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Effects of Aroclor 1254 and No. 2 Fuel Oil, Singly and in Combination, on Predator-Prey Interactions in Coho Salmon (*Oncorhynchus kisutch*)

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In a previous paper (FOLMAR et al. 1981), we presented evidence that the seawater soluble fraction of Cook Inlet Crude oil impaired the ability of adult coho salmon (Oncorhynchus kisutch) to capture prey. In the present study we examined the effects of No. 2 fuel oil on the same predator-prey interaction. Since aquatic organisms under natural conditions are simultaneously exposed to more than one toxicant (MALINS and COLLIER 1981), we also evaluated the effects of fuel oil plus polychlorinated biphenyls (PCBs), which are common xenobiotics in the marine environment and potentially hazardous to the biota.

METHODS AND MATERIALS

Experimental fish were obtained from the following sources: coho salmon from Domsea Farms at Gorst, WA. and rainbow trout (Salmo gairdneri) fry from Trout Lodge, Tacoma, WA. The trout fry were 3.2 ± 0.3 cm ($\bar{X}$ ± S.D.), while the coho predators were 28.0 ± 5.2 cm in fork length. The trout fry were maintained (fed to satiation) on a diet of Oregon Moist pellets (OMP). The coho salmon predators were maintained on OMP until four weeks prior to the experiments, from which time they were fed exclusively on live rainbow trout fry (10 fish/day).

The experiments were conducted during September, 1981. For these studies, the coho predators were randomly divided into 18 groups of 3 fish each. Four of the groups were non-injected controls, 3 groups were injected with salmon oil carrier, 4 groups were injected with PCB in salmon oil, 3 groups were exposed to fuel oil in seawater and 4 groups were injected with PCB in salmon oil and then exposed to fuel oil.

Seven days prior to fuel oil exposure, fish receiving PCB were injected with a single intraperitoneal (ip) injection of 150 g/kg Aroclor 1254 in a salmon oil carrier. The fish injected with the salmon oil-only received a single 100 µl ip injection. All the salmon were freeze-branded for identification (FUJIHARA & NAKATANI 1967).

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Circular fiberglass tanks (1.2 m diameter, 55 cm deep, capacity of 600 L) were used for holding, fuel oil exposure, and the predator-prey evaluations. Seawater inflow rates to the circular tanks provided for a 95% exchange within 24 h. Water samples were collected twice weekly during the experimental period and analyzed for total hydrocarbon content (MacLEOD et al. 1976, MALINS et al. 1980) and for water quality properties. The total hydrocarbon concentration in the inflowing seawater during the fuel oil exposure was determined to be 800 $\pm$ 170 µg/L ($\bar{X} \pm$ S.D.) by gas chromatography. Properties of the water in both the control and exposure tanks were as follows ($\bar{X} \pm$ S.D.): salinity, 28.4 $\pm$ 1.4 o/oo; temperature, 13.9 $\pm$ 0.7 °C; pH, 7.7 $\pm$ 0.2; and dissolved oxygen, 6.0 $\pm$ 0.3 mg/L (APHA STANDARD METHODS 1975).

Predator-prey interactions were observed for each of the groups at 3, 10 and 17 days after the initiation of the oil exposure. The methods of observation have been previously described (FOLMAR et al. 1981). Liver samples (n=3) were collected from each predator group after the 17th day predator-prey evaluations and analyzed for PCB and hydrocarbon content (MALINS et al. 1980). Statistical methods were those of SOKAL & ROHLF (1969).

RESULTS

Most of the fish subjected to the fuel oil treatment began to show behavioral modifications after 5 days of exposure. Those fish showing the behavioral changes were, in general, lethargic and did not attempt to capture the prey presented to them (Figure 1). Statistical analysis showed that there were significant differences ($P \leq 0.05$, G-test) in the number of prey consumed between the control and treatment groups at all three sampling periods (3,10,17 days).

PCB content of the livers from fish sacrificed at the termination of the predator-prey evaluations were as follows ($\bar{X} \pm$ SEM, n=3); control, 63 $\pm$ 8 µg/kg; carrier-injected, 44 $\pm$ 13 µg/kg; PCB injected, 329 $\pm$ 98 µg/kg; oil exposed, 58 $\pm$ 21 µg/kg; PCB injected plus oil exposed 309 $\pm$ 83 µg/kg. Concentrations of all hydrocarbons detected by gas chromatography were significantly higher ($P \leq 0.05$ ANOVA) in the livers of the fish exposed to fuel oil only than in the fish which were injected with PCB seven days prior to the fuel oil exposure. The highest hydrocarbon concentrations detected were those of the naphthalenic compounds (Table 1).

DISCUSSION

Our studies have shown that exposure to No. 2 fuel oil, Aroclor 1254 or both substances in combination significantly impaired the capturing of prey by coho salmon predators (Figure 1). Since both xenobiotics alone greatly reduced the predatory behavior of the coho, it was not possible to determine whether

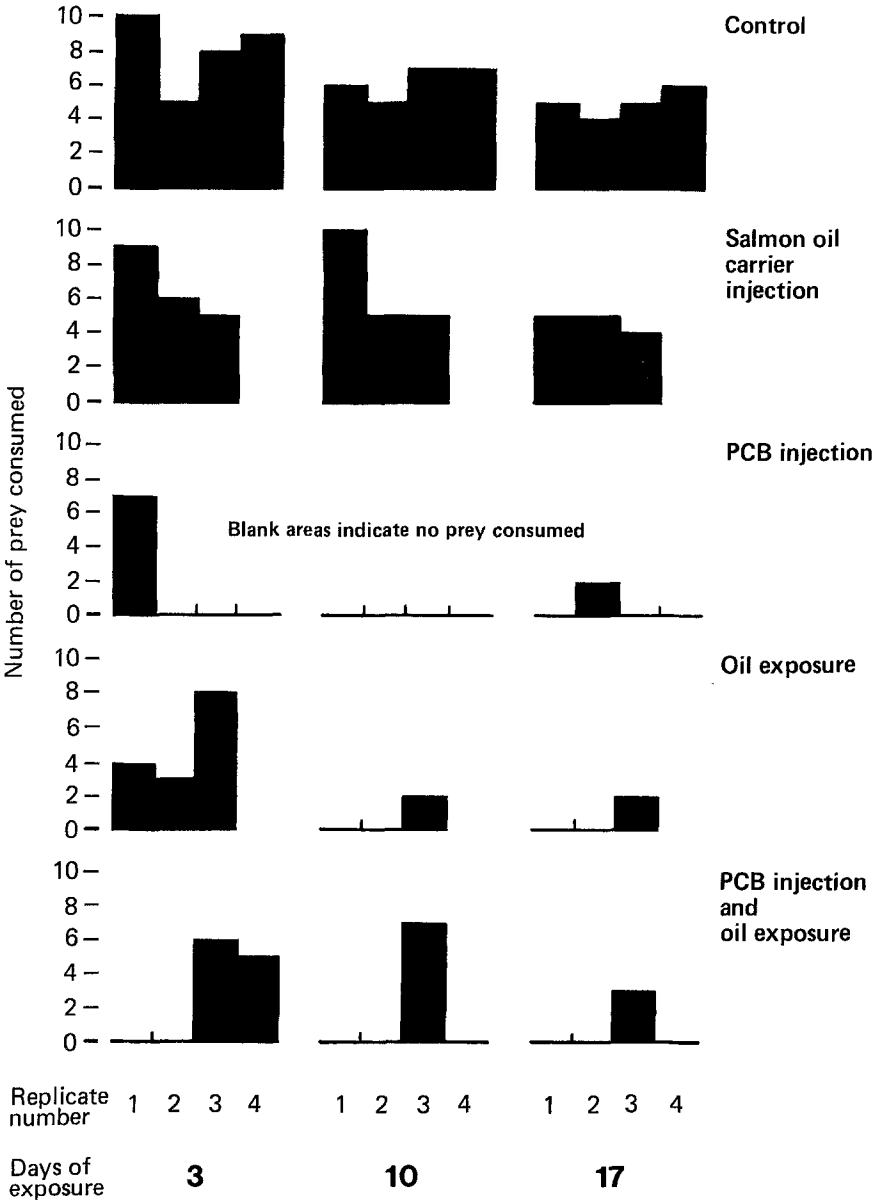

Figure 1. Ten rainbow trout fry were offered to each of the replicates in the 5 experimental groups of coho salmon after 3, 10 and 17 days of oil exposure. The histograms represent the number of prey consumed by each of the groups at the 3 sampling periods. Each numbered subgroup represents the same 3 predators throughout the experiment. Absence of a bar represents no prey consumed.

TABLE 1. Concentrations of hydrocarbons(g/kg, X±S.D.,n=3) detectable by gas chromatography in the livers of fuel oil-treated and PCB-injected plus fuel oil-treated coho salmon predators.

CHEMICAL	OIL ONLY	PCB+OIL
1,2,3,4-Tetramethylbenzene	174±79	65±20
Naphthalene	233±55	119±22
2-Methylnaphthalene	1190±276	480±26
1-Methylnaphthalene	550±95	237±23
2,6-Dimethylnaphthalene	650±174	290±60
Acenaphthalene	142±18	<3.8
1,3,5-Trimethylnaphthalene	307±110	133±30
Fluorene	173±49	87±4
Dibenzothiophene	83±45	<4.2
Phenanthrene	79±30	<4.1

there was an interaction between the two. One subgroup (3) of the PCB plus fuel oil exposure group continued to feed throughout the experiment. This observation may have been related to the "eater" and "noneater" phenomenon we previously observed in coho salmon after exposure to crude oil (FOLMAR et al. 1981).

Hydrocarbon concentrations were greater in the livers of fish exposed to fuel oil only than in fish injected with PCB prior to fuel oil exposure (Table 1). In a study using rainbow trout, EGAAS & VARANASI (1982) found that benzo(a)pyrene (BaP) was metabolized at a higher rate by liver extracts from fish previously injected with PCB than by liver extracts from fish receiving corn oil injections only. This suggests that the lower hydrocarbon burdens in the group receiving both treatments in our study may have resulted from increased activity of the mixed-function oxygenase system, induced by PCB injections prior to the fuel oil exposure.

In another study we exposed yearling coho salmon (same age class as the coho predators) to PCB and fuel oil under the same test conditions as those to which the predators in the present study were exposed, except the latter fish were fed OMP not live prey. In this study there were no significant differences among the groups in food consumption or in growth during the six week test period. These observations suggest that exposure to PCB or fuel oil do not simply suppress appetite, but directly affect behavior (capturing of prey), since the xenobiotic-exposed fish continued to eat pelleted food at the same rate as the controls.

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