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A COMPARISON OF TRACE CONTAMINANTS IN DISEASED FISHES FROM THREE AREAS

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ABSTRACT

Fin erosion diseases in flatfishes collected off southern California, in Puget Sound, and in the New York region, appeared to be related to the discharge of toxic wastes. To narrow the range of possible causative agents, trace contaminant concentrations were measured in fishes with eroded fins and compared to levels in apparently normal specimens from the same areas and from control areas. Patterns in the three regions were then compared. Sediment properties were also studied. The species investigated were the Dover sole (Microstomus pacificus), the starry flounder (Platichthys stellatus), and the winter flounder (Pseudopleuronectes americanus).

Levels of total PCB in the tissues of fishes with eroded fins from the three regions were similar--median muscle levels differed by less than a factor of ten; median liver concentrations, by less than a factor of five; and brain levels were not statistically different. Levels of total DDT differed by two to three orders of magnitude. There were no apparent patterns in metals accumulation or depression in fish tissue that were common to all three regions. In all three species, changes in liver size and/or fat content were present in specimens collected in areas receiving toxic wastes.

Keywords: fin erosion, flatfishes, chlorinated hydrocarbons, metals, liver size and total lipids, California, Washington, New York.

APPENDIX 1

Analytical Techniques

Chlorinated Hydrocarbons

SEDIMENTS. The sample was first dried in an oven at about 60°C. Then 5 to 30g of sediment were weighed into a cellulose thimble and placed into a Soxhlet extraction apparatus. The Soxhlet flask was charged with 200ml of hexane and the extraction was run for an 18-hour period. The extract was then cleaned-up using a Florisil column prior to concentration and injection.

ORGANISMS. Approximately 0.2 to 10g of tissue were homogenized in a small blender and weighed into a beaker. The homogenate was covered with 20ml of acetonitrile and the mixture ground with a high speed blender for about 1 min. The blade was rinsed twice with 20ml of acetonitrile. This rinsing solution was added to the beaker with the sample, and then decanted and passed through filter paper into a 500ml separatory funnel. The sample was rinsed 3 times with 20ml of acetonitrile and the rinse decanted into the 500ml separatory funnel with the other acetonitrile extract. Estimating that the tissue was 80% water, deionizedwater was added to the funnel to make a total of 12ml water in the mixture, 50ml of hexane were then added. The separatory funnel was shaken for a period of 1 min and the two layers were allowed to separate; the hexane (upper) layer was then collected. Extraction of the acetonitrile fraction was repeated twice with 50ml of hexane, and the resulting hexane extracts were combined.

FLORISIL CLEAN-UP COLUMN. The hexane extracts were concentrated and cleaned up on a Florisil column. The Florisil (MCB, FX 284) was activated at 700°C for 4 hrs and stored under hexane in the dark until use.

The Florisil was then packed in the column (22mm ID) to a height of 8cm and covered with 1cm of anhydrous granular sodium sulfate. After a sample was placed on the column, it was eluted with 45ml of 6 percent diethyl ether in hexane (by volume).

INSTRUMENTATION. The samples were injected into a gas chromatograph with a ^{63}Ni electron-capture detector with the following parameters: nitrogen carrier gas with a flow rate of 20ml/min and 60ml/min detector purge; injector, column, and detector temperatures for DDT's and PCB's of 235^0, 200^0, and 280^0 C, respectively (HCB determinations were run with a column temperature of 150^0C); glass columns, 6mm O.D., 2mm I.D.; and 1.83m(6ft) long, packed with 1.5 percent OV-17 and 1.95 percent QF-1 on 80/100 mesh gas chrom Q. Calculations were made by comparison of sample peak heights to the peak heights of standards.

In some cases, because of interference, samples were saponified. In saponified samples, DDT is converted to DDE, and DDD to DDMU. DDMU is not included in total DDT numbers.

Concentrations were corrected for florisil extraction efficiency, blanks, and hexane extraction efficiency.

Metals (from Young et al. 1977)

OPTICAL EMISSION SPECTROSCOPY. Over the past decade, a specialized optical emission spectrometer system has been developed by G. Alexander at the Laboratory of Nuclear Medicine (University of California at Los Angeles) to determine the levels of stable elements present in dry biological tissue. The heart of the system is an optical emission spectometer covering the wavelength range of 210nm to 670nm and having a reciprocal linear dispersion of 0.68mm/mm. Forty-four detector units are

arranged on the focal circle of this instrument. Each detector is comprised of a secondary slit, a mirror to focus this slit image on the cathode of a photomultiplier tube and an interference filter to eliminate unwanted scattered light originating from the grating of the spectrometer.

In order to carry out the analysis, the sample must be volatilized, the resulting molecules dissassociate into atoms, and these atoms are excited by means of an electrical discharge to give off the characteristic optical spectra for the elements present within the tissue. To accomplish this, a crater electrode with a 1.9mm diameter stem is used. Five to fifteen milligrams of freeze-dried sample are weighed into the crater. No additional materials are added to the sample. A 12.5 ampere D.C. arc is drawn between the electrodes to volatilize the sample and excite the elements. During this process, each detector charges a capacitor at a rate proportional to the intensity of the light received. Thus, when the sample has been consumed, each capacitor is charged to a voltage proportional to the total intensity received by the detector. By relatively simple calculations, the electrode background can be subtracted from each signal and a net intensity derived.

By suitable standardization, these net intensities can be converted into concentrations. In this system, the total intensities are automatically transferred to IBM cards and then processed by means of an IBM 360-91 computer to concentrations.

ATOMIC ABSORPTION SPECTROSCOPY. At the Southern California Coastal Water Research Project Laboratory, biological samples are digested in the wet state and then analyzed for trace metals utilizing a Varian Techtron AA6 atomic absorption spectrometer. First, 0.2 - 2 wet grams of each tissue sample are digested in 10ml of a 1:1 nitric acid solution

(redistilled by G. Frederick Smith Chem. Co.) until the remaining volume is about 2ml. After this procedure is repeated once, the final residue is boiled with 20ml of 1:9 hydrochloric acid solution for 15 min and then filtered through an acid-washed Whatman No. 40 filter. The filtrate is then diluted to an appropriate volume for analysis. Silver, cadmium, chromium, copper, nickel, and lead are measured by injecting 2.5µl of sample into the graphite furnace of the AA6. Zinc levels are determined by aspirating the sample into an air-acetylene flame. Process blanks are analyzed with each set of samples. The concentration of target trace metals are determined from corresponding standard curves. The experimental conditions of the spectrophotometer are given below:

GENERAL INSTRUMENT PARAMETERS:

Element	Wave Length nm	Lamp Current mA	S.B.P. nm
Ag	328.1	3	0.5
Cd	228.8	3	0.5
Cr	357.9	5	0.2
Cu	324.7	3	0.5
Ni	232.0	5	0.2
Pb	217.0	5	1.0
Zn	213.9	5	0.5

Atomizer Settings:

		Voltage	Time (second)
Dry		2-3	50
Ash		4.5-6.0	20
Atomize	Ag	6.5	2
	Cd	7.0	2
	Cr	7.0	2
	Cu	7.0	2
	Ni	7.5	2
	Pb	6.0	2

Flame Conditions:	Supply Pressure	Flow Meter
Air	50 psi	3.0
Acetylene	10 psi	2.0

OES-AAS INTERCALIBRATION

To evaluate the utility of optical emission spectroscopy D. Young, et al. (1977), conducted an intercalibration program between the OES laboratory at UCLA and the Project's AAS laboratory. Replicate specimens of five fish species were sampled for the edible white muscle tissue, and gonadal and liver tissue. These thirty samples were lyophilized (freeze-dried) overnight, and 10 dry mg of each was analyzed by OES, while approximately 1 dry gm was analyzed by AAS. The results of the intercalibration study indicate that of the seven metals compared in the samples four (Cd, Cr, Ni, and Pb) generally were not quantifiable by the OES technique. The OES lower limit levels are close to the levels normally present in fish tissue. For the other three (Ag, Cu, and Zn), the median ratios of concentrations determined by OES and AAS for the 10 comparisons in each tissue class are shown below:

Median Ratios: OES/AAS

Tissue	Ag	Cu	Zn
Muscle	6.0	1.25	0.84
Gonad	2.8	1.12	0.78
Liver	2.8	1.18	0.48

These results indicate generally satisfactory agreement, on the average, between the two methods for Cu and Zn in these tissues (with the possible exception of the factor-of-two discrepancy for Zn in liver). It appears that there is a distinct bias between the methods in the case of Ag, with the OES method yielding values 3-6 times those of the AAS method, on the average. The reason for this difference is not known, but two obvious potential causes are spectral interference in the OES analyses for Ag, or loss of this metal during acid digestion of the sample prior to analysis by AAS.

APPENDIX 2

Description of Specimens

	Specimen No.	mm SL	mm TL	Weight (g)	Sex	Probable Age	% Dorsal Fin Eroded
DOVER SOLE							
	1	184	221	95.6	F	4	
	2	181	217	99.9	M	4	
Dana	3	185	220	86.0	F	3	
Point	4	181	211	88.5	M	4	
	5	185	222	94.9	M	4	
Nov 18	6	180	216	87.8	F	4	
1976	7	186	221	102.4	F	6	
	8	176	207	89.2	M	4	
	9	166	197	63.3	F	4	
	10	186	221	81.9	M	4	
	11	192	229	106.8	M	5	
	12	177	209	76.6	F	4	
	13	181	218	83.2	F	4	
	14	185	222	87.2	F	4	
Palos	15	172	204	69.6	F	3	
Verdes	16	189	224	91.0	M	4	
	17	185	223	100.0	M	4	
Nov 5	18	177	212	69.4	M	3	
1976	19	183	217	79.2	F	4	
	20	161	193	58.9	F	3	
	21	168	200	69.0	M	6	
	22	182	219	96.8	M	5	
	23	179	209	74.0	F	4	
	24	162	193	64.8	M	3	
	25	186	221	101.4	M	3	76
	26	165	198	83.1	F	4	42
Palos	27	183	224	89.5	F	4	23
Verdes	28	180	211	89.5	F	4	24
	29	187	226	98.2	F	4	73
Nov 5	30	171	204	75.5	M	3	83
1976	31	190	234	90.0	F	4	94
	32	178	213	83.9	M	4	53
	33	174	215	78.4	M	4	24
	34	179	215	84.1	F	4	13
	35	174	208	87.7	M	4	10
	36	175	208	79.5	M	4	83

Specimen No.		mm SL	mm TL	Weight (g)	Sex	Probable Age	Fin Disease
STARRY FLOUNDER	37	232	281	242.0	M	3	
	38	223	277	266.6	F	4	
	39	236	291	284.2	M	3	
	40	202	257	203.7	F	3	
McCalister	41	216	274	224.8	F	4	
Creek	42	194	238	139.6	M	2	
	43	210	261	163.9	F	2	
30 March	44	195	240	181.1	F	2	
1977	45	201	250	194.1	F	3	
	46	212	260	200.5	F	2	
	47	184	227	144.5	M	2	
	48	211	262	165.4	M	3	
	49	181	228	154.2	F	4	
	50	179	222	151.2	F	2	
	51	179	220	138.2	F	3	
	52	184	230	153.2	M	3	
Duwamish	53	188	236	168.5	F	2	
River	54	159	199	99.0	F	3	
	55	159	196	102.0	F	3	
25 March	56	164	205	114.1	M	3	
15 April	57	179	221	115.6	F	2	
1977	58	157	193	93.3	F	3	
	59	152	191	82.5	M	2	
	60	155	192	87.7	M	2	
	61	210	266	235.2	F	4	✓
	62	172	211	115.9	M	6	✓
	63	140	174	61.8	M	2	✓
	64	183	226	162.1	F	2	✓
	65	182	225	126.7	F	3	✓
Duwamish	66	161	201	100.0	F	2	✓
River	67	158	200	93.1	F	4	✓
	68	166	207	112.8	F	3	✓
25 March	69	163	209	114.6	M	2	✓
15 April	70	159	201	94.8	F	4	✓
1977	71	146	180	79.4	M	3	✓
	72	148	159	64.8	M	5	✓

Specimen No.		mm SL	mm TL	Weight (g)	Sex	Probable Age	Fin Disease
WINTER FLOUNDER	73	220	271	213.8	M	2	
	74	219	268	282.5	F	2	
	75	239	288	339.9	F	2	
Great Bay,	76	243	295	294.5	M	3	
N.J.	77	236	284	320.5	M	2	
	78	247	298	364.1	M	4	
March	79	240	299	328.1	M	3	
1977	80	232	292	353.8	M	3	
	81	235	296	314.7	M	2	
	82	245	306	374.6	M	3	
	83	245	296	424.6	F	3	
	84	250	306	388.9	F	3	
	85	191	231	183.1	F	2	
	86	181	224	156.7	M	2	
	87	179	218	162.5	F	2	
Sandy Hook/	88	199	255	234.9	F	3	
Raritan Bay	89	192	237	176.8	F	2	
	90	210	262	209.5	F	2	
June	91	172	213	132.0	M	2	
1977	92	185	234	178.6	F	2	
	93	165	198	112.8	M	2	
	94	176	218	144.7	M	2	
	95	198	247	222.0	F	2	
	96	227	285	293.4	F	3	
	97	193	250	215.0	F	2	✓
	98	195	250	178.4	M	3	✓
	99	173	215	122.3	M	2	✓
	100	188	233	169.4	F	2	✓
	101	158	203	92.5	M	2	✓
Sandy Hook/	102	193	246	205.2	M	2	✓
Raritan Bay	103	176	221	166.7	M	2	✓
	104	221	269	273.6	F	3	✓
June	105	170	185	92.8	M	2	✓
1977	106	230	278	274.4	F	2	✓
	107	209	257	230.0	M	2	✓
	108	159	199	108.7	F	3	✓
	109	176	217	149.0	F	2	
	110	160	201	131.0	M	2	
	111	173	216	147.3	F	2	
Apex	112	176	214	143.1	F	2	
dump	113	170	211	133.3	M	2	
area	114	171	210	130.8	F	2	
	115	169	209	145.9	M	2	
Oct.	116	160	196	116.8	F	2	
1977	117	170	210	123.6	M	2	
	118	182	220	147.9	M	2	

Specimen No.		mm SL	mm TL	Weight (g)	Sex	Probable Age	Fin Disease
WINTER FLOUNDER							
	119	172	210	149.4	M	2	
Apex	120	175	214	131.7	F	2	
Oct.	121	185	225	138.8	F	2	✓
1977	122	189	222	141.7	F	2	✓
	123	172	208	123.2	F	2	✓

APPENDIX 3

Trace Metal Analyses by Atomic Absorption Spectroscopy

Specimen No.	Ag	Cd	Cr	Cu	Ni	Pb	Zn
LIVER (µg/g wet weight)							
Dover Sole							
3	0.103	1.14	0.051	2.13	<0.20	0.253	26.1
5	0.122	0.603	<0.034	2.48	<0.15	1.30	23.1
6	0.074	0.613	<0.039	2.82	<0.16	0.315	16.5
8	0.153	1.07	0.126	1.58	<0.29	0.438	23.0
11	0.093	1.40	0.062	1.95	<0.13	<0.098	20.1
12	0.060	0.428	0.079	2.97	<0.32	1.05	43.6
28	0.128	0.661	0.196	4.35	<0.07	<0.059	26.8
29	0.097	0.768	0.204	3.19	<0.05	<0.044	24.0
31	0.246	1.05	0.582	8.27	<0.16	0.471	40.2
32	0.098	0.369	0.171	3.55	<0.08	0.138	30.9
34	0.091	0.342	0.205	1.90	<0.07	0.154	26.2
35	0.129	0.257	0.229	4.13	<0.08	0.152	24.7
Starry Flounder							
37	0.055	0.830	0.049	7.03	<0.07	0.146	32.3
41	0.032	0.720	0.024	4.69	<0.06	0.096	25.4
44	0.066	0.167	0.041	8.56	<0.10	0.153	39.0
45	0.139	0.417	0.194	5.94	<0.19	0.353	41.5
46	0.080	0.458	0.036	15.1	<0.05	0.140	42.3
48	0.069	0.605	0.106	4.79	<0.08	0.141	31.1
65	0.165	0.151	<0.020	3.65	<0.12	0.205	30.7
66	0.135	0.225	0.040	1.82	<0.09	0.189	31.4
67	0.076	0.337	0.050	4.33	<0.07	0.144	26.9
68	0.108	0.164	<0.023	4.59	<0.10	0.245	24.2
70	0.144	0.142	0.041	4.48	<0.10	0.293	24.4
71	0.131	0.066	0.044	4.41	<0.14	0.233	27.5
MUSCLE (Ag, Cd, Cr, Cu, Ni, Pb in ng/g and Zn in µg/g wet weight)							
Dover Sole							
3	<5	2	9	74	<43	<70	2.11
5	<6	3	21	67	<43	<78	1.84
6	<5	<2	<12	58	<43	<86	1.98
8	<5	9	12	87	<37	<77	2.00
11	<7	<2	14	81	<47	<73	1.85
12	<5	10	<10	52	<39	<87	1.72
28	<5	3	13	103	<36	<78	2.39
29	<5	4	<8	58	<32	<71	2.03
31	<5	15	14	67	<36	<73	1.90
32	<5	<2	18	100	<26	<73	2.42
34	<6	<2	<9	73	<43	<80	2.05
35	<5	9	8	84	<30	<69	2.15

Specimen No.	Ag	Cd	Cr	Cu	Ni	Pb	Zn
MUSCLE (Ag, Cd, Cr, Cu, Ni, Pb in ng/g and Zn in µg/g wet weight)							
Starry Flounder							
37	<6	12	14	237	<47	<78	3.89
41	<5	132	<9	104	<44	<83	3.19
44	<6	11	<9	201	<42	<78	3.60
45	<5	<2	<9	129	<35	<78	2.90
46	<5	3	<8	142	<31	<68	4.35
48	<5	3	<8	174	<30	<70	3.27
65	<5	<2	<9	159	<33	<76	4.18
66	<5	<2	11	115	<44	<85	3.68
67	<5	<2	15	191	<41	<88	3.14
68	<5	3	<10	146	<37	<73	3.83
70	<5	<2	<9	172	<35	<83	3.49
71	<5	<2	<8	162	<35	<74	3.81
LIVER (µg/g wet weight)							
Winter Flounder							
74	0.265	0.082	<0.018	9.35	<0.069	0.162	35.7
76	0.079	0.081	<0.020	2.37	<0.076	<0.061	26.8
77	0.233	0.076	<0.021	4.61	<0.030	0.149	29.2
80	0.050	0.233	<0.020	2.20	<0.076	<0.061	27.9
81	0.062	0.107	<0.029	1.47	<0.111	<0.089	23.3
84	0.122	0.052	0.047	5.72	<0.090	0.386	32.8
97	0.181	0.148	0.033	3.37	<0.117	<0.094	25.9
98	0.146	0.138	<0.025	3.77	<0.094	<0.076	27.2
100	0.050	0.168	<0.032	2.94	<0.123	<0.099	37.2
101	0.119	0.228	<0.067	4.58	<0.259	0.207	27.4
102	0.231	0.106	<0.027	7.52	<0.104	0.156	34.6
107	0.111	0.089	<0.026	4.41	<0.099	<0.079	26.7
110	0.042	0.024	0.066	1.44	<0.132	<0.105	24.6
113	0.081	<0.010	<0.032	3.61	<0.123	<0.099	28.2
115	0.275	0.037	<0.044	8.20	<0.169	0.214	31.2
116	0.109	0.022	<0.040	4.38	<0.155	<0.124	31.3
117	0.050	0.031	<0.036	2.28	<0.139	<0.111	29.4
120	0.119	0.035	<0.045	6.79	<0.175	<0.140	33.3
MUSCLE (µg/g wet weight)							
Winter Flounder							
74	0.001	0.016	<0.005	0.101	<0.021	<0.024	4.24
76	0.002	0.001	<0.005	0.111	<0.020	<0.023	6.21
77	0.001	<0.001	<0.005	0.108	<0.019	<0.022	5.07

Specimen No.	Ag	Cd	Cr	Cu	Ni	Pb	Zn
80	0.004	0.004	0.023	0.089	<0.023	<0.027	4.45
81	<0.001	0.001	<0.005	0.070	<0.022	<0.025	2.86
84	0.007	<0.001	0.009	0.113	<0.019	<0.022	3.71
97	0.003	<0.001	0.009	0.110	<0.020	<0.023	3.73
98	0.002	<0.001	0.010	0.124	<0.020	<0.023	4.10
100	0.005	0.002	0.011	0.119	<0.023	<0.026	4.29
101	0.004	<0.001	0.011	0.108	<0.021	<0.024	4.02
102	0.005	<0.001	0.019	0.185	<0.020	<0.030	6.48
107	0.013	<0.001	0.005	0.135	<0.019	<0.022	4.50
110	0.001	<0.001	0.006	0.109	<0.020	<0.018	3.47
113	0.004	<0.001	0.017	0.112	<0.021	<0.023	3.77
115	0.002	<0.001	0.009	0.102	<0.021	<0.024	3.58
116	0.001	0.001	0.011	0.115	<0.020	<0.023	3.86
117	0.003	<0.001	0.007	0.113	<0.021	<0.024	4.29
120	<0.001	0.002	<0.005	0.098	<0.020	<0.023	3.50

APPENDIX 4

Chlorinated Hydrocarbons in Fish Tissues

Table 1. Total PCB (mg/kg wet weight) in the muscle tissue of southern California Dover sole, November 1976.

	Dana Point (#1-12)	Palos Verdes No Apparent Fin Erosion (#13-24)	Palos Verdes Fin Erosion (#25-36)
	N.D.*	0.95	1.2
	0.006	1.4	0.75
	0.008	2.0	2.4
	0.007	0.83	1.3
	0.019	2.2	1.8
	0.014	0.40	0.55
	0.007	1.2	0.43
	0.016	1.8	0.16
	0.021	0.037	2.0
	0.007	0.10	0.77
	0.006	1.1	0.61
	0.012	1.2	1.5
median	0.008	1.2	0.98
95% confidence limits	0.006 - 0.016	0.40-1.8	0.55 - 1.8
mean		1.1	1.1
standard deviation		0.70	0.69
coefficient of variation		64%	63%
range	<0.001 - 0.021	0.037- 2.2	0.16 - 2.4

* Not detected.

Table 2. Total PCB (mg/kg wet weight) in the liver tissue of southern California Dover sole, November 1976.

	Dana Point (#1-12)	Palos Verdes Shelf: No Apparent Fin Erosion (#13-24)	Palos Verdes Shelf: Fin Erosion (#25-36)
	0.12	26	20
	N.D.*	17	8.7
	0.007	14	56
	0.11	8.8	7.4
	0.083	28	30
	0.019	11	18
	0.013	13	20
	0.036	10	18
	0.059	0.76	37
	0.009	5.5	20
	0.16	18	16
	0.18	22	22
median	0.048	14	20
95% confidence limits	0.009 - 0.12	8.8 - 22	16 - 30
mean		15	23
standard deviation		8.1	13
coefficient of variation		54%	57%
range	N.D. - 0.18	0.76 - 28	7.4 - 56

* Not detected

Table 3. Total PCB (mg/kg wet weight) in the brain tissue of Dover sole (composites of 3 individuals) from southern California, November 1976.

	Dana Point	Palos Verdes No Apparent Fin Erosion	Palos Verdes Fin Erosion
	0.025	0.99	1.3
	0.069	0.94	1.0
	0.14	0.67	1.0
	0.055	0.78	0.83
median	0.12	0.86	1.0
mean	0.072	0.84	1.0
standard deviation	0.049	0.15	0.20
coefficient of variation	68%	18%	20%
range	0.025 - 0.14	0.67 - 0.99	0.83 - 1.3

Table 4. Total PCB (mg/kg wet weight) in the muscle tissue of starry flounder from Washington, March - April, 1977.

	McCalister Creek (#37-48)	Duwamish River Estuary No Apparent Fin Disease (#49-60)	Duwamish River Estuary Fin Disease (#61-72)	n 2)
	0.071	0.23	0.16	
	0.009	0.29	0.16	
	0.037	0.21	0.54	
	0.010	0.26	0.22	
	0.043	0.22	0.69	
	0.038	0.19	0.27	
	0.076	0.29	0.71	
	0.016	0.22	0.17	
	0.024	0.27	0.44	
	0.027	0.31	2.1	
	0.012	0.36	0.42	
	0.007	0.46	0.40	
median	0.026	0.26	0.41	
95% confidence limits	0.010 - 0.043	0.22 - 0.31	0.19 - 0.69	
mean	0.031	0.28	0.52	
standard deviation	0.023	0.076	0.53	
coefficient of variation	74%	27%	102%	
range	0.007 - 0.076	0.19 - 0.46	0.16 - 2.1	

Table 6. Total PCB (mg/kg wet weight) in brain tissue of starry flounder (composites of 3 individuals) from Washington, March - April 1977.

	McCalister Creek	Duwamish River Estuary No Apparent Fin Disease	Duwamish River Estuary Fin Disease
	0.29	0.49	0.67
	0.27	0.48	0.87
	0.19	0.46	1.3
	0.056	1.2	3.1
median	0.23	0.48	1.1
mean	0.20	0.66	1.5
standard deviation	0.11	0.36	1.1
coefficient of variation	55%	55%	73%
range	0.056 - 0.29	0.46 - 1.2	0.67 - 3.1

Table 7. Total PCB (mg/kg, wet weight) in muscle tissue of winter flounder from New York, 1977.

	Great Bay (# 73-84)	Raritan Bay No Apparent Fin Erosion (#85-96)	Raritan Bay Fin Erosion (#97-108)	Apex area No Apparent Fin Erosion (#109-120)	Apex area Fin Erosion (#121-123)
	0.14	0.076	0.10	0.13	0.093
	0.032	0.074	0.077	0.12	0.079
	0.005	0.11	0.11	0.094	0.11
	0.040	0.10	0.10	0.16	
	0.029	0.12	0.14	0.090	
	0.047	0.097	0.11	0.15	
	0.042	0.083	0.084	0.12	
	0.064	0.087	0.073	0.15	
	0.051	0.12	0.13	0.10	
	0.061	0.085	0.13	0.086	
	0.040	0.076	0.14	0.077	
	0.036	0.10	0.10	0.062	
Median	0.041	0.092	0.10	0.11	0.093
95% confidence limits	0.032-0.061	0.076-0.11	0.084-0.13	0.086-0.15	
Mean	0.049	0.094	0.11	0.11	
standard deviation	0.032	0.016	0.023	0.032	
coefficient of variation	65%	17%	21%	29%	
range	0.005-0.14	0.074-0.12	0.073-0.14	0.062-0.16	0.079-0.11

Table 8. Total PCB (mg/kg wet weight) in the liver tissue of winter flounder from New York 1977.

	Great Bay (#73-84)	Raritan Bay		Apex area	
		No Apparent Fin Erosion (#85-96)	Fin Erosion (#97-108)	No Apparent Fin Erosion (#109-120)	Fin Erosion (#121-123)
	2.4	5.9	2.8	6.5	10
	0.68	4.5	1.4	8.9	2.0
	0.74	9.3	-	3.9	2.8
	1.2	5.8	5.1	4.5	
	1.2	4.6	2.1	9.3	
	0.87	2.3	4.0	6.5	
	0.91	9.8	7.4	3.3	
	0.78	6.2	4.3	5.6	
	0.70	4.2	7.1	3.5	
	0.25	9.9	5.4	3.6	
	1.3	5.5	3.1	0.48	
	1.2	5.7	1.9	2.1	
Median	0.89	5.8	4.2	4.2	2.8
95% confidence limits	0.70-1.2	4.5-9.3	1.9-7.1	3.3-6.5	
Mean	1.0	6.1	4.1	4.8	
standard deviation	0.53	2.4	2.0	2.6	
coefficient variation	53%	39%	49%	54%	
range	0.25-2.4	2.3-9.9	1.4-7.4	0.48-9.3	2.0-10

Table 9. Total PCB (mg/kg wet weight) in brain tissue of winter flounder from New York, 1977.

	Great Bay	Raritan Bay		Apex area	
		No Apparent Fin Erosion	Fin Erosion	No Apparent Fin Erosion	Fin Erosion
	0.28	0.52	0.46	0.75	0.47
	0.035	0.58	2.0	1.1	
	0.18	1.6	1.7	0.52	
	0.14	0.77	2.0	0.60	
Median	0.16	0.68	1.8	0.68	
Mean	0.16	0.87	1.5	0.74	
standard deviation	0.10	0.50	0.73	0.26	
coefficient variation	62%	57%	49%	35%	
range	0.035-0.28	0.052-1.6	0.46-2.0	0.52-1.1	

Table 10. Total DDT (mg/kg wet weight) in the muscle tissue of southern California Dover sole, November 1976.

	Dana Point (#1-12)	Palos Verdes No Apparent Fin Erosion (#13-24)	Palos Verdes Fin Erosion (#25-36)
	N.D.	16	18
	0.024	22	9.2
	0.043	34	42
	0.029	16	17
	0.026	34	30
	0.043	7.1	8.2
	0.017	16	4.8
	0.041	26	2.6
	0.021	0.86	28
	0.013	2.0	16
	0.026	19	9.3
	0.037	17	23
median	0.026	16	16
95% confidence limits	0.017 - 0.041	7.1 - 26	8.2 - 28
mean		17	17
standard deviation		11	12
coefficient of variation		65%	71%
range	<0.001 - 0.043	0.86-34	2.6 - 42

Table 11. Total DDT (mg/kg wet weight) in the liver tissue of southern California Dover sole, November 1976.

	Dana Point (#1-12)	Palos Verdes Shelf No Apparent Fin Erosion (#13-24)	Palos Verdes Shelf Fin Erosion (#25-36)
	1.1	450	310
	0.24	280	140
	0.38	260	1,100
	0.16	190	160
	0.42	490	570
	0.74	210	250
	0.30	200	370
	0.22	180	250
	0.28	29	660
	0.39	130	310
	0.86	320	220
	0.83	330	430
median	0.38	240	310
95% confidence limits	0.24 - 0.83	180 - 330	220 - 570
mean	0.49	260	400
standard deviation	0.31	130	270
coefficient of variation	63%	50%	68%
range	0.16 - 1.1	29 - 490	140 - 1,100

Table 12. Total DDT (mg/kg wet weight) in the brain tissue of Dover sole (composites of 3 individuals) from southern California, November 1976.

	Dana Point	Palos Verdes	
		No Apparent Fin Erosion	Fin Erosion
	0.16	19	20
	0.21	13	19
	0.17	9.5	19
	0.15	13	17
median	0.16	13	19
mean	0.17	14	19
standard deviation	0.026	3.9	1.3
coefficient of variation	15%	28%	6.8%
range	0.15 - 0.21	9.5 - 20	17 - 20

Table 13. Total DDT (mg/kg wet weight) in the muscle tissue of starry flounder from Washington, March – April 1977.

	McCalister Creek (#37-48)	Duwamish River Estuary No Apparent Fin Disease (#49-60)	Duwamish River Estuary Fin Disease (#61-72)
	0.031	0.026	0.024
	<0.004	0.018	0.023
	0.015	0.018	0.061
	0.027	0.012	0.021
	0.007	0.033	0.023
	0.008	0.018	0.038
	0.012	0.047	0.14
	<0.004	0.016	0.025
	0.008	0.031	0.045
	0.012	0.008	0.18
	0.008	0.032	0.026
	0.005	0.020	0.087
median	0.008	0.019	0.032
95% confidence limits	0.005 – 0.015	0.016 – 0.032	0.023–0.087
mean		0.023	0.058
standard deviation		0.011	0.052
coefficient of variation		49%	90%
range	<0.004 – 0.031	0.008 – 0.047	0.021–0.18

Table 14. Total DDT (mg/kg wet weight) in the liver tissue of starry flounder from Washington, March-April, 1977.

	McCalister Creek (#37-48)	Duwamish River Estuary No Apparent Fin Erosion (#49-60)	Duwamish River Estuary Fin Erosion (#61-72)
	0.054	1.9	1.5
	0.032	1.8	1.8
	0.20	0.98	1.9
	0.027	1.0	0.98
	0.037	1.3	0.93
	N.D.	1.0	1.2
	0.16	1.1	2.3
	0.003	0.98	0.69
	0.021	1.1	3.1
	0.038	1.6	11
	N.D.	2.4	1.5
	N.D.	4.2	3.8
median	0.030	1.2	1.6
95% confidence limits	N.D. - 0.054	1.0 - 1.9	0.98 - 3.1
mean		1.6	2.6
standard deviation		0.93	2.8
coefficient of variation		58%	110%
range	N.D. - 0.20	0.98- 4.2	0.69 - 11

Table 15. Total DDT (mg/kg wet weight) in brain tissue of starry flounder (composites of 3 individuals) from Washington, March - April 1977.

	McCalister Creek	Duwamish River Estuary No Apparent Fin Disease	Duwamish River Estuary Fin Disease
	0.035	0.021	0.058
	0.015	0.025	0.028
	0.011	0.021	0.053
	0.003	0.059	0.10
median	0.013	0.023	0.056
mean	0.016	0.032	0.060
standard deviation	0.014	0.018	0.030
coefficient of variation	88%	56%	50%
range	0.003 - 0.035	0.021 - 0.059	0.028 - 0.10

Table 16. Total DDT (mg/kg wet weight) in muscle tissue of winter flounder from New York.

	Great Bay (#73-84)	Raritan Bay		Apex area	
		No Apparent Fin Erosion (#85-96)	Fin Erosion (#97-108)	No Apparent Fin Erosion (#109-120)	Fin Erosion (#121-123)
	0.035	0.006	0.012	0.021	0.009
	<0.005	0.011	0.010	0.011	0.014
	<0.003	0.009	0.021	0.014	0.003
	<0.006	0.008	0.019	0.014	
	<0.007	0.016	0.021	0.014	
	<0.005	0.012	0.016	0.020	
	<0.006	0.010	0.006	0.014	
	<0.015	0.006	0.008	0.011	
	<0.005	0.012	0.020	0.007	
	<0.007	<0.006	0.015	0.016	
	<0.005	0.004	0.026	0.003	
	0.003	0.008	0.022	0.004	
Median	<0.006	0.008	0.018	0.014	0.009
95% confidence limits		0.006-0.012	0.010-0.021	0.007-0.016	
Mean			0.016	0.012	
standard deviation			0.006	0.006	
coefficient of variation			38%	50%	
range	<0.003-0.035	0.004-0.016	0.006-0.026	0.003-0.021	0.003-0.014

Table 17. Total DDT (mg/kg wet weight) in the liver tissue of winter flounder from New York 1977.

	Great Bay (#73-84)	Raritan Bay		Apex area	
		No Apparent Fin Erosion (#85-96)	Fin Erosion (#97-108)	No Apparent Fin Erosion (#109-120)	Fin Erosion (#121-123)
	0.61	0.73	0.37	1.2	1.5
	0.31	0.79	0.23	0.94	0.26
	0.28	0.80	-	0.45	0.57
	0.46	0.84	0.92	0.50	
	0.49	0.68	0.27	1.4	
	0.30	0.25	0.60	0.76	
	0.26	1.3	0.97	0.36	
	0.26	0.63	0.56	0.69	
	0.22	0.67	1.6	0.26	
	0.10	1.1	0.66	0.44	
	0.37	0.79	0.63	0.055	
	0.65	0.92	0.40	0.52	
Median	0.30	0.79	0.62	0.51	0.57
95% confidence limits	0.26-0.49	0.67-0.92	0.37-0.97	0.36-0.94	
Mean	0.36	0.79	0.66	0.63	
standard deviation	0.16	0.26	0.39	0.39	
coefficient of variation	44%	33%	59%	62%	
range	0.10-0.65	0.25-1.3	0.23-1.6	0.055-1.4	0.26-1.5

Table 18. Total DDT (mg/kg wet weight) in brain tissue of winter flounder from New York, 1977.

	Great Bay	Raritan Bay		Apex area	
		No Apparent Fin Erosion	Fin Erosion	No Apparent Fin Erosion	Fin Erosion
	0.056	0.030	0.052	0.76	0.12
	0.015	0.021	0.10	1.3	
	0.043	0.11	0.090	0.12	
	0.036	0.047	0.12	0.061	
Median	0.040	0.038	0.095	0.44	
Mean	0.038	0.052	0.090	0.56	
standard deviation	0.017	0.040	0.029	0.59	
coefficient of variation	45%	77%	32%	105%	
range	0.015-0.056	0.021-0.11	0.052-0.12	0.061-1.3	

APPENDIX 5

Liver Characteristics

Table 1. Liver-somatic index (wet weight ratio x 100) of *Microstomus pacificus* from Dana Point and the Palos Verdes shelf, November 1976.

	Dana Point (#1-12)	Palos Verdes	
		Apparently Healthy (#13-24)	Fin Erosion (#25-36)
	0.7	2.4	3.3
	0.8	1.3	2.7
	0.8	2.8	2.6
	0.6	1.9	2.5
	1.2	2.8	2.6
	0.8	1.5	2.5
	0.7	2.7	1.6
	1.0	3.0	2.4
	0.8	0.9	1.8
	0.8	1.9	3.0
	1.0	2.1	3.8
	0.6	2.4	2.9
median	0.8	2.2	2.6
95% confidence limits	0.7 - 1.0	1.5 - 2.8	2.4 - 3.0
mean	0.8	2.1	2.6
standard deviation	± 0.17	± 0.66	± 0.59
standard error	± 0.05	± 0.19	± 0.17
coefficient of variation	21%	31%	23%
range	0.6 - 1.2	0.9 - 3.0	1.6 - 3.8
standard length (mm)			
mean	182	177	178
standard deviation	6.6	9.2	7.2
coefficient of variation	3.6%	5.2%	4.1%
range	166 - 192	161 - 189	165 - 190

Table 2. Percent total lipid in the liver tissue of southern California Dover sole, November 1976.

	Dana Point (#1-12)	Palos Verdes Shelf No Apparent Fin Erosion (#13-24)	Palos Verdes Shelf Fin Erosion (#25-36)
	16	35	38
	7.6	30	25
	11	31	22
	10	27	27
	7.5	33	40
	9.1	23	28
	6.2	28	19
	6.2	24	23
	7.5	8.8	29
	9.0	14	29
	12	32	24
	12	35	34
median	9.0	29	28
95% confidence limits	7.5 - 12	23 - 33	23 - 34
mean	9.5	27	28
standard deviation	2.9	8.2	6.4
coefficient of variation	31%	30%	23%
range	6.2 - 16	8.8 - 35	19 - 40

Table 3. Liver-somatic index (wet weight ratio x 100) of *Platichthys stellatus* from the McCalister Creek and the Duwamish River Estuary in Washington, March-April 1977.

	McCalister Creek (#37-48)	Duwamish R. E. Apparently Healthy (#49-60)	Duwamish R. E. Fin Disease (#61-72)
	1.5	2.9	3.6
	1.9	3.6	2.2
	1.5	2.3	2.8
	1.6	4.1	2.4
	1.4	2.8	2.8
	1.4	3.1	2.1
	1.9	2.3	3.5
	1.7	3.5	2.7
	1.5	3.9	3.9
	1.3	2.9	3.3
	1.3	2.6	2.5
	1.8	3.4	2.1
median	1.5	3.0	2.8
95% confidence limits	1.4 - 1.8	2.6 - 3.6	2.2 - 3.5
mean	1.6	3.1	2.8
standard deviation	0.21	0.59	0.62
coefficient of variation	13%	19%	22%
range	1.3 - 1.9	2.3 - 4.1	2.1 - 3.9

Table 4. Percent total lipid in the liver tissue of starry flounder from Washington, March - April 1977

	McCalister Creek (#37-48)	Duwamish River Estuary No Apparent Fin Erosion (#49-60)	Duwamish River Estuary Fin Erosion (#61-72)
	4.1	23	32
	7.6	33	17
	6.1	24	18
	4.4	47	21
	3.5	26	34
	3.2	44	18
	6.0	19	14
	6.6	44	28
	4.8	20	29
	3.7	27	26
	4.6	16	30
	4.4	42	12
median	4.5	26	24
95% confidence limits	3.7 - 6.1	20 - 44	17 - 30
mean	4.9	30	23
standard deviation	1.4	11	7.5
coefficient of variation	29%	37%	33%
range	3.2 - 7.6	16 - 47	12 - 34

Table 5. Ratios of freeze-dried weight to wet weight of liver tissue from starry flounder from Washington, 1977.

	McCalister Creek (#37-48)	Duwamish River Estuary No Apparent Fin Erosion (#49-60)	Duwamish River Estuary Fin Erosion (#61-72)
	0.18	0.30	0.41
	0.22	0.41	0.28
	0.21	0.32	0.29
	0.19	0.47	0.33
	0.16	0.20	0.25
	0.18	0.40	0.16
	0.20	0.31	0.23
	0.19	0.49	0.34
	0.20	0.29	0.34
	0.19	0.32	0.34
	0.22	0.26	0.33
	0.20	0.44	-
median	0.20	0.32	0.33
95% confidence limits	0.18-0.21	0.29-0.44	0.23-0.34
mean	0.20	0.35	0.30
standard deviation	0.017	0.090	0.068
coefficient of variation	8.5%	26%	23%
range	0.16-0.22	0.20-0.49	0.16-0.41

Table 6. Liver-somatic index in winter flounder from New York, 1977.

	Great Bay (Mar 77) (#73-84)	Sandy Hook/Raritan Bay No Apparent Fin Damage (Jun 77) (#85-96)	Sandy Hook/Raritan Bay Fin Damage (Jun 77) (#97-108)	Apex dump area No Apparent Fin Damage (Oct 77) (#109-120)	Apex dump area Fin Damage (Oct 77) (#121-23)
	1.6	1.7	1.7	2.7	2.6
	3.0	2.7	2.2	2.6	1.6
	3.4	3.0	-	1.9	1.5
	2.8	2.2	2.4	2.0	
	2.5	2.3	2.0	2.7	
	2.0	3.2	1.7	2.2	
	1.9	2.7	3.1	1.9	
	1.4	2.2	2.8	2.2	
	2.0	2.2	-	2.2	
	1.2	2.5	2.6	1.6	
	3.1	3.0	1.8	2.3	
	3.6	3.3	1.8	1.3	
median	2.2	2.6	2.1	2.2	1.6
95% confidence limits	1.6-3.1	2.2-3.0	1.7-2.8	1.9-2.6	
mean	2.4	2.6	2.2	2.1	
standard deviation	0.80	0.48	0.50	0.43	
coefficient of variation	33%	18%	23%	20%	
range	1.2-3.6	1.7-3.3	1.7-3.1	1.3-2.7	1.5-2.6
N	12	12	10	12	3

Table 7. Percent lipid in the liver tissue of winter flounder from New York, 1977.

	Great Bay (Mar 77) (#73-84)	Sandy Hook/Raritan Bay No Apparent Fin Damage (Jun 77) (#85-96)	Sandy Hook/Raritan Bay Fin Damage (Jun 77) (#97-108)	Apex dump area No Apparent Fin Damage (Oct. 77) (#109-120)	Apex dump area Fin Damage (Oct 77) (#121-23)
	6.3	17	6.0	26	20
	17	19	7.4	26	9.1
	13	24	-	13	7.2
	17	21	11	7.5	
	14	18	6.8	30	
	10	7.1	9.2	12	
	8.1	24	29	18	
	6.7	23	17	20	
	9.1	25	15	14	
	6.0	27	19	17	
	15	20	7.6	29	
	19	23	7.7	14	
median	12	22	9.2	18	9.1
95% confidence limits	6.3-17	18-24	6.8-19	13-26	-
mean	12	21	12	19	12
standard deviation	4.6	5.2	7.1	7.3	6.9
coefficient of variation	38%	25%	59%	38%	58%
range	6.0-19	7.1-27	6.0-29	7.5-30	7.2-20

Table 8. Ratios of freeze-dried weight to wet weight of liver tissue from winter flounder from New York, 1977.

	Great Bay (#73-84)	Raritan Bay		Apex area	
		No Apparent Fin Erosion (#85-96)	Fin Erosion (#97-108)	No Apparent Fin Erosion (#109-120)	Fin Erosion (#121-123)
	0.24	0.30	0.23	0.38	0.35
	0.33	0.32	0.25	0.40	0.27
	0.28	0.36	-	0.30	0.26
	0.32	0.32	0.28	0.32	
	0.30	0.30	0.27	0.40	
	0.28	0.22	0.28	0.30	
	0.25	0.36	0.38	0.30	
	0.24	0.36	0.32	0.34	
	0.24	0.35	0.28	0.26	
	0.22	0.37	0.31	0.32	
	0.31	0.32	0.26	0.39	
	0.34	0.36	-	0.27	
median	0.28	0.34	0.28	0.32	0.27
95% confidence limits	0.24-0.32	0.30-0.36	0.25-0.32	0.30-0.39	
mean	0.28	0.33	0.29	0.33	
standard deviation	0.041	0.042	0.042	0.050	
coefficient of variation	15%	13%	14%	15%	
range	0.22-0.34	0.22-0.37	0.23-0.38	0.26-0.40	0.26-0.35