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PCB and Metal Concentrations in American Lobsters from the Acushnet River Estuary and Long Island Sound

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The American lobster, Homarus americanus, is commonly found in coastal waters adjacent to heavily industrialized areas where pollutant input generally occurs. Environmental contamination is known to affect many aspects of lobster biology (Mercaldo-Allen and Kuropat in press). Heavy metals, pesticides, pulp mill effluent, petroleum hydrocarbons and other pollutants can adversely affect lobster physiology and behavior (Cooper and Uzmann 1980). Sublethal concentrations of contaminants can stress lobsters, making them more susceptible to disease or other conditions that would normally be tolerated (Aiken and Waddy 1986). Lobster embryos and larvae, particularly the first-stage, are sensitive to a variety of organic and metal pollutants (Phillips and Sastry 1980; Aiken and Waddy 1986).

Sediments in New Bedford Harbor, Massachusetts, are heavily contaminated with polychlorinated biphenyls (PCBs); edible tissues of lobsters collected there have been found to contain PCB concentrations exceeding the FDA action level of 2 μg/g wet wt (Metcalf and Eddy 1981; Prince 1986). PCBs are strongly lipophilic and accumulate in fatty tissues including egg masses (Metcalf and Eddy 1981). Metals and PCBs are contaminants of concern in Long Island Sound (Greig and Sennefelder 1985). This study examines whether field exposure of ovigerous female lobsters to PCBs results in subsequent contamination of embryos, first-stage larvae, postlarvae, and juvenile offspring of "berried" lobsters from New Bedford Harbor and selected locations in Long Island Sound. Metal contamination in the embryos and offspring of Long Island Sound lobsters was also measured.

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MATERIALS AND METHODS

During 1985 and 1986, ovigerous lobsters were trap-collected from the Acushnet River estuary adjacent to New Bedford Harbor, Massachusetts. In 1988, the focus was shifted to Long Island Sound where lobsters were trap-collected near Milford, New Haven Harbor, and Penfield Reef, off Bridgeport/Fairfield, Connecticut. Rye, New York replaced Bridgeport as a collection site for 1989. Collections were made from February through April. Lobsters were assigned identifying tag numbers and held at the NMFS Laboratory in Milford, CT., in recirculating, refrigerated seawater tanks at 9°C to delay hatching.

In Long Island Sound, release of larvae into the water column begins in late May and early June, when ambient seawater temperatures approach 15°C. At this time, ovigerous females were removed from the recirculating tanks as needed and placed into individual glass aquaria with flowing ambient seawater. Hatching occurred over several days; larvae were collected throughout each day and placed into planktonkreisels which received flowing sand-filtered seawater at ambient temperature and salinity. Larvae were fed frozen San Francisco Bay Brand[1] brine shrimp up to three times per day. Planktonkreisels were cleaned three times per week at which time the larvae were dipped in deionized fresh water for 1 minute as a preventative against disease (Syslo pers. commun.).

Upon molting to the postlarval stage, the lobsters were moved to individual rearing containers for growth. The lobsters were held in sand-filtered flowing seawater in either 500-μm (15 x 15 x 13 cm deep) or 250-μm (15.6 x 13.1 x 13.8 cm deep) mesh Nitex screen bags. Each bag was suspended from a styrofoam float in one of four 4 x 6 ft fiberglass tanks. A submersible pump in each corner of the tank ensured adequate water circulation. Holding bags were cleaned one to three times a week. Juveniles were fed frozen brine shrimp daily for two months, followed by a diet of fresh blue mussels, clams, bits of flounder flesh, crab legs, and frozen krill. The juvenile lobsters

[1] The use of trade names does not imply endorsement by NOAA/NMFS.

were reared at ambient temperature and salinity for a minimum of 180 and a maximum of 220 days.

Embryos, first-stage (all years), postlarvae (1985 only), and juveniles (1986, 1988 only) from each female were sampled. One to three grams of embryos were removed from each female upon capture, placed in a hexane-rinsed vial, and frozen at -20°C until analyzed. Upon hatching, first-stage lobsters were similarly sampled. In 1985, approximately twenty-five postlarval lobsters per female were pooled for analysis (0.6 to 0.8 gm pooled weight). During 1986, one to five juvenile lobsters from each female were sampled individually at the conclusion of the growth period. For 1988, two juvenile offspring from each female were sacrificed for PCB determinations. PCBs in tissues were analyzed using the saponification method described in Stout and Beezhold (1979) and measured by gas liquid chromatography (Perkin-Elmer model Sigma 300) using a packed column of 3% OV17 on gas chrom WHP (100-120) mesh (Greig and Sennefelder 1987). A standard of Aroclor 1254 was used for comparison. The detection limit for PCB using this procedure was 0.02 μg/g.

For 1988 and 1989, one gram of embryos were removed from each female and frozen in acid-washed polyethylene containers to determine copper, cadmium, lead, and chromium concentrations. A similar quantity of first-stage larvae was also collected for metals analysis. Four juvenile lobsters from each female were sampled during 1988 after the growth period. Metal analyses were conducted by graphite furnace atomic absorption spectrophotometry (Perkin-Elmer model 2380, HGA 400 furnace, AS-40 autosampler) using a nitric acid/hydrogen peroxide digestion procedure (Greig et al. 1982). An inhouse reference material (oyster homogenate) was used between batches. The detection limits were determined using 3 times the average blank.

RESULTS AND DISCUSSION

Elevated concentrations of PCBs were measured in embryos and offspring of lobsters collected in New Bedford Harbor, Massachusetts (Table 1) and may reflect extensive contamination of sediments. PCBs were present, but at much lower levels, in lobsters from Long Island Sound (Tables 1 and 2). PCB was most concentrated in the embryos,

was measured at a reduced level in the newly hatched first-stage larvae and occurred in very small amounts in the postlarvae and juveniles.

Table 1. PCB concentrations (μg/g wet wt) in embryos and offspring of American lobsters from the New Bedford Harbor area of the Acushnet River Estuary and from Milford in Long Island Sound.

Site	Tissue	Mean	Min.	Max.	N
Milford	Embryos	1.56	0.51	2.80	13
1985	Stage-1	0.54	<0.03	1.30	6
	Postlarv	<0.10	<0.09	0.02	5
New	Embryos	11.2	2.10	29.3	11
Bedford	Stage-1	3.93	0.54	11.4	7
1985	Postlarv	<0.16	<0.13	0.30	3
Milford	Embryos	1.36	0.68	1.90	10
1986	Stage-1	0.40	0.30	0.50	4
	Juveniles	0.03	0.02	0.05	6
New	Embryos	9.68	3.90	16.6	12
Bedford	Stage-1	3.66	2.60	4.90	5
1986	Juveniles	<0.03	<0.02	0.09	12

In contaminated striped bass embryos and larvae, a consistent reduction in PCB body burden was shown to occur over the first month of life. This was attributed to dilution of parentally contributed PCB as tissues increased in size during rapid larval growth (Westin et al. 1983). A similar decline in measured PCB burden was observed in this study through the progressive developmental stages. Levels were highest in the embryos, declined by the first-stage, and reached low levels in postlarvae and juveniles, reflecting perhaps the significant increase in size which occurs during the first six months of the lobster's life. PCB may be depurated or metabolized from the tissues over time or may be removed from the body as the old shell is cast off during molting. The young lobsters molted several times during the growth period.

Copper concentrations from Long Island Sound samples were high, ranging from 172 to 227 μg/g dry wt in embryos, but were reduced considerably to 24.9-27.9 μg/g in juveniles (Table 3). Hepatopancreas

Table 2. PCB concentrations (μg/g wet wt) in embryos and offspring of American lobsters from four sites in Long Island Sound.

Site	Tissue	Mean	Min.	Max.	N
Bridgept.	Embryos	2.42	1.10	4.40	15
1988	Stage-1	0.34	0.22	0.46	7
	Juveniles	0.05	0.03	0.05	4
Milford	Embryos	1.59	0.57	2.60	28
1988	Stage-1	0.35	0.25	0.46	11
	Juveniles	0.04	0.03	0.06	7
New	Embryos	1.74	1.10	2.4	18
Haven	Stage-1	0.51	0.09	1.69	7
1988	Juveniles	0.04	0.03	0.05	3
Milford	Embryos	3.58	1.09	9.12	11
1989	Stage-1	3.29	0.07	10.7	8
New	Embryos	1.08	0.12	2.21	16
Haven	Stage-1	5.16	1.80	9.00	5
1989					
Rye	Embryos	1.43	0.28	3.46	14
1989	Stage-1	0.80	0.10	2.6	7

copper concentrations in adult lobsters from Long Island Sound have been measured at 5 to 7 times the levels found at locations north of Cape Cod (Engel pers. commun.).

High copper burden in embryos and first-stage larvae is noteworthy since Johnson and Gentile (1979) found that larval lobsters demonstrate twice the sensitivity to copper of adults (McLeese 1974).

A 96-hr LC50 of 48 μg/L was measured for first-stage larvae at 20°C (Johnson and Gentile 1979) and an LT50 of 56 μg/L at 5 and 13°C was determined for adults (McLeese 1974). Adult mortality due to copper exposure increased with warmer temperatures (McLeese 1974). Wilder (1952) exposed adult lobsters to wooden tanks floored with sheets of copper; all of the animals died within 18 hrs of exposure.

Table 3: Copper concentrations (μg/g dry wt) in embryos and offspring of American lobsters from four sites in Long Island Sound.

Site	Tissue	Mean	Min.	Max.	N
Bridgept.	Embryos	220	164	257	5
1988	Stage-1	148	93.5	201	7
	Juveniles	24.9	22.2	27.1	4
Milford	Embryos	227	153	353	20
1988	Stage-1	180	120	244	13
	Juveniles	27.9	24.3	30.7	7
New	Embryos	200	151	239	5
Haven	Stage-1	160	120	204	6
1988	Juveniles	25.8	25.2	26.6	3
Milford	Embryos	203	139	384	13
1989	Stage-1	132	89.3	154	7
New	Embryos	172	132	229	19
Haven	Stage-1	110	90.5	130	4
1989					
Rye	Embryos	175	105	309	16
1989	Stage-1	127	107	147	4

Copper has been shown to affect lobster chemoreception. The chemosensory response of lobsters to herring muscle extract, applied for 3 minutes, was reduced by simultaneous presentation of copper at 4 to 80 times the lethal threshold (McLeese 1975). This reduction

resulted from an attempt to avoid or escape the copper. Exposure of adult lobsters to 0.7 to 1.8 times the lethal threshold of copper for 48 hrs caused a gradual reduction in chemosensory response.

Embryos, first-stage, and juvenile offspring from Long Island Sound females contained mean cadmium concentrations of <0.66 μg/g (dry wt) and mean lead concentrations of <4.12 μg/g (dry wt). Although chromium concentrations were variable, embryos and offspring from all of the study sites contained mean concentrations below 6.09 μg/g (dry wt).

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