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Polychlorinated Biphenyls in Blue Crabs from South Carolina

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The blue crab (Callinectes sapidus Rathbun) is one of the most valuable fishery resources in South Carolina. Blue crabs ranked fifth (1984) and fourth (1985) in economic value behind shrimp, swordfish, oysters (1985) and hard clams (1984), but first in terms of total weight both years. Total landings have exceeded $2x10^6$ kg/yr.

Blue crabs are important members of the estuarine food web due to their numbers and their multiple roles as scavengers, predators and prey. Also of great importance is the blue crab's ability to tolerate wide variations in salinity and its consequent omnipresence throughout the estuaries up to and beyond the water's edge. Because of their omnivorous feeding characteristics, wide distribution and close association with bottom sediments, the potential exists for blue crabs to bioaccumulate pollutants residing in those sediments (Duke et al. 1970) as has been shown for fiddler crabs (Clark et al. 1986). It follows that human health risk upon consumption of such crabs and biomagnification through the food web become primary concerns.

During the spring of 1985, commercial crab fishermen in Beaufort County, South Carolina contacted the South Carolina Wildlife and Marine Resources Department (SCWMRD) concerning their perceptions of significantly declining catch rates in the Campbell Creek-Whale Branch area. Using knowledge of previously documented elevated polychlorinated biphenyls (PCB) levels in the sediments of the upper portion of Campbell Creek (Marcus et al. In press), the SCWMRD initiated analysis of crab tissue from the area to ascertain the body burdens of PCBs. Initial screening results indicated potentially significant levels of PCBs in blue crabs at which time, SCWMRD contacted the SC Department of Health and Environmental Control (SCDHEC) for more intensive study and definition of the situation. The subsequent work reported here was conducted between June and October 1985.

MATERIALS AND METHODS

Legally harvestable ($\geq$12.7 cm in carapace width) blue crabs were

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collected from baited commercial-style traps deployed over one-half of a tidal cycle (about 6 hours) at Stations 2, 3 and 4 (Figure 1). Initial screening by SCWMRD used backfin and claw meat from crabs removed with stainless steel microspatulas and clam knives washed in pesticide-grade hexane. All hepatopancreatic material was carefully avoided. Samples were extracted immediately after weighing with pesticide-grade methanol, followed by solid phase extraction on C-8 extraction columns. Samples were then analyzed on a Tracor 540 gas chromatograph using an electron capture detector (ECD) and a 2m x 0.25 in x 2mm packed column with 1.5% OV-17 and 1.95% OV-202 on Chrom W-HP 100/120 packing. Analyses were conducted isothermally at 200°C.

The expanded study conducted by SCDHEC used backfin and somatic muscle tissue from crabs harvested at Stations 1-8 (Figure 1). The claws, carapace and hepatopancreatic material was removed using stainless steel scissors and forceps rinsed with pesticide-grade isopropanol before breaking the body into halves. The exposed backfin tissue was extracted from the shell with clean stainless steel scissors and forceps rinsed with pesticide-grade isopropanol. Caution was taken to avoid contamination of backfin tissue and instruments with any residual hepatopancreatic material. Twenty grams of homogenous tissue were extracted with 190 ml of 10% ethyl ether/90% petroleum ether and concentrated by water bath. The extract volume was restored to 5.0 ml with 50% methylene chloride/50% n-hexane and loaded into the sample loop of the GPC for clean-up. Subsequently, the purified extracts were concentrated to a volume of 0.5 ml and then restored to 1.0 ml. Analysis was performed on a Tracor Model 560/565 gas chromatograph using a 63 Ni ECD. A Supelco port (100/120 mesh) coated with 1.5% SP 2250/1.95% SP 2401 packed column was used at 200°C isothermal. Ten percent of the samples were replicated while spiked samples were processed with each batch run. Mean recoveries were approximately 90%.

RESULTS AND DISCUSSION

The initial response by SCWMRD to concerns of local commercial crabbers documented the presence of PCBs in the backfin tissue of crabs from the Campbell Creek area (Table 1). Preliminary screening showed that levels generally formed a gradient pattern, with higher levels observed nearer an existing wastewater treatment facility outfall and lower levels measured farther away from the outfall. The presence of PCBs in the sediments of Campbell Creek had been confirmed previously as a result of industrial activities associated with the wastewater treatment facility (Marcus *et al.* In press). Sediment concentrations ranged from 24.2 mg/kg (dry weight) at the outfall (Station 2) to <0.010 mg/kg at the mouth of Campbell Creek (Station 4).

The detection of PCBs in a commercially-important species resulted in concerns over the distribution of PCBs in the area and in any associated implications for harm to the resource. These concerns were addressed by SCDHEC through an expanded reconnaissance of

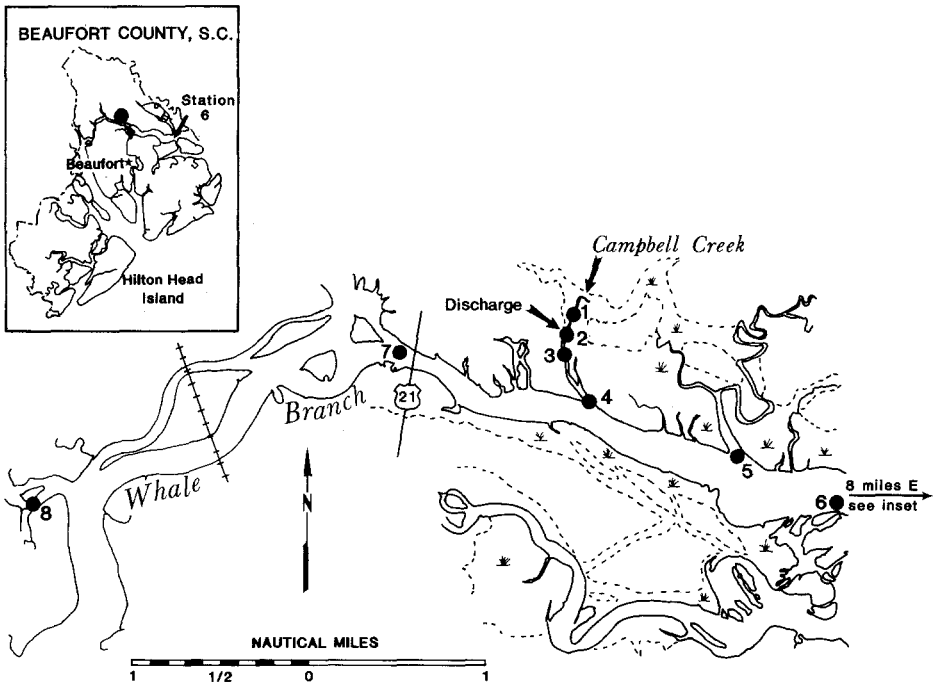

Figure 1. Station locations for blue crab-PCB study in Beaufort County, South Carolina

crab tissue in the Campbell Creek area and measurement of PCB levels in crabs from 16 sites along the coastline of the State.

The expanded reconnaissance confirmed the elevated PCB levels in crabs from Campbell Creek, but indicated much lower levels from the surrounding area (Table 2). The highest mean total concentration was 0.861 mg/kg from immediately at the outfall structure with somewhat lower concentrations of 0.227 mg/kg and 0.158 mg/kg

Table 1. Levels of PCBs (mg/kg, wet weight) in blue crab backfin and claw tissue from Campbell Creek, Beaufort County, South Carolina taken in initial screen by SCWMRD.

Station	Total PCBs Range	Number of Crabs	Sampling Period
2	1.26 - 7.73	7	June - October 1985
3	0.26 - 2.79	8	July - October 1985
4	< 0.20 - 0.81	9	July - October 1985

measured 100 m north and 300 m south of the outfall, respectively. Once at the mouth of Campbell Creek, concentrations decreased dramatically there and at all other locations except Station 8, with mean total levels ranging from 0.026 mg/kg to 0.228 mg/kg. The portion of Campbell Creek with the highest mean tissue concentration (Station 2) was also the area of highest sediment levels.

Table 2. Levels of PCBs (mg/kg, wet weight) in blue crab backfin and somatic muscle tissue from Campbell Creek and surrounding area, Beaufort County, South Carolina taken during an expanded study on October 10, 1986 by SCDHEC.

Station	Total PCBs[a]		Aroclor 1248[a]		Aroclor 1254[a]	
	Mean	SE	Mean	SE	Mean	SE
1	0.227	0.040	0.083	0.016	0.144	0.033
2b	0.361	0.129	0.422	0.087	0.439	0.056
3	0.158	0.068	0.074	0.033	0.084	0.036
4	0.059	0.030	0.026	0.005	0.047	0.018
5b	0.042	0.021	<0.020	0.000	0.042	0.021
6b	0.026	0.005	<0.020	0.000	0.026	0.005
7	0.101	0.080	0.059	0.038	0.057	0.036
8	0.228	0.135	0.030	0.009	0.212	0.144

a. SE = standard error; n=3
b. Station 2 significantly higher than stations 5 and 6 ($p < .05$; Kruskal-Wallis H test)

The expanded sampling effort indicated that the PCB contamination of crab tissue was a near-field effect in Campbell Creek related to the off-marsh industrial facility operations. This was confirmed by results from the sampling of 16 different sites along the coastline (Table 3). PCBs were detected in backfin tissue at only 5 of 16 stations with concentrations ranging from 0.095 mg/kg to 0.372 mg/kg. The Coosaw River and Whale Branch stations exhibited concentrations of <0.020 mg/kg which generally corresponded to Stations 5 and 6 of the expanded study (0.042 mg/kg and 0.026 mg/kg, respectively). Eisenberg and Topping (1984) reported levels up to 0.08 mg/kg in blue crabs from the Chesapeake Bay. Crabs from the Hudson River have contained 0.16 mg/kg to 0.29 mg/kg (NYDEC 1981). These data suggest that while PCBs are present in the tissue of blue crabs over a wide area, higher tissue levels can be related to a known source and likely bounded to a limited geographic area. No discrete or mean levels approached the recommended action level of 2.0 mg/kg (USFDA 1984).

Other than human exposure to contaminated crab tissue via diet, the potential influence of these levels on the organisms themselves should be considered. Little information exists in the literature on PCB toxicity to blue crabs, although this species is known to bioaccumulate PCBs from water and sediment (Nimmo *et al.*

Table 3. Levels of PCBs in blue crab backfin and somatic muscle tissue (mg/kg, wet weight) and sediments (mg/kg, dry weight) from the coast of South Carolina.

Location	Total PCBs	
	Tissue[a]	Sediment[b]
Little River Inlet	<0.020	0.129; <0.010
Murrells Inlet	0.134	<0.010; <0.010
North Inlet	0.095	<0.010; <0.010
Winyah Bay	<0.020	<0.010; <0.010
S. Santee River	<0.020	<0.010; <0.010
Bulls Bay	<0.020	<0.010; <0.010
Wando River	<0.020	<0.010; 0.622
Charleston Harbor	<0.020	<0.010; <0.010
Stono River	0.175	<0.010; <0.010
S. Edisto River	<0.020	<0.010; <0.010
Coosaw River	<0.020	<0.010; <0.010
Whale Branch	<0.020	<0.010; <0.010
Trencharas Inlet	<0.020	<0.010; <0.010
Broad River	<0.020	<0.010; <0.010
May River	0.372	<0.010; <0.010
Savannah River	0.123	<0.010; <0.010

a. one composite sample of n=15 from 1986
b. 1985 sample; 1986 sample

1975). Clark et al. (1986) have shown that fiddler crabs (Uca pugilator and U. minax) bioaccumulate a much lower level of PCBs from sediment exposure (bioaccumulation factors (BAFs) of 0.19 to 1.07) than would be expected from water exposure (BAFs of 10^4 to 10^5 based on fishes and invertebrates). Vernberg et al. (1977) have reported a 96 hour static LC50 of 10 ug/l for U. pugilator larvae exposed to Aroclor 1254. While no specific toxicity information regarding PCBs and blue crabs was located, plausible inferences made using toxicity data from other crab species and the known peristence of PCBs are certainly reasons for concern.

This investigation resulted in additional monitoring and investigative activities at the associated industrial facility. A more complete definition of the PCB contamination at that site was accomplished with amelioration pursued via the NPDES permit process and other regulatory/administrative procedures. Any current input of PCBs to the estuarine system has been halted, leaving accumulations in the sediments as the source of concern. However, the much lower BAFs from sediment exposure relative to water exposure and the slow movement of PCBs in sediment if undisturbed has allowed for careful planning to address the situation in an environmentally-sound manner.

Overall, the PCB levels measured in blue crabs from the Campbell Creek area appeared to fall within the ranges observed in South Carolina and elsewhere. The exception to this was those crabs collected from the area of Campbell Creek where the highest sediment concentration of PCBs existed. The detection and measurement of a pollutant or pollutant suite in the environment is a realistic warning for further investigation. However, the presence of a pollutant may not result directly in measurable ecological impact (Long 1985). Thus, the necessity remains for direct examination of the biota from both an ecological and a resource standpoint (Mathews and Marcus 1986). Through cooperation of the two State agencies established for these purposes (SCDHEC-ecological; SCWMRD-resource), this objective of a healthy biota is being pursued with efficiency.

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