4.0 Bivalve Monitoring

4.1 Background

The purpose of monitoring contaminant concentrations in bivalve tissue for the RMP is two-fold. First, bivalves integrate the bioavailable portion of contaminants in the water column over time, and second, for many contaminants, bivalves are good indicators of contaminant transfer from water into the food web. Bivalves will accumulate certain contaminants in concentrations much greater than those found in ambient water (Vinogradov, 1959). This phenomenon is a result of the limited ability of bivalves to regulate the concentrations of most contaminants in their tissues. This method of active biomonitoring has been widely applied by the California State Mussel Watch Program (Phillips, 1988; Rasmussen, 1994) and others (Young *et al*., 1976; Wu and Levings, 1980; Hummel *et al*., 1990; Martincic *et al*., 1992). For reviews of bioaccumulation monitoring, see Luoma and Linville (1996) and Gunther and Davis (1997).

Bivalves were collected from sites thought to be uncontaminated and transplanted to 15 stations in the Estuary during the wet season (April) and the dry season (September). Contaminant concentrations in tissues, survival, and biological condition were measured before deployment (referred to as time zero (T-0) or background) and at the end of the 90-100 day deployment period. Because of the variability between each individual bivalve organism, composite samples of tissue were made from T-0 organisms and from surviving organisms from each deployment site (up to 45 individuals) for analyses of trace contaminants. The *Corbicula* reference site for the wet season was not optimal, since initial concentrations were found to be high after changing the site from Lake Isabella and Putah Creek to Lake Chabot. For the dry season clams could no longer be found at "clean" sites and consequently additional specimen were collected from a native population in the Sacramento and the San Joaquin rivers.

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 where density gradients tend to maintain higher salinities. 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. Detailed sampling and analysis methods are included in the *Description of Methods*. Data are tabulated in the *Data Tables*.

Overall, the bivalve bioaccumulation and condition study objectives for 1998 were met, although the unusual wet season with extremely high freshwater inputs from January until March caused high mortality rates in *Mytilus* spp. during the winter/spring deployment.

4.2 Accumulation Factors

In addition to using the absolute tissue concentrations at the end of each deployment period and comparing them to initial tissue concentrations prior to transplanting the bivalves to the Estuary (T-0), this report uses accumulation factors (AFs) to indicate accumulation or depuration (loss of constituents from bivalve tissue) during the 90-100 day deployment period. The accumulation factor is calculated by dividing the 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 bivalve sample to the Estuary. An AF less than 1 indicates that the bivalves decreased in contaminant concentration during the deployment period, while an AF above 1 indicates accumulation.

4.3 Guidelines

State consumption advisories for the public are issued by the U.S. EPA to protect residents from the health risks of consuming contaminated noncommercially caught fish and wildlife. These advisories inform the public that high concentrations of chemical contaminants have been found in local fish and wildlife and include recommendations to limit or avoid consumption of certain fish and wildlife species from specific waterbodies or waterbody types. The U.S. EPA is developing guidance documents for estimating risks to human health from the consumption of chemically contaminated, non-commercial fish and wildlife. Figures 4.1-4.16 used the recommended tissue screening values (SVs) for use in State fish/shellfish consumption advisory programs for the general adult population* from table 5-2 of EPA document #823-R-95-007 (*Methods for Sampling and Analyzing Contaminants in Fish and Shellfish Tissue*). Tissue guidelines are generally expressed in wet weight, while the RMP tissue data are reported in dry weight. A wet-to-dry weight conversion factor of 7 was applied to the guideline values for comparative purposes. This value is based on an average moisture content in bivalves of 85%. Listed in Table 4.1 are converted dry weight SVs for those parameters reported by the RMP.

It should be noted that the U.S. EPA screening values only apply to human health risks associated with consuming contaminated fish and wildlife. No screening values exist for the protection of wildlife consuming containated fish or shellfish, although evidence exists of adverse effects on wildlife above certain contaminant thresholds (e.g., Young *et al*., 1998).

*general adult population: Risk level = 10^{-5} for carcinogens given an average consumption rate of 6.5 g/day for a body weight of 70Kgs

4.4 Biological Condition and Survival

The biological condition (expressed as the ratio of dry tissue weight to shell cavity volume) and survival rates of transplanted bivalves following exposure to Estuary water are evidence that the animals were healthy and capable of bioaccumulation at most sites (Figures 4.17 and 4.18). However, the data on survival and condition of the transplants indicate that certain sites are generating physiological stress in the animals at certain times, which confounds the interpretation of bioaccumulation data and interferes with the bivalves' usefulness as biomonitors.

4.5 Bivalve Trends

Transplanted bivalves are valuable in assessment of 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 one-hour interval represented by RMP water samples or the approximate 20 year interval represented by RMP sediment samples.

This section presents plots of RMP bivalve bioaccumulation data for trace elements and trace organics from 1993 to 1998 (Figures 4.19 and 4.20). 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). Presented in this manner, the plots are capable of showing the presence or absence of both trends and accumulation during deployment. In many cases (e.g., arsenic) there was either little accumulation or even net depuration during deployment. Cadmium in mussels has exhibited a consistent seasonal pattern, with higher concentrations in summer samples in all six years. The trace metals database accumulated so far is fairly noisy, and clear trends are not expected to be discernible for the near future.

4.6 Discussion

This section is not yet available.

4.7 References

Basin Plan 1995. Regional Water Quality Control Plan, San Francisco Basin (Region 2). June 21, 1995. California Regional Water Quality Control Board, Oakland. CA.

Gunther, A.J. and J.A. Davis. 1997. An evaluation of bioaccumulation monitoring with transplanted bivalves in the RMP. In 1996 Annual Report: San Francisco Estuary Regional Monitoring Program for Trace Substances. San Francisco Estuary, Richmond, CA pp. 187-200.

Hummel, H., R.H. Bogaards, J. Nieuwenhiuze, L. DeWolf, and J.M. VanLiere. 1990. Spatial and seasonal differences in the PCB content of the mussel Mytilus edulis. Science of the Total Environment 92:155-163.

Long, E.R. and L.G. Morgan, 1990. The potential for biological effects of sediment-sorbed contaminants tested in the NSTProgram. NOAA Tech. Memo. NOS OMA 52. US NOAA, Seattle, WA, 175pp.

Long, E.R. D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Env. Mgmt. 19:81–97.

Luoma, S.N. and R. Linville. 1996. A comparison of selenium and mercury concentrations in transplanted and resident bivalves from north San Francisco Bay. In 1995 Annual Report: San Francisco Estuary Regional Monitoring Program for Trace Substances. San Francisco Estuary, Richmond, CA pp. 160-170.

Martincic, D., Z. Kwokal, Z. Peharec, D. Margus, and M. Branica. 1992. Distribution of Zn, Pb, Cd, and Cu between seawater and transplanted mussels (Mytilus galloprovinciatis). Science of the Total Environment 119:211-230.

Phillips, P.T. 1988. California State Mussel Watch ten year data summary, 1977-1987. Water Quality Monitoring Report No. 87-3, Division of Water Quality, State Water Resources Control Board.

Rasmussen, D. 1994. State Mussel Watch Program, 1987–1993 Data Report. State Water Resources Control Board 94-1WQ.

U.S. EPA. 1995. Guidance for Assessing Chemical Contaminant Data for Use In Fish Advisories, Volume 1: Fish Sampling and Analysis (second edition). EPA Doc # 823-R-95-007.

U.S. EPA. 1995. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance Final Rule. Federal Register Vol. 62, No. 150, Dec. 22, 1992.

U.S. EPA. 1997. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Proposed Rule. Federal Register Vol. 62, No. 150, August 5, 1997.

U.S. EPA. Methods for Sampling and Analyzing Contaminants in Fish and Shellfish Tissue. U.S. EPA document #823-R-95-007. http://www.epa.gov/OST/fishadvice/vol1/doc2ndx.html.

Vinogradov, A.P. 1959. The geochemistry of rare and dispersed chemical elements in soils. Chapman and Hall, London.

Wu, R.S.S. and C.D. Levings. 1980. Mortality, growth and fecundity of transplanted mussel and barnacle populations near a pulp mill outfall. Marine Pollution Bulletin 11:11-15.

Young, D.R., T.C. Heesen, and D.J. McDermott. 1976. An offshore biomonitoring system for chlorinated hydrocarbons. Marine Pollution Bulletin 7:156-159.

Young, D., M. Becerra, D. Kopec, and S. Echols. 1998. GC/MS Analysis of PCB congeners in blood of the harbor seal Phoca vitulina from San Francisco Bay. Chemopshere 37(4):711-733.

Table 4.1. Tissue quality guidelines used for evaluation of 1998 RMP results (U.S. EPA #823-R-95-007). These guidelines are screening values recommended for use in state fish/shellfish consumption advisory programs for the general adult population. 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.

Parameter	Screening Value dry weight	Unit
As	21	ppm
Cd	70	ppm
Cr	4.2	ppm
Se	350	ppm
TBT	2.1	ppm
Dieldrin	49	ppb
Endrin	21000	ppb
Gamma-HCH	560	ppb
Heptachlor Epoxide	70	ppb
Hexachlorobenzene	490	ppb
Mirex	14000	ppb
Total Chlordanes (SFEI)	560	ppb
Total DDTs (SFEI)	2100	ppb
Total PAHs (SFEI)	70	ppb
Total PCBs (SFEI)	70	ppb