2001 Regional Monitoring Program

Bivalve Tissue Results

4.0 Bivalve Monitoring

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4.1 Background

The RMP Status and Trends program has been analyzing bivalve tissue for trace contaminants since 1993. Bivalves accumulate chemical contaminants through the food web and through ambient water. Bivalves act as transfer vectors of contaminants to higher trophic levels of the aquatic food web. Contaminant concentrations in tissue can be at levels much greater than those found in ambient water due to the organism's inability to metabolize certain contaminants (Vinogradov, 1959) and due to the affinity of some chlorinated hydrocarbons for lipid rich tissue in bivalves. (Stout et al., 1981). Biomonitoring of bivalves has been widely applied by the California State Mussel Watch Program (Phillips, 1988; Rasmussen, 1994) and other studies (Young et al., 1976; Wu and Levings, 1980; Hummel et al., 1990; Martincic et al., 1992). The RMP is extending the long-term monitoring of the State Mussel Watch Program at several stations in the Bay. For reviews of bioaccumulation monitoring, see Luoma and Linville (1996), Gunther and Davis (1997) and Gunther et al., (1999).

In 2001, bivalves for transplanting were collected from two uncontaminated sites; *Mytilus californianus* from Bodega Head and *Crassostrea gigas* from Tomales Bay. The bivalves were deployed at a total of 12 sites within the Estuary. The transplant studies were conducted with bagged and caged bivalves during the dry season (July through September). Caged bivalves were used in addition to the bagged samples in order to test a method that could lower predation and require less maintenance. The study area ranged from Coyote Creek (BA10) in the South Bay to the Napa River (BD50) in the North Bay (Figure 1).

The RMP no longer transplants *Corbicula fluminea* at the Sacramento and San Joaquin river stations. Uncontaminated specimens could not be found from a "clean" reference site. Consequently, resident *Corbicula fluminea* were collected for analysis from these stations.

All bivalves were kept on ice after collection and deployed within 72 hours. Multiple species were deployed at several stations due to uncertain salinity regimes and tolerances. The effects of high short-term flows of freshwater on the transplanted bivalves west of Carquinez Strait were minimized by deploying the bivalves near the bottom of the water column, where density gradients tend to maintain higher salinities. Chemical analyses were performed on a composite of each species at each deployment site. Detailed sampling and analysis methods are included in the *Description of Methods*. Data are tabulated in the *Data Tables*.

Contaminant concentrations in tissue of transplanted bivalves were measured before deployment (referred to as time zero [T-0] or background) and at the end of the 90-100 day deployment period. Survival and biological condition indices were also measured. Because of the potential variability and the small tissue mass in individual bivalves, composite samples of tissue were made from each deployment site (up to 45 individuals) for analyses of trace contaminants.

Samples were analyzed for up to 11 trace metals (Table 19) and 85 synthetic organic chemicals, including PAHs (Table 20), PCBs (Table 21), and pesticides (Table 22). Aluminum is not biologically available to bivalves and is only measured as a surrogate for sediment retained in the bivalve gut. Therefore aluminum is not depicted in the graphs. Tissue concentrations of trace metals and organic chemicals are reported on a dry weight basis to reduce data variability due to moisture content.

Overall, the bivalve bioaccumulation and condition study objectives for 2001 were met. The RMP Design Integration Workgroup determined that it is sufficient to analyze tissue concentrations in bivalves only once per year

during the dry season, when Estuary conditions are more consistent on an interannual basis. The 2001 bivalve deployment marks the second year of annual dry season monitoring.

4.2 Accumulation Factors

In addition to reporting the absolute tissue concentrations prior to and after each bivalve deployment period, this report uses accumulation factors (AF) to indicate accumulation or depuration (loss of contaminants from bivalve tissue by metabolism) during the 90-100 day deployment period for mussels and oysters. The accumulation factor is calculated by dividing the final contaminant concentration in transplants by the initial bivalve concentration at T-0. For example, an accumulation factor of 1.0 indicates that the concentration of a specific contaminant remained the same during the deployment period compared to the initial contaminant level prior to transplanting the bivalves to the Estuary. An AF less than 1 indicates that the bivalves decreased in contaminant concentration during the deployment period, while an AF greater than 1 indicates accumulation. Accumulation factors are not calculated in *Corbicula fluminea*, since they were collected as resident clams and not transplanted from a clean site.

4.3 Guidelines

Screening Values (SVs) were developed following EPA guidance for evaluation of contaminants in fish tissue in a study from two California Lakes (Brodberg, 1999) (Table 4.1). Screening values are defined as concentrations of target analytes in fish or shellfish tissue that are of potential public health concern. Exceedance of screening values should be taken as an indication that more intensive site-specific monitoring and/or evaluation of human health risk should be conducted. The calculations were based on a 70 kg adult using a cancer risk of 10⁻⁵ for carcinogens. A consumption rate of 21 g/day was used. Although these Screening Values are applied to human consumption of contaminated fish, there may also be potential adverse effects in wildlife that consume contaminated fish.

The screening values are used for comparison purposes only and do not suggest a possible public health concern, since the bagged bivalves in the RMP are temporary residents of the Estuary and are used as indicators of bioaccumulative contaminants for status and trends analyses. No follow-up action is triggered when bivalve values are above guidelines.

Tissue guidelines are generally expressed in wet weight, while the RMP tissue data are reported in dry weight. Conversion to dry weight reduces the variability in results that occur due to varying moisture content of the samples. A wet-to-dry weight conversion was applied to the guideline values for comparative purposes, using a multiplication factor of 7. This value is based on average moisture content in bivalves of 85% (1998 RMP data). SVs for those parameters reported by the RMP have been converted to dry weight and are listed in Table 4.1.

4.4 Biological Condition and Survival

The biological condition index (expressed as the ratio of dry tissue weight to shell cavity volume) and the survival rates of the transplanted bivalves (following exposure to Estuary water) are used as general indicators of bivalve health (Figure 4.14-4.15). However, the data on survival and condition of the transplants indicate that certain sites are generating non-contaminant related, physiological stress in the animals at certain times, which confounds the interpretation of bioaccumulation data and interferes with the bivalves' usefulness as biomonitors. In addition, during 2001 the RMP began calculating the growth mean as an indicator of bivalve health. The growth mean is a measure of growth of the composite of bivalves at a particular site in comparison to the T-0. The growth mean is determined by taking the dry weight of each individual and subtracting the dry weight of the T-0 for that species. This calculation is done for each individual bivalve. The mean of all the individuals at a particular site is then calculated to give the growth mean.

Since the winter cruise of 1999, comparisons between the traditionally used *Mytilus californianus* and the hybrid Bay mussel (*Mytilus galloprovincialis / trossulus / edulis*) have been conducted. This comparison evaluates potential artifacts introduced by using an open-ocean intertidal mussel (*Mytilus californianus*) as an indicator organism versus a related species adapted to more variable estuarine conditions. Comparing the condition index and percent survival of these two species may show that one species is better for deployment in the Estuary.

4.5 Bivalve Trends

Transplanted bivalves are valuable in assessing long-term trends because they provide an integrated measure of contamination over a three-month period. This interval is more appropriate for assessment of interannual trends than the "snapshot" represented by discrete RMP water samples, which are more subject to short-term hydrological variations and other disturbances, or by sediment samples that represent the mixed and highly dynamic sediment layer reflecting approximately 20 years of contaminant deposits and re-suspension of sediment. Bivalves have been shown to complement fish tissue contaminant concentration data in detecting changes in contaminant availability to the food web (Russell and Gobas, 1989).

Figures 4.16-4.26 present trend plots of RMP bivalve bioaccumulation data for trace elements and trace organics from 1993 to 2001. Trends for *Corbicula fluminea* are not depicted due to the shift from transplanted to resident organisms. Concentrations in these plots are expressed as net bioaccumulation or depuration during the deployment period (initial concentrations prior to deployment have been subtracted from final concentrations measured after deployment). The data points on the trend plots represent an average of all sites for a particular species. The range bars depict the minimum and maximum accumulation for that species. Since the wet season sampling was discontinued in 2000, seasonal patterns will no longer be monitored.

4.6 Discussion

Bivalve monitoring is conducted in the San Francisco Estuary to measure contaminant accumulation in bivalve tissue during the dry season as one measure of the potential bioavailability of contaminants of concern throughout the Bay. It is also a valuable tool to indicate long-term contaminant trends. As currently designed, this program component is unable to compare contaminant bioavailability and accumulation in different regions of the Estuary due to the different species deployed. Varying salinities in the Estuary prevent the deployment of one species throughout the study area (see *Description of Methods* and Gold and Bell, 1998).

Trace Metals

In general, oysters accumulate trace metals more readily than mussels. The mean accumulation of cadmium and selenium was lower in mussels in comparison to 2000 while mean accumulation for copper, nickel, zinc and silver was higher than 2000 (4.16 - 4.23). The mean accumulation of cadmium, copper, nickel, silver and zinc was higher in oysters in comparison to 2000 while the mean accumulation of selenium was lower. Negative accumulation factors (depuration) were calculated for 86% of the mussel sites for cadmium and 43% of the mussel sites for silver (Figures 4.1 and 4.6). There was also depuration of these two analytes in some of the mussel sample sites in 2000. There was no depuration of any of the contaminants in oysters.

Trace Organics

In comparison to 2000, the 2001 average concentrations were lower in all three species for DDTs and chlordanes and were higher in bivalves for PAHs and PCBs (Figure 4.9-4.13). Average dieldrin concentrations increased in oysters and clams and decreased in mussels. The average bioaccumulation of trace organics for 2001 seemed to increase versus 2000 for PAHs and PCBs and decrease for DDTs for both oysters and mussels. Average accumulation decreased in mussels for chlordanes and increased for dieldrin between 2000 and 2001. For oysters,

the dieldrin 2001 accumulation factors are not available due to the T-0 being a non-detect. For PCBs, Coyote Creek (BA10) has a concentration 35 times higher than the T-0 resulting in a higher accumulation factor compared to other oyster sites in 2001. Oysters showed an average PCB accumulation factor approximately five times higher than in 2000.

Since chlorinated hydrocarbons are much more soluble in fat tissue than in water, they partition into the lipidrich tissue of aquatic organisms (Stout et al., 1981). Animals with higher proportions of lipid in their tissue usually have higher concentrations of chlorinated hydrocarbons (Phillips, 1980). Factors such as season, reproductive cycle, water temperature, condition of the organism, and species can affect the lipid levels of samples collected for analysis and can cause variability in results. Normalization to lipid weight may reduce this variability and the lipidnormalized results are more comparable for evaluating bioaccumulation of organic compounds. The sum of each organic compound class is divided by the lipid concentration of that sample.

The lipid normalized data (not shown) for dieldrin and chlordane showed a decrease in average concentration from 1997 to 2001. DDT shows a decrease in average concentration from 1998 to 2001. PCBs and PAHs show no discernable trend in average concentration over the time period for lipid normalized data.

Condition and Survival

In 2001, all of the sites with deployed oysters had a lower condition index than the T-0 site (Figure 4.15). Of these sites, Petaluma River (BD15) and Davis Point (BD40) had relatively lower survival rates of 66% and 79% respectively. The oyster samples for 2000 also showed lower survival rates of 55% and 67%, respectively, for these two sites. For mussels, all sites had a higher condition index than the T-0 site except for Red Rock (BC61) and Pinole Point (BD30).

Condition, percent lipid, and percent moisture measurements were made prior to deployment and after the transplants were collected to show natural variables affecting condition, such as weight loss due to reproduction. Weight loss due to reproduction can account for a decrease in contaminant concentrations by transfer of contaminants to gonadal tissue. At the sampling sites for *Crassostrea gigas*, which are located near the river-mouths Davis Point (BD40) and Petaluma River (BD15), low salinity ranges can cause higher mortality rates in oysters. They are deployed at sites with lower expected salinities because the tolerance of the organism to freshwater exposure is higher than in mussels (as low as 10‰), but their optimum salinity range for adult growth is reported at 35‰ (Mann et al., 1994). Salinity measurements during both deployment and collection times were within the acceptable range of 24 - 27‰. Other factors may be contributing to the lower survival at these two sites.

In 2000 a special study was implemented to test a new system of bivalve deployment. Predation of deployed bivalves can increase mortality especially at the Central Bay sites Horseshoe Bay (BC21) and Yerba Buena Island (BC10). Bivalves in cages were deployed in addition to the bagged bivalves at certain sites in order to determine which method produces higher survival. This study continued in 2001 with the number of sites having both caged and bagged bivalves increasing to seven sites. At Yerba Buena Island, survival was approximately 8 times higher for caged *Mytilus californianus* vs. bagged and 21 times higher for caged *Mytilus edulis* vs. bagged bivalves. In 2000 none of the bagged *Mytilus californianus* survived at Yerba Buena Island while 90% of the caged bivalves survived. Preliminary results show that mortality due to predation decreases in cages and that cages do not hinder bivalve growth during deployment (Dane Hardin, AMS, pers. comm.).

A comparison study of the bay mussel *Mytilus edulis* and the open-ocean intertidal mussel *Mytilus californianus* continued in 2001. In terms of bivalve growth (growth mean), there was no significant difference between the two species (Dane Hardin, AMS, pers. comm.).

4.7 References

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Table 4.1. California Screening Values calculated according to USEPA guidance (USEPA, 1995). Calculations were based on a 70 kg adult and a fish consumption value of 21 g/day. Guidelines were specifically developed for a California lake fish study and should be used as reference values in bivalve tissue concentrations only. No follow-up actions are associated with bivalve tissue concentrations above these screening values.

Screening values have been converted to dry weight using a conversion factor of 7, which is based on an 85% average moisture content in bivalves.

	Screening Value dr	у
PARAMETER	weight	dry unit
Cd	21	ppm
Se*	14	ppm
Dieldrin	14	ppb
Endrin	7,000	ppb
gamma-HCH	210	ppb
Heptachlor Epoxide	28	ppb
Hexachlorobenzene	140	ppb
Total Chlordanes (SFEI)	210	ppb
Total DDTs (SFEI)	700	ppb
Total PCBs (SFEI)	140	ppb

* Selenium screening value recommended by the California Office of Environmental Health Hazard Assessment. California lake fish study has Se SV of 140 ppm.



Figure 4.9. Sum of PAH concentrations in parts per billion dry weight (ppb) in two transplanted and one native bivalve species at 15 RMP stations during the dry-season sampling period. T-0 (time zero) is the initial concentration before deployment in the Estuary. Accumulation factors ranged from 4.69 to 26.2. Median concentrations were highest in *C. fluminea*, intermediate in *C. gigas, and lowest in M. californianus*. The highest measured concentration was in *C. gigas*, at Napa River (BD50).



Figure 4.10. Sum of PCB concentrations in parts per billion dry weight (ppb) in two transplanted and one native bivalve species at 15 RMP stations during the dry-season sampling period. Accumulation factors ranged from 4.64 to 35.63. Median concentrations were highest in *C. fluminea*, intermediate in *C. gigas*, and lowest in *M. californianus*. The highest measured concentration was in *C. fluminea*, at Sacramento River (BG20).



Figure 4.11. Sum of DDT concentrations in parts per billion dry weight (ppb) in two transplanted and one native bivalve species at 15 RMP stations during the dry-season sampling period. Accumulation factors ranged from 3.55 to 13.3. Median concentrations were highest in *C. fluminea*, intermediate in *C. gigas*, and lowest in *M. californianus*. The highest measured concentration was in *C. fluminea*, at Sacramento River (BG20).



Figure 4.12. Sum of chlordane concentrations in parts per billion dry weight (ppb) in two transplanted and one native bivalve species at 15 RMP stations during the dry-season sampling period. Accumulation factors ranged from 2.38 to 84.69. Median concentrations were highest in *C. fluminea*, intermediate in *C. gigas*, and lowest in *M. californianus*. The highest measured concentration was in *C. gigas* at Coyote Creek (BA10).

Dieldrin in Bivalves, September 2001



Figure 4.13. Dieldrin concentrations in parts per billion dry weight (ppb) in two transplanted and one native bivalve species at 15 RMP stations during the dry-season sampling period. $\mathbf{\nabla}$ = not detected. Accumulation factors ranged from 1.81 to 3.27. Median concentrations were highest in *M. californianus*, intermediate in *C. fluminea*, and lowest in *C. gigas*. The highest measured concentration was in *M. californianus* at Yerba Buena Island (BC10).



Figure 4.1. Cadmium concentrations in parts per million dry weight (ppm) in three bivalve species at 15 RMP stations during the dry season sampling period. T-0 (time zero) is the initial concentration before deployment in the Estuary. Accumulation factors ranged from 0.74 (depuration) to 3.36. Median concentrations were highest in *C. gigas,* intermediate in *M. californianus,* and lowest in *C. fluminea.* The highest measured concentration was in *C. gigas,* at Napa River (BD50).



Figure 4.2. Copper concentrations in parts per million dry weight (ppm) in three biv alve species at 15 RMP stations during the dryseason sampling periods. T-0 (time zero) is the initial concentration before deployment in the Estuary. Accumulation factors ranged from 1.73 to 12.0. Median concentrations were highest in *C. gigas*, intermediate in *C. fluminea*, and lowest in *M. californianus*. The highest measured concentration was in *C. gigas*, at Napa River (BD50).



Figure 4.3. Lead concentrations in parts per million dry weight (ppm) in three biv alve species at 15 RMP stations during the dryseason sampling period. B = blank contamination > 30% of measured concentation. T-0 (time zero) is the initial concentration before deployment in the Estuary. Accumulation factors ranged from 0.95 to 1.51 in M. californianus. Due to blank contamination in the T-0 sample for *C. gigas*, no accumulation factors could be calculated. Median concentrations were highest in *C. fluminea*, intermediate in *M. californianus*, and lowest in *C. gigas*. The highest measured concentration was in *M. californianus*, at Red Rock (BC61). ★ means no analyzed data.



Figure 4.4. Nickel concentrations in parts per million dry weight (ppm) in three bivalve species at 15 RMP stations during the dryseason sampling period. T-0 (time zero) is the initial concentration before deployment in the Estuary. Accumulation factors ranged from 1.63 to 10.04. Median concentrations were highest in *C. fluminea*, intermediate in *M. californianus*, and lowest in *C. gigas*. The highest measured concentration was in *C. fluminea*, at Sacramento River (BG20).

Selenium in Transplanted Bivalves, September 2001



Figure 4.5. Selenium concentrations in parts per million dry weight (ppm) in three bivalve species at 15 RMP stations during the dryseason sampling period. T-0 (time zero) is the initial concentration before deployment in the Estuary. Accumulation factors ranged from 1.21 to 2.65. Median concentrations were highest in *C. fluminea*, intermediate in *C. gigas*, and lowest in *M. californianus*. The highest measured concentration was in *C. fluminea*, at San Joaquin River (BG30).



Figure 4.6. Silver concentrations in parts per million dry weight (ppm) in three bivalve species at 15 RMP stations during the dryseason sampling period. T-0 (time zero) is the initial concentration before deployment in the Estuary. Accumulation factors ranged from 0.69 (depuration) to 15.92. Median concentrations were highest in *C. gigas*, intermediate in *C. fluminea* and lowest in *M. californianus*. The highest measured concentration was in *C. gigas*, at Davis Point (BD40).



Figure 4.7. Tributyltin concentrations in parts per billion dry weight (ppb) in three bivalve species at 15 RMP stations during the dryseason sampling period. \forall = not detected. T-0 (time zero) is the initial concentration before deployment in the Estuary. Accumulation factors ranged from 1.0 to 47.2. Median concentrations were highest in *C. fluminea*, intermediate in *M. californianus* and lowest in *C. gigas.* The highest measured concentration was in *M. californianus*, at Yerba Buena Island (BC10).



Figure 4.8. Zinc concentrations in parts per million dry weight (ppm) in three bivalve species at 15 RMP stations during the dryseason sampling period. T-0 (time zero) is the initial concentration before deployment in the Estuary. Accumulation factors ranged from 1.20 to 3.39. Median concentrations were highest in *C. gigas,* intermediate in *C. fluminea* and lowest in *M. californianus.* The highest measured concentration was in *C. gigas,* at Napa River (BD50).





BA40

BC10

BC21

BC61

BB71

BD30

BA30

0-L

A *Corbicula* reference site for the dry season was not available, since clams could no longer be found at "clean" sites. Consequently, resident specimens were collected from a population in the Sacramento River (BG20) and San Joaquin River (BG30). Bars indicate standard error of values.

Bivalve Survival (2001)







Figures 4.14. Percent survival of transplanted bivalves following exposure to Estuary conditions during the dry season (September) of 2001.

Cadmium, mg/kg, dry weight



Figure 4.16. Cadmium accumulation or depuration in parts per million dry weight (ppm) in two transplanted biv alve species for 16 sampling periods from 1993–2001. Initial (T-0) concentrations are subtracted from tissue concentrations after retrieval to give concentrations accumulated or depurated (negative value) during deployment in the Estuary. Bars indicate the range of values of all stations where species were deployed. Note different y-axis scales. **★** means no analyzed data available.

Copper, mg/kg, dry weight Mytilus californianus



Figure 4.17. Copper accumulation or depuration in parts per million dry weight (ppm) in two transplanted bivalve species for 16 sampling periods from 1993–2001. Initial (T-0) concentrations are subtracted from tissue concentrations after retrieval to give concentrations accumulated or depurated (negative value) during deployment in the Estuary. Bars indicate the range of values of all stations where species were deployed. Note different y-axis scales. ★ means no analyzed data available.

Lead, mg/kg, dry weight Mytilus californianus



Figure 4.18. Lead accumulation or depuration in parts per million dry weight (ppm) in two transplanted bivalve species for 16 sampling periods from 1993–2001. Initial (T-0) concentrations are subtracted from tissue concentrations after retrieval to give concentrations accumulated or depurated (negative value) during deployment in the Estuary. Bars indicate the range of values of all stations where species were deployed. Note different y-axis scales. ★ means no analyzed data available.

Nickel, mg/kg, dry weight Mytilus californianus



Figure 4.19. Nickel accumulation or depuration in parts per million dry weight (ppm) in two transplanted bivalve species for 16 sampling periods from 1993–2001. Initial (T-0) concentrations are subtracted from tissue concentrations after retrieval to give concentrations accumulated or depurated (negative value) during deployment in the Estuary. Bars indicate the range of values of all stations where species were deployed. Note different y-axis scales. \star means no analyzed data available.

Selenium, mg/kg, dry weight

Mytilus californianus



Figure 4.20. Selenium accumulation or depuration in parts per million dry weight (ppm) in two transplanted bivalve species for 16 sampling periods from 1993–2001. Initial (T-0) concentrations are subtracted from tissue concentrations after retrieval to give concentrations accumulated or depurated (negative value) during deployment in the Estuary. Bars indicate the range of values of all stations where species were deployed. Note different y-axis scales. ★ means no analyzed data available.





Figure 4.21. Silver accumulation or depuration in parts per million dry weight (ppm) in two transplanted biv alve species for 16 sampling periods from 1993–2001. Initial (T-0) concentrations are subtracted from tissue concentrations after retrieval to give concentrations accumulated or depurated (negative value) during deployment in the Estuary. Bars indicate the range of values of all stations where species were deployed. Note different y-axis scales. \star means no analyzed data available.

Tributyltin, ug/kg, dry weight

Mytilus californianus



Figure 4.22. Tributyltin accumulation or depuration in parts per billion dry weight (ppb) in two transplanted bivalve species for 5 sampling periods from 1998–2001. Initial (T-0) concentrations are subtracted from tissue concentrations after retrieval to give concentrations accumulated or depurated (negative value) during deployment in the Estuary. Bars indicate the range of values of all stations where species were deployed. ★ means no analyzed data available.

Zinc, mg/kg, dry weight

Mytilus californianus



Figure 4.23. Zinc accumulation or depuration in parts per million dry weight (ppm) in two transplanted bivalve species for 16 sampling periods from 1993–2001. Initial (T-0) concentrations are subtracted from tissue concentrations after retrieval to give concentrations accumulated or depurated (negative value) during deployment in the Estuary. Bars indicate the range of values of all stations where species were deployed. Note different y-axis scales. \star means no analyzed data available.

Sum of PAHs µg/kg, dry weight

Mytilus californianus



Figure 4.24. PAH accumulation or depuration in parts per billion dry weight (ppb) in two species of transplanted biv alves for 15 sampling periods from 1993–2001 (mean of all stations). Accumulation or depuration was calculated by subtracting initial tissue (T-0) concentrations from concentrations after deployment. Bars indicate range of values within a sampling period. ★ means no analyzed data available.

Sum of PCBs µg/kg, dry weight *Mytilus californianus*



Figure 4.25. PCB accumulation or depuration in parts per billion dry weight (ppb) in two species of transplanted bivalves for 15 sampling periods from 1993–2001 (mean of all stations). Accumulation or depuration was calculated by subtracting initial tissue (T-0) concentrations from concentrations after deployment. Bars indicate range of values within a sampling period. ★ means no analyzed data available.

Sum of DDTs µg/kg, dry weight *Mytilus californianus*



Figure 4.26. DDT accumulation or depuration in parts per billion dry weight (ppb) in two species of transplanted biv alves for 15 sampling periods from 1993–2001 (mean of all stations). Accumulation or depuration was calculated by subtracting initial tissue (T-0) concentrations from concentrations after deployment. Bars indicate range of values within a sampling period. ★ means no analyzed data available.

2001 Regional Monitoring Program

Bivalve Tissue Data Tables

Table 17. Ancillary bivalve tissue data, 2001.

NS = not sampled, NA = not available.

CFLU - *Corbicula fluminea*, CGIG - *Crassostrea gigas*, MCAL - *Mytilus californianus* T-0 = time of bivalve deployment into the Estuary from the source indicated under station name heading.

Station Code	Station	Date	Cruise	Species	% Lipids - TIS-ORG-GERG	% Moisture - TIS-ORG-GERG	% Solids - TIS-ORG-GERG	% Solids - Se	% Solids - Ag, Al, Cd, Cu, Ni, Pb, Zn	Dry Weight - TIS-ORG-GERG	Growth Mean	Growth Standard Error
5.000		0.000.0000.0		05111	%	%	g	%	%	g	g	g
BG20	Sacramento River	9/30/2001	2001-09	CFLU	8.40	95.2	4.80	4.65	5.05	0.49	NA	NA
BG30	San Joaquin River	9/30/2001	2001-09	CFLU	5.90	96.6	3.40	3.80	4.78	0.34	NA	NA
BD50	Napa River	9/28/2001	2001-09	CGIG	4.40	93.3	6.70	6.15	5.96	0.69	-1.05	0.07
BD40	Davis Point	9/28/2001	2001-09	CGIG	76.70	90.5	9.50	7.30	7.19	0.97	-0.08	0.12
BD30	PINOLE POINT	9/27/2001	2001-09		7.40	87.4	12.60	13.03	12.27	1.28	-0.26	0.05
BD20	San Pablo Bay	9/27/2001	2001-09		7.00	90.8	9.20	0.97	1.20	0.97	-0.27	0.11
DD ID DC61	Petaluma River	9/27/2001	2001-09		7.90	93.1	6.90 15.60	0.41	5.35 10.57	0.7	-1.14	0.05
BC01 BC21	Horseshoe Bay	9/25/2001	2001-09		5.00	04.4 91.2	19.00	12.14	12.07	1.7	-0.15	0.00
BC10	Verba Buena Island	9/25/2001	2001-09	MCAL	8 20	82.2	17.80	13.45	13.42	1.83	0.43 NA	0.05 NA
BB71		9/26/2001	2001-09	MCAL	6.30	84.8	15.20	14 22	13.00	1.00	-0.02	0.05
BΔ40	Redwood Creek	9/26/2001	2001-09	MCAL	7 10	86.1	13.20	14.50	13.33	1.50	-0.02	0.05
BA30	Dumbarton Bridge	9/26/2001	2001-09	MCAL	7.10	84.4	15.50	14.31	13.12	1.55	-0.00	0.00
BA10	Covote Creek	9/26/2001	2001-09	CGIG	12 10	88.3	11 70	8 88	8.04	1 23	0.00	0.12
T-0	Tomales Bay	5/28/2001	2001-09	CGIG	9.80	86.7	13.30	10 44	10.13	1.43	NA	NA
T-0	Bodega Head	5/29/2001	2001-09	MCAL	7.00	81.7	18.30	14.38	15.12	1.86	NA	NA

Table 18. Bivalve condition index and survival, 2001.

NA = not analyzed, NA* = resident bivalves used.

CFLU - Corbicula fluminea, CGIG - Crassostrea gigas, MCAL - Mytilus californianus

T-0 = time of bivalve deployment into the Estuary from the source indicated under station name heading.

Station Code	Station	Date	Cruise	Species	CI Mean	CI Standard Error	ی Survival per Species %	% Survival per Species (caged)
BC30	Sacramonto Divor	0/20/2001	2001.00	CELLI	0.045	0.003	% NA	<u>%</u>
BG30	San Joaquin River	9/30/2001	2001-09	CELU	0.045	0.003	NΔ	NΔ
BD50	Nana River	9/28/2001	2001-09	CGIG	0.004	0.000	94	NA
BD40	Davis Point	9/28/2001	2001-09	CGIG	0.081	0.004	79	NA
BD30	Pinole Point	9/26/2001	2001-09	MCAL	0.090	0.003	98	NA
BD20	San Pablo Bay	9/27/2001	2001-09	CGIG	0.071	0.003	86	NA
BD15	Petaluma River	9/27/2001	2001-09	CGIG	0.052	0.002	66	NA
BC61	Red Rock	9/25/2001	2001-09	MCAL	0.102	0.003	93	100
BC21	Horseshoe Bay	9/25/2001	2001-09	MCAL	0.156	0.003	98	98
BC10	Yerba Buena Island	9/25/2001	2001-09	MCAL	0.135	0.004	9	75
BB71	Alameda	9/27/2001	2001-09	MCAL	0.128	0.003	NA	NA
BA40	Redwood Creek	9/26/2001	2001-09	MCAL	0.124	0.003	99	NA
BA30	Dumbarton Bridge	9/26/2001	2001-09	MCAL	0.121	0.007	99	NA
BA10	Coyote Creek	9/26/2001	2001-09	CGIG	0.078	0.003	95	NA
T-0	Tomales Bay	5/28/2001	2001-09	CGIG	0.116	0.006	NA	NA
T-0	Bodega Head	5/29/2001	2001-09	MCAL	0.115	0.003	NA	NA
T-0	Tomales Bay	6/2/2001	2001-09	MEDU	0.089	0.004	NA	NA

Table 19. Trace element concentration in bivalve tissue, 2001. Units expressed as dry weight.

NA = not analyzed, ND = not detected, NS = not sampled, b = blank contamination <30% of measured concentration, e = estimated value.

2001-09

CFLU - Corbicula fluminea, CGIG - Crassostrea gigas, MCAL - Mytilus californianus

Accuracy (%error)

T-0 = time of bivalve deployment into the Estuary from the source indicated under station name heading.

station Code	station	bate	ruise	pecies	6 Solids - Se	6 Solids - Ag, Al, Cd, Cu, Ni, Pb, Zn	Aq	ΔΙ	Δs	Cd	Cr	Gu	На
	07			07	%	%	ma/ka	ma/ka	ma/ka	ma/ka	ma/ka	ma/ka	ma/ka
BG20	Sacramento River	9/30/2001	2001-09	CFLU	4.65	5.05	ND	b 5426.014	NA	4.927	NA	b 211.50	NA
BG30	San Joaquin River	9/30/2001	2001-09	CFLU	3.80	4.78	0.139	b 3874.113	NA	3.694	NA	b 269.38	NA
BD50	Napa River	9/28/2001	2001-09	CGIG	6.15	5.96	9.591	b 633.590	NA	19.676	NA	b 607.32	NA
BD40	Davis Point	9/28/2001	2001-09	CGIG	7.30	7.19	13.217	b 495.500	NA	17.596	NA	b 429.83	NA
BD30	Pinole Point	9/27/2001	2001-09	MCAL	13.03	12.27	ND	b 1031.956	NA	7.428	NA	10.074	NA
BD20	San Pablo Bay	9/27/2001	2001-09	CGIG	6.97	7.28	4.033	b 571.338	NA	11.853	NA	b 382.97	NA
BD15	Petaluma River	9/27/2001	2001-09	CGIG	6.41	5.35	11.897	b 792.376	NA	18.908	NA	b 561.29	NA
BC61	Red Rock	9/25/2001	2001-09	MCAL	12.14	12.57	ND	b 844.444	NA	6.743	NA	9.19	NA
BC21	Horseshoe Bay	9/25/2001	2001-09	MCAL	15.43	15.42	0.03	b 482.331	NA	7.637	NA	9.507	NA
BC10	Yerba Buena Island	9/25/2001	2001-09	MCAL	13.46	13.74	0.05	b 681.864	NA	5.863	NA	9.579	NA
BB71	Alameda	9/26/2001	2001-09	MCAL	14.22	13.99	0.20	b 859.745	NA	6.454	NA	9.197	NA
BA40	Redwood Creek	9/26/2001	2001-09	MCAL	14.59	13.7	0.36	b 614.926	NA	5.565	NA	9.35	NA
BA30	Dumbarton Bridge	9/26/2001	2001-09	MCAL	14.31	13.12	0.33	b 483.099	NA	6.334	NA	9.23	NA
BA10	Coyote Creek	9/26/2001	2001-09	CGIG	8.88	8.04	13.0	b 677.682	NA	8.807	NA	269.605	NA
T-0	Tomales Bay	5/28/2001	2001-09	CGIG	10.44	10.13	0.83	b 25.98	NA	5.854	NA	50.608	NA
T-0	Bodega Head	5/29/2001	2001-09	MCAL	14.38	15.12	0.029	b 70.50	NA	7.548	NA	5.31	NA
Quality Assurance Tabl	es												
Average Of Blanks Per	r Cruise		2001-09					5.1				0.1	
Standard Deviation of	Blanks		2001-09					NA				NA	
Average Method Detec	tion Limit		2001-09				0.03	0.26	NA	0.09	NA	0.09	NA
Number of replicates			2001-09				2	2	NA	2	NA	2	NA
Standard Deviation of	Replicates		2001-09				0.01	30	NA	0.5	NA	0.8	NA
Precision (RSD%)			2001-09				ND	5	NA	7	NA	9	NA

ND

4

NA

21

NA

NA

15

Table 19. Trace element concentration in bivalve tissue, 2001 (continued). Units expressed as dry weight.

NA = not analyzed, ND = not detected, NS = not sampled, b = blank contamination <30% of measured concentration, e = estimated value.

CFLU - Corbicula fluminea, CGIG - Crassostrea gigas, MCAL - Mytilus californianus

T-0 = time of bivalve deployment into the Estuary from the source indicated under station name heading.

tation Code	tation	late	ruise	pecies	6 Solids - Se	6 Solids - Ag, Al, Cd, Cu, Ni, Pb, Zn	Ni	Bh	50	70	DET	MRT	TET	TTRT
0 O	о О		0	S	%	%	ma/ka	ma/ka	ma/ka	ma/ka	ua/ka Sn	ua/ka Sn	ua/ka Sn	ua/ka Sn
BG20	Sacramento River	9/30/2001	2001-09	CFLU	4.65	5.05	22.179	r 2.21	11.59	208.605	lp, r 51.47	r 57.38	68.59	ND
BG30	San Joaquin River	9/30/2001	2001-09	CFLU	3.80	4.78	16.167	r 1.35	17.66	192.766	lp, r 91.94	r 196.37	64.33	ND
BD50	Napa River	9/28/2001	2001-09	CGIG	6.15	5.96	2.69	r 0.25	10.07	1251.697	lp, r 21.83	r 41.45	79.82	ND
BD40	Davis Point	9/28/2001	2001-09	CGIG	7.30	7.19	2.094	ND, r	4.84	1138.256	ND, p, r	ND, r	55.25	ND
BD30	Pinole Point	9/27/2001	2001-09	MCAL	13.03	12.27	5.345	r 1.30	4.43	203.238	lp, r 12.68	r 19.31	46.68	ND
BD20	San Pablo Bay	9/27/2001	2001-09	CGIG	6.97	7.28	2.116	r 0.32	6.18	733.892	lp, r 12.03	r 12.96	25.34	ND
BD15	Petaluma River	9/27/2001	2001-09	CGIG	6.41	5.35	5.244	ND, r	7.68	1194.322	ND, p, r	r 15.81	ND	ND
BC61	Red Rock	9/25/2001	2001-09	MCAL	12.14	12.57	5.011	r 1.19	5.57	212.607	lp, r 28.24	r 96.5	38.28	ND
BC21	Horseshoe Bay	9/25/2001	2001-09	MCAL	15.43	15.42	3.305	r 1.36	5.26	162.368	lp, r 2.08	ND, r	50.02	ND
BC10	Yerba Buena Island	9/25/2001	2001-09	MCAL	13.46	13.74	3.12	r 1.19	4.16	190.876	lp, r 6.36	r 3.2	120.8	ND
BB71	Alameda	9/26/2001	2001-09	MCAL	14.22	13.99	4.234	r 1.48	5.28	197.815	lp, r 5.27	ND, r	69.65	ND
BA40	Redwood Creek	9/26/2001	2001-09	MCAL	14.59	13.7	3.147	r 1.26	4.24	190.98	lp, r 15.84	r 45.74	13.01	ND
BA30	Dumbarton Bridge	9/26/2001	2001-09	MCAL	14.31	13.12	2.741	r 1.19	3.96	202.266	ND, p, r	ND, r	9	ND
BA10	Coyote Creek	9/26/2001	2001-09	CGIG	8.88	8.04	2.129	r 0.52	6.34	770.003	ND, p, r	ND, r	ND	ND
T-0	Tomales Bay	5/28/2001	2001-09	CGIG	10.44	10.13	0.522	ND, r	3.79	368.905	ND, p, r	ND, r	ND	ND
T-0	Bodega Head	5/29/2001	2001-09	MCAL	14.38	15.12	1.679	r 0.61	3.28	134.803	ND, p, r	ND, r	2.56	ND
ality Assurance Ta	ables													
Average Of Blank	s Per Cruise		2001-09											
Standard Deviation	on of Blanks		2001-09											
Average Method	Detection Limit		2001-09				0.04	0.09	0.02	0.09	1.2	2.7	3	0.9
Number of replic	ates		2001-09				2	2	2	2	2	2	2	2
Standard Deviation	on of Replicates		2001-09				0.1	0.05	0.07	20	3.6	5.3	10	0
Precision (RSD%))		2001-09				3	4	2	11	< 40 >	ND	17	ND
Accuracy (%error	r)		2001-09				9	< 49 >	4	22	< 55 >	< 42 >	5	2

Table 20. PAH concentrations in bivalve tissue, 2001. LPAH = low molecular weight PAHs, NA = not analyzed, ND = not detected, NS = not sampled. Units expressed as dry weight. T-0 = time of bivalve deployment into the Estuary from the source indicated under station name heading. CFLU - Corbicula fluminea, CGIG - Crassostrea gigas, MCAL - Mytilus californianus.

Station Code	Station	Date	Cruise	Species	Sum of PAHs	% Solids - TIS-ORG-GERG	Total LPAH	Biphenyl	Naphthalene	1-Methylnaphthalene	2-Methylnaphthalene	2,6-Dimethylnaphthalene	2,3,5-Trimethylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Dibenzothiophene	Fluorene	Phenanthrene	1-Methylphenanthrene
					µg/kg	%	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
No Blank Contam.																				
BG20	Sacramento River	9/30/2001	2001-09	CFLU	611.10	4.80	339.8	31.7	102.9	51.8	67.3	ND	ND	ND	ND	53.6	ND	ND	32.5	ND
BG30	San Joaquin River	9/30/2001	2001-09	CFLU	720.00	3.40	551.5	63.2	161.7	98.9	111.3	ND	ND	ND	ND	60	ND	ND	56.4	ND
BD50	Napa River	9/28/2001	2001-09	CGIG	843.90	6.70	459.9	45.4	125.6	74.4	93.3	ND	ND	ND	ND	28.8	ND	27.5	50.3	14.6
BD40	Davis Point	9/28/2001	2001-09	CGIG	710.50	9.50	194.9	15.7	36.7	23.9	27.3	ND	ND	ND	ND	53	ND	ND	38.3	ND
BD30	Pinole Point	9/27/2001	2001-09	MCAL	550.70	12.60	138.3	ND	23.7	10.6	15	ND	ND	ND	11.7	38.4	ND	ND	38.9	ND
BD20	San Pablo Bay	9/27/2001	2001-09	CGIG	524.10	9.20	169.9	17.8	42.7	23.7	28.4	ND	ND	ND	ND	30.6	ND	ND	26.7	ND
BD15	Petaluma River	9/27/2001	2001-09	CGIG	454.90	6.90	159.5	25.9	56	25.1	34	ND	ND	ND	ND	ND	ND	ND	18.5	ND
BC61	Red Rock	9/25/2001	2001-09	MCAL	246.30	15.60	130.4	8.9	19.1	9.9	12.9	ND	ND	ND	9.7	30.5	ND	9.2	18.1	12.1
BC21	Horseshoe Bay	9/25/2001	2001-09	MCAL	205.70	18.80	147	10.4	23.5	13.6	18.2	ND	ND	ND	11.4	36.9	ND	12.2	20.8	ND
BC10	Yerba Buena Island	9/25/2001	2001-09	MCAL	616.40	17.80	416.4	8.3	19.6	12.3	16.5	ND	ND	19.1	51.6	169.9	5.2	27.3	77.1	9.5
BB71	Alameda	9/26/2001	2001-09	MCAL	280.50	15.20	156.3	13.5	30.9	18.5	22	ND	ND	ND	11.8	39.1	ND	ND	20.5	ND
BA40	Redwood Creek	9/26/2001	2001-09	MCAL	161.80	13.90	86.4	ND	21.2	10.7	13.3	ND	ND	ND	9.1	22.1	ND	ND	10	ND
BA30	Dumbarton Bridge	9/26/2001	2001-09	MCAL	245.60	15.60	121.5	13.4	29.5	16.5	20.7	ND	ND	ND	7.9	19.2	ND	ND	14.3	ND
BA10	Coyote Creek	9/26/2001	2001-09	CGIG	700.70	11.70	126.6	12.3	27.6	15.5	19.7	ND	ND	ND	ND	29.4	ND	ND	22.1	ND
T-0	Tomales Bay	5/28/2001	2001-09	CGIG	32.20	13.30	13.3	ND	ND	ND	5.8	ND	ND	ND	ND	ND	ND	ND	7.5	ND
Т-0	Bodega Head	5/29/2001	2001-09	MCAL	34.50	18.30	34.5	ND	15.9	8.2	10.4	ND	ND	ND	ND	ND	ND	ND	ND	ND
ality Assurance Tabl	es																			
Average Of Blanks	Bor Cruiso		2001-00																	
Average Of Blattics			2001-09																	
Standard Deviation			2001-09						40	-	-	10	•	40	0	0	0	40	•	0
Average Method De	etection Limit		2001-09					11	13	5	5	10	8	13	8	8	3	12	8	6
Number of replicat	es		2001-09					2	2	2	2	2	2	2	2	2	2	2	2	2
Standard Deviation	of Replicates		2001-09					5.0	7.4	5	6	0.8737	0.2	2	0.2	3	0.4	1.8	3	2
Precision (RSD%)			2001-09					NA	NA	40	39	NA	NA	NA	NA	9	NA	NA	13	NA
Accuracy (%error)			2001-09						17							< 610 >			14	

Table 20. PAH concentrations in bivalve tissue, 2001 (continued). HPAH = high molecular weight PAHs, NA = not analyzed, ND = not detected, NS = not sampled.

Units expressed as dry weight. T-0 = time of bivalve deployment into the Estuary from the source indicated under station name heading. CFLU - Corbicula fluminea, CGIG - Crassostrea gigas, MCAL - Mytilus californianus.

Station Code	Station	Date Cruise	Species	Sum of PAHs	Total HPAH	% Solids - TIS-ORG-GERG	Benz(a)anthracene	Chrysene	Fluoranthene	Pyrene	Benzo(a)pyrene	Benzo(e)pyrene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Dibenz(a,h)anthracene	Perylene	Benzo(ghi)perylene	Indeno(1,2,3-cd)pyrene
				µg/kg	µg/kg	%	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
No Blank Contam.																		
BG20	Sacramento River	9/30/2001 2001-09	CFLU	611.10	271.3	4.80	ND	24.6	65.8	76.3	18.7	28.1	15.6	ND	ND	16.1	15.1	11
BG30	San Joaquin River	9/30/2001 2001-09	CFLU	720.00	168.5	3.40	ND	ND	66.3	76.5	ND	25.7	ND	ND	ND	ND	ND	ND
BD50	Napa River	9/28/2001 2001-09	CGIG	843.90	384	6.70	33.7	36.2	82.7	77.3	25.8	40.1	32.9	11.5	ND	24	12	7.8
BD40	Davis Point	9/28/2001 2001-09	CGIG	710.50	515.6	9.50	33.5	44.3	136.7	103.1	25.1	62.5	45	15.8	ND	27.3	13.4	8.9
BD30	Pinole Point	9/27/2001 2001-09	MCAL	550.70	412.4	12.60	43.3	21.7	71	90.9	51.5	32.8	29.2	9	4	11.8	23.1	24.1
BD20	San Pablo Bay	9/27/2001 2001-09	CGIG	524.10	354.2	9.20	19	22.6	80.3	66.8	20.8	52.1	35.4	10.8	ND	23.2	13.5	9.7
BD15	Petaluma River	9/27/2001 2001-09	CGIG	454.90	295.4	6.90	16.4	19.1	45.7	63.1	24.1	46	30.9	ND	ND	16.5	19.5	14.1
BC61	Red Rock	9/25/2001 2001-09	MCAL	246.30	115.9	15.60	8.5	8.5	18.4	21.4	15.1	10.3	9.7	ND	ND	6.3	9.7	8
BC21	Horsesnoe Bay	9/25/2001 2001-09	MCAL	205.70	58.7	18.80	ND	ND 12.0	13.5	15.3	9.7	5.8	3.9	ND		4	4	2.5
BC10	Yerba Buena Island	9/25/2001 2001-09	MCAL	616.40	200	17.80	21.4	13.9	59.5	55	12.9	9.5	9.1	ND		5.7	1.8	5.2
DD/1	Alameda Dedward Creek	9/26/2001 2001-09	MCAL	200.50	75 4	13.20	7.0 ND	0.3	21.3	20.0	10.2	10.9	9.1			5.0 E 1	10.5	0./
DA40	Redwood Creek	9/26/2001 2001-09	MCAL	101.00	104 1	15.90			10.0	14	12.1	9.1	1.0			5.1	0.9	1.0
BA30 BA10	Covote Creek	9/20/2001 2001-09	CCIC	245.00	574.1	11 70	24.5	7.0	84.8	21.5	11.1	13	74.4	21.4	36	16.4	33.3	20.1
	Tomales Bay	5/28/2001 2001-09	CGIG	32.20	18.0	13 30		55.1 ND	11 /	7.5		ND	74.4 ND		3.0 ND		55.5 ND	
T-0	Bodega Head	5/29/2001 2001-09	MCAL	34.50	ND	18.30	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
luality Assurance Tab	les																	
Average Of Blanks	Per Cruise	2001-09																
Standard Deviation	of Blanks	2001-09																
Average Method De	tection Limit	2001-09					8	8	6	5	6	5	5	6	2	4	4	3
Number of replicate		2001-00					2	2	2	2	2	2	2	2	2	2	2	2
Standard Deviation	of Replicates	2001-03					10	10	20	30	8	20	20	6	0.6	7	7	3
	or replicates	2001-09					NIA	NA NA	20	50	40	20	20	NIA	0.0		50	22
		2001-09					17		< /U >	< 04 >	43	< / y >	< 90 ×		NA		50	J2
Accuracy (%error)		2001-09					17	< 10 >	3	3	24	21	23	20		23	5	13

Table 21. PCB concentration in bivalve tissue, 2001.

B = blank contamination >30% of measured concentration, b = blank contamination <30% of measured concentration.

NA = not analyzed, ND = not detected. Units expressed as dry weight.

CFLU - Corbicula fluminea, CGIG - Crassostrea gigas, MCAL - Mytilus californianus. <u>T</u>-0 = time of bivalve deployment into the Estuary from the source indicated under station name heading.

Station Code	Station	Date	Cruise	Species	SUM of PCBs (SFEI)	% Solids - TIS-ORG-GERG	PCB 008	PCB 017/18	PCB 018	PCB 028	PCB 031	PCB 033	PCB 044	PCB 049	PCB 052	PCB 056	PCB 056/60	PCB 060	PCB 066	PCB 070	PCB 074
					µg/kg	%	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
No Blank Contam.																					
BG20	Sacramento River	9/30/2001	2001-09	CFLU	358.92	4.80	ND	3	c017	ND	ND	ND	ND	3.69	3.74	C056	ND	C056	ND	ND	ND
BG30	San Joaquin River	9/30/2001	2001-09	CFLU	144.3	3.40	ND	ND	c017	ND	ND	ND	ND	ND	ND	C056	ND	C056	ND	ND	ND
BD50	Napa River	9/28/2001	2001-09	CGIG	36.19	6.70	ND	ND	c017	ND	ND	ND	ND	ND	ND	C056	ND	C056	ND	ND	ND
BD40	Davis Point	9/28/2001	2001-09	CGIG	148.46	9.50	1.33	ND	c017	ND	ND	ND	ND	4.69	4.89	NA	NA	ND	1.83	ND	ND
BD30	Pinole Point	9/27/2001	2001-09	MCAL	70.16	12.60	ND	ND	c017	ND	ND	ND	ND	2.19	4.38	C056	ND	C056	1.46	ND	ND
BD20	San Pablo Bay	9/27/2001	2001-09	CGIG	119.13	9.20	3.73	ND	c017	ND	ND	ND	ND	1.32	ND	C056	ND	C056	2.63	ND	ND
BD15	Petaluma River	9/27/2001	2001-09	CGIG	74.54	6.90	ND	ND	c017	ND	ND	ND	ND	ND	4.35	C056	ND	C056	ND	ND	ND
BC61	Red Rock	9/25/2001	2001-09	MCAL	86.19	15.60	ND	1	c017	ND	ND	ND	ND	1.17	3.85	C056	ND	C056	1.52	2.5	ND
BC21	Horseshoe Bay	9/25/2001	2001-09	MCAL	77.81	18.80	ND	3.4	c017	ND	ND	ND	ND	1.77	2.91	C056	0.69	C056	1.18	2.53	ND
BC10	Yerba Buena Island	9/25/2001	2001-09	MCAL	159.92	17.80	ND	2.1	c017	ND	ND	ND	3.11	1.46	4.91	C056	1.96	C056	2.15	3.53	3.38
BB71	Alameda	9/26/2001	2001-09	MCAL	155.71	15.20	ND	ND	c017	ND	ND	ND	1.34	2.89	4.14	C056	1.93	C056	1.76	4.75	ND
BA40	Redwood Creek	9/26/2001	2001-09	MCAL	142.66	13.90	ND	1.8	c017	1.35	ND	ND	1.32	2.51	4.08	C056	ND	C056	2.73	4.85	ND
BA30	Dumbarton Bridge	9/26/2001	2001-09	MCAL	126.93	15.60	ND	2	c017	ND	ND	ND	1.2	2.27	4.86	C056	ND	C056	2.18	4.36	ND
BA10	Coyote Creek	9/26/2001	2001-09	CGIG	286.45	11.70	ND	2.3	c017	2.75	ND	ND	2.91	5.78	5.01	NA	NA	ND	3.08	5.44	ND
T-0	Tomales Bay	5/28/2001	2001-09	CGIG	6.86	13.30	ND	ND	c017	ND	ND	ND	ND	ND	ND	C056	ND	C056	1.05	ND	1.17
T-0	Bodega Head	5/29/2001	2001-09	MCAL	9.03	18.30	ND	1.1	c017	ND	ND	ND	ND	2.54	ND	C056	ND	C056	ND	ND	1.51
uality Assurance Tab	les																				
Average Of Blanks	Per Cruise		2001-09																		
Standard Deviation	of Blanks		2001-09																		
Average Method De	etection Limit		2001-09		0.9		0.5	0.7		0.8	0.9	0.9	1.3	0.9	0.9		0.9		0.4	0.9	0.9
Number of replicat	tes		2001-09		0		0	0		0	0	0	1	1	1		1		1	1	0
Standard Deviation	of Replicates		2001-09		NC		NC	NC		NC	NC	NC	0.91	2	0.6		34		2	2	NC
Precision (RSD%)			2001-09		NC		NC	NC		NC	NC	NC	NC	54	14		131		59	33	NC
Accuracy (%error)			2001-09		NA		NA	NA		NA	NA	NA	5	18	14		NA		3	NA	NA

Table 21. PCB concentration in bivalve tissue, 2001 (continued).

B = blank contamination >30% of measured concentration, b = blank contamination <30% of measured concentration.

NA = not analyzed, ND = not detected. Units expressed as dry weight.

CFLU - Corbicula fluminea, CGIG - Crassostrea gigas, MCAL - Mytilus californianus. PCB 087 co-elutes with PCB 115 but PCB 115 contributes a minor amount to this result. T-0 = time of bivalve deployment into the Estuary from the source indicated under station name heading.

Station Code	Station	Date	Cruise	Species	SUM of PCBs (SFEI)	8 % Solids - TIS-ORG-GERG	PCB 087	PCB 095	PCB 097	PCB 099	PCB 101	PCB 105	PCB 110	PCB 118	PCB 128	PCB 132	PCB 132/153	PCB 138	PCB 141	PCB 149
					µу/кд	70	µу/кд	µу/кд	µу/кд	µу/кд	µу/кд	µу/кд	µу/кд	µу/кд	µу/кд	µу/кд	µу/кд	µу/кд	µу/кд	µу/кд
BG20 BG30 BD50 BD40 BD15 BC61 BC21 BC10 BB71 BA40 BA30 BA10 T-0 T-0	Sacramento River San Joaquin River Napa River Davis Point Pinole Point San Pablo Bay Petaluma River Red Rock Horseshoe Bay Yerba Buena Island Alameda Redwood Creek Dumbarton Bridge Coyote Creek Tomales Bay Bortena Head	9/30/2001 9/30/2001 9/28/2001 9/27/2001 9/27/2001 9/25/2001 9/25/2001 9/25/2001 9/26/2001 9/26/2001 9/26/2001 5/28/2001	2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09	CFLU CFLU CGIG MCAL CGIG CGIG MCAL MCAL MCAL MCAL MCAL CGIG CGIG MCAI	358.92 144.3 36.19 148.46 70.16 119.13 74.54 86.19 77.81 155.71 142.66 126.93 286.45 6.86 9.03	4.80 3.40 6.70 9.50 12.60 9.20 6.90 15.60 18.80 15.20 13.90 15.60 11.70 13.30	6.08 2.29 1.99 4.35 1.08 3.15 3.19 1.27 1.39 3.16 2.8 2.16 1.95 5.56 1.12	6.47 4.81 ND 4.81 2.21 4.26 4.25 3.32 2.07 7.54 6.07 4.77 4.2 12.22 ND	ND ND ND ND ND ND ND ND ND ND ND ND ND N	8.54 3.78 ND 3.82 6.51 5.82 ND 8.71 6.06 9.23 12.89 9.73 7.63 9.27 ND	17.24 7.38 2.58 12.84 6.93 9.93 6.14 6.16 5.29 12.41 14.45 11.96 9.93 20.66 ND	ND ND 1.58 ND ND ND 1.5 2.12 1.69 2.07 2.07 3.95 ND	16.17 9.79 4.39 13.21 6.74 11.7 9.33 7.84 7.23 12.75 10.74 9.64 8.81 21.58 ND	11.26 7.13 ND 8.16 3.64 5.73 3.65 4.18 4.02 8 6.7 7.78 7.08 14.94 ND	5.52 ND ND 1.41 1.03 1.06 ND 1.19 1 2.36 2.08 2.31 2.23 2.92 ND	c132 c132 c132 c132 c132 c132 c132 c132	82.17 44.63 11.14 34.91 13.56 26.17 17.55 13.66 14.24 29.38 27.62 28.48 26.69 65.38 2.44 2.21	43.06 17.64 4.7 11.29 6.91 11.12 7.66 9.63 7.81 15.71 17.47 16.03 14.18 23.86 1.08	8.66 ND ND ND ND ND ND 1.13 1.74 ND 1.2 ND	16.56 9.82 5.56 16.25 5.79 14.26 7.83 7.73 7.04 12.97 12.95 11.25 10.17 28.78 ND
-																				
Assurance	e Tables																			
Average	Of Blanks Per Cruise	Ð	2001-09																	
Average	Method Detection Li	mit	2001-09				0.6	0.9	0.9	0.9	0.6	0.7	1.0	1.5	0.5		1.1	0.9	0.9	0.9
Number	umber of replicates						1	1	0	1	1	1	1	1	1		1	1	1	1
Standard	andard Deviation of Replicates						0.2	3	NC	5	5	2	8.2	8.7	1		13	6	2	4
Precision	andard Deviation of Replicates ecision (RSD%)		2001-09				7	34	NC	56	29	56	NC	68	47		36	28	67	27
Accuracy	curacy (%error)						NA	11	NA	21	13	9	16	5	7		NA	25	NA	18

Table 21. PCB concentration in bivalve tissue, 2001 (continued).

B = blank contamination >30% of measured concentration, b = blank contamination <30% of measured concentration. NA = not analyzed, ND = not detected. Units expressed as dry weight. CFLU - Corbicula fluminea, CGIG - Crassostrea gigas, MCAL - Mytilus californianus. T-0 = time of bivalve deployment into the Estuary from the source indicated under station name heading.

Station Code	Station	Date	Cruise	Species	SUM of PCBs (SFEI)	e % Solids - TIS-ORG-GERG	PCB 151	PCB 153	PCB 156	PCB 157/173/201	PCB 158	PCB 170	PCB 174	PCB 177	PCB 180	PCB 183	PCB 187	PCB 194	PCB 195	PCB 201
					µg/кд	70	µg/кg	µд/кд	µg/кд	µg/кĝ	µg/кĝ	µg/кĝ	µg/кg	µg/кд	µд/кд	µg/кg	µg/кĝ	µg/кĝ	µg/кĝ	µg/к₫
BG20 BG30 BD40 BD20 BD15 BC61 BC10 BB71 BA40 BA40 BA40 BA40 T-0 T-0	Sacramento River San Joaquin River Davis Point Pinole Point San Pablo Bay Petaluma River Red Rock Horseshoe Bay Yerba Buena Island Alameda Redwood Creek Dumbarton Bridge Coyote Creek Tomales Bay Bodega Head	9/30/2001 9/30/2001 9/28/2001 9/27/2001 9/27/2001 9/27/2001 9/25/2001 9/25/2001 9/26/2001 9/26/2001 9/26/2001 5/28/2001 5/29/2001	2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09	CFLU CGIG CGIG MCAL CGIG MCAL MCAL MCAL MCAL MCAL MCAL CGIG CGIG MCAL	358.92 144.3 36.19 148.46 70.16 119.13 74.54 86.19 77.81 159.92 155.71 142.69 126.93 286.45 6.86 9.03	4.80 3.40 6.70 9.50 12.60 9.20 6.90 15.60 18.80 15.80 13.90 15.60 11.70 13.30 18.30	ND ND 2.92 ND 1.72 ND 2.25 1.19 3.03 2.4 1.84 1.45 7.92 ND ND	c132 c132 c132 c132 c132 c132 c132 c132	3.18 ND ND ND ND 1.72 1.89 2.49 0.81 1.18 1.18 1.18 1.56 ND ND	4.29 2.83 0.44 0.42 0.48 0.26 0.38 0.03 0.46 0.67 0.48 0.27 1.24 0.00 0.00	ND ND ND ND ND ND ND ND 1.26 0.8 1.41 ND ND	16.38 ND ND ND ND ND ND 1.52 1.24 ND ND ND ND ND ND	ND ND ND ND ND ND ND ND ND ND ND ND ND N	7.93 3.75 ND 3.94 1.75 3.15 2.14 2.05 1.51 3.04 3.15 3.05 2.91 7.75 ND ND	48.72 18.41 Q Q Q Q Q Q Q Q Q Q Q Q Q Q D ND	9.38 ND 1.88 1.19 1.71 ND 1.6 1.39 3.1 3.19 2.47 2.26 3.84 ND ND	32.26 14.87 5.83 14.35 4.79 11.67 8.45 5.84 5.1 9.48 10.91 9.48 10.91 9.85 26.17 ND ND	7.92 ND ND ND ND ND ND ND ND ND ND ND ND ND	ND ND ND ND ND ND ND ND ND ND ND ND ND 0.17	c157 c157 c157 c157 c157 c157 c157 c157
Assurance	Tables																			
Average C	of Blanks Per Cruise		2001-09																	
Standard	Deviation of Blanks	14	2001-09				0.0		0.0		0.0		0.0	0.0	2	0.0		0.0	0.00	
Average I	f replicates	lit	2001-09				0.9		0.9		0.9	1.4	0.9	0.9	3	0.9	2.0	0.9	0.09	
Standard	Deviation of Replicat	tes	2001-09				3		0.1		NC	0.48	NC	1	3	2	5.6	NC	NC	
Precision	(RSD%)		2001-09				63		NC		NC	NC	NC	31	NA	45	38	NC	NC	
Accuracy	(%error)		2001-09				22		< 58 >		NA	29	NA	NA	< 89 >	9	NA	NA	NA	

Table 22. Pesticide concentration in bivalve tissue, 2001. NA = not analyzed, ND = not detected, NS = not sampled.

CFLU - Corbicula fluminea, CGIG - Crassostrea gigas, MCAL - Mytilus californianus. T-0 = time of bivalve deployment into the Estuary from the source indicated under station name heading.

Station Code	Station	Date	Cruise	Species	Sum of DDTs (SFEI)	% Solids - TIS-ORG-GERG	0,p^-DDD	o,p^.DDE	0,p^.DDT	0.00.∿q,q	p,p^-DDE	700-^q,q	Sum of Chlordanes (SFEI)	alpha-Chlordane	gamma-Chlordane	cis-Nonachior	trans-Nonachlor	Heptachlor	Heptachlor Epoxide	Oxychlordane
					ng/g	%	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
No Blank Contam.																				
BG20	Sacramento River	9/30/2001	2001-09	CFLU	98.58	4.80	10.56	ND	ND	28.31	56.10	3.61	11.39	4.47	2.34	ND	4.58	ND	ND	ND
BG30	San Joaquin River	9/30/2001	2001-09	CFLU	70.16	3.40	7.13	ND	ND	24.79	35.35	2.89	5.92	2.38	ND	ND	3.54	ND	ND	ND
BD50	Napa River	9/28/2001	2001-09	CGIG	20.76	6.70	1.84	ND	ND	7.72	9.86	1.34	0.83	ND	ND	ND	0.83	ND	ND	ND
BD40	Davis Point	9/28/2001	2001-09	CGIG	68.26	9.50	6.90	1.72	ND	27.9	28.84	2.9	8.56	3.35	1.28	ND	3.93	ND	ND	ND
BD30	Pinole Point	9/27/2001	2001-09	MCAL	27.54	12.60	2.74	0.56	ND	12.07	11.06	1.11	5.67	2.54	1.88	ND	1.25	ND	ND	ND
BD20	San Pablo Bay	9/27/2001	2001-09	CGIG	48.51	9.20	5.17	0.95	ND	18.89	20.90	2.6	4.05	1.76	ND	ND	2.29	ND	ND	ND
BD15	Petaluma River	9/27/2001	2001-09	CGIG	27.04	6.90	2.64	ND	ND	8.53	13.73	2.14	0.98	ND	ND	ND	0.98	ND	ND	ND
BC61	Red Rock	9/25/2001	2001-09	MCAL	27.96	15.60	3.25	0.59	ND	11.82	11.25	1.05	3.00	1.92	ND	ND	1.08	ND	ND	ND
BC21	Horseshoe Bay	9/25/2001	2001-09	MCAL	21.15	18.80	3.09	ND	ND	8.58	8.53	0.95	3.10	1.49	0.77	ND	0.84	ND	ND	ND
BC10	Yerba Buena Island	9/25/2001	2001-09	MCAL	32.99	17.80	3.74	ND	ND	14.22	13.65	1.38	7.53	3.25	1.90	0.77	1.61	ND	ND	ND
BB71	Alameda	9/26/2001	2001-09	MCAL	23.43	15.20	2.99	0.37	ND	9.51	9.45	1.11	4.51	2.20	0.95	ND	1.36	ND	ND	ND
BA40	Redwood Creek	9/26/2001	2001-09	MCAL	22.36	13.90	2.01	0.48	ND	6.85	12.36	0.66	9.76	4.13	1.87	0.81	2.95	ND	ND	ND
BA30	Dumbarton Bridge	9/26/2001	2001-09	MCAL	22.87	15.60	2.73	0.54	ND	6.77	12.21	0.62	9.67	3.95	1.94	0.91	2.87	ND	ND	ND
BA10	Coyote Creek	9/26/2001	2001-09	CGIG	70.51	11.70	6.43	ND	0.75	20.99	40.91	1.43	24.56	8.11	4.89	1.76	9.80	ND	ND	ND
T-0	Tomales Bay	5/28/2001	2001-09	CGIG	5.30	13.30	ND	ND	ND	1.98	3.32	ND	0.29	ND	ND	ND	ND	0.29	ND	ND
T-0	Bodega Head	5/29/2001	2001-09	MCAL	5.96	18.30	ND	ND	0.31	0.72	4.93	ND	1.26	0.57	ND	ND	0.69	ND	ND	ND
uality Assurance Table	es																			
Average Of Blanks P	er Cruise		2001-09																	
Standard Deviation of	of Blanks		2001-09																	
Average Method Det	ection Limit		2001-09				1.5	0.4	0.4	0.4	0.7	0.3		0.09	0.1	0.3	0.2	0.3	1.6	0.5
Number of replicate	s		2001-09				1	1	0	1	1	1		1	1	0	1	0	0	0
Standard Deviation of	of Replicates		2001-09				0.83	0.08	NC	1.0	10	0.8		0.2	0.03	NC	1	NC	NC	NC
Precision (RSD%)			2001-09				23	NC	NC	11	< 59 >	< 46 >		7	3	NC	< 56 >	NC	NC	NC
Accuracy (%error)			2001-09				NA	NA	NA	8	11	28		19	16	< 39 >	28	NA	NA	NA

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Station Code	Station	Date	Cruise	Species	% Solids - TIS-OR	Aldrin	Dieldrin	Endrin	alpha-HCH	beta-HCH	delta-HCH	gamma-HCH	Mirex
					%	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
BG20 BG30 BD50 BD40 BD30 BD15 BC61 BC21 BC10 BB71 BA40 BA30 BA10 T-0	Sacramento River San Joaquin River Napa River Davis Point Pinole Point San Pablo Bay Petaluma River Red Rock Horseshoe Bay Yerba Buena Island Alameda Redwood Creek Dumbarton Bridge Coyote Creek Tomales Bay	9/30/2001 9/30/2001 9/28/2001 9/27/2001 9/27/2001 9/27/2001 9/25/2001 9/25/2001 9/26/2001 9/26/2001 9/26/2001 9/26/2001 9/26/2001	2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09 2001-09	CFLU CFLU CGIG CGIG CGIG CGIG MCAL MCAL MCAL MCAL MCAL CGIG CGIG	4.80 3.40 6.70 9.50 12.60 9.20 6.90 15.60 18.80 17.80 15.20 13.90 15.60 11.70 13.30	ND ND ND ND ND ND ND ND ND ND ND	5.45 4.42 ND 5.51 2.15 ND 6.15 4.21 7.63 5.39 7.46 5.59 3.6 ND	ND ND ND ND ND ND ND ND ND ND ND ND	1.03 ND 0.87 ND 0.45 0.52 ND 0.29 0.59 0.44 0.32 ND 0.28 ND 0.28 ND 0.28	ND ND ND 1.08 ND ND ND ND ND ND ND ND	ND ND ND ND ND ND ND ND ND ND ND ND	ND ND ND ND ND ND ND 0.54 ND 0.55 0.54 0.68 ND	ND ND ND ND ND ND ND ND ND ND ND ND
1-0	войеда неай	5/29/2001	2001-09	INICAL	16.30	ND	2.33	ND	1.10	0.71	ND	ND	ND
Assurance	e Tables												
Average (Of Blanks Per Cruise		2001-09										
Standard	Deviation of Blanks		2001-09										
Average I	Method Detection Lin	nit	2001-09			0.3	0.9	0.3	0.3	0.7	0.2	0.4	0.6
Number o	of replicates		2001-09			0	1	0	1.0	0	0	0	0
Standard	Deviation of Replica	ites	2001-09			NC	3.3	NC	0.2	NC	NC	NC	NC
Precision	(RSD%)		2001-09			NC	< 106 >	NC	NC	NC	NC	NC	NC
Accuracy	(%error)		2001-09			NA	NA	NA	NA	NA	NA	NA	NA

 Table 22. Pesticide concentration in bivalve tissue, 2001 (continued). NA = not analyzed, ND = not detected, NS = not sampled.

 CFLU - Corbicula fluminea, CGIG - Crassostrea gigas, MCAL - Mytilus californianus.

T-0 = time of bivalve deployment into the Estuary from the source indicated under station name heading.