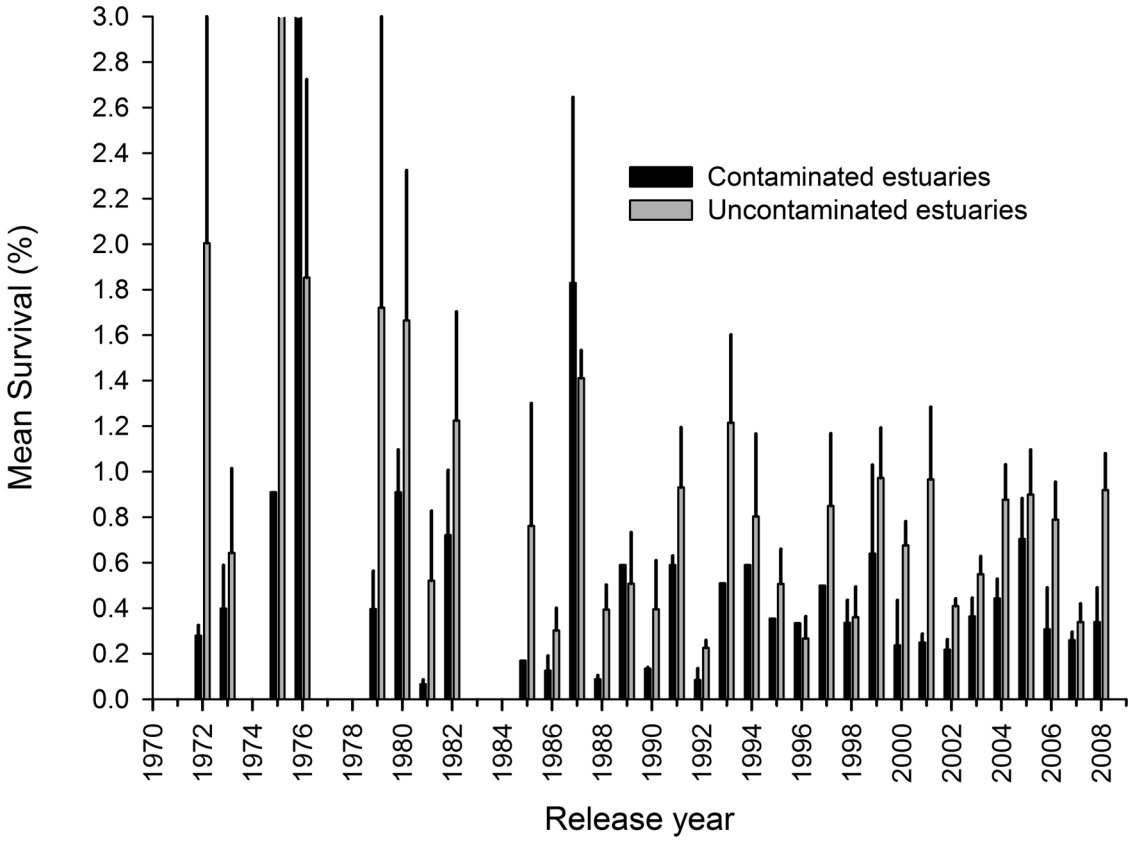
Table 5. Means and *p* values for statistical tests comparing fish parameters for groups released into contaminated versus uncontaminated estuaries.

	ANOVA (all years)			Wilcoxon (year by year)	
	SAR (%)	Mass × contamination	Mass (g)	SAR	Mass
Chinook					
Mean uncontaminated	0.87 (0.07), *n* = 164		6.49 (0.15)	28 years	21 years
Mean contaminated	0.48 (0.06), *n* = 80		6.21 (0.21)	4 years	11 years
p value	<0.0001	0.27	0.28	<0.0001	0.25
Coho					
Mean uncontaminated	6.9 (0.42), *n* = 120		25.0 (0.39)	13 years	11 years
Mean contaminated	8.1 (0.48), *n* = 106		26.1 (0.40)	23 years	25 years
p value	0.07	0.75	0.05	0.013	0.08

Note: Mean and standard error (SE in parentheses) values for smolt-to-adult return rate (SAR) and release mass (g wet mass) for all years. *p* values from ANOVAs for SAR and mass as the dependent variable. *n* shows the number of hatchery releases for each group. The *p* value for the interaction term mass × contamination from an ANCOVA (with SAR as the dependent variable) also shown. Under "Wilcoxon" values are the years of dominance for each categorical group (contaminated or uncontaminated estuary). For Chinook, the SAR was higher for fish from uncontaminated estuaries for 28 out of 32 years of data.

Fig. 2. Mean and standard error smolt-to-adult return rate (SAR) for groups of hatcheries releasing juvenile Chinook to contaminated and uncontaminated estuaries.



whether this is true for smaller estuaries with fewer fish but relatively high densities. Fish that reside for days instead of weeks can still accumulate high concentrations of contaminants in a short period of time through high rates of ingestion and ventilation. To test the hypothesis that observed SAR values were influenced by estuary size, an ANOVA was run for hatcheries releasing only into large estuaries (>2.5 km^2; see Table 1). The results were essentially identical to that determined for all estuaries (mean SAR values 0.48 for contaminated estuaries versus 0.83 for uncontaminated estuaries; $p < 0.007$), indicating that estuary size is likely not an important factor for this analysis.

Analysis and discussion

This analysis supports the conclusion that Chinook from contaminated estuaries have a lower probability of completing their life cycle compared with fish transiting estuaries that are considered uncontaminated. The overall pattern of reduced survival for ocean-type Chinook that migrate through contaminated estuaries in Puget Sound is robust because of the large number of fish, hatcheries, and estuaries spanning more than 37 years of data. Because this dataset encompasses decades of data and myriad factors are known to influence salmonid survival, high variability was