/77	2.7
Bluefish, *Pomatomus saltatrix*	2	KK	5/21/77	1.0
	2	KK	5/21/77	1.6
	2	S	8/30/79	16.5
	2	S	8/30/79	1.4
American eel, *Anguilla rostrata*	1	H	7/10/79	24.0[c]
	2	Q	7/10/79	38.0
	1	A	7/11/79	460.0
	1	A	7/11/79	730.0
	1	A	7/11/79	670.0
	1	A	7/11/79	430.0
	1	A	7/11/79	430.0

a. Composite sample of 3 flounder.
b. Composite sample of 5 flounder.
c. Composite sample of 3 eels.

Table 1. Continued

Species	Area	Site	Date	PCB (ppm)
Tautog, *Tautoga onitis*	3	AAA	10/16/79	0.3
	3	AAA	10/16/79	0.8
	3	AAA	10/16/79	0.1
	2	II	6/10/80	1.1
	2	LL	6/10/80	0.2
	3	GGG	6/10/80	0.9
	3	GGG	6/10/80	1.1
	3	GGG	6/10/80	0.7
	3	GGG	6/10/80	0.7
	2	Y	6/10/80	4.6
	2	Z	6/10/80	0.8
	2	Z	6/10/80	0.1
Silver hake, *Merluccius bilinearis*	2	U	9/23/76	0.7
Red hake, *Urophycis chuss*	3	EEE	10/16/79	0.1
Fourspot flounder, *Paralichthys oblongus*	3	AAA	6/10/80	0.8
Cunner, *Tautogolabrus adspersus*	2	U	9/23/76	20.0
Black sea bass, *Centropristis striata*	3	III	10/ 4/79	0.4
Butterfish, *Peprilus triacanthus*	4	QQ	9/23/76	0.3
Blue crab, *Callinectes sapidus*	2	M	8/14/79	4.2[n]
	1	G	8/16/79	4.2[o]
	1	A,B,&C	9/23/76	1.0[p]
	1	G	9/23/76	5.6
Soft-shelled clam, *Mya arenaria*	1	D	9/23/76	53.0
	1	E	9/23/76	21.0
	1	F	9/23/76	22.0
	1	F	8/16/79	14.6
Oyster, *Crassostrea virginica*	1	NN	8/16/79	15.8
Quahog, *Mercenaria mercenaria*	2	Q	9/23/76	1.3
	2	DD	9/23/76	0.2
	2	CC	9/23/76	0.2
	3	AA	9/23/76	0.5
	2	Z	9/23/76	0.4

n. Composite sample of 5 blue crabs.
o. Composite sample of 4 blue crabs.
p. Three sites sampled.

Table 2. Concentrations of PCB's in New Bedford area lobsters, *Homarus americanus*.

Area	Site	Date	PCB (ppm)
2	T	3/16/77	7.9
2	T	3/14/77	1.2
2	T	5/ 6/77	9.3
2	T	7/ 6/78	2.7
2	T	7/ 6/78	9.0
2	T	7/ 6/78	1.7
2	T	7/ 6/78	2.5
2	T	7/ 6/78	1.4
2	T	7/ 6/78	1.0
2	T	7/ 6/78	2.7
2	T	7/ 6/78	1.7
2	T	7/ 6/78	1.4
2	T	7/ 6/78	1.4
2	T	7/ 6/78	1.7
2	T	4/20/79	2.0
2	T	4/20/79	20.6
2	T	4/20/79	8.7
2	T	4/20/79	6.1
2	T	8/ 8/79	68.2
2	S	3/14/77	2.2
2	S	5/ 6/77	6.3
2	S	7/ 6/78	3.5
2	S	7/ 6/78	5.4
2	S	7/ 6/78	2.2
2	S	7/ 6/78	3.7
2	S	4/20/79	17.0
2	S	8/ 8/79	15.4
2	R	3/18/77	3.1
2	R	5/ 6/77	11.7
2	R	5/ 6/77	8.2
2	R	7/ 6/78	4.7
2	P	3/16/77	1.0
2	Q	4/20/79	15.6
2	Q	4/20/79	7.6
2	Q	4/20/79	1.1
2	Q	4/20/79	0.8
2	Q	8/16/79	31.1
2	Q	8/16/79	30.3
2	Q	8/16/79	23.8
2	Q	8/16/79	26.6
2	M	8/16/79	63.4
2	M	8/16/79	27.4
3	HH	3/17/77	2.1
3	HH	5/ 6/77	5.8
3	HH	8/14/79	11.6
3	HH	8/14/79	12.4
3	RR	10/ 5/79	10.6

Table 2. Continued

Area	Site	Date	PCB (ppm)
4	OOO	12/14/79	3.4 *
4	OOO	12/14/79	3.4 *
4	NNN	12/19/79	5.2 *
4	NNN	12/14/79	5.2 *
4	NNN	12/14/79	5.2 *
4	QQQ	12/14/79	2.0 *
4	QQQ	1/18/80	2.0 *
4	PPP	12/14/79	4.8 *
4	PPP	1/22/80	4.8 *
4	PPP	1/22/80	4.8 *
4	PPP	1/22/80	4.8 *
4	RRR	1/18/80	7.2 *
4	RRR	1/18/80	7.2 *
4	SSS	12/19/79	2.2 *
4	SSS	1/18/80	2.2 *
4	SSS	1/18/80	2.2 *
4	SSS	1/18/80	2.2 *
4	SSS	1/18/80	2.2 *

Eels

Eels have contained the highest PCB levels of all species tested. Three factors contribute to this phenomenon: 1) eels spend most of their adult life (5-20 yrs) in the same water body (Fahay 1978); 2) they are chiefly nocturnal and often lie buried in the mud during the daytime (Bigelow and Schroeder 1953). Their activity is reduced as water temperature declines and they spend most of the winter burrowed in the mud in direct contact with the PCB-laden sediment; 3) their body tissue is comprised of 26% fat (Tesch 1977). This is approximately 10 times higher than the average fat content of other species tested. Fat provides the principal storage site for PCB compounds, which are lipophilic (Nimmo et al. 1971b).

Winter flounder

Over the four-year testing period, most winter flounder collected from Areas 1 and 2 have contained PCB concentrations exceeding the FAL. The PCB levels, however, are substantially lower than those found in eels. Of note, there is an apparent reduction in the average contamination levels since 1976 (Table 3). A factor possibly contributing to the elevated levels in winter flounder is the animal's habit of lying buried in the substrate except when actively feeding or migrating (Bigelow and Schroeder 1953). In addition, flounder spend their entire first year of life in the estuary. Most adult fish leave the estuary in the spring after spawning and migrate to cooler water, returning to the estuary in autumn. However, Howe et al. (1976) found that approximately 20% of the flounder up to age IV pass the summer in the estuary.

Bluefish

During 1979, one bluefish was found to contain 16.5 ppm of PCB. However, the average level of the other three bluefish analyzed was only 1.3 ppm. The bluefish is a migratory pelagic species, generally traveling in like-size groups (Wilk 1977). Although it is caught in New Bedford outer harbor from May-October, temporal size range of sportfish catches indicate that most fish remain in the area no longer than four to five weeks before moving elsewhere (R. Lawton pers. comm.)[2]. Test results from other locations in the state are all below the FAL.

Other finfish

Striped bass, silver hake, and butterfish were never found to contain PCB's which exceeded the FAL.

Shellfish

The distribution of shellfish is such that all oysters and soft-shell clams were taken from Area 1 and all quahogs from Area 2. One would suspect that these shellfish dwelling on or in the substrate and feeding at the sediment-water interface would have a high PCB content. This was true of soft-shell clams and oysters (Table 1). However, quahogs contained relatively low amounts of PCB's. Only one sample exceeded 2 ppm concentration (Table 1). This may be attributed to the very low fat content of the quahog (0.9%), as listed in Gibbons (undated), when compared to soft-shell clams (1.9%) and oysters (1.8%) and lower level of PCB contamination in Area 2 sediment.

[2]R.P. Lawton, Senior Marine Fisheries Biologist, Massachusetts Division of Marine Fisheries, Sandwich, MA 02563

fall fishing, according to Stewart, was the result of immigration from deeper water in conjunction with a second mass molt.

The task of examining the data for possible trends in PCB levels is confounded by seasonal movements of lobsters in an out of the study area. Furthermore, daily movements may expose each lobster to contact with varying amounts of PCB's. The rate of uptake of PCB's in lobsters has not been investigated. Studies conducted on other crustaceans indicate that PCB uptake may be rapid (Nimmo et al. 1971a; Sanders and Chandler 1972). Nimmo et al. (1974) found that the shrimp (Palaemonetes pugio) concentrated PCB's within a few days of exposure. Following exposure to water containing 0.17 ppb PCB for 7 days, the test shrimp were found to contain in excess of 1200 ppb PCB. However, further testing revealed that up to 90% of the PCB content per individual was depurated within four weeks following the cessation of exposure treatments.

Table 2 lists PCB levels of the 111 lobsters analyzed. During the study period lobsters with PCB concentrations exceeding the FAL were sampled at most sites. The present closure boundaries do not appear to extend beyond the region of contamination. Nevertheless, only 30% of the samples collected from Area 3 in 1980 exceeded the FAL compared to 70% in 1979.

Furthermore, no contaminated lobsters were found in three of the five southernmost sampling locations (Figure 3), i.e., sites UU, ZZ, and EE. Only one contaminated lobster was sampled at sites VV and YY, respectively. Since the aforementioned sites were only sampled in 1979 and 1980, additional data are needed to determine the appropriateness of the spatial delimitation of the closed area.

Because of the importance of the local lobster fishery, data were subjected to greater scrutiny than the previous species discussed. Table 4 lists

average PCB levels for each sampling year by area. The reason for the high average values in 1979 is unknown. Forty-two percent of the total lobster samples were collected that year. It was found that the high readings obtained from the 1979 sampling, greatly influenced pooled data averages when assembled by sex, size, or season. Examining the variables within an individual year is more enlightening.

Average PCB content by area was the only consistent pattern observed. For each year where data exist, the highest average readings were recorded from Area 2 followed by Areas 3 and 4, respectively. It is reasonable to assume that lobsters taken from Area 2 accumulate at least some PCB's from their immediate environment. Limited sediment analyses undertaken by DMF and Camp Dresser and McKee, Inc. (1979) indicate that PCB's are present in Areas 1 and 2. A possible PCB contamination source in Areas 3 and 4 is the "spoil area" (Figure 3). Sediments from this site have not been analyzed.

Data found in Table 5 suggest that with an increase in size of lobsters taken from Area 2 during 1978 and 1979, there is an increase in the average PCB level. Non-migratory lobsters who are older and larger animals would have been exposed to PCB's for a longer period of time and might be expected to contain higher PCB levels. However, the large difference between 1978 and 1979 concentrations intimate that some factor in addition to exposure time has an influence on PCB uptake.

Analyses of average PCB levels grouped by sex (Table 5) and season (Table 6) do not reveal any apparent trends. Utilizing Wilcoxon's signed rank test, differences in average PCB content between sexes were found not to be statistically significant. Gaps in the data record when grouped by season preclude the use of statistical analysis.

Table 6. Average PCB concentrations, in ppm, for lobsters in areas 2, 3, and 4 during each season for each year. Numbers of individuals in parenthesis.

Season	Year	Area 2	Area 3	Area 4
3/1 - 6/30	1977	5.7 (9)	4.0 (2)	
	1978			
	1979	3.3 (3)		
	1980		3.0 (15)	
7/1 - 9/30	1977			
	1978	2.9 (16)		
	1979	36.2 (3)	12.0 (2)	
	1980		3.6 (12)	
10/1 - 12/31	1977			
	1978			
	1979		3.5 (13)	3.3 (11)
	1980			4.0 (11)

Appendix 1.

The Commonwealth of Massachusetts
Department of Public Health
600 Washington Street
Boston 02111

JONATHAN E. FIELDING, M.D., M.P.H.
Commissioner

Drew Kolet-
H.

CONTACT: Pat Mazza 727-2660
2661

FOR RELEASE - Tuesday, March 8, 197[illegible] - AM

Public Health Commissioner Dr. Jonathan Fielding today requested that bottom feeding fish, shellfish and eels not be taken for eating from the Acushnet River area for health reasons. This area extends north of a line between Pickletson's Point to Wilbur Point.

Fielding made this request after reviewing the results of a recent state survey that revealed the presence of Polychlorinated Biphenyls (PCB) in that area which is a recreational fishing area -- not commercial.

The survey revealed that fish in the Acushnet River -- an area that has been closed to shellfish taking for many years because of bacterial pollution -- have been affected by PCB contamination.

PCBs have been used in industrial production and were deposited in the river over the past 10 years. They are no longer being deposited. The fish in this area have been found to have PCB levels that exceed the Federal standard for food.

Fielding noted that the specific health effects of PCBs are not totally known to date, but that it could cause serious illness if ingested frequently over an extended period of time. He continued, "This problem really affects the recreational fisherman who fishes in this river area and then [illegible] home and freezes the catch to

eat over a period of time. This sport fisherman and his family could ingest a fair amount of PCB over a period of time." "With this in mind," Fielding continued, "I am now issuing a health warning to recreational fishermen not to eat shellfish, bottom feeding fish and eels from this area."

Fielding is also extending a health warning to recreational fishermen not to eat bottom feeding fish from the area just beyond the Acushnet River area, north of a line running from Wilbur Point to Gong "3" on Hursett Rock to Rocky Point on West Island. Samples taken from this area showed bottom feeding fish to have elevated PCB levels.

Fielding noted, "These affected areas are used for recreational fishing. There is no commercial fishing in either of these areas for which I have issued health warnings. This fact has been further verified by no increased PCB levels found in fish samples at commercial landings and in the marketplace."

The Department of Public Health will continue to monitor the fish at commercial landings and in the markets as a further precaution.

The Department of Environmental Quality Engineering and the Division of Marine Fisheries have done the sampling and laboratory testing on the fish, shellfish and crustaceans in these waters for PCB determinations. According to DEQE Commissioner David Standley, they will continue the monitoring efforts.

State health and environmental officials have met with legislators and community representatives of the affected areas in advance of issuing these health warnings.

Appendix 2. Compiled by John Farrington, WHOI.

PCB Analysis.

Results of samples taken in New Bedford Harbor and Buzzards Bay analyzed by Massachusetts State and U.S. Federal Labs.

Sediment				Aroclor 1254, 10^{-6} g/g Dry Wt. Laboratory[1]					
Date	Sample	Location	Site	C.C.	L.E.S.	E.P.A.	F.D.A.	W.H.O.I.	S.M.U
5/10/76	Sediment (Composite Grab)	Acushnet River	ARS-10	—		620			
			HBS-4	—		143			
			HBS-5	—		2			
			HBS-6	—		0.5			
9/23/76	" "	" "	E	85		47			
			HU	88		75			
			J	18		61			
			MM	23		22			
9/23/76		Outer Harbor	K	0.5		70			
			LL	—		4			
			JJ	0.16		0.3			
5/10/78	Cores Avg. 0-6 cm	Acushnet River Inner Harbor	1		9.0				
			2		3.0				
			3		3.5				
			4		4.6				
			5		5.9				
			6		5.1				
			7		26.0				
			8		17.1				
			9		13.4				
			10		2.4				
			11		4.5				
			12		5.3				
			12A		9.8				
			13		8.6				
			14		2.7				
			15		7.2				
			16		7.0				
			17		7.9				
			19		7.4				
			20		5.2				
		Outer Harbor	22		7.2				
			22A		7.6				
			23		0.4				
6/73	Sediment Grab	Outer Harbor	—					8.4	
6/79	Core 0-4 cm	" "	23					0.2/0.3*	
5/73	Composite Grab	Buzzards Bay	14 Sta.						0.07 to 0.54

*Results indicate 10^{-6} g/g dry wt. of Aroclor 1242/1254.

Laboratory Identification:

C.C. — Massachusetts Division of Marine Fisheries, Cat Cove Marine Laboratory.

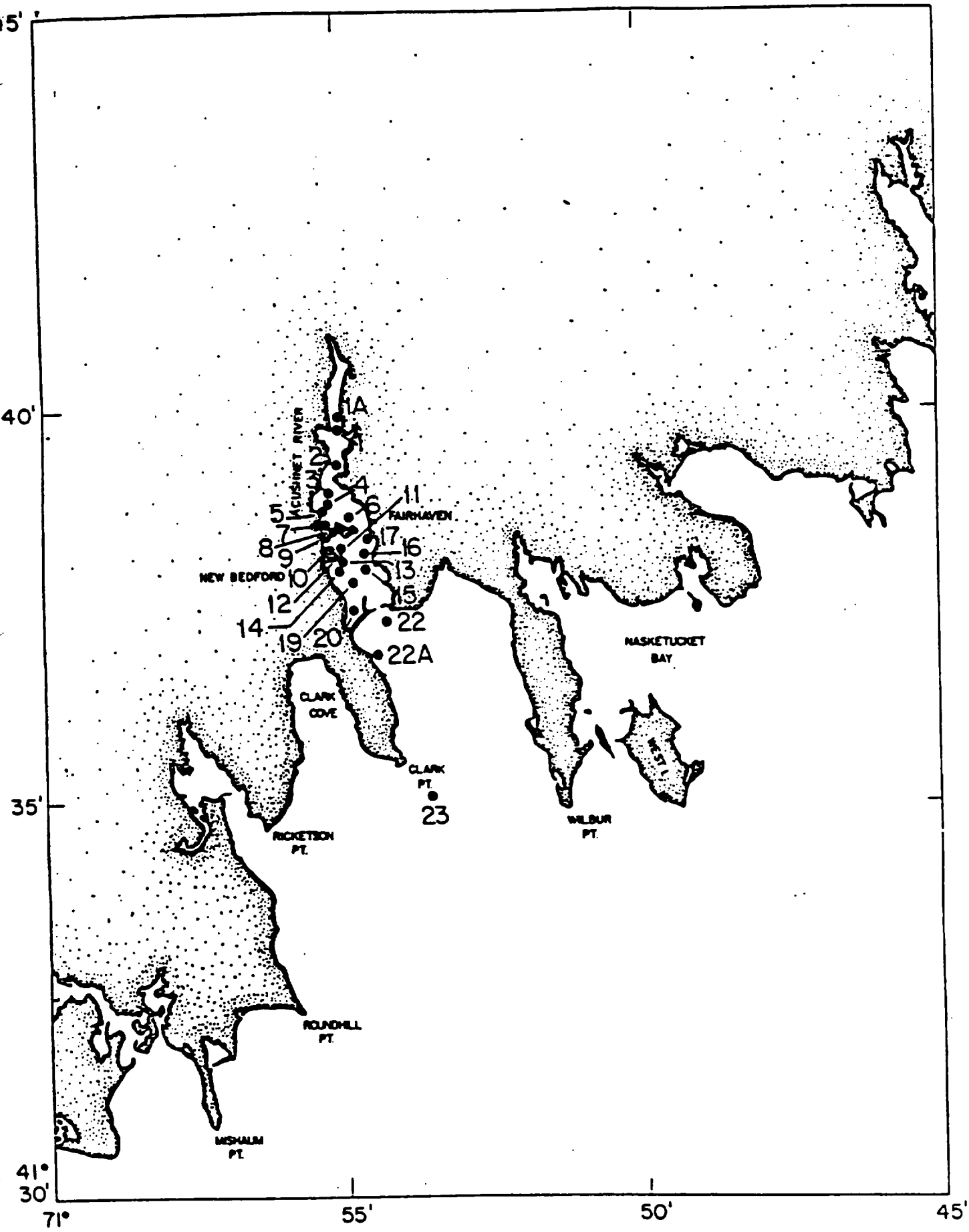
L.E.S. — Massachusetts Department of Environmental Quality Engineering, Lawrence Experimental Station.

E.P.A. — U.S. Environmental Protection Agency, Florida Lab.

F.D.A. — U.S. Food & Drug Administration, Boston Lab.

W.H.O.I. — Woods Hole Oceanographic Institution.

S.M.U. — Southeastern Massachusetts University.


45'
40'
35'
41°
30'
71°
55'
50'
45'
1A
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
19
20
22
22A
23
KLUSHNET RIVER
FAIRHAVEN
NEW BEDFORD
CLARK COVE
CLARK PT.
RICKETSON PT.
WILBUR PT.
NASKETUCKET BAY
ROUNDHILL PT.
MISHAUM PT.

LITERATURE CITED (Continued)

Nimmo, D.R., R.P. Blackman, A.J. Wilson, and J. Forester. 1971a. Toxicity and Distribution of A 1254 in the Pink Shrimp, Panaeus duorarum. Mar. Biol. 11:191-197.

_____, P.D. Wilson, R.P. Blackman, and A.J. Wilson. 1971b. Polychlorinated Biphenyls Absorbed from Sediments by Fidler Crabs and Pink Shrimp. Nature 231:50-52.

_____, J. Forester, P.T. Heitmuller, and G.H. Cook. 1974. Accumulation of Aroclor 1254 in P. pugio in Lab and Field Exposures. Bull. of Environ. Contain. and Tox. 11(4):303-308.

Sanders, H.J. and J. Chandler. 1972. Biological Magnification of a PCB (Aroclor 1254) from Water by Aquatic Invertebrates. Bull. of Env. Contam. and Tox. 7(5):257-263.

Stewart, L.L. 1972. The Seasonal Movements, Population Dynamics, and Ecology of the Lobster, Homarus americanus (Milne-Edwards), off Rain Island, Connecticut. Ph. D. thesis, Univ. of Conn., Storrs.

Summerhayes, C.P., J.P. Ellis, P. Stoffers, S.R. Briggs, and M.G. Fitzgerald. 1977. Fine-grained Sediment and Industrial Waste Distribution and Dispersal in New Bedford Harbor and Western Buzzards Bay, Massachusetts. Woods Hole Ocean. Inst. Tech. Rept. No. 76-115.

Tesch, F.W. 1977. The Eel, Biology and Management of Anguillid Eels. Chapman and Hall Ltd., London. 434 pp.