

Reproductive Success, Xenobiotic Contaminants and Hepatic Mixed-Function Oxidase (MFO) Activity in *Platichthys stellatus* Populations From San Francisco Bay*

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To identify some specific effects of organic contaminants on fisheries in an urbanized estuary we compared the reproductive success of starry flounder from San Francisco Bay with concentrations of tissue contaminants and hepatic mixed-function oxidase (MFO) activity. We found significantly lower ($P < 0.05$) sediment concentrations of total identified polynuclear aromatic hydrocarbons (PAHs) in the less urbanized San Pablo Bay (SP) area (Fig. 1) than in the more urbanized central bay (CB) stations (Table 1). For flounder in early gametogenesis (August and September) the SP fish ($n = 20$) had significantly lower ($P < 0.01$) liver concentrations of Aroclor 1260 ($0.34 \pm 0.14 \mu\text{g/g}$) than those at the CB stations: Berkeley (BK, $n = 20$, $1.6 \pm 1.6 \mu\text{g/g}$); Oakland (OK, $n = 16$, $2.3 \pm 2.8 \mu\text{g/g}$); and Alameda (AL, $n = 4$, $2.2 \pm 1 \mu\text{g/g}$). A similar pattern existed for DDT concentrations: SP = $0.2 \pm 0.16 \mu\text{g/g}$; BK = $0.41 \pm 0.34 \mu\text{g/g}$; OK = $0.4 \pm 0.53 \mu\text{g/g}$; and AL = $0.4 \pm 0.33 \mu\text{g/g}$. Total PAHs in livers were as follows: SP = $0.14 \mu\text{g/g}$; BK = $2.6 \mu\text{g/g}$; OK = $1.4 \mu\text{g/g}$; and AL = $14 \mu\text{g/g}$. Although gonad index, liver index, and presence of fin rot are inversely related to aryl hydrocarbon hydroxylase (AHH) activity, healthy fish in a similar reproductive state have lower AHH activities in the

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SP area. For example, in August and September, 1984, mean AHH activities were as follows: SP = 203 ± 89 , and CB = 355 ± 200 pmol 3-OH-B[a]P mg microsomal protein min. We found a log-linear relationship for AHH activity and its percent inhibition by 7,8-benzoflavone (10^{-4} M) and only a few fish from SP showed enhanced AHH activity after addition of 7,8-benzoflavone. This suggests that most of the starry flounder in San Francisco Bay are induced.

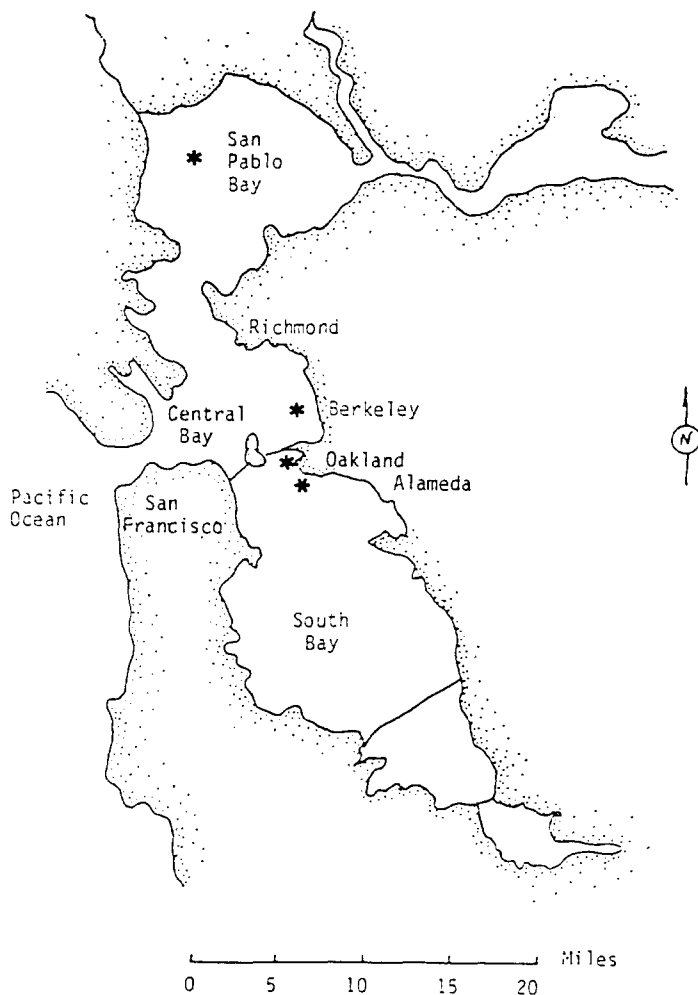


Fig. 1. San Francisco Bay with major starry flounder collection locations.

Reproductive fish captured during the previous December through February were injected with carp pituitary extract (1 mg/kg/day) to induce the final stages of gametogenesis and spawning. Using a standard protocol for each spawning female, we determined the percent of floating (viable) eggs, fertilization success, embryological success (fertilization through hatching), proportions of normal larvae, and total viable hatch. Variability of fertilization success for 300 crosses was distributed as follows: random error = 13 %, male = 1 %, between-spawn = 66 %, and between-female = 20 %. Generally, females spawned three times before chemical analyses and enzyme assays were performed.

In a short supplementary experiment, we evaluated the effect of pituitary injections on MFO activity. The AHH activity was not affected by 5 days of pituitary injection at the standardized dose. In addition, we compared the number of injection days for the females spawned in the 1982–1983 and 1983–1984 seasons to fertilization success and AHH activities. After 41 days percent fertilization and AHH activity correlated positively with the number of injection days. Therefore, in the analyses of reproductive success we included only the fish that received injections for less than 41 days.

We also compared reproductive success to concentrations of tissue contaminants and MFO activity for all females spawned ($n = 27$) and for all females from each capture site. For all females spawned, the total PCB content of eggs correlated inversely with embryological success ($r = -0.49$, $P = 0.02$) and hatching success ($r = -0.41$, $P = 0.04$). The relationship between PCB content of eggs and embryological success correlated even better ($r = -0.59$, $P < 0.012$) when PCBs were normalized to lipid content. Log-hepatic AHH activity of spawned females correlated inversely with fertilization success ($R = -0.60$, $P = 0.001$), embryological success ($r = -0.40$, $P = 0.045$); and viable hatch ($r = -0.46$, $P = 0.019$).

A comparison of spawning females by capture site shows that those from SP and CB sites differ in fertilization success (SP = 60 %, CB = 49 %), liver concentrations of total chlorinated hydrocarbons (SP = $0.81 \mu\text{g/g}$, CB = $2.5 \mu\text{g/g}$), and hepatic MFO activity (SP = 32, CB = 47), which is consistent with an effect of contaminant on reproductive success.

The chemical data support a hypothesis that chronic contamination of reproductive tissues by relatively low PCB concentrations ($< 200 \mu\text{g/kg}$) is having a pervasive deleterious effect on the reproductive success of

TABLE 1
Concentrations of Organic Contaminants and Total Organic Carbon in San Francisco Bay Sediment ($\pm$ SD). Numbers of Samples at Each Site are Given in Parentheses

Chemical parameter	Central Bay			
	San Pablo Bay (3)	Berkeley (3)	Oakland (3)	Alameda (2)
Polynuclear aromatic hydrocarbons (PAH) ($\mu\text{g/kg dry}$)				
9,10 dihydroanthracene	0.96 ± 1.7	1.1 ± 1.3	70 ± 87	2.5
phenanthrene	200 ± 27	300 ± 35	580 ± 220	69
anthracene	40 ± 4	180 ± 57	240 ± 81	13
1-methylphenanthrene	110 ± 28	100 ± 21	280 ± 87	19
fluoranthene	140 ± 19	330 ± 71	400 ± 57	55
pyrene	130 ± 19	280 ± 68	330 ± 67	45
benzanthracene	110 ± 30	180 ± 44	270 ± 26	25
chrysene/triphenylene	180 ± 120	230 ± 51	260 ± 130	36
benzo[b]fluoranthene	660 ± 390	140 ± 746	1300 ± 220	99
benzo[k]fluoranthene	370 ± 430	360 ± 110	400 ± 72	31
benzo[e]pyrene	160 ± 96	330 ± 270	290 ± 78	24
benzo[a]pyrene	130 ± 49	330 ± 160	250 ± 100	22
perylene	110 ± 68	110 ± 37	120 ± 44	6
benzo[ghi]pyrene	170 ± 106	260 ± 85	350 ± 140	21
Total identified PAHs	2600 ± 1300	4600 ± 1800	5660 ± 760	470
Total organic carbon ($\mu\text{g/g dry}$)	310 ± 10	230 ± 30	250 ± 30	45

starry flounder in San Francisco Bay. Similar findings have been reported for Baltic flounder.¹ The relationships of AHH activity to reproductive success may, however, have several interpretations:

- (i) another expression of PCB contamination,
- (ii) an effect of the binding toxic intermediates of MFO metabolism to egg macromolecules,²
- (iii) an indirect effect of contaminants on viability through vitellogenin production³ or hormone levels,⁴ or
- (iv) an artifact of pituitary injection.

The correlation of effects with PCB concentrations in these females favor interpretations (i)–(iii); however, additional studies may differentiate among these possibilities.

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