

Acknowledgments

David G. Smith, Marine Research, Inc., Woods Hole, Mass., identified the specimens. Equipment and facilities were furnished by the University of Maine, Orono, Maine. P. C. Jensen operated the RV *Cypris*. Research funds for this and associated research were provided by the Maine Yankee Atomic Power Company.

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CHLORINATED HYDROCARBONS IN SEA-SURFACE FILMS AND SUBSURFACE WATERS AT NEARSHORE STATIONS AND IN THE NORTH CENTRAL PACIFIC GYRE

Chlorinated hydrocarbons, DDT residues, and polychlorinated biphenyls (PCB's) entering the oceans via atmospheric transport, runoff, and outfalls (National Academy of Sciences 1971) may be concentrated in the lipid constituents (Garrett 1967; Duce et al. 1972) found in surface films. The chlorinated hydrocarbons can then enter marine food chains, most probably by association with particulate detritus and subsequent ingestion by filter-feeding organisms. Further concentration in higher trophic levels is well documented (see, for example, Harvey et al. 1971) and will not be discussed here.

There have been only two reported studies on the concentration of DDT residues and PCB's in surface films. Seba and Corcoran (1969) found high concentrations of *p,p'*DDT, *p,p'*DDE, *o,p'*DDT, aldrin, and dieldrin in the surface microlayer collected at locations in Biscayne Bay, Fla., and 10 miles offshore in the Florida Strait. Duce et al. (1972) found that PCB's (but no DDT residues) were concentrated in surface films from Narragansett Bay, R.I. Seawater collected at 1-2 m in the California Current was analyzed for DDT residues (Cox 1971) and these results will be taken as subsurface water concentrations in California coastal waters.

This note reports on the content of *p,p'*DDT, *p,p'*DDE, and PCB's in surface films collected at coastal stations off southern California and Mexico; and in surface films, subsurface waters, and particulate matter from the North Central Pacific Gyre (Table 1).

Methodology

All surface films were collected with a Monel¹ or stainless steel screen (Garrett 1965) into 2.5-liter glass bottles. The coastal samples (SIO 1-2; M 1-4) were poisoned with mercuric chloride. The Cato samples were filtered on shipboard through solvent-extracted and ignited GF/C glass-fiber filters. The filters were frozen in glass vials at -20°C, and the filtrate preserved with 75 ml of hexane. Subsurface samples were collected in 2.5-liter glass bottles 10-15 cm below the surface and treated as above. In all operations the surface films were collected from a skiff at least 0.5 mile upwind from the ship. All glassware, screens, filters, etc., were scrupulously freed of organic matter by ignition at 550°C, rinsing with double distilled solvents, or both.

In the laboratory, the filtrates were acidified to pH 2 with distilled 6N HCl and extracted with three 60-ml portions of hexane. The hexane extracts were dried by passage through anhydrous Na₂SO₄, and then concentrated to 10-15 ml in a Kuderna-Danish evaporator. This extract was further reduced to 50 μl in vacuo, put onto an alumina microcolumn (McClure 1972), and eluted with 3.5 ml of hexane. The eluate was dried in vacuo and taken up in 50 μl of isoctane. The filters were extracted in a soxhlet overnight with 20 ml of

¹Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

TABLE 1.—Sample locations, collection dates, and sea conditions.

| Sample number and description | | Sample location | Collection date | Sea conditions |
|-------------------------------|---|---|-----------------|---------------------------|
| SIO-1 | Surface film | Off SIO Pier | 7-July-71 | Calm. Moderate film |
| SIO-2 | Surface film | Off SIO Pier | 7-July-71 | Calm. Moderate film |
| ² M-1 | Surface film | Lat. 21°30'N, long. 108°30'W Mouth of Gulf of Calif. | 23-Oct.-71 | Calm. No visible film |
| M-2 | Surface film | Lat. 19°10'N, long. 104°30'W 4 mi. off Manzanillo | 25-Oct.-71 | Calm. Well-developed film |
| M-3 | Surface film | Lat. 17°37.2'N, long. 101°33'W Zihuatenejo Harbor | 28-Oct.-71 | Calm. Slight film |
| M-4 | Surface film | Lat. 16°49'N, long. 99°53'W 1 mile off Acapulco | 30-Oct.-71 | Calm. Slight film |
| Cato I-4 | Surface film filtrate and filter | Lat. 31°51.9'N, long. 127°25.0'W | 10-June-72 | Calm. No visible film |
| | Subsurface water filtrate and filter | California Current | | |
| Cato I-A1 | Surface film filtrate and filter | Lat. 30°59.1'N, long. 155°24.0'W | 27-June-72 | Choppy. No visible film |
| | Subsurface water filtrate and filter | North Central Pacific Gyre | | |
| Cato I-A2 | Surface film filtrate and filter | Lat. 31°1.8'N, long. 155°25.8'W | 29-June-72 | Choppy. No visible film |
| | Subsurface water filtrate and filter | North Central Pacific Gyre | | |

¹Scripps Institution of Oceanography.²Mexico.

a 50:50 acetone-hexane solution, the extracts dried over anhydrous Na₂SO₄, and dried in vacuo. The residues were taken up in 50 μl of hexane and treated identically as the above water samples.

Aliquots of the isoctane solutions were injected into a Hewlett-Packard model 5750B gas chromatograph equipped with a Ni⁶³ electron capture detector and a 6-foot glass column packed with either 1.5% OV-17 and 1.95% QF-1 or 5% SP2401 on 100/200 mesh Supelcoport. Column temperature was 195°C. An alkaline (KOH, NaOH) precolumn for saponification of DDT residues was used to give confirmatory identification (Miller and Wells 1969). Retention times and peak heights were compared with standard mixtures of *p,p'*DDT, *p,p'*DDE, and Aroclor 1254. Reagent and apparatus blanks were essentially zero, and reextraction of the water sample with hexane showed no additional traces of DDT residues or PCB's. The minimum detectable amounts of *p,p'*DDT, *p,p'*DDE, and PCB's (as Aroclor 1254) are 5×10^{-12} g, 3×10^{-12} g, and 1×10^{-10} g, respectively.

Results and Discussion

In the North Central Pacific Gyre (Table 2), the concentration of DDT residues in surface films and subsurface waters was less than 0.03 ng/liter for all samples, while the PCB content was two orders of magnitude higher, and PCB's were always present. A higher concentration of PCB's in the surface films as compared to the subsurface

TABLE 2.—Concentrations of PCB's, *p,p'*DDT, and *p,p'*DDE in surface films and subsurface waters. All values in nanograms per liter.

| Station | Sample | PCB's | <i>p,p'</i> DDT | <i>p,p'</i> DDE |
|-----------|---------------------|----------------|-----------------|-----------------|
| SIO-1 | Surface film | 11 | 15 | 0.4 |
| SIO-2 | Surface film | 50 | 12 | 0.2 |
| M-1 | Surface film | 90 | <0.02 | <0.01 |
| M-2 | Surface film | 12 | 6.8 | 0.4 |
| M-3 | Surface film | 24 | 8.3 | 1.8 |
| M-4 | Surface film | 13 | 2.1 | 0.1 |
| Cato I-4 | Surface film | 4.9 | 0.3 | 0.1 |
| | filtrate and filter | 3.1 | 0.1 | <0.01 |
| | Subsurface water | 1.6 | <0.02 | <0.01 |
| | filtrate and filter | 0.9 | <0.02 | <0.01 |
| Cato I-A1 | Surface film | 3.3 | <0.02 | <0.01 |
| | filtrate and filter | 2.9 | <0.02 | <0.01 |
| | Subsurface water | 3.6 | <0.02 | <0.01 |
| | filtrate and filter | 1.1 | <0.02 | <0.01 |
| Cato I-A2 | Surface film | 3.5 | <0.02 | <0.01 |
| | filtrate and filter | 1.7 | <0.02 | <0.01 |
| | Subsurface water | (contaminated) | | |
| | filtrate and filter | 0.7 | <0.02 | <0.01 |

¹These lower limits are greater than the absolute minimum amounts detectable due to sample splitting during analysis.

waters was significant but not striking, largely because well-defined surface films were not present at the time of sampling.

In the California and Mexican coastal waters, both PCB and DDT residue concentrations in the surface films were slightly higher (as would be expected) than in the 1-2 m subsurface waters of the nearshore California Current (Cox 1971).

The available data in the literature pertaining to the chlorinated hydrocarbon content of surface films and subsurface waters is collected in Table 3. This table does not include a considerable amount of unpublished data taken in conjunction with outfall studies and pollution problems in general.

TABLE 3.—Comparison of this work with literature values for the concentration of PCB's and DDT residues in surface films and subsurface waters. All values in nanograms per liter, and are the sum of filtrate and filter from Table 2 where applicable.

| Reference | Location | PCB's | | DDT residues | |
|--------------------------|------------------------------|-----------------|-------------------|---------------|---------------------------|
| | | Surface films | Subsurface waters | Surface films | Subsurface waters |
| Seba and Corcoran (1969) | Biscayne Bay | ND ¹ | ND | 185-13,710 | <1 |
| | Florida Strait | ND | ND | 70 | <1 |
| Duce et al. (1972) | Narragansett Bay | 450-4,200 | <50-150 | undetected | undetected |
| Cox (1971) | Nearshore California Current | ND | ND | ND | 2.3-5.6 (1-2 m depths) |
| This work | California coastal | 11-50 | ND | 12.2-15.4 | ND |
| | Mexican coastal | 12-90 | ND | <0.03-11.2 | ND |
| | Offshore California Current | 8.0 | 2.5 | 0.4 | 0.1 |
| | North Central Pacific Gyre | 5.2-6.2 | 4.7 | <0.02 | <0.01 |

¹Not determined.

The primary aim of this work has been to establish open ocean concentrations of PCB's and DDT residues in surface films and subsurface waters in oligotrophic regions of the ocean such as the North Central Pacific Gyre. The PCB content of open ocean waters are significantly lower relative to inshore waters, and represent the first such numbers for an open ocean environment in the Northeast Pacific.

Acknowledgments

We thank H. Bezdek for collection of the surface film samples from the Mexican coastal waters (M 1-4).

This work was supported by AEC Contract AT(11-1)GEN 10, P.A. 20.

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HATCHING SURVIVAL OF HYBRIDS OF *ONCORHYNCHUS MASOU* WITH *SALMO GAIRDNERI* AND WITH NORTH AMERICAN SPECIES OF *ONCORHYNCHUS*

The cherry salmon, *Oncorhynchus masou*, which is native only to Asian watersheds discharging into the northwestern Pacific Ocean, is a recent introduction to North America. While cherry salmon have been crossed with some Asian salmonids, information on their ability to hybridize with North American salmonids has not been reported in the literature. The primary purpose of these experiments was to determine hatching survival of some interspecific crosses involving cherry salmon, leading to a sound basis for predicting their effects on indigenous salmonid species and their potential value in salmon management.