Near-Field Receiving Water Monitoring of Trace Metals and a Benthic Community Near the Palo Alto Regional Water Quality Control Plant in South San Francisco Bay, California: 2006

U.S. GEOLOGICAL SURVEY

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Prepared in cooperation with the
CITY OF PALO ALTO, CALIFORNIA

U.S. Department of the Interior
U.S. Geological Survey

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U.S. DEPARTMENT OF THE INTERIOR
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Conversion Factors, Abbreviations, and Acronyms

Conversion Factors

Multiply	**By**	**To obtain**
foot (ft)	0.3048	meter
gallon (gal)	3.785	liter (L)
inch (in.)	2.54	centimeter
inch (in.)	25,400	micrometer (μm)
micromolar (μM)	molecular weight	micrograms per liter
micron (μm)	1,000,000	meter
mile (mi)	1.609	kilometer
ounce (oz)	28.35	gram (g)
part per million	1	microgram per gram (μg/g)

Temperature in degrees Celsius (° C) is converted to degrees Fahrenheit (° F) with the following equation:

° F = (1.8 x ° C) + 32

Abbreviations and Acronyms

Abbreviations and Acronyms	**Meaning**
CI	Condition Index
ERL	Effects Range-Low
ERM	Effects Range-Median
ICP-OES	Inductively Coupled Plasma-Optical Emission Spectrophotometry
IRMS	Isotopic Ratio Mass Spectrophotometry
MDL	Method Detection Limit
MLLW	Mean Low Low Water
MRL	Method Reporting Level
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
PARWQCP	Palo Alto Regional Water Quality Control Plant
RWQCB	California Regional Water Quality Control Board
SFEI	San Francisco Estuary Institute
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

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Abstract

Results reported herein include trace element concentrations in sediment and in the clam *Macoma petalum* (formerly reported as *Macoma balthica* (Cohen and Carlton 1995)), clam reproductive activity, and benthic macroinvertebrate community structure for a mudflat one kilometer south of the discharge of the Palo Alto Regional Water Quality Control Plant in South San Francisco Bay. This report includes data collected for the period January 2006 to December 2006, and extends a critical long-term biogeochemical record dating back to 1974. These data serve as the basis for the City of Palo Alto's Near-Field Receiving Water Monitoring Program, initiated in 1994.

Metal concentrations in both sediments and clam tissue during 2006 were consistent with results observed since 1990. Most notably, copper and silver concentrations in sediment and clam tissue increased in the last year but the values remain well within range of past data. Other metals such as chromium, nickel, vanadium, and zinc remained relatively constant throughout the year except for maximum values generally occurring in winter months (January-March). Mercury levels in sediment and clam tissue were some of the lowest seen on record. Conversely, selenium concentrations reached a maximum level but soon returned to baseline levels. In all, metal concentrations in sediments and tissue remain within past findings. There are no obvious directional trends (increasing or decreasing).

Analyses of the benthic-community structure of a mudflat in South San Francisco Bay over a 31-year period show that changes in the community have occurred concurrent with reduced concentrations of metals in the sediment and in the tissues of the biosentinel clam *M. petalum* from the same area. Analysis of the reproductive activity of *M. petalum* shows increases in reproductive activity concurrent with the decline in metal concentrations in the tissues of this organism. Reproductive activity is presently stable, with almost all animals initiating reproduction in the fall and spawning the following spring of most years. The community has shifted from being dominated by several opportunistic species to a community where the species are more similar in abundance, a pattern that suggests a more stable community that is subjected to less stress. In addition, two of the opportunistic species (*Ampelisca abdita* and *Streblospio benedicti*) that brood their young and live on the surface of the sediment in tubes, have shown a continual decline in dominance coincident with the decline in metals. *Heteromastus filiformis*, a subsurface polychaete worm that lives in the sediment, consumes sediment and organic particles

residing in the sediment, and reproduces by laying their eggs on or in the sediment, has shown a concurrent increase in dominance. These changes in species dominance reflect a change in the community from one dominated by surface dwelling, brooding species to one with species with varying life history characteristics. For the first time since its invasion in 1986, the non-indigenous filter-feeding clam *Corbula* (*Potamocorbula*) *amurensis* has shown up in small, but persistent, numbers in the benthic community.

Introduction

Environmental Monitoring

Determining spatial distributions and temporal trends of metals in sediments and benthic organisms is common practice for monitoring environmental contamination. These data can be the basis for inferring ecological implications of metal contamination. Another common method of environmental monitoring is to examine the community structure of sediment dwelling benthic organisms (Simon 2002). Spatial and temporal changes in community structure reflect the response of resident species to environmental conditions, although the underlying cause(s) for the response may be difficult to identify and quantify. Integrating measurements of metal exposure and biological response can provide a more complete view of anthropogenic disturbances and the associated effects on ecosystem health.

Environmental Exposure to Trace Metals

Sediment particles can strongly bind metals, effectively removing them from solution. As a result, sediments may accumulate and retain metals released to the environment. Thus, concentrations of metals in sediments serve as a record of metal contamination in an estuary, with some integration over time. Fluctuations in the record may be indicative of changes in anthropogenic releases of metals into the environment.

Metals in sediments are also indicative of the level of exposure of benthic animals to metals through contact with, and ingestion of, bottom sediments and suspended particulate materials. However, geochemical conditions of the sediment affect the biological availability of the bound metals. Assimilation of bioavailable sediment-bound metal by digestive processes and the relative contribution of this source of metals relative to metals in the aqueous phase are not well understood. Thus, in order to better estimate bioavailable metal exposures, the tissues of the organisms themselves may be analyzed for trace metals. Benthic organisms concentrate most metals to levels higher than those that occur in solution. Therefore, the record of tissue metal concentrations can be a more sensitive indicator of anthropogenic metal inputs than the sediment record. Different species concentrate metals to different degrees. However, if one species is analyzed consistently, the results can be employed to indicate trace-element exposures to the local food web. For example, silver (Ag), copper (Cu) and selenium (Se) contamination, originally observed in clams (*Macoma petalum* formerly reported as *Macoma balthica* (Cohen and Carlton 1995)) at the Palo Alto mudflat, was later found in diving ducks, snails, and mussels also from that region (Luoma and others, USGS, unpublished data).

Biological Response to Trace Metals

Contaminants can adversely affect benthic organisms at several organizational levels. For example, responses to a pollutant at the cellular or physiological level of an individual can result in changes at the population level, such as reductions in growth, survival and reproductive success. Community level responses to population level impairment can include overall shifts in species abundance, favoring metal-tolerant species that can result in changes in predator/prey interactions and competition for available resources. Changes in the benthic community can ultimately result in changes at the ecosystem level due to that community's importance in the cycling of carbon in aquatic environments (Alpine and Cloern 1992 provides a local example).

In all aquatic environments, benthic organisms may be exposed to contaminants at all life stages through a variety of routes - sediment, water and food (Wang and Fisher 1999 provides a summary of the potential transport of trace elements through food). Toxicant exposure is related to contaminant concentration as well as duration. Even at low contaminant levels, long-term exposure can impact benthic organisms. The added complexity of synergistic or antagonistic effects between different contaminants, and between contaminants and natural stressors, makes the determination of causal relationships difficult to identify and quantify, even on a site-specific basis. However, a time-integrated picture of ecosystem response to contaminant loading can be provided by field studies which link changes in exposure at multiple time scales (in this case seasonal to decadal) to changes at individual, population and community levels.

RWQCB and NPDES

The California Regional Water Quality Control Board (RWQCB) has prescribed a Self Monitoring Program with its re-issuance of the National Pollutant Discharge Elimination System (NPDES) permits for South San Francisco Bay dischargers. The recommendation includes specific receiving water monitoring requirements.

Since 1994, the Palo Alto Regional Water Quality Control Plant (PARWQCP) has been required to monitor metals and other specified parameters using sediments and the clam *M. petalum* at an inshore location in South San Francisco Bay. In addition to the required monitoring, PARWQCP has undertaken monitoring of the benthic community as a whole. The monitoring protocols have been designed to be compatible with or complement the RWQCB's Regional Monitoring Program. Monitoring efforts are being conducted by the U. S. Geological Survey (USGS) and are coordinated with 30 years of previous data collections and investigations by the USGS at this inshore location.

Objectives

The data presented by this study include trace-metal concentrations in sediments and clams, clam reproductive activity and benthic-community structure. These data, and those collected in earlier studies, (Hornberger and others 2000a; Luoma and others 1991; 1992; 1993; 1995; 1996; 1997; 1998; Wellise and others 1999; David and others 2002; Moon and others 2003; 2004; 2005; Shouse and others 2003; 2004; Thompson and others 2002; Cain and others 2006) were used to meet the following objectives:

- Provide data to assess seasonal and annual trends in trace-element concentrations in sediments and clams, reproductive activity of clams and benthic-community structure at a site designated in the RWQCB's Self-Monitoring Program guidelines for PARWQCP
- Present the data within the context of historical changes in South Bay and within the context of other locations in San Francisco Bay published in the international literature
- Coordinate inshore receiving water monitoring programs for PARWQCB and provide data compatible with relevant aspects of the Regional Monitoring Program. The near-field data will augment the Regional Monitoring Program as suggested by the RWQCB

- Provide data that could support other South San Francisco Bay issues or programs, such as development of sediment quality standards.

Approach

Despite the complexities inherent in monitoring natural systems, the adopted approach has been effective in relating changes in near-field contamination to changes in reproductive activity of a clam (Hornberger and others 2000b) and in benthic-community structure (Kennish 1998). This study, with its basis in historical data, provides a context within which future environmental changes can be assessed.

Metal concentrations were monitored in sediments and a resident species, *M. petalum*. Analysis of trace-element concentrations in the sediments provides a record of metal contamination of the site. The concentration and bioavailability of sediment-bound metals are affected by hydrology and geochemical factors (Thomson-Becker and Luoma 1985; Luoma and others 1995). Thus, ancillary data, including grain-size distribution, organic carbon, aluminum and iron content of the sediment, regional rainfall, and surface salinity were collected to interpret seasonal, annual, and inter-annual variation in metal concentrations. The tissue of *M. petalum* provides a direct measure of exposure to bioavailable metals.

Biological response of the benthic community to metal exposure was examined at three levels of organization: individual, population, and community. At the individual level, concentrations of metals in the tissues of *M. petalum* were compared with physiological indicators. Two common animal responses to environmental stress are reduced reproductive activity and reduced growth. Growth and reproduction in *M. petalum* occur on fairly regular seasonal cycles. Seasonally, a clam of a given shell length will increase somatic tissue weight as it grows during the late winter and spring. Reproductive tissue increases during the early stages of reproduction, and subsequently declines during and after reproduction. These cycles can be followed with the condition index (CI) which is an indicator of the physiological condition of the animal, and specifically is the total soft tissue weight of a clam standardized to shell length. Inter-annual differences in growth and reproduction, expressed in the CI, are influenced by the availability and quality of food, as well as other stressors such as pollutant exposure and salinity extremes. Earlier studies (Hornberger and others 2000b) have shown that reproductive activity of *M. petalum* has increased with declining metal concentrations in animals from this location. Therefore, CI and reproductive activity of *M. petalum* appear to be useful indicators of physiological stress by pollutants at this location, and continue to be monitored for this study.

At the population level, trends of the dominant benthic species were examined to see if certain species have been more affected than others by environmental change. It has been shown that most taxonomic groups have species that are sensitive to elevated silver (Luoma and others 1995) and that some crustacean and polychaete species are particularly sensitive to elevated sedimentary copper (Morrisey and others 1996, Rygg 1985). In addition, the benthic community was examined for changes in structure: that is, shifts in the species composition of the macroinvertebrate community resulting in a change in the function of the community. We hypothesized that a shift in community composition and potentially in function of the benthic community in the ecosystem would result from changes in the concentrations of specific metals or from a composite of all contaminants for several reasons. First, prior studies have shown that South Bay benthic communities were dominated by opportunistic species in the 1980s (see Nichols and Thompson 1985a). This opportunistic species might become less dominant as environmental stressors decrease. Second, environmental pollutants may differentially affect benthic species that use different feeding and reproductive modes. An intertidal mudflat community, such as this study site, should include a combination of species that feed on particles in the water column, on settled and buried food particles in the mud, and on other organisms. Any absence of one of these feeding groups may show limitations on species due to environmental stressors that target specific feeding groups. For example, pollutants attached to sediment particles are more likely to affect species that consume the sediment as part of their feeding mode or those species that lay their eggs in the sediment.

Previous analysis of this community has shown no correlation between changes in the community and measured environmental parameters (i.e. salinity, air and water temperature, delta outflow, precipitation, chlorophyll *a*, sediment total organic carbon, and biological oxygen demand: Shouse 2002). Therefore, the community data was only compared to trace-metal data in this report.

Study Site

The Palo Alto site (PA) is adjacent to Sand Point on a mudflat on the western shore of San Francisco Bay (not a slough) (*Figure 1*). The site is one kilometer south of the intertidal discharge point of the PARWQCP. The station is 12 m from the edge of the marsh and 110 cm above mean low low water (MLLW).

The sediment and biological samples from this location reflect a response of the receiving waters to the effluent just beyond the location of discharge. Earlier studies (Thomson and others 1984) have shown that dyes, natural organic materials in San Francisquito Creek and waters in the PARWQCP discharge move predominantly south toward Sand Point and thereby influence the mudflats in the vicinity of Sand Point. Spatial distributions of metal concentrations near the PARWQCP site were described by Thomson and others (1984) (also reported by Hornberger and others 2000a; Luoma and others 1991; 1992; 1993; 1995; 1996; 1997; 1998; Wellise and others 1999; David and others 2002; Moon and others 2003; 2004; 2005; Shouse and others 2003; 2004; Thompson and others 2002; Cain and others 2006). Earlier work by Thomson and others (1984) showed that San Francisquito Creek and the Yacht Harbor were minor sources of most trace elements compared to the PARWQCP. The PARWQCP appeared to be the primary source of the elevated metal concentrations at the PA site in the spring of 1980, based upon spatial and temporal trends of Cu, Ag and zinc (Zn) in clams and sediments (Thomson and others 1984; Cain and Luoma 1990). Metal concentrations in sediments and clams (*M. petalum*), especially Cu and Ag, have declined substantially since the original studies as more efficient treatment processes and source control were employed (Hornberger and others 2000b). Frequent sampling each year was necessary to characterize those trends since there was significant seasonal variability (Cain and Luoma 1990; Luoma and others 1985). This report characterizes data for the year 2006, employing the methods described in the succeeding section.

Previous reports (Luoma and others 1995; 1996; 1997; 1998; Wellise and others 1999) also included data for a site in South Bay that that was influenced by discharge from the San Jose/Santa Clara Water Pollution Control Plant (SJ). Samples were collected from this site from 1994 to September 1999. Comparison of data from this site and the Palo Alto site allowed differentiation of local and regional long-term metal trends.

Methods

Sampling Frequency

In dynamic systems such as San Francisco Bay, the environmental effects of anthropogenic stressors are difficult to distinguish from natural seasonal changes. Frequent sampling increases the probability that anthropogenic effects can be identified. Analyses of early data (1974 through 1983; Nichols and Thompson 1985a, 1985b) showed that when differences are small, benthic samples need to be collected at monthly to bimonthly intervals to make the distinction between natural and anthropogenic effects. Therefore, samples were collected, with a few exceptions, on a monthly basis from the exposed mudflat at low tide between January and December 2006. Samples collected in the field included surface sediment, the deposit-feeding clam *M. petalum,* surface water, and sediment cores for community analysis. Surface water, surface sediment and *M. petalum* were not collected during the months of July, August and November. Cores for benthic-community analyses were collected during all months except October and December.

Measurements of Metal Exposure

Sediment

Sediment samples were scraped from the visibly oxidized (brownish) surface layers (top 1-2 cm) of mud. These surface layers represent recently deposited sediments and detritus, or sediments affected by recent chemical reaction with the water column. The sediment also supports microflora and fauna, a nutritional source ingested by *M. petalum.* Sediment samples were immediately taken to the laboratory and sieved through a 100 μm mesh polyethylene screen with distilled water to remove large grains that might bias interpretation of concentrations. The mesh size was chosen to match the largest grains typically found in the digestive tract of *M. petalum*. All sediment data reported herein were determined from the fraction that passed through the sieve (< 100 μm), termed the silt/clay fraction. Previous studies have shown little difference between metal concentrations in sieved and unsieved sediments when silt/clay type sediment dominates at a site. However, where sand-size particles dominate the bed sediment, differences in metal concentrations can be substantial. Sediments in extreme South San Francisco Bay can vary spatially and temporally in their sand content (Luoma and others 1995; 1996; 1997; 1998; Wellise and others 1999; David and others 2002; Moon and others 2003; 2004 Cain and others 2005; SFEI 1997). Where sand content varies, sieving reduces the likelihood that differences in metal concentrations are the result of sampling sediments of different grain size. Some differences between the USGS and the Regional Monitoring Program results (SFEI 1997) reflect the bias of particle size on the latter's data.

To provide a measure of bulk sediment characteristics at a site, and thus provide some comparability with bulk sediment determination such as that employed in the Regional Monitoring Program – San Francisco Estuary Institute (SFEI 1997), the fraction of sediment that did not pass through the sieve (•100 μm) was determined. This fraction is termed sand fraction. Bulk sediment samples were sieved to determine the percent sand and percent silt/clay (<100 μm) (*Appendix A*). The percentage of the bulk sediment sample composed of sand-sized particles (percent sand) was determined by weighing the fraction of sediment that did not pass through the sieve (•100 μm), dividing that weight by the total weight of the bulk sample, and multiplying the quotient by 100. The percentage of silt/clay in the sediment was determined similarly by weighing the sediment that passed through the sieve (grain size <100 μm).

The silt/clay fraction was dried at 60° C, weighed, and then subsampled to provide replicates weighing 0.4 to 0.6 g. These were re-dried (60° C), re-weighed, and then digested by hot acid reflux (10 ml of 16 normal (N) nitric acid) until the digest was clear. This method provides a 'near-total' extraction of metals from the sediment and is comparable with the recommended procedures of the U.S. Environmental Protection Agency (USEPA) and with the procedures employed in the Regional Monitoring Program. It also provides data comparable to the historical data available on San Francisco Bay sediments. While near-total analysis does not result in 100% recovery of all metals, recent comparisons between this method and more rigorous complete decomposition show that trends in the two types of data are very similar (Hornberger and others 1999). After extraction, samples were evaporated until dry, then reconstituted in dilute hydrochloric acid (10 % or 0.6 N). The hydrochloric acid matrix was specifically chosen because it mobilizes silver (Ag) into solution through the creation of Ag-chloro complexes. Sediment extracts were allowed to equilibrate with the hydrochloric acid (minimum of 48 hours) before they were filtered (0.45 µm) into acid-washed polypropylene vials for elemental analysis. Another set of replicate subsamples from the silt/clay fraction were directly extracted with 12 mL of 0.6 N hydrochloric acid (HCl) for 2 hours at room temperature. This partial extraction method extracts metals bound to sediment surfaces and is operationally designed to obtain a crude chemical estimate of bioavailable metal. The extract was pressure filtered (0.45 µm) before elemental analysis.

Organic carbon was determined using a continuous flow isotope ratio mass spectrophotometer (IRMS) (*Appendix A*). Prior to the analysis, sediment samples were acidified with 12 N HCl vapor to remove inorganic carbon.

Water pooled on the surface of the mudflat was collected in a bottle and returned to the lab where it was measured for salinity with a handheld refractometer.

Clam Tissue

M. petalum were collected by hand on each sampling occasion. Typically, 60-120 individuals were collected, representing a range of sizes (shell length). As they were collected, the clams were placed into a screw-cap polypropylene container (previously acid-washed) containing site water. These containers were used to transport the clams to the laboratory.

In the laboratory, the clams were removed from the containers and gently rinsed with de-ionized water to remove sediment. A small amount of mantle water was collected from randomly selected clams for the determination of salinity with a refractometer. The salinity of the mantle water and the surface water collected from the site (above) were typically within 1 ppt (*‰*) of each other. Only surface water values are reported here. Natural sand-filtered seawater (obtained from U.C. Santa Cruz, Long Marine Labs, Santa Cruz, CA) was diluted with de-ionized water to the measured salinity of the site water. Clams were immersed in this water and moved to a constant temperature room (12° C) for 48 hours to allow for the egestion of sediment and undigested material from their digestive tracts. Clams were not fed during this depuration period. After depuration, the clams were returned to the laboratory and further prepared for chemical analysis.

Elemental analysis, excluding mercury and selenium

The shell length of each clam was measured with electronic calipers and recorded digitally. Clams were separated into 1 mm size classes (e.g. 10.0-10.9 mm, 11.0-11.9mm, etc). The soft tissues from all of the individuals within a given size class were dissected from the shell and collected in pre-weighed 20 mL screw-top borosilicate glass vials to form a single composite sample for elemental analysis. The sample for each collection was thus composed of six to ten composites, with each composite consisting of 2 to 19 clams of a similar shell length. The vials were capped with a glass reflux bulb and transferred to convection oven (70ºC). After the tissues were dried to constant weight, they were digested by reflux in sub-boiling 16 N nitric. The tissue digests were then dried and reconstituted in 0.6 N hydrochloric acid for trace-element analysis.

Analysis for mercury and selenium

Samples collected in late winter (January and February), spring (April), and summer (June and September) were analyzed for total mercury (Hg) and selenium (Se). Approximately 40 clams were selected from the collection. The only criterion for selection was that the range of sizes (shell length) within this group was representative of the larger collection. Otherwise the selection of individuals was random. Selected individuals were grouped according to size to form 3-4 composites, each containing a minimum of ~1.25 g wet weight. To meet this requirement, especially for the smaller clams, the 1-mm size classes were usually combined to form broader size classes (within 3-4 mm of each other as appropriate). Once the composites were formed, the clams were dissected as described above, and the soft tissue was placed into pre-weighed 30 mL screw top polycarbonate vials. These vials were closed and transferred to a freezer (-20º C). Once frozen, the samples were freeze-dried. After drying, the samples were shipped to the USGS analytical laboratory in Atlanta, GA where they were prepared and analyzed for selenium and mercury according to the method described by Elrick and Horowitz (1985).

Analytical

Sediment and tissue concentrations of aluminum (Al), chromium (Cr), copper (Cu), iron (Fe), nickel (Ni), silver (Ag), vanadium (V) and zinc (Zn) were determined using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). Mercury (Hg) and Selenium (Se) were determined in both sediment and clam tissues by Hydride Atomic Absorption Spectrophotometry. Analytical results are included in *Appendix B*, *Appendix C*, and *Appendix D*.

Quality Assurance

The polypropylene containers used in the field, depuration containers, glass-reflux bulbs, and all glassware and plastic used for metal analysis were first cleaned to remove contamination. Cleaning consisted of a detergent wash and rinse in de-ionized water, followed with a 1 N nitric-acid wash and thorough rinse in double-deionized water (approximately 18 M resistivity). Materials were dried in a dust-free positive pressure environment, sealed, and stored in a dust free cabinet.

Samples prepared for ICP-OES analysis (i.e. all elements except selenium and mercury) were accompanied with procedural blanks and standard reference materials issued by the National Institute of Standards and Technology (NIST). Analysis was preceded with instrument calibration, followed by quality-control checks with prepared quality-control standards before, during (approximately every 10 samples) and after each analytical run. Analyses of reference materials (NIST 2079, San Joaquin soils and NIST 2976, mussel tissue) were consistent for the method and generally were within the range of certified values reported by NIST. Recoveries of Cd, Ni, and Pb in NIST 2976 tend to be less than the certified concentrations (*Appendix E*). Method detection limits (MDL) and reporting levels (MRL) were determined using the procedures outlined by Glaser and others (1981), Childress and others (1999), and USEPA (2004) (*Appendix F*). A full quality-assurance/quality-control plan is available upon request.

A variety of standard reference materials were prepared according to the method used for the determination of selenium and mercury. Observed concentrations fell within the range of certified values for these materials (*Appendix D*).

Other data sources

Precipitation data for San Francisco Bay is reported at San Francisco International Airport and was obtained from the California Data Exchange Center 2006.

Biological Response

Condition Index

The condition index (CI) is a measure of the clam's physiological state derived from the relationship between soft tissue weight and shell length and reported as the soft tissue dry weight (grams) for a clam of a particular shell length (mm). Specifically, for each collection, the relationship between the average shell length and tissue dry weight of the composites was fit with a linear regression, and from that regression the tissue dry weight was predicted for a normalized shell length of 25 mm.

Reproductive Activity

A minimum of 10 clams of varying sizes (minimum of 5 mm) were processed for reproductive activity concurrent with samples for metal analyses. Clams were immediately preserved in 10% formalin at the time of collection. The visceral mass of each clam was removed in the laboratory, stored in 70% ethyl alcohol, and then prepared using standard histological techniques. Tissues were dehydrated in a graded series of alcohol, cleared in toluene (twice for one hour each), and infiltrated in a saturated solution of toluene and Paraplast® for one hour, and two changes of melted Tissuemat® for one hour each. Samples were embedded in Paraplast® in a vacuum chamber and then thin sectioned (10 µm) using a microtome (Weesner, 1960). Sections were stained with Harris' hematoxylin and eosin and examined with a light microscope. Each individual was characterized by size (length in mm), sex, developmental stage, and condition of gonads, thus allowing each specimen to be placed in one of five qualitative classes of gonadal development (previously described by Parchaso, 1993) (*Appendix G*).

Community Analysis

Samples for benthic-community analysis were collected with an 8.5 cm diameter x 20 cm deep hand-held core. Three replicate samples were taken arbitrarily, within a square-meter area, during each sampling date.

Benthic-community samples were washed on a 500 µm screen, fixed in 10% formalin and then later preserved in 70% ethanol. Samples were stained with rose bengal solution. All animals in all samples were sorted to species level where possible (some groups are still not well defined in the bay, such as the oligochaetes), and individuals for each species were enumerated. Taxonomic work was performed in conjunction with a private contractor familiar with the taxonomy of San Francisco Bay invertebrates (Susan McCormick, Colfax, CA) (*Appendix H*). S. McCormick also compared and verified her identifications with previously identified samples.

Results and Discussion

Salinity

Surface water salinity is related to the seasonal weather pattern in Northern California, which is characterized by a winter rainy season defined by months with rainfall amounts greater than 0.25 inches (November through April) and a summer dry season (May through October)

(*Figure 2*). The 12 year (1994-2006) average annual rainfall is 24.6 inches. At 29.5 inches, precipitation for 2006 was slightly above average. Within the three year period 2004-2006 rainfall ranged from 23.2 (2004) to 33.1 (2005). Rainfall during March and April of 2005 and 2006 was especially elevated compared to the average.

Surface-water salinity typically exhibits a seasonal pattern that is generally the inverse of regional rainfall (*Figure 3*, *Table 1*). This pattern was again observed in 2006. The salinity minimum of 8 parts per thousand (ppt) occurred in April, consistent with the late season rainfall and elevated inflow of freshwater from surface water runoff. This was the lowest spring time salinity since 2000. Salinities continually increased during the dry season and reached their maximum (25 ppt) in the fall (October).

Sediments

Metal concentrations in surface sediments from Palo Alto typically display an annual periodicity of seasonal patterns. Thomson-Becker and Luoma (1985) suggested that this inter-annual variation is related to changes in the size distribution of sediment particles caused by deposition of fine-grained particles in the winter and their subsequent wind-driven re-suspension in the summer and fall. The authors showed that the composition of surface sediments was dominated by fine-grained particles, and accompanied by high Al and Fe concentrations, during the period of freshwater input (low salinities through April), reflecting annual terrigenous sediment inputs from runoff. Coarser sediments dominated later in the year because the seasonal diurnal winds progressively winnow the fine sediments into suspension through the summer. This pattern was observed again in 2006 (*Figure 4*, *Appendix A*).

In 2006, the percent of silt/clay in the sediment was at its maximum (87%) in April and declined to 35% in May following prolonged spring rainfall. Aluminum and Fe concentrations generally varied with the percentage of silt/clay-sized particles (*Figure 4*, *Table 1*), as described above, reflecting the contribution of clays composed of Al and Fe.

The total organic carbon (TOC) content of the sediments varied modestly during the year, coincident with other sedimentary constituents (*Table 1*). TOC content was highest during the winter (values from January through April averaged 1.4%) compared with the balance of the year (average 1.1%).

The metals Cr, Ni and V are highly enriched in some geologic formations within the watershed. In North San Francisco Bay, studies of sediment cores indicated that concentrations of these elements similar to those reported here were derived from natural geologic inputs (Hornberger and others, 1999; Topping and Kuwabara, 2003). Inputs of minerals bearing Cr, Ni, and V appear to vary seasonally as suggested by the variable concentrations of these metals in surface sediments. Typically, maximum concentrations coincide with winter/spring maximums in fine sediments, while minimum concentrations occur during the late summer/fall (*Figure 5*, *Table 2*). The minimum Ni concentration in the fall of 2004 (52 µg/g in October) and the following winter/spring maximum in 2005 (85 µg/g in March) were the lowest seasonal concentrations observed. This pattern was broken in 2006, as minimum levels in June (68 µg/g) were more typical of the record. Concentrations of Cr and V declined from their maximum concentrations in the winter of 2002/2003 to concentrations similar to those prior to 2003.

Copper concentrations in sediments are shown with sediment guidelines set by the National Oceanic and Atmospheric Administration (Long and others, 1995). Long and others defined values between ERL (Effects Range-Low) and ERM (Effects Range-Median) as concentrations that are occasionally associated with adverse effects (21 - 47% of the time for different metals). Values greater than the ERM were frequently associated with adverse effects (42% - 93% of the time for different metals). It must be remembered, however, that these effects levels were derived mostly from bioassay data and are not accurate estimates of sediment toxicity. In 2005, Cu concentrations were near or below the ERL (34 µg/g) for the entire year, the first time this has been observed. However, in 2006, the concentrations increased to the highest levels observed since 2000 and exceeded the ERL for the entire year. The typical seasonal pattern was observed in 2006. Cu concentrations peaked in January (55 µg/g) and then gradually declined throughout the year. The minimum concentration (37 µg/g) was observed earlier in the year (June) compared to past years which typically occurred in fall/winter months (*Figure 6*, *Table 2*) Near-total Cu concentrations appear to have been declining gradually since at least 2000. Over the same period, partial-extractable concentrations have remained relatively constant outside of the typical seasonal variation (*Figure 6*).

Copper concentrations in the surface sediments (for all years (1977-2006)) were highly correlated with copper loadings in effluent from the PARWQP, driven by the 1977-1988 data (r^2= 0.77, p<0.0001 *Figure 7*). However, since 1989, the variability observed in the sediments has not correlated well with the generally low copper loadings (r^2= 0.29 *Figure 7*) and is indicative of the influence by other factors.

For the third consecutive year, near-total and partial-extractable Zn concentrations were below the Zn ERL (150 µg/g) (*Figure 8*, *Table 2*) with the exception of January 2006. Concentrations in that sample were the highest ever observed (310 µg/g), but were consistent in high concentrations of other elements. The concentration immediately returned below the ERL in February.

The concentration of partial-extractable Ag in Palo Alto sediments are well below the Ag ERL (1 µg/g), but greater than the established concentration for uncontaminated sediments in San Francisco Bay (regional background) (Hornberger and others, 1999) (*Figure 9*, *Table 2*). The seasonal pattern observed in 2005 was not evident in Ag concentrations in 2006. In that year, Ag concentrations were exceptionally stable. Long term directional trends in the annual mean concentrations were not evident.

Mercury concentrations in sediment during 2006 ranged between 0.2 µg/g (January) to 0.3 µg/g (December) (*Figure10*, *Table 2*). These are amongst the lowest ever observed in the record (1994-2006). Conversely, in April of 2004, concentrations of Hg in the sediment (0.5 µg/g) were the highest observed in this study. Otherwise, Hg concentrations were within the range usually observed within San Francisco Bay (0.2 - 0.4 µg/g).

Selenium concentrations have increased slightly in the past four years (annual means 0.4 µg/g, 0.4 µg/g, 0.4 µg/g, and 0.5 µg/g respectively) but remain within the overall range of data since analysis of this element in 1994 (*Figure 10*, *Table 2*). Increasing concentrations of selenium vary in magnitude from year to year. In 2006, concentrations ranged between 0.4 µg/g (May and December) to 0.8 µg/g (January).

Clam Tissue

Metal concentrations in the soft tissues of *Macoma petalum* reflect the combined metal exposures from water and food. Exposures to Cu and Ag at Palo Alto are of special interest due to the high tissue concentrations observed at this site in the past (*Figure 11* and *Figure 12*, *Table 3* and *Table 4*, respectively). During the period 1977 – 1987, the range in annual concentrations of Cu and Ag were 95-287 and 45-106 µg/g, respectively. Since 1987, concentrations have been considerably lower: 24-71 µg-Cu /g and 2-20 µg-Ag/g. Concentrations were particularly low and stable from 1997 through 2005. Annual mean concentrations of Cu and Ag for 2006 were, respectively, 45 ± 8 and 3.8 ± 0.8 µg/g, a two-fold increase from 2005, but still within the error of means from recent years (2002-2004 for copper and 1997-2002 for silver). Copper concentrations in the clams were highly correlated with copper loadings in PARWQP effluent for all years,1977-2006, driven by the high concentrations and loadings in 1977-1988 (r^2= 0.90, p<0.0001 *Figure13*). However, in recent years (1989-2006), inter-annual variation in copper concentrations in the clam do not correlate with copper loadings (r^2= 0.10 *Figure 13*).

Intra-annual variations in Ag and Cu concentrations in clam soft tissues display a consistent seasonal signal, with fall/winter maxima and spring/summer minima, although it is common for the amplitude of this seasonal cycle to vary from year to year. For example, the winter maxima and the magnitude of seasonal Cu and Ag concentrations were greater between 1994 and 1996 than in subsequent years (*Figure14*, *Figure15*). The magnitude of the decline in Cu and Ag concentrations during the spring/summer of 2005 was comparable to previous years; however, the subsequent increase in tissue concentrations was not as great as in previous years and as of December, concentrations were only about half the maximum values observed in 2004. Then in 2006, concentrations increased steadily throughout the year, reaching a maximum concentration in November (83 μg/g for Cu and 7.9 μg/g for Ag). Concentrations this high have not been observed since 1997. These trends most likely reflect the interaction of the changing exposure regime of the site (the long term decline in metal concentrations) with the annual growth cycle of *M. petalum* (Cain and Luoma 1990).

As with Cu and Ag, tissue concentrations of Cr (*Figure 16*, *Table 5*), Ni (*Figure17*, *Table 5*) and Zn (*Figure18*, *Table 5*) also exhibited seasonal cycles. The seasonal cycles of Cr and Ni were very similar in terms of their timing and magnitude throughout the record (1994 - 2006). Neither element exhibited a clear temporal trend (either decreasing or increasing) in concentration. Maximum concentrations occurred in the winter of 1996-1997, while 2000 – 2002 was a period of relatively low winter-maximum concentrations. In 2003, concentrations increased somewhat and have remained relatively comparable through 2006. In addition to the typical seasonal pattern, Zn concentrations exhibited a slight long-term decline through 2005. During 1994-1997, Zn concentrations were notably higher throughout the year when compared to subsequent years. However, in 2006, concentrations increased notably to values comparable to those observed in the mid to late 90s. Wellise and others (1999) observed that seasonal and inter-annual patterns of Cr, Ni, and Zn in *M. petalum* at Palo Alto were generally similar to those from the San Jose site, suggesting that regional-scale processes may be more important than treatment plant inputs in controlling the bioavailability of these elements.

Before 2006, mercury concentrations in *M. petalum*, like Zn, have trended slightly lower since 1994 (*Figure19*). The highest concentrations observed during the record occurred in September 1994 and during the winters of 1995 and 1996 (all 0.5 μg/g). The seasonal (summer/fall) low concentration in 1995 (0.3 – 0.4 μg/g) was the highest recorded, also. Concentrations declined after 1996 and reached the minimum value in 2005. Concentrations in 2006 returned to the maximum concentrations observed in 1994 and 1995.

Selenium concentrations in *M. petalum* vary seasonally like other elements (*Figure20*, *Table 5*). Long-term trends in the data are not evident. However, the annual maximum concentrations (during summer/fall) have increased somewhat since 2002. Concentrations in 2006 appear consistent with this more recent feature.

The condition index for *M. petalum* at Palo Alto extends back to 1988 (*Figure21*). As previously discussed, the data fluctuate seasonally in relation to growth and reproductive cycles, and annual cycles differ in magnitude. For example, the maximum value in the CI during 1994-1999 was generally less than preceding or succeeding years. Since 2003 the maximum CI has steadily declined. In 2006, the maximum CI was one of the lowest observed.

Reproduction of *Macoma petalum*

Earlier studies (Hornberger and others 2000b; Shouse and others 2004) found that low reproductive activity in *M. petalum* in the late 1970s was related to highly elevated concentrations of silver (and perhaps Cu) in the soft tissues. This finding has implications for the reproductive success of the population. Following the decline in tissue concentrations of Ag and Cu in the 1980s, reproductive activity of *M. petalum* improved (*Figure22*). Furthermore, the low reproductive activity observed during the late 1970s has not been observed during the entire period of reduced metal exposures. Data for 2006 show that *M. petalum* continues to be highly reproductive relative to the 1970s with a high percentage of the animals being reproductively active at any time during the normal seasonal cycle of reproduction which begins in fall with spawning occurring the following spring (see Appendix *G* for detailed reproduction data for 2006 and *Figure 23* for short term history of reproduction).

Benthic Community

Estimates of species diversity and total animal abundance are simple metrics that are used in assessing environmental stress on biological communities. Species diversity, as estimated by a time series of number of species, has remained consistent throughout the recent study with the exception of small temporary increases as seen in 2006 *(Figure 24).* Total animal abundance shows the same trend *(Figure 25).* The difficulty with these types of metrics is that they do not consider the possibility that one species can take the place of another. Depending on the characteristics of the new species, the community structure and function may change as a result of this exchange of species. The details of changes in species composition are important because they may reflect the relative ability of species to accommodate environmental stress and redistribute site resources. In general, the species composition has changed little in 2006 relative to that seen in 2004 and 2005.

Three common bivalves (*Macoma petalum*, *Mya arenaria*, and *Gemma gemma*) have not shown any consistent trend over the 30-year period and did not show any significant deflection from the norm in 2006 *(Figure26*, *Figure27*, and *Figure28*). There was significant seasonal and inter-annual variability in species abundances for all species and that is well illustrated in these three bivalves. There were six species that did show trends in their abundance throughout the study and these trends continued through the 2004-2006 period. The first species, *Ampelisca abdita*, is a small crustacean that lives above the surface of the mudflat in a tube built from selected sediment particles. *A. abdita* showed a general decline in both the annual average abundances and annual maximum abundances (seasonal peaks in abundance; *Figure29*). The second species to show a significant trend was the small polychaete worm *Streblospio benedicti*, which also builds a tube above the surface of the mudflat. As with *A. abdita*, *S. benedicti* annual maximum abundances declined, as well as annual average abundances *(Figure 30).* The maximum seasonal abundance of the small burrowing crustacean *Grandiderella japonica*, a deposit feeder, declined through the 1980s but has since become more abundant *(Figure 31). Neanthes succinea*, a burrowing polychaete that feeds on surface deposits and scavenges for detrital food, similarly showed large seasonal fluctuations in abundance through the 1980s. *N. succinea* abundance had increased by the late 1990s and the annual average abundances and annual maximum abundances *(Figure 32)* remained relatively stable until 2005 and 2006 when the abundance decreased. Two species showed an increase in abundance within the time series. The first was the polychaete worm *Heteromastus filiformis (Figure 33)*, a deposit feeding, burrowing species that lives deep in the sediment (usually 5-20 cm below the surface of the mudflat). Abundance increased sharply in 1985 and then partially receded in the late 1980s. Abundances since 2000 have remained higher than in the late 1970s and 2006 abundance was similar to those seen since 2002. The second species showing an increase was *Nippoleucon hinumensis*, a small burrowing crustacean, which appeared in the dataset in 1988 *(Figure 34)* following its introduction into the bay in 1986 (Cohen and Carlton 1995). *Corbula amurensis*, a non-indigenous filter feeding bivalve, first appeared in the benthic community in significant numbers in April 2005 and persisted into 2006 with peaks in abundance occurring in spring and fall *(Appendix H)*.

As stated earlier, multivariate analyses of population data of the dominant species with environmental parameters did not reveal any relationships, except with the concentration of silver and copper in the sediment and in the tissue of *Macoma petalum* (using data as reported by David and others 2002). Therefore, this update will only consider those metals. Comparison of metal concentration and benthic species abundance can be made by plotting the metals and individual species together over the period of the study. The worm *H. filiformis* has increased in abundance with the decrease in silver and copper through time *(Figure 35)*. Because the natural spatial variability (that is, the large standard deviations around the monthly means) and seasonal variability of invertebrate abundance and metal concentration can be quite large, the annual average abundances for *H. filiformis* and annual average metal concentrations are shown *(Figure 36)* and *(Figure 37)*. To interpret these plots, we must first examine the life history characteristics of this species and determine if there is some mechanism by which this organism could be responding to a decrease in silver or copper in the environment. *H. filiformis* has continual tissue contact with the sediment both at the exterior of its body, as well as within its body, due to its lifestyle of burrowing through the sediment and consuming a diet of mud and organic particles. In addition, this is one of the few species in the present community that reproduces exclusively by laying its eggs in the sediment. The larvae hatch after two to three days and spend two to three days in the plankton before settling back to the mud as juvenile worms (Rasmussen 1956). One hypothesis as to why *H. filiformis* increased in abundance may be that either the adult worms or the eggs are less stressed in the present environment. Because of its mode of reproduction and short planktonic larval period, this species is not likely to move into an area quickly after the environment becomes acceptable. Therefore, it is not possible to identify either the identity of the metal or the threshold concentration of the metal to which the animal is responding without laboratory tests. However, other investigators have shown that silver can adversely affect reproduction in invertebrates and that adult *H. filiformis* can tolerate high levels of copper (Ahn and others 1995). The gradual increase in *H. filiformis* abundance through 1984 may be a response to the gradual reduction of metals in the environment, or may indicate that it took several years for the population to build up in the area. The large abundance increase in 1985 and 1986, followed by a decline and leveling out of abundance, may be an example of the “boom and bust” principle whereby a species rises to levels too high for the habitat to support, and then declines in abundance until it levels out to a habitat-supportable abundance (Begon and others 1986). It is unclear, based on only nine years of data since the early 1990s, if this species has established a stable abundance.

The two species that have declined in abundance coincident with the decline in metals, the crustacean *A. abdita (Figure38*, *Figure39* and *Figure40)* and the worm *S. benedicti (Figure 41, Figure42*, and *Figure 43)* have very similar life history characteristics. Both species live on the surface of the sediment in tubes that are built from sediment particles, are known as opportunistic and are thus capable of rapid increase in population size and distribution, brood their young, and produce young that are capable of either swimming or settling upon hatching. It is unclear why these species have become less competitive in the present day environment, but their very low numbers in the last several years indicate that there is a major shift in the community as both species were numerically very dominant in the benthic community in the 1970s and 1980s. Unlike *A. abdita* and *S. benedicti*, there has been no significant decline in the abundance of *G. gemma (Figure 44, Figure45, and Figure 46)*, the small clam that reproduces by brooding their young and lives on the sediment surface. However, *G. gemma* returned to much lower numbers in 2006 following a very large abundance peak in 2005. All three species are suspension feeders and thus consume water borne particles, although *S. benedicti* may also deposit feed.

The change in function of the benthic community over time can be examined by ranking the top ten species by abundance and plotting the ln (abundance +1) against the rank of each species *(Figure47).* The plot for 2006 is indicative of a healthy benthic community with the top eight species having similar densities. If we examine similar plots for August of four years during our study (1977, 1989, 2002, and 2006), we can see that the shape of the curve has changed greatly between 1977 and 2006 *(Figure48).* The series of lines shows a community that was heavily dominated by three species in 1977 and 1989 when compared to the community in 2002 when there was one dominant species. The 1977 community plot is the most extreme and reflects a bimodal species distribution with three species dominating the community and the remainder having similar but relatively low abundances. In contrast, the 2006 community plot has the flattest line (unimodal species distribution) which is indicative of a more evenly diverse community.

It is informative to then examine these plots within the context of the life history characteristics of each species to determine if shifts in plot shape coincide with a shift in community structure and function that might be indicative of a healthier environment. We have shown two critical life history characteristics here: feeding mode *(Figure48)* and reproductive mode (*Figure49).* The 1977 community was dominated by filter-feeding species (species that consume particles in the water column), species that have the option of either filter-feeding or feeding on the sediment surface (mixed feeders), and one species that feeds on food particles on the sediment surface. In 1989 the species composition had shifted such that filter feeding species and subsurface deposit feeding species (those that ingest sediment and strip the food off of the sediment in their gut) dominated the community. In 2002 we again saw a shift towards species that could either filter feed or deposit feed (mixed feeders) and those species that feed on subsurface sediment. The most recent data shows that this homogenous community (the abundances are most similar between species) is mostly composed of a mix of subsurface deposit feeding species and mixed feeding species. Thus, over the period of this study we have seen a shift from a community dominated by species who fed either in the water column or on recently settled food particles on the sediment surface, to a community of species who feed directly on the subsurface sediment and those capable of feeding in the water column or on the sediment surface.

An examination of these rank-abundance plots using reproductive mode as the descriptor for each point is equally informative *(Figure49).* The dominant species in 1977 were species that brood their young and release fully functional juveniles into the environment. In 1989 there were still several brooders but there were also two species that lay their eggs in the sediment. Although two brooding species remain in the ten most abundant species in the 2002 and 2006 plots, the reproductive mode of the dominant species has shifted to those that spawn their gametes into the water column and those that lay eggs in the sediment (oviparous). It is possible that some of the metal contaminants found in the sediment in the 1970's at this location limited the success of species that consumed the sediment for food, laid eggs in the sediment, or depended on water borne larvae to repopulate the community.

Summary

Long-term Observations

Since 1974, USGS personnel have monitored and conducted basic research on the benthic sediments and biological community in the vicinity of the discharge of the Palo Alto Regional Water Quality Control Plant (PARWQCP). The time series presented here updated previous findings (Luoma and others 1991; 1992; 1993; 1995; 1996; 1997; 1998; Wellise and others 1999; David and others 2002; Moon and others 2003; 2004; 2005; Shouse and others 2003; 2004; Thompson and others 2002; Cain and others 2006) with additional data from January 2006 through December 2006, to create a record spanning 33 years. This long-term dataset includes sediment chemistry, tissue concentrations of metals, condition index and reproductive activity in *M. petalum*, and population dynamics of benthic-invertebrate species. The time series encompasses the period when exceptionally high concentrations of copper and silver were found in *M. petalum* (1970s) and the subsequent period when those concentrations declined. The sustained record of biogeochemical data at this site provides a rare opportunity to examine the biological response to metal contamination within this ecosystem.

Studies during the 1970s showed that sediments and *M. petalum* at the Palo Alto site contained highly elevated levels of metals, especially Ag and Cu, as a result of metal-containing effluent being discharged from the PARWQCP to South Bay. In the early 1980s, the point-source metal loading from the nearby Palo Alto Regional Water Quality Control Plant was significantly reduced as a result of advanced treatment of influent and source mitigation. Coincident with declines in metal loadings, concentrations of metals in the sediment and in the clam *M. petalum* (serving as a biomonitor of metal exposures) also declined as previously described by Hornberger and others (2000). Inter-annual trends in clams and sediments are highly correlated with copper loadings from PARWQCP. Metal levels in sediments and clams respond relatively quickly to changes in metal loading; the reduction in metal loadings by the PARWQCP resulted in a reduction in metal concentrations in both the sediment and *M. petalum* within a year (Hornberger and others, 2000b).

Biological responses to metal inputs to South Bay were assessed at different levels of organization. These responses are interpreted within the appropriate temporal context. Because metal exposures were already high when the study began, interpretations are based on observed changes in biological attributes as metal inputs declined. In general, discernable responses at the organism level (i.e. reproductive activity, a manifestation of a cellular or physiological change) to metal exposure may occur within a relatively short time, while population and community level responses take longer to develop. Stable changes in the benthic community may take a relatively long period of time to be expressed because of the normally high degree of intra-annual variability of benthic-community dynamics, which reflects the cumulative response to natural and anthropogenic disturbances. It is therefore critical that sampling frequency and duration be conducted at temporal scales appropriate to characterize the different biological responses.

During the first 10 years of this study, when the metal concentrations were high and declining, the benthic community was composed of non-indigenous, opportunistic species that dominated due to their ability to survive the many physical disturbances on the mudflat (Nichols and Thompson 1985a, 1985b). These disturbances included sediment erosion and deposition, and aerial exposure at extreme low tides, in addition to less well defined stresses. The possible effects of metal exposure as a disturbance factor were not considered in the analyses by Nichols and Thompson, as the decline in metal concentrations in *M. petalum* and sediment had just begun.

However, data collected throughout the period of declining metal exposure have revealed biological responses to this metal decline. Reproductive activity improved within a year or two of reduced metal exposure, and responses at the population and community levels were observed afterward. Identification of these responses was possible because the frequency of sampling allowed long-term trends related to metal contamination to be identified within the context of repeating seasonal cycles and unrelated inter-annual variation.

2004-2006

Copper and Ag concentrations in sediments and the soft tissues of the clam *M. petalum* during the three year period between 2004 and 2006 were representative of the concentrations observed since 1991 following significant reductions in concentrations during the 1980s that coincided with reductions in the discharge of these elements from PARWQCP. Since 1991, Cu and Ag concentrations in sediments and clams have remained relatively low and stable (compared to the late 1970s and the 1980s). Inter-annual variation during the 15 years since 1991 did not correlate with discharge of Cu and Ag from PARWQCP, suggesting that, similar to other elements of regulatory interest including Cr, V, Ni, and Zn, regional scale factors now largely influence sedimentary and bioavailable concentrations (e.g. Luoma and others 1998). Other variables, such as precipitation and accelerated erosion of salt marsh banks in recent years, may influence the seasonal and year to year patterns in sedimentary and tissue concentrations and should still be investigated.

The long-term dataset demonstrates various adverse impacts of contaminants on benthic organisms. Decreasing particulate concentrations of trace metals in the local environment have benefited resident populations of invertebrates, as evidenced by increased reproductive activity in *M. petalum* that has been sustained though 2006. The abundances of individual species showed no remarkable variability during 2004-2006. The species abundances of the 2006 community were the most homogenous, that is the ten most abundant species had the most similar abundances we have observed during this long term study. The interpretation that shifts in species abundance at Palo Alto were a response to decreasing contaminants continue to be supported by the most recent sediment and community data. The community has shifted from being dominated by species that live on the surface, filter food out of the water column or consume particles on the sediment surface, and brood their young, to a community dominated by species that live on and below the surface, consume the sediment directly to harvest food particles, and spawn and lay eggs in the sediment.

Value of Long-Term Monitoring

This study highlights the importance of long-term ecosystem monitoring. The decadal time series produced during the course of sustained efforts at this site have made it possible to describe trends, identify previously undocumented phenomena, and pose otherwise unrecognized hypotheses that have guided past detailed explanatory studies and can guide future studies. Monitoring studies cannot always unambiguously determine the causes of trends in metal concentrations or benthic-community structure. The strength and uniqueness of this study is the integrated analysis of metal exposure and biological response at intra- and inter-annual time scales over multiple decades. Changes and trends in community structure that may be related to anthropogenic stressors, as was seen in this study, can only be established with a concerted and committed effort of sufficient duration and frequency of sampling. Such rare field designs allow biological responses to natural stressors to be characterized and separated from those introduced by man. Through interpreting time series data, it has been possible to separate anthropogenic effects from natural annual and inter-annual variability. The data from the recent record (that is, within the past decade) increasingly appear to be indicative of an integrated regional ecological baseline with indicators of metal contamination, and greater physiological well-being of aquatic life and benthic-community structure. Changes are occurring in the South Bay watershed. For example, implementation is beginning in the South Bay Salt Ponds Restoration Program; with unknown implications (positive or negative) for all of South Bay. Nanotechnologies, many of which include metal-based products in forms for which we have no experience, are beginning to take hold in consumer products. The long-term, detailed, integrated ecological baseline that has been established at this sampling site will be uniquely valuable in assessing the response of the South Bay environment as our dynamic activities in the watershed continue to change.

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Figures

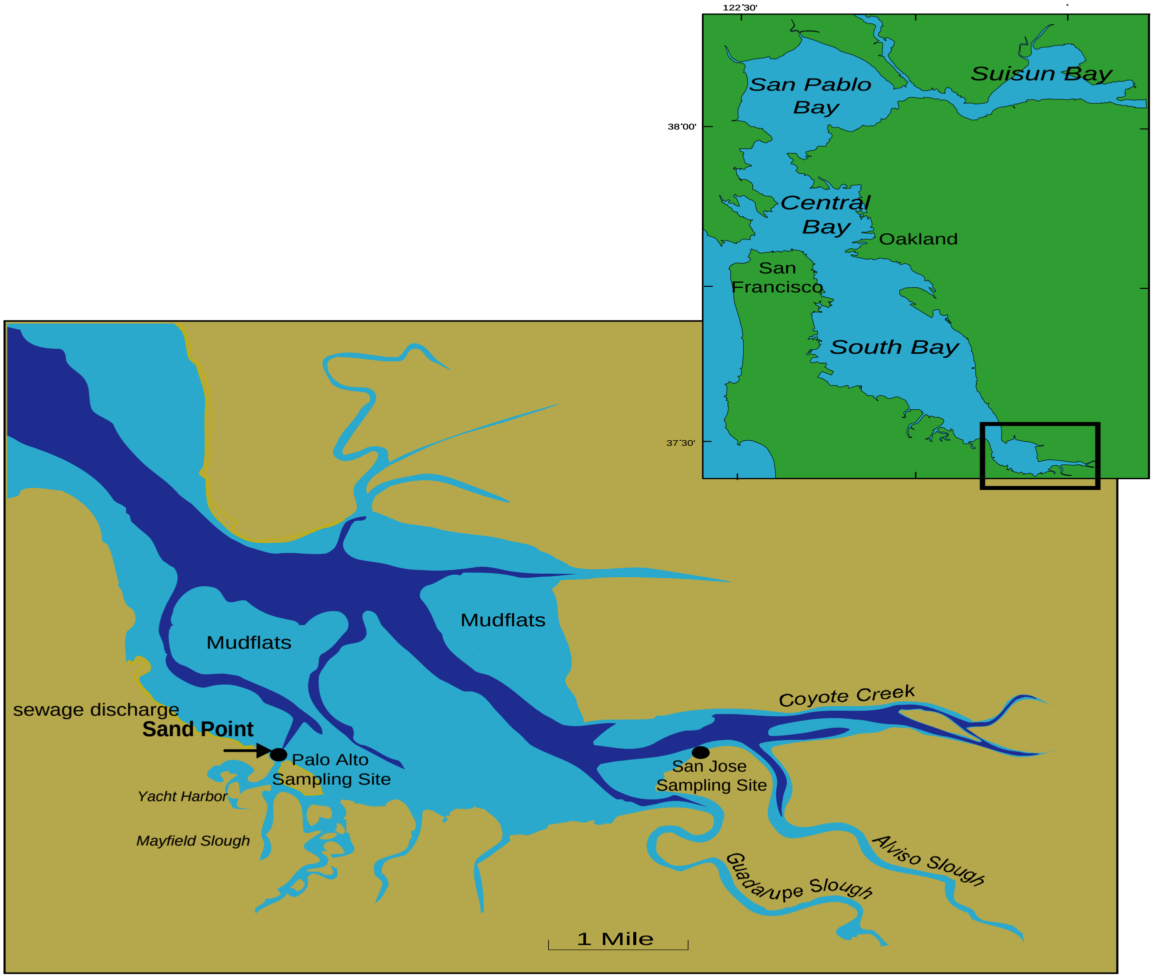


Figure 1. Location of the Palo Alto sampling site in South San Francisco Bay.

The intertidal zone is shaded light blue, subtidal in dark blue, and shoreline in brown. Effluent from the Palo Alto Regional Water Quality Control Plant is discharged approximately 1 mile north/west of the sampling site. The San Jose sampling site (inactive) also is shown for reference.

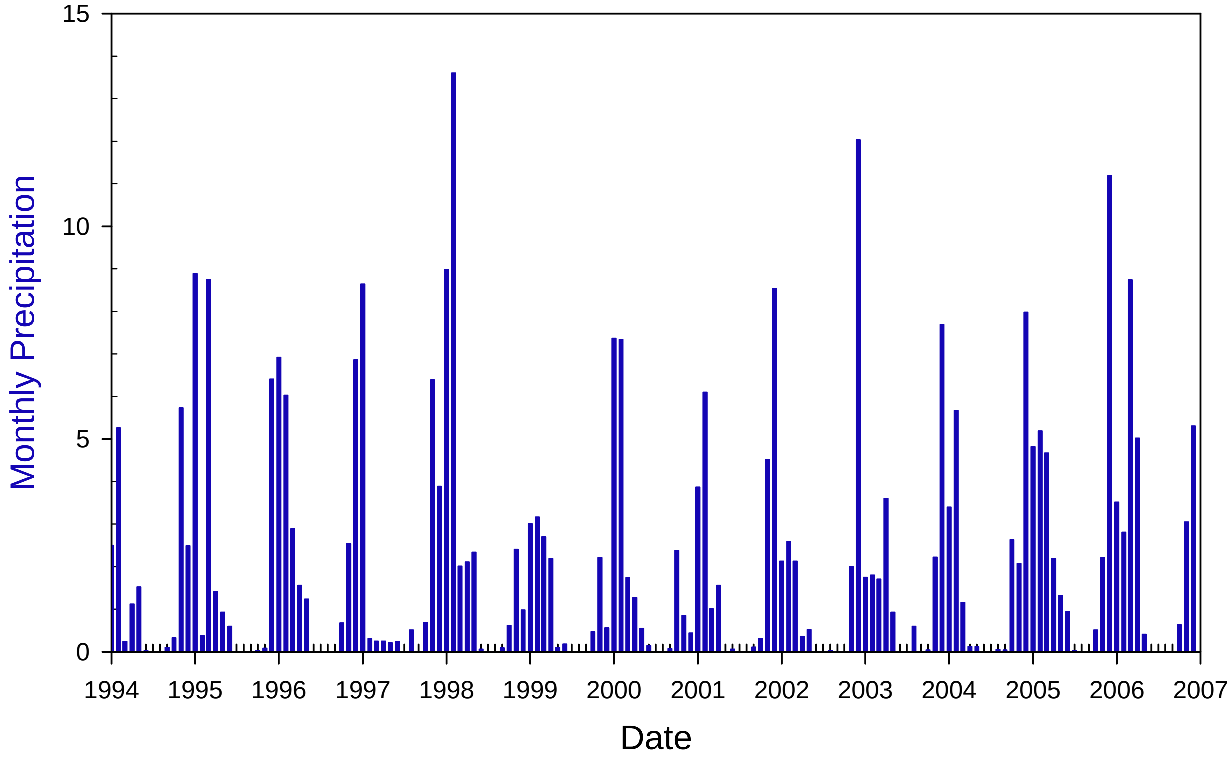


Figure 2. Precipitation

Data from San Mateo gauge station from 1994 through 2006. Precipitation is in inches.

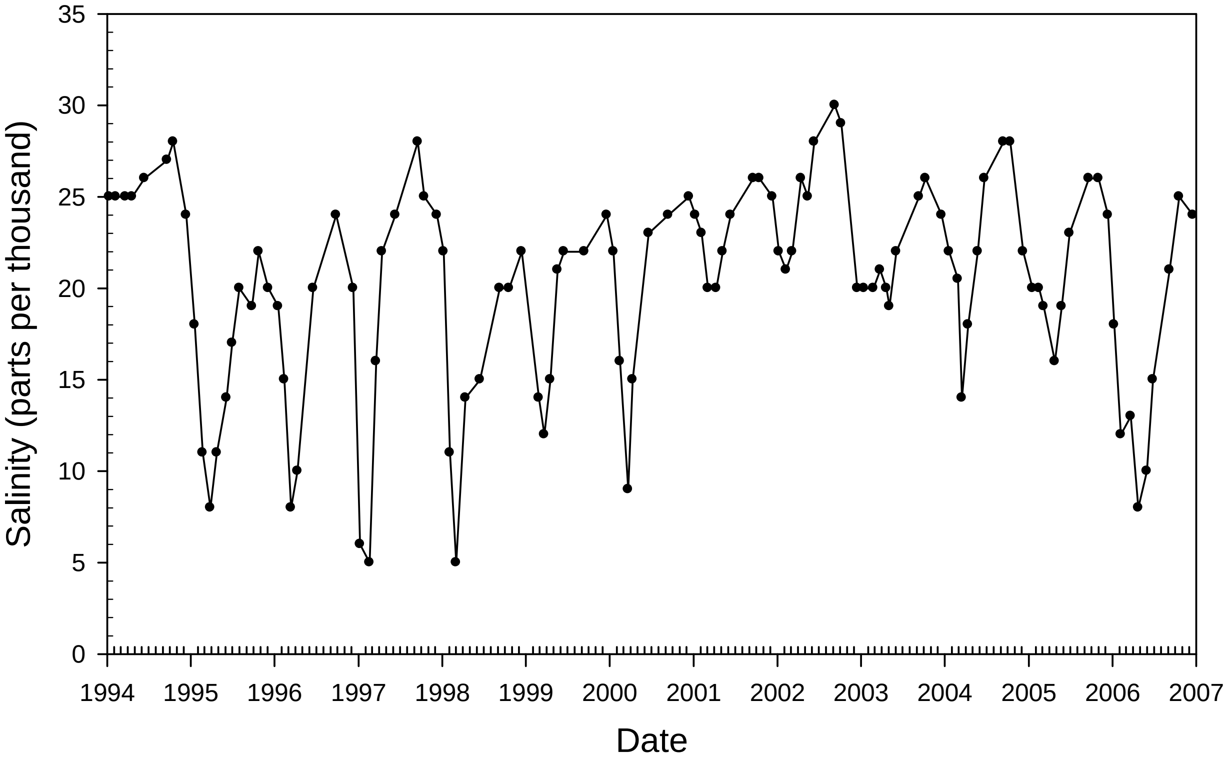


Figure 3. Water column salinity

Data from Palo Alto site from 1994 through 2006.

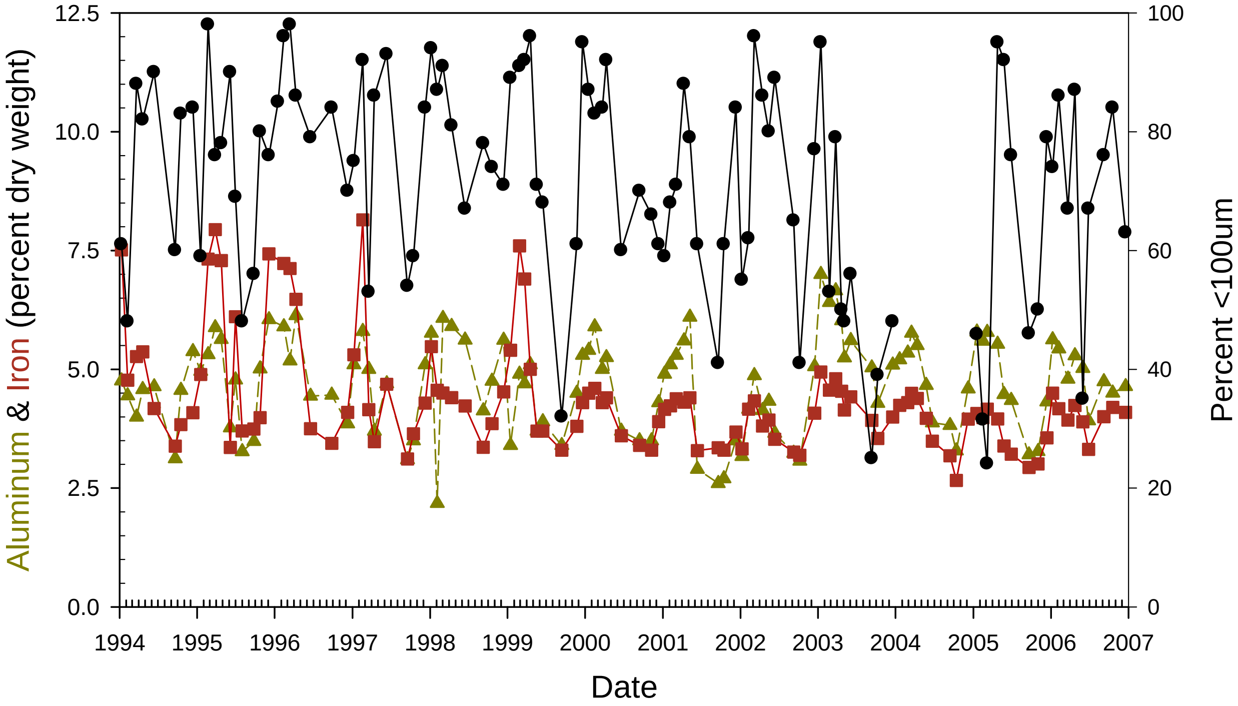


Figure 4. Aluminum, iron and silt/clay in sediments

Data are for the period from 1994 through 2006. Percent aluminum (▲), iron (■) and silt/clay (●) extracted by near-total digest. Data for percent fines for 2004 contain unquantifiable biases due to errors in sample processing, and therefore have been censored.   Data for 2004 are shown in Appendices A-2 and A-3 for qualitative purposes only.

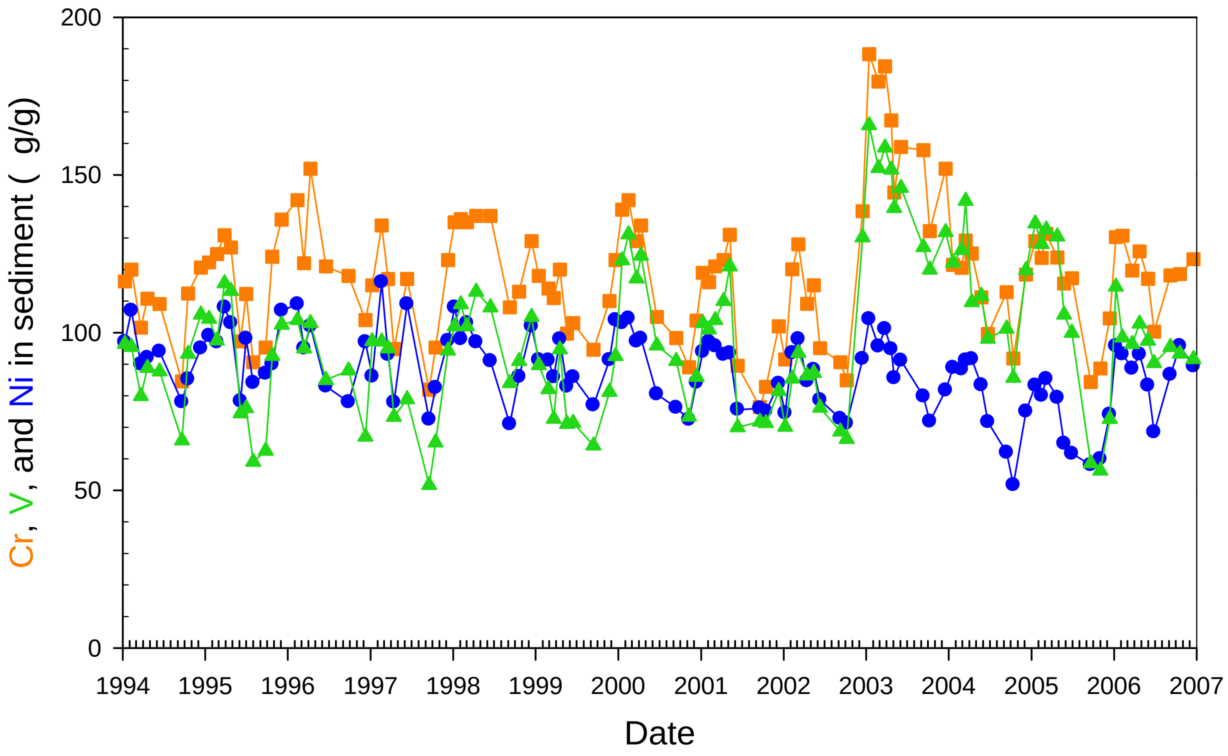


Figure 5. Chromium, nickel and vanadium in sediments

Data are for the period from 1994 through 2006. Concentrations of chromium (Cr) (■), nickel (Ni) (●) and vanadium (V) (▲) extracted by near-total digest.

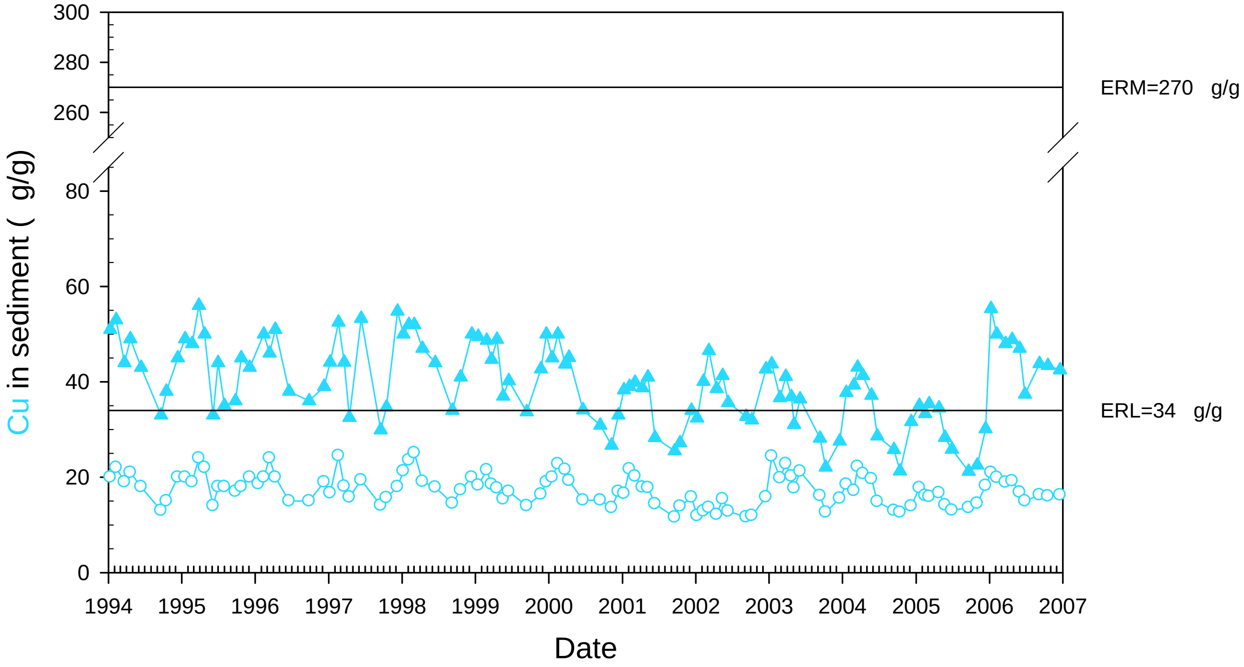


Figure 6. Copper in sediments

Data are for the period from 1994 through 2006. Near-total (▲) and partial-extractable (○) copper.

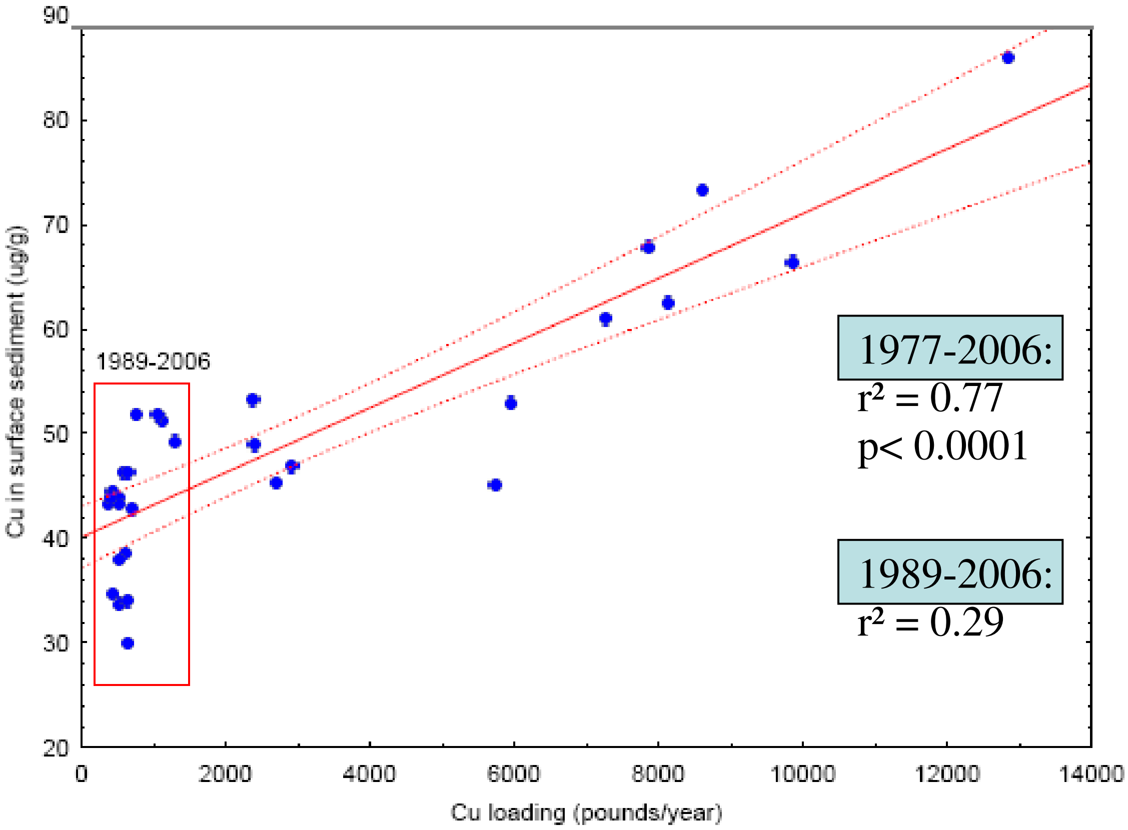


Figure 7. Correlation between copper effluent from PARWQP and copper concentrations in surface sediments

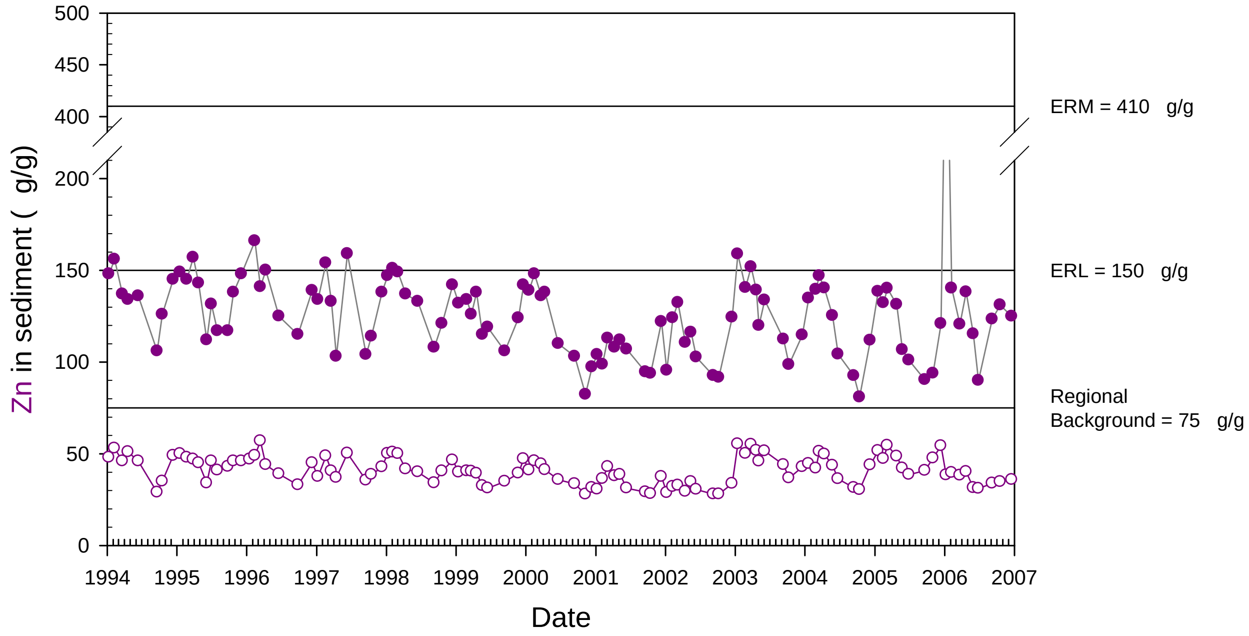


Figure 8. Zinc in sediments

Data are for the period from 1994 through 2006. Near-total (●) and partial-extractable (○) zinc.

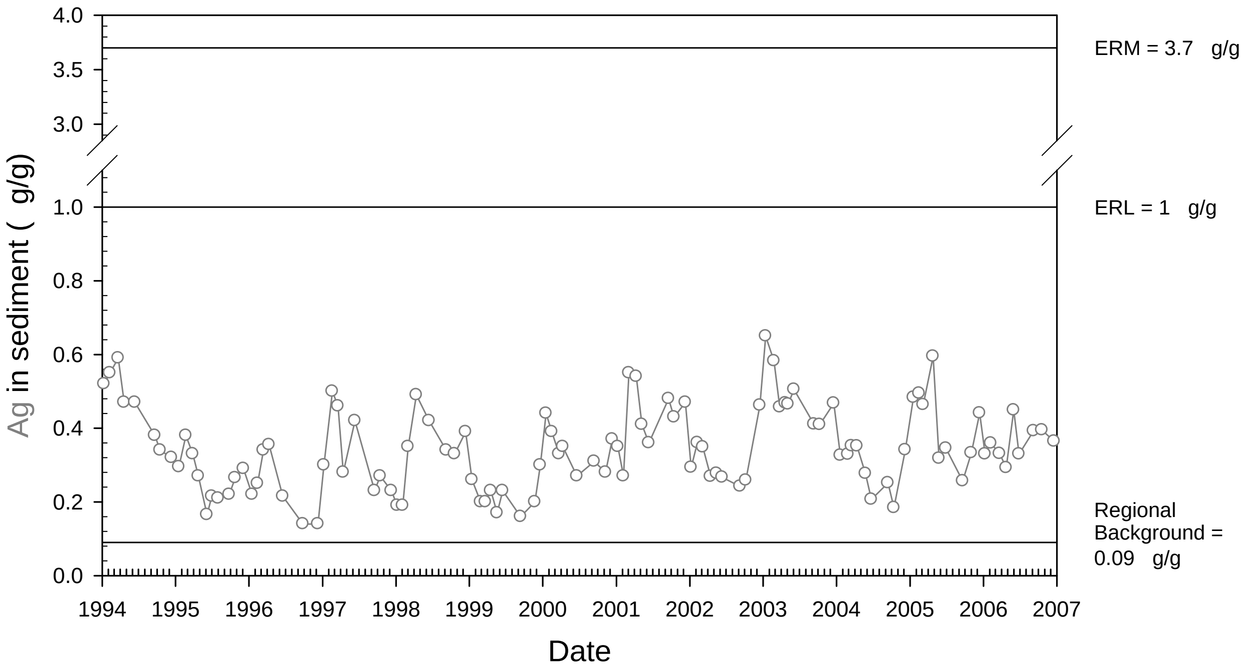


Figure 9. Silver in sediments

Data are for the period from 1994 through 2006. Data represent partial-extractable silver (treatment with 0.6 N hydrochloric acid).

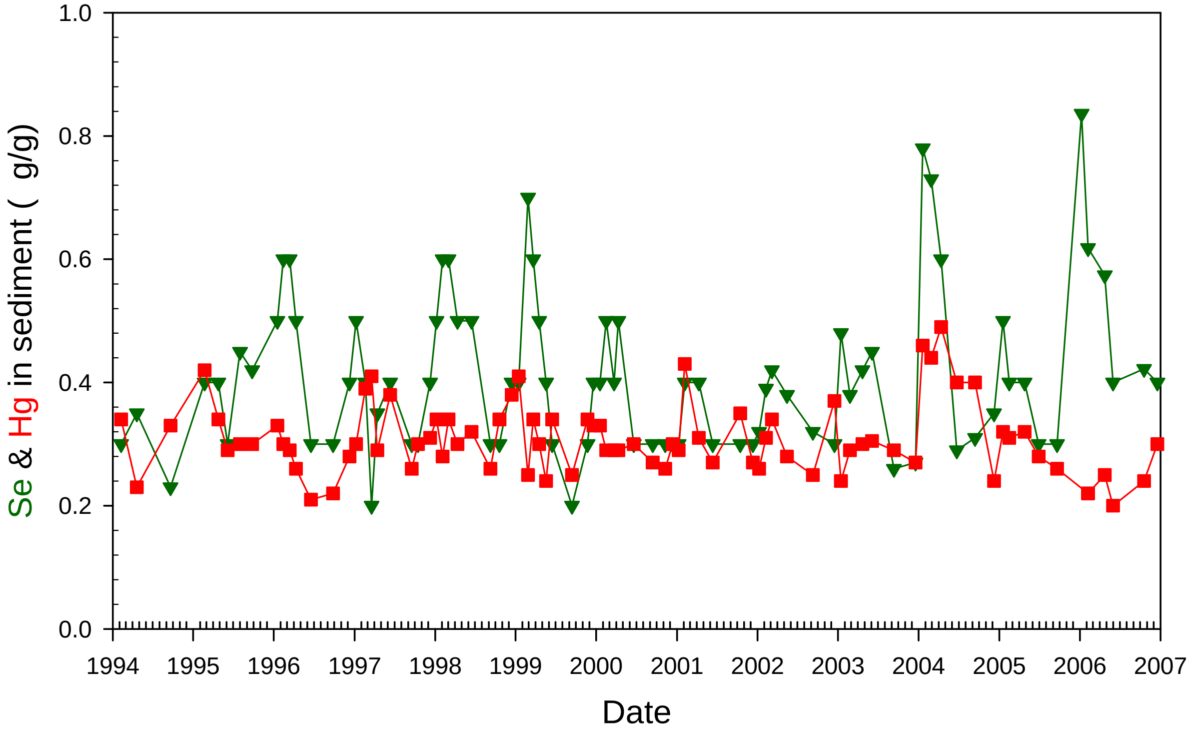


Figure 10. Selenium and mercury in sediments

Data are for the period from 1994 through 2006. Selenium (▼); mercury (🟥).

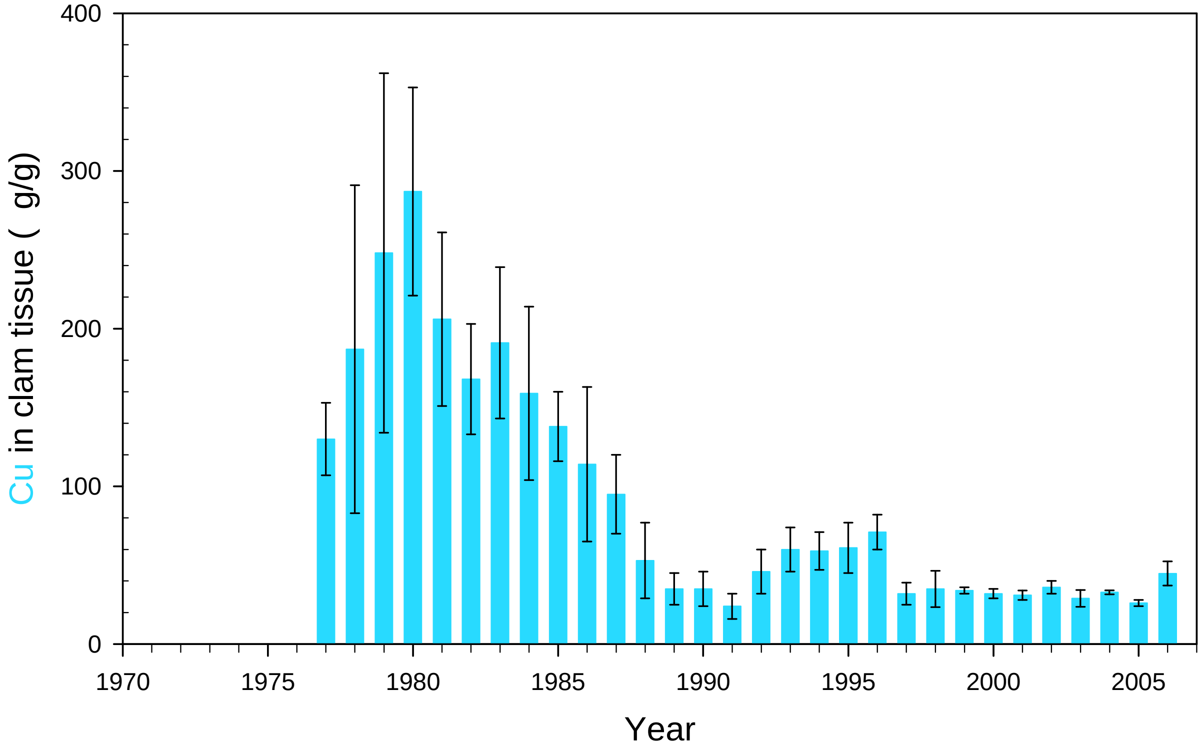


Figure 11. Annual mean copper in *Macoma petalum*

Data are for the period from 1977 through 2006. The error bars are the standard error of the mean (SEM).

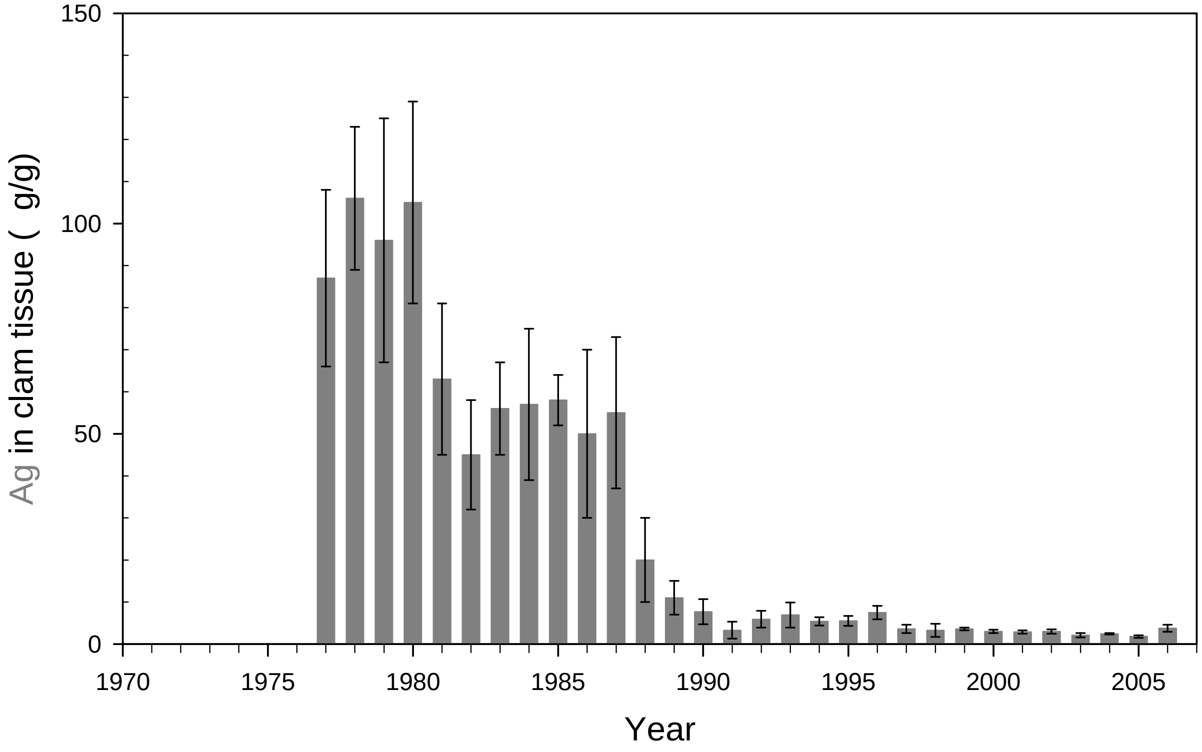


Figure 12. Annual mean silver in *Macoma petalum*

Data are for the period from 1977 through 2006. The error bars are the standard error of the mean (SEM).

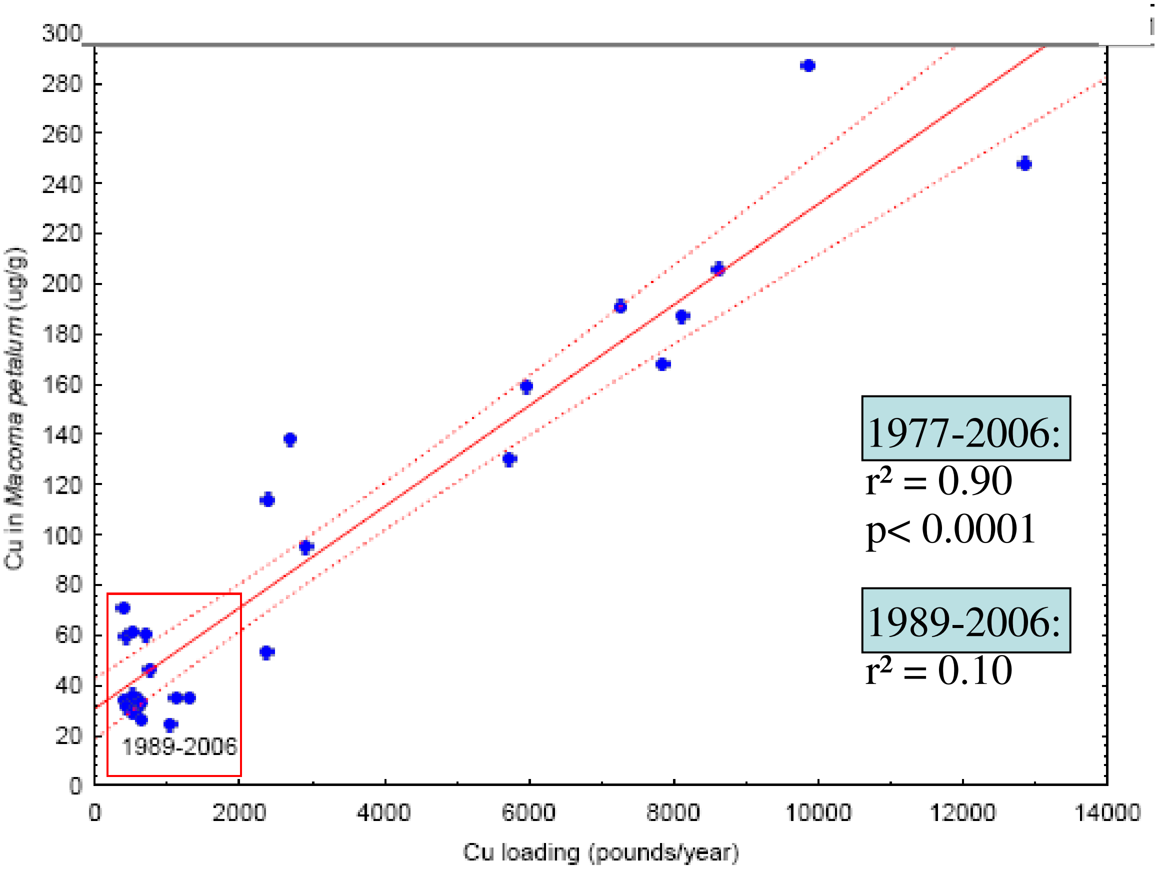


Figure 13. Correlation between copper loadings from the PARWQP and copper concentrations in *Macoma petalum*

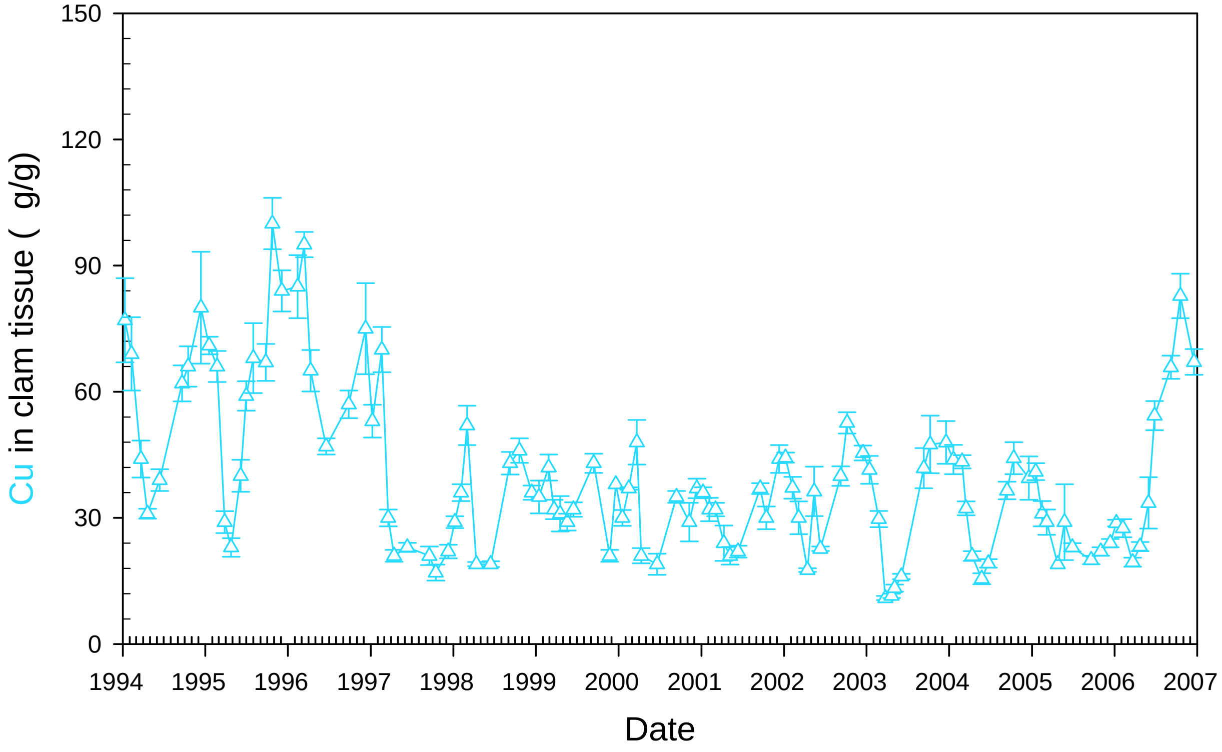


Figure 14. Copper in *Macoma petalum*

Each value is the mean concentration for the sample collected on a given date. The error bar is the standard error of the mean (SEM).

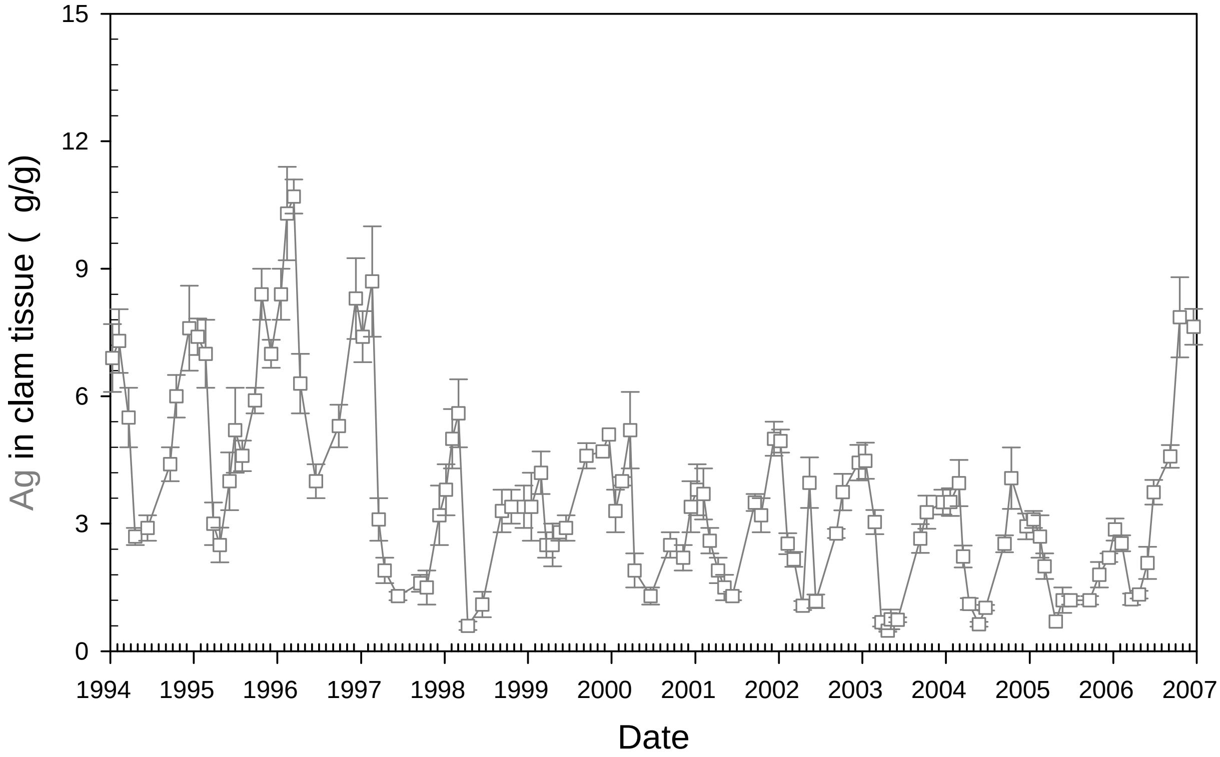


Figure 15. Silver in *Macoma petalum*

Each value is the mean concentration for the sample collected on a given date. The error bar is the standard error of the mean (SEM).

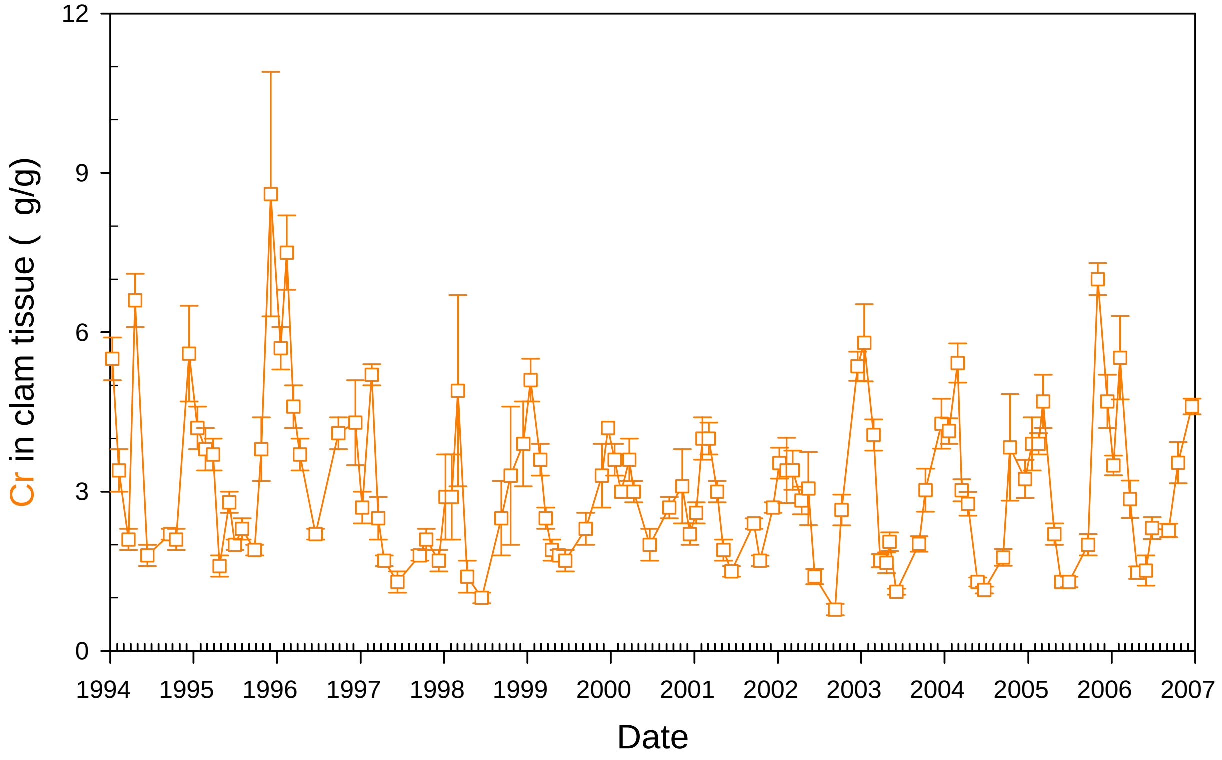


Figure 16. Chromium in *Macoma petalum*

Each value is the mean concentration for the sample collected on a given date. The error bar is the standard error of the mean (SEM).

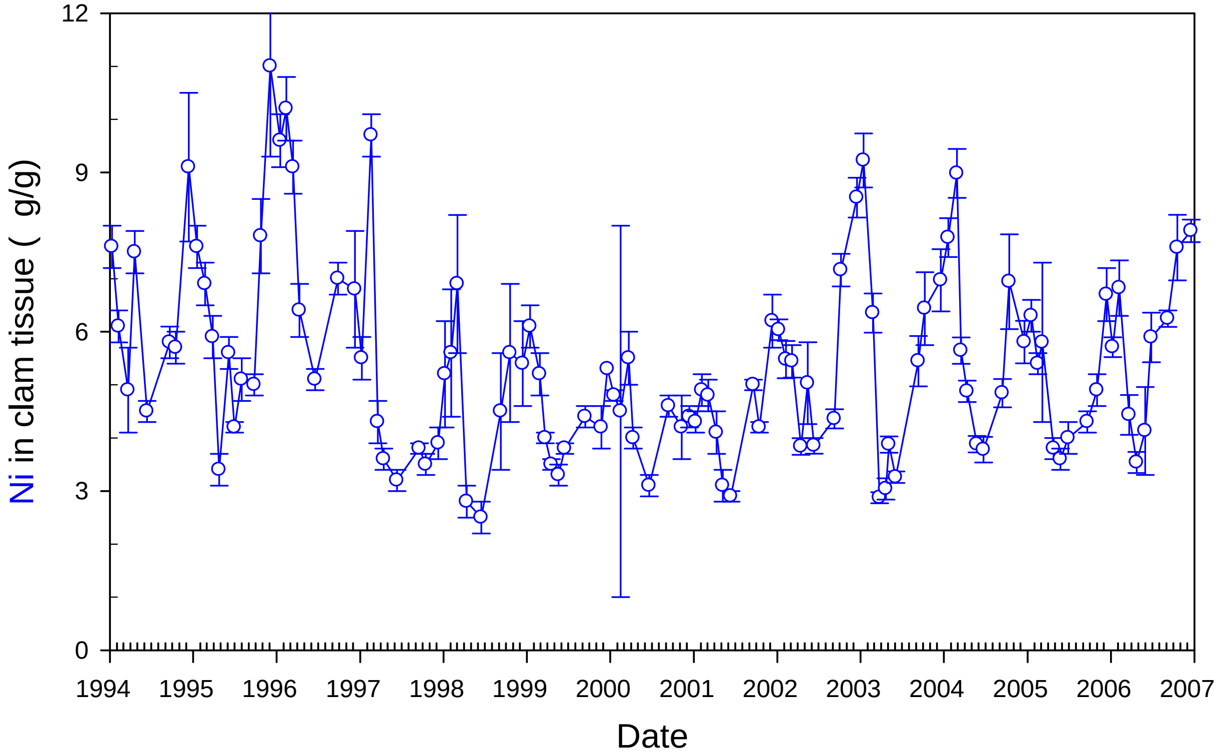


Figure 17. Nickel in *Macoma petalum*

Each value is the mean concentration for the sample collected on a given date. The error bar is the standard error of the mean (SEM).

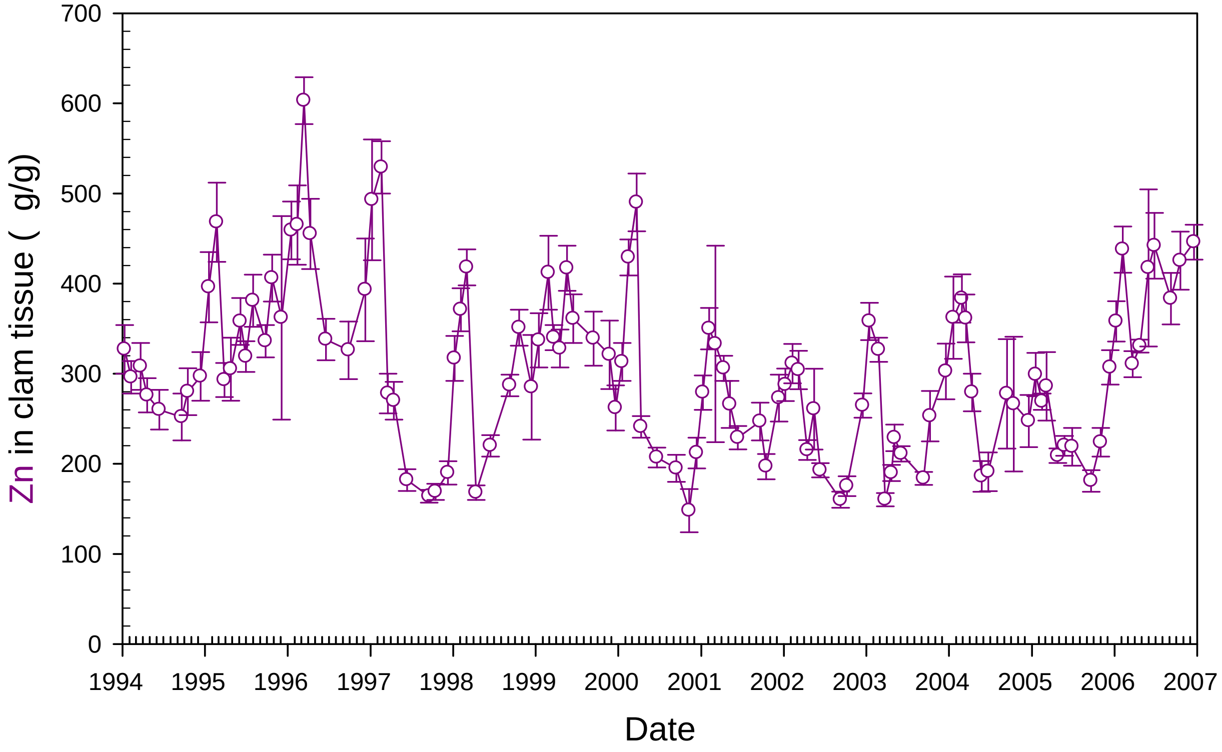


Figure 18. Zinc in *Macoma petalum*

Each value is the mean concentration for the sample collected on a given date. The error bar is the standard error of the mean (SEM).

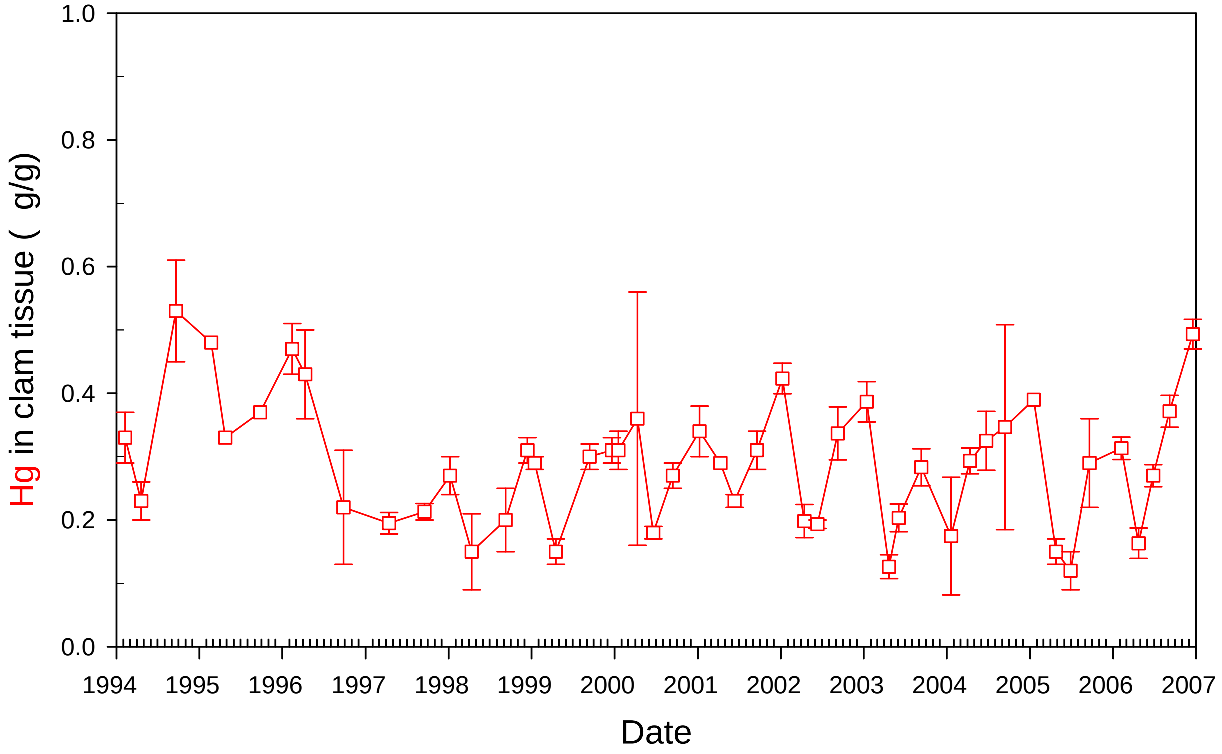


Figure 19. Mercury in *Macoma petalum*

Each value is the mean concentration for the sample collected on a given date. The error bar is the standard error of the mean (SEM).

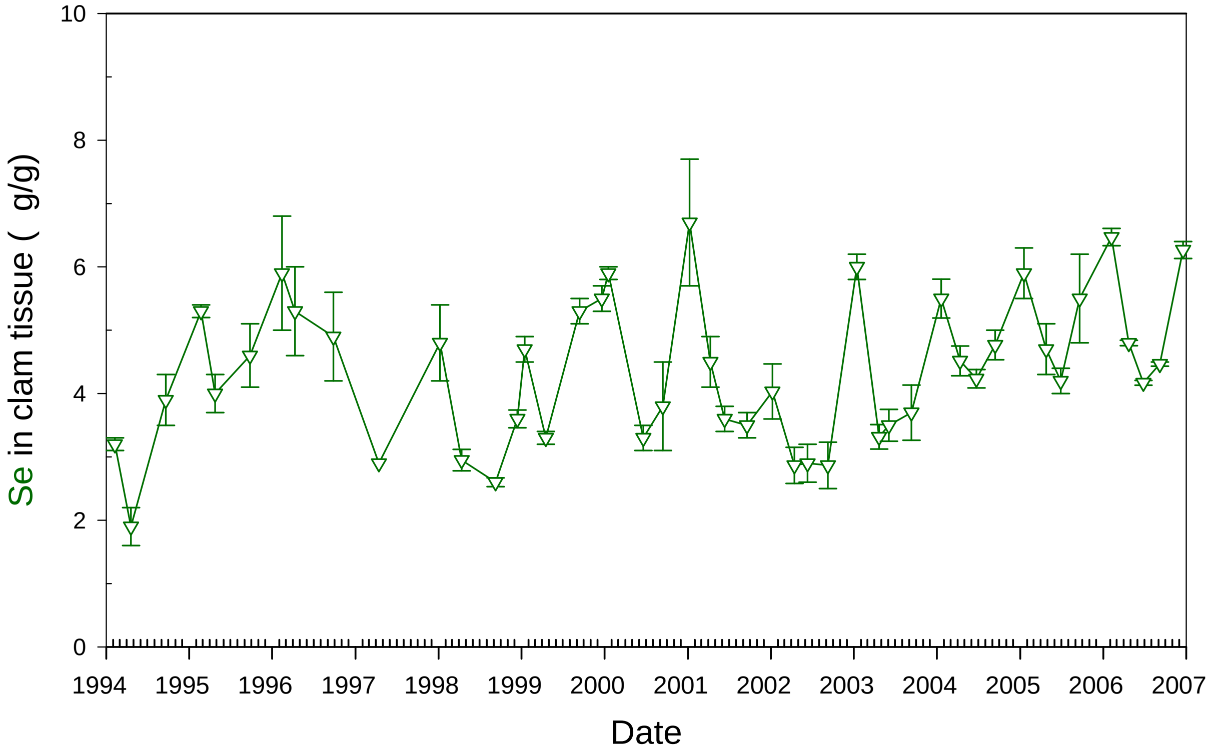


Figure 20. Selenium in *Macoma petalum*

Each value is the mean concentration for the sample collected on a given date. The error bar is the standard error of the mean (SEM).

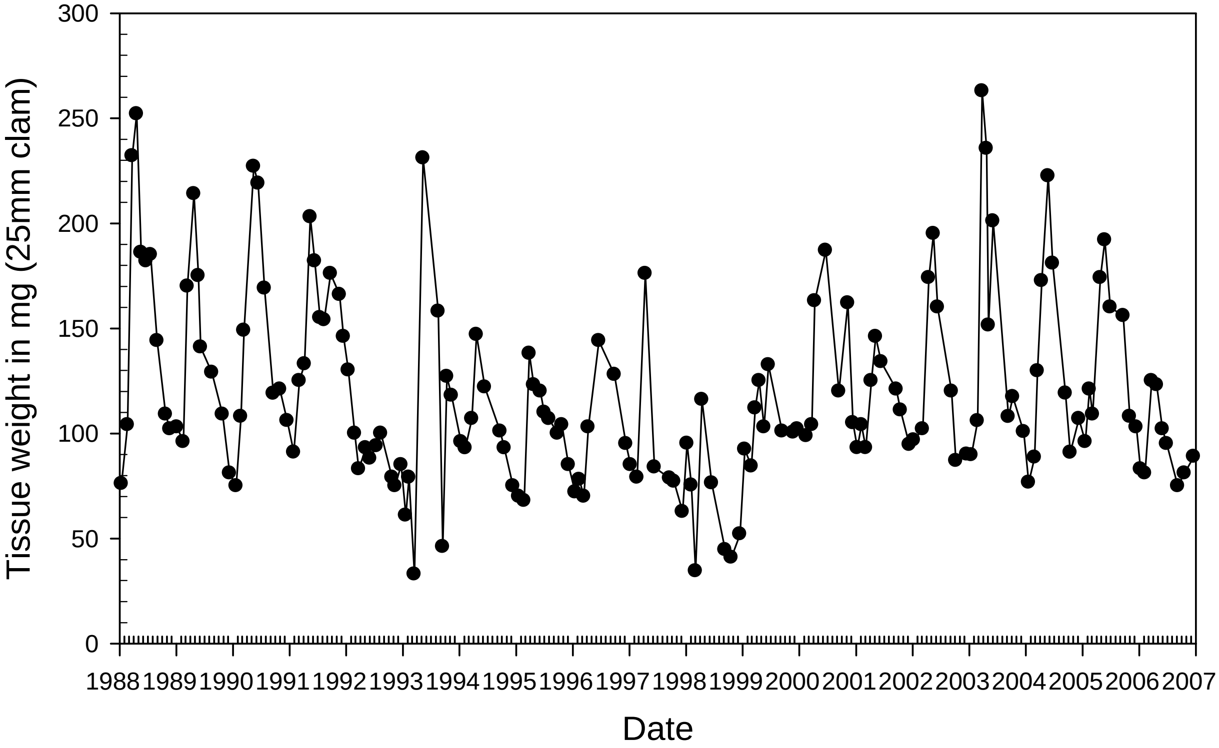


Figure 21. Condition index of *Macoma petalum*

The condition index (CI) is defined as the weight of the soft tissues for an individual clam having a shell length of 25 mm.

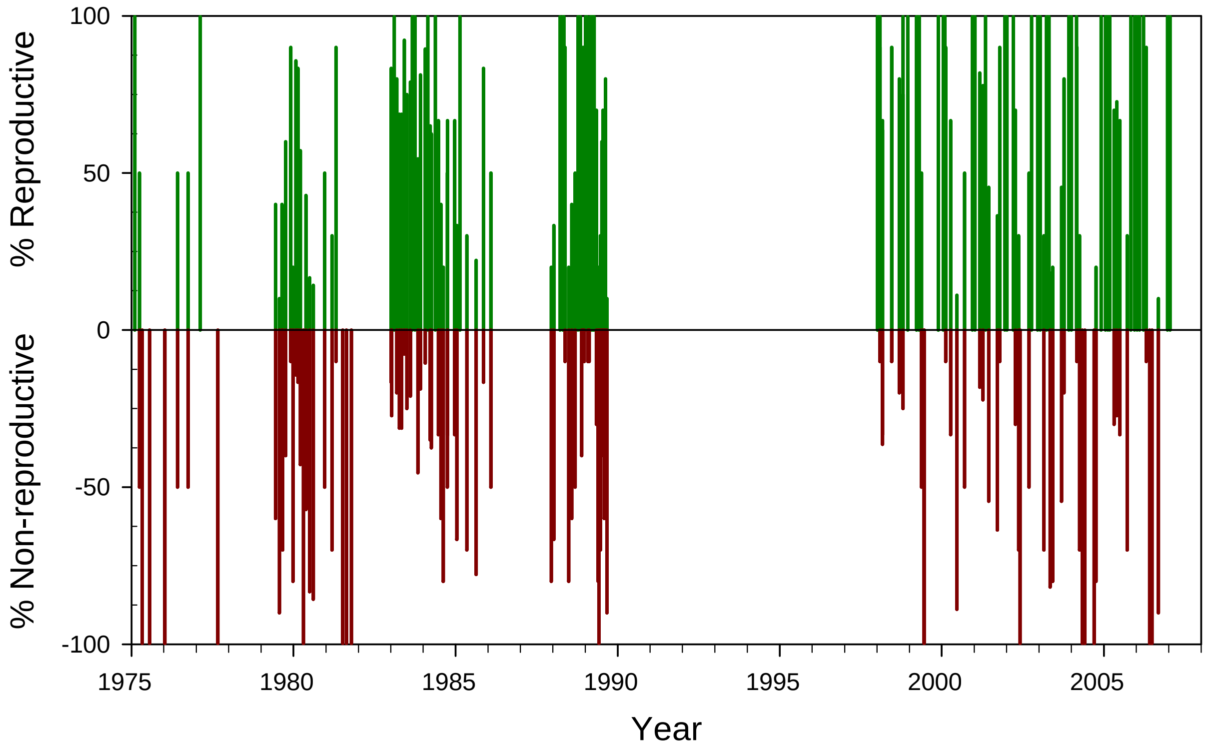


Figure 22. Reproductive activity of *Macoma petalum*

Data are for the period from 1974 through 2006.

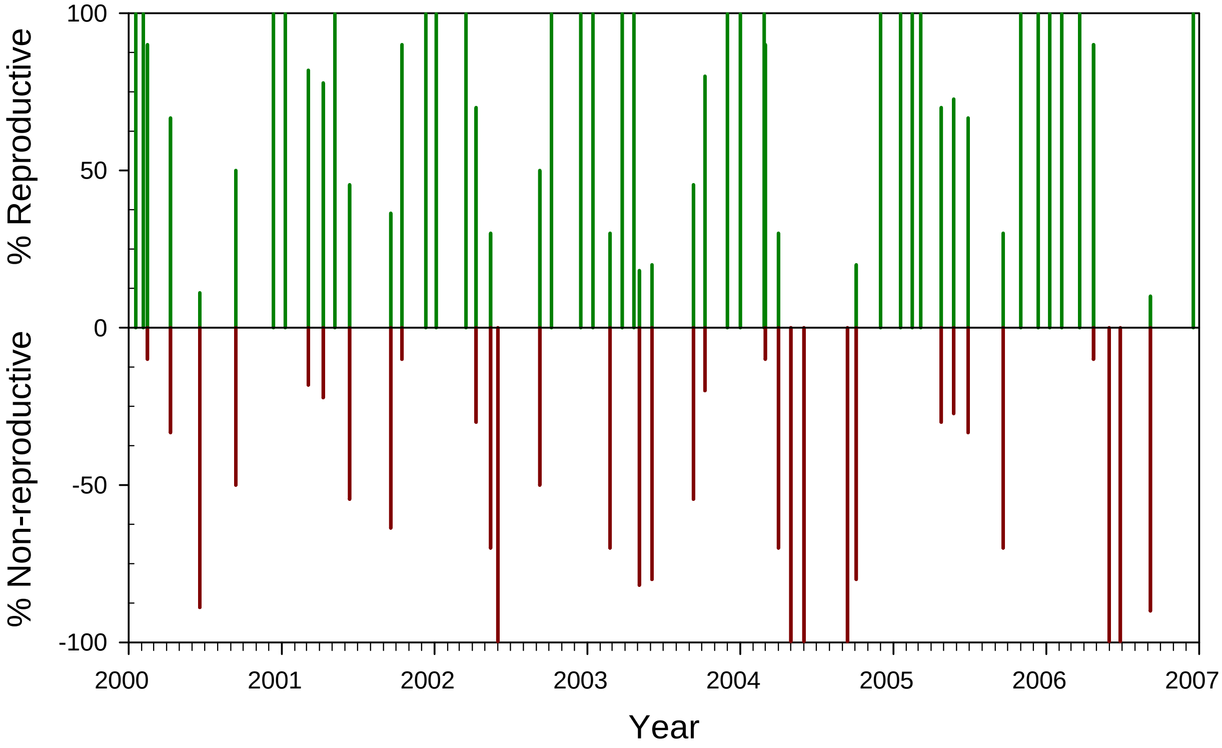


Figure 23. Reproductive activity of *Macoma petalum* 2000 through 2006.

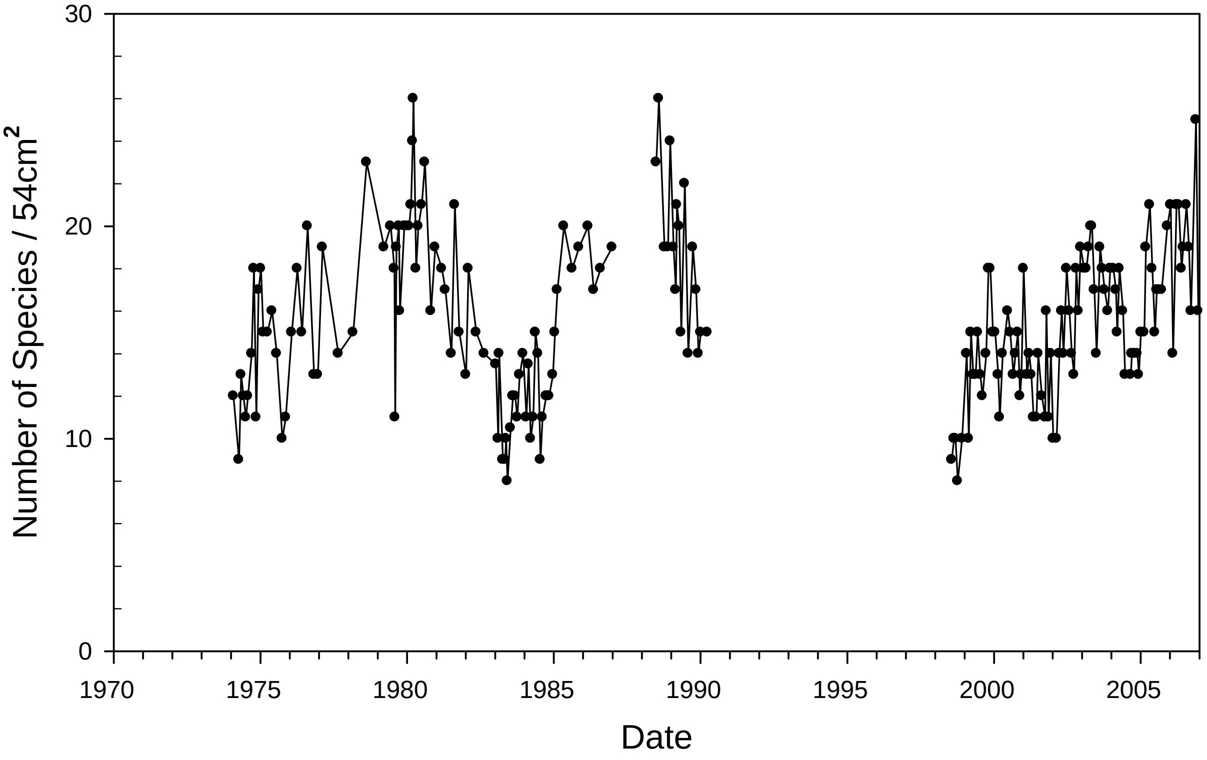


Figure 24. Total number of species present

Data are for the period from 1974 through 2006.

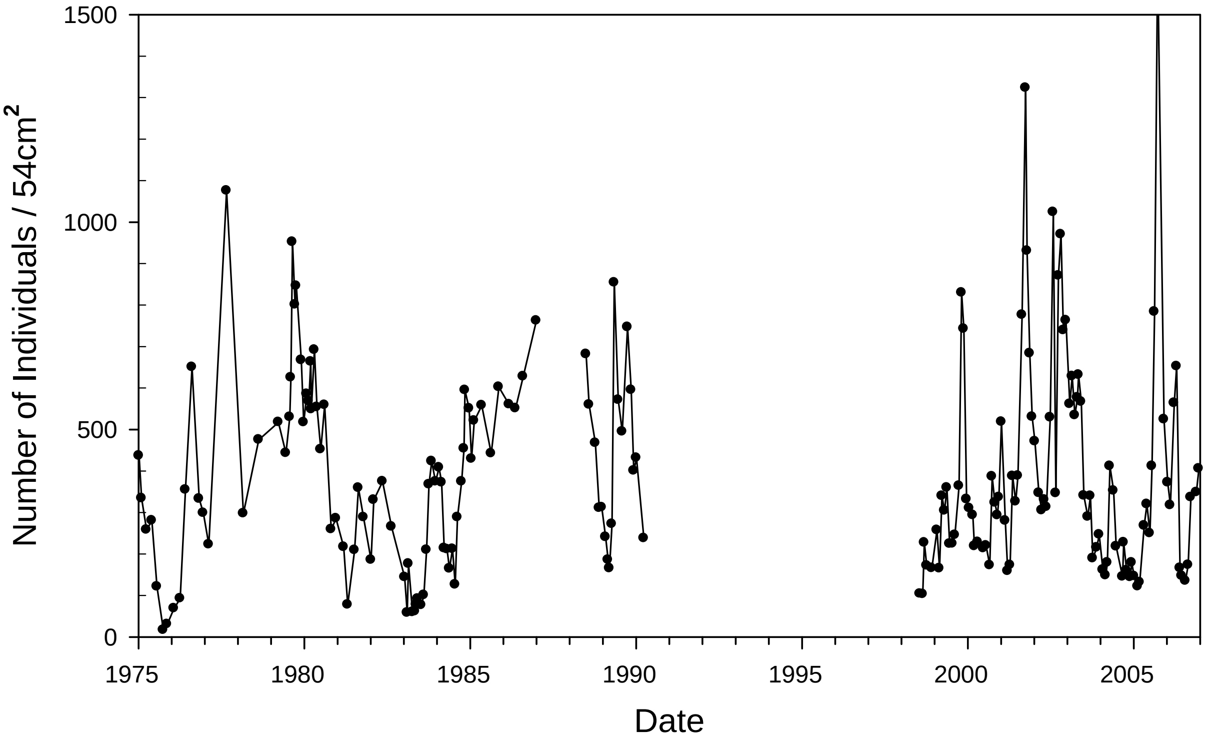


Figure 25. Total average number of individuals present

Data are for the period from 1974 through 2006.

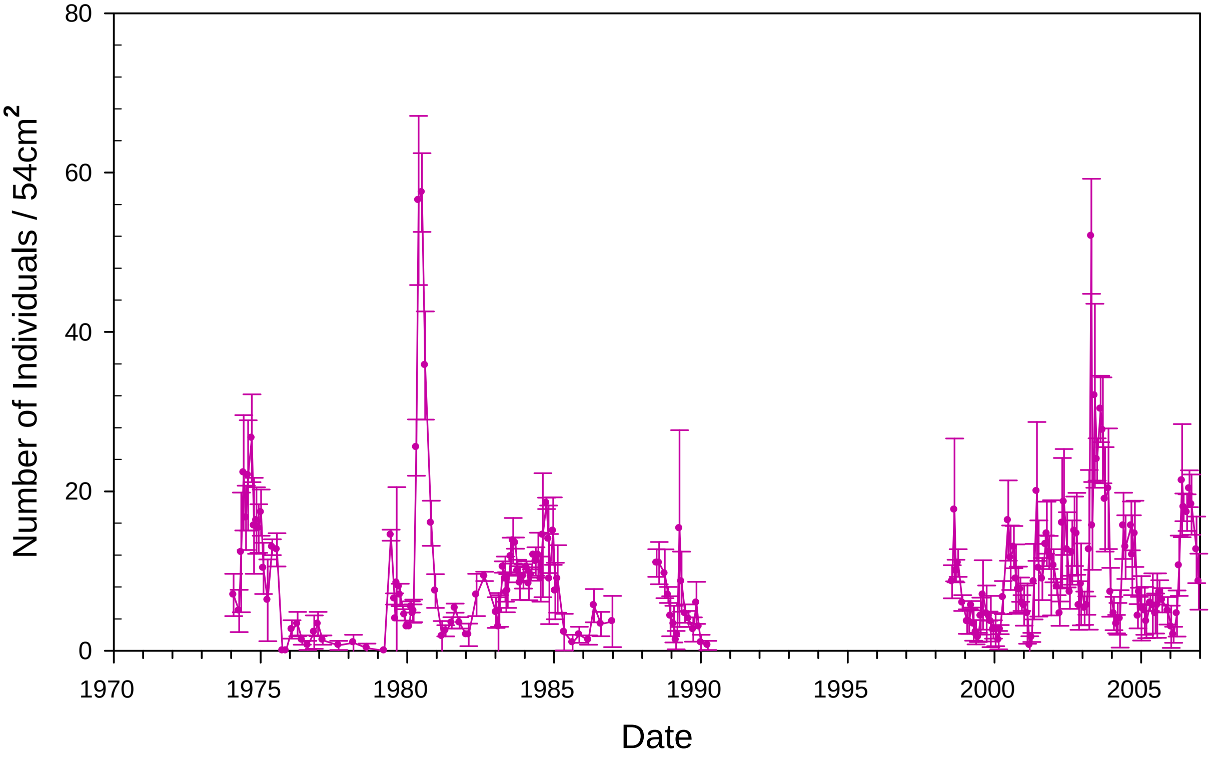


Figure 26. Average abundance of *Macoma petalum*

Data are for the period from 1974 through 2006. Error bars represent standard deviation from 3 replicate samplings.

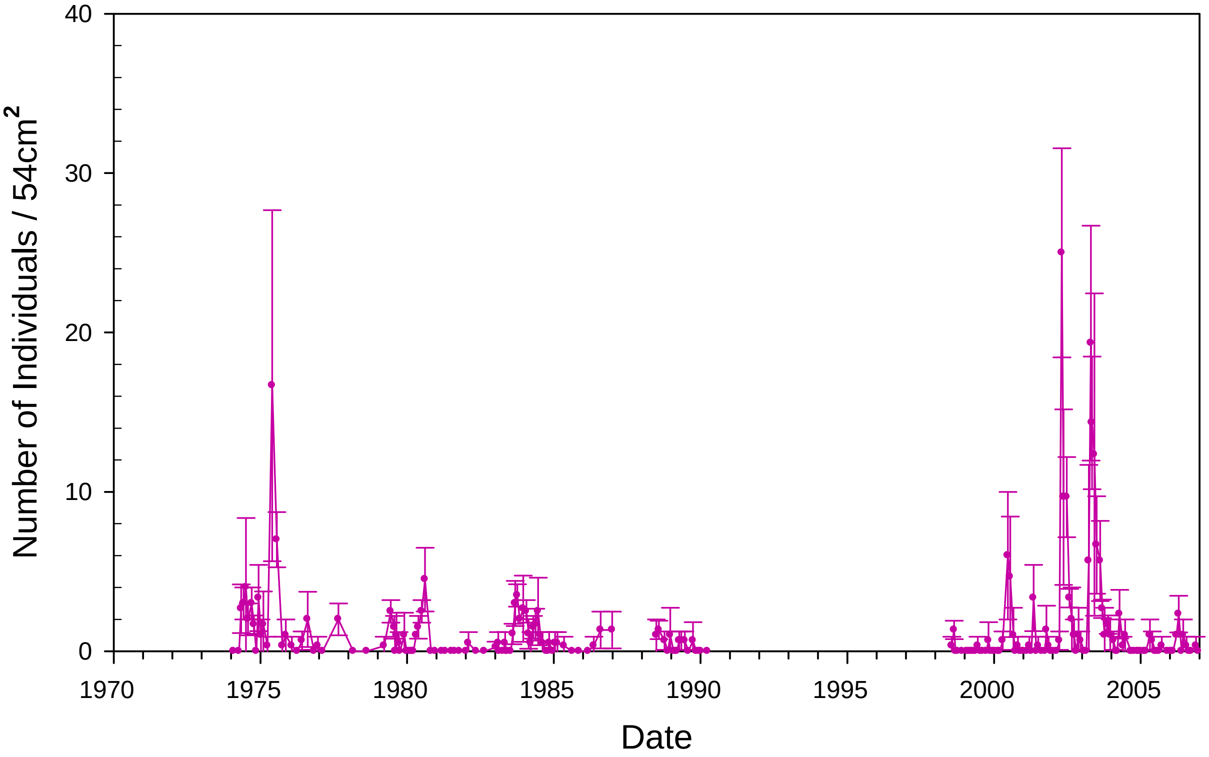


Figure 27. Average abundance of *Mya arenaria*

Data are for the period from 1974 through 2006. Error bars represent standard deviation from 3 replicate samplings.

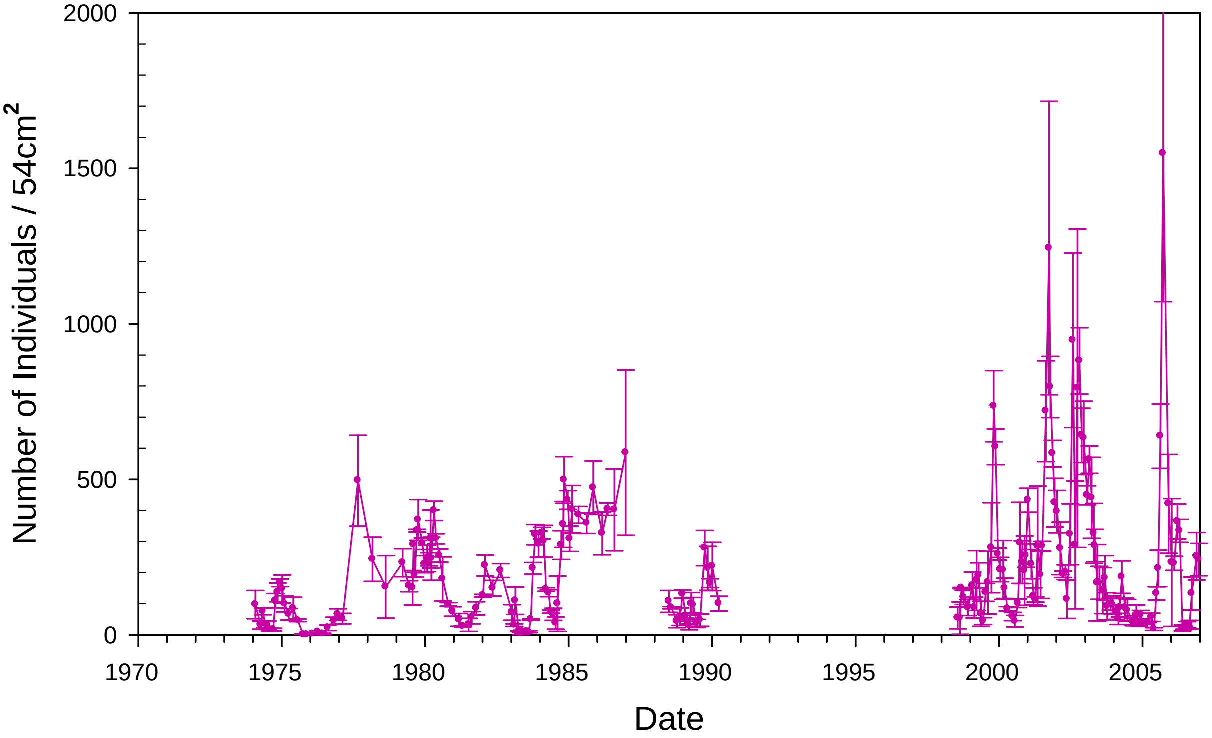


Figure 28. Average abundance of *Gemma gemma*

Data are for the period from 1974 through 2006. Error bars represent standard deviation from 3 replicate samplings.

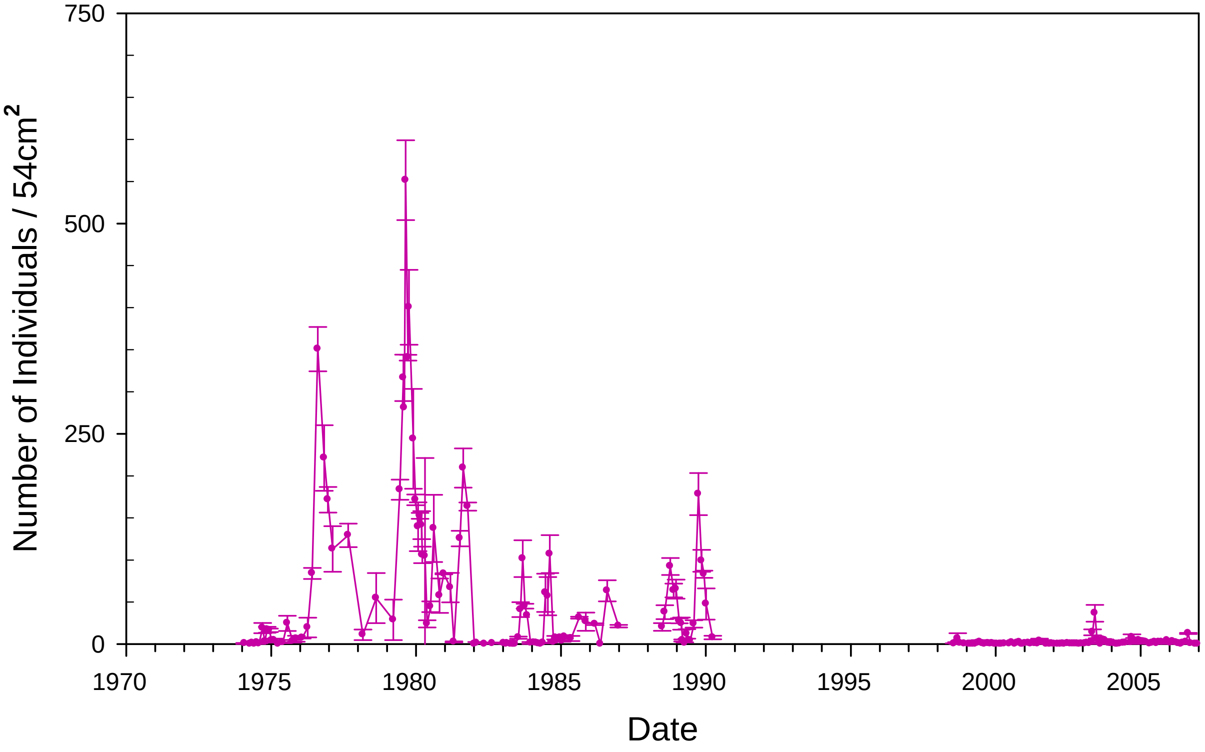


Figure 29. Average abundance of *Ampelisca abdita*

Data are for the period from 1974 through 2006. Error bars represent standard deviation from 3 replicate samplings.

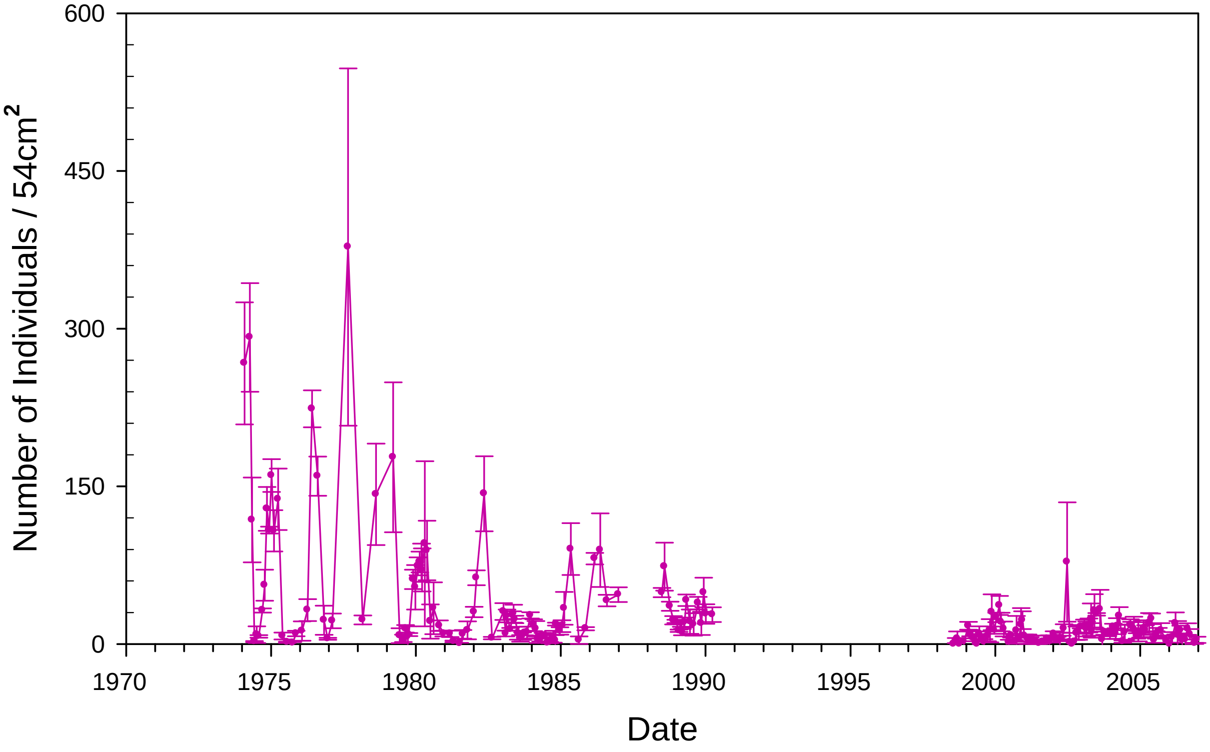


Figure 30. Average abundance of *Streblospio benedicti*

Data are for the period from 1974 through 2006. Error bars represent standard deviation from 3 replicate samplings.

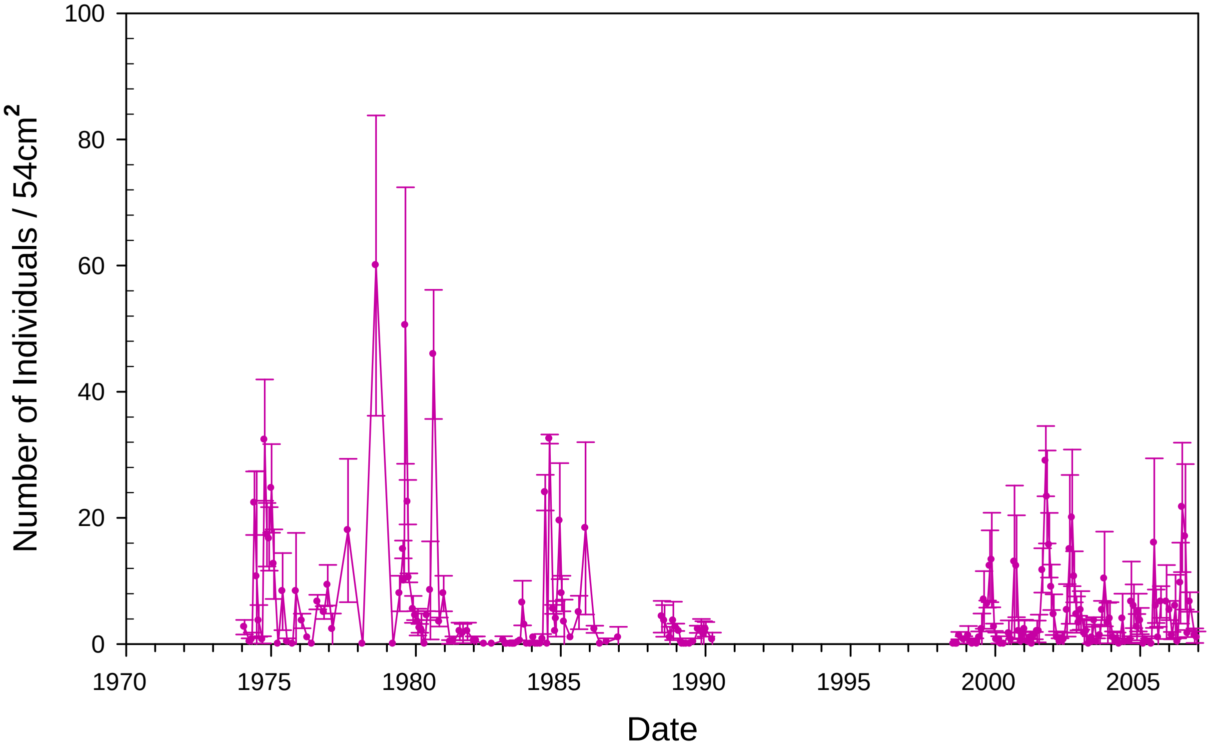


Figure 31. Average abundance of *Grandiderella japonica*

Data are for the period from 1974 through 2006. Error bars represent standard deviation from 3 replicate samplings.

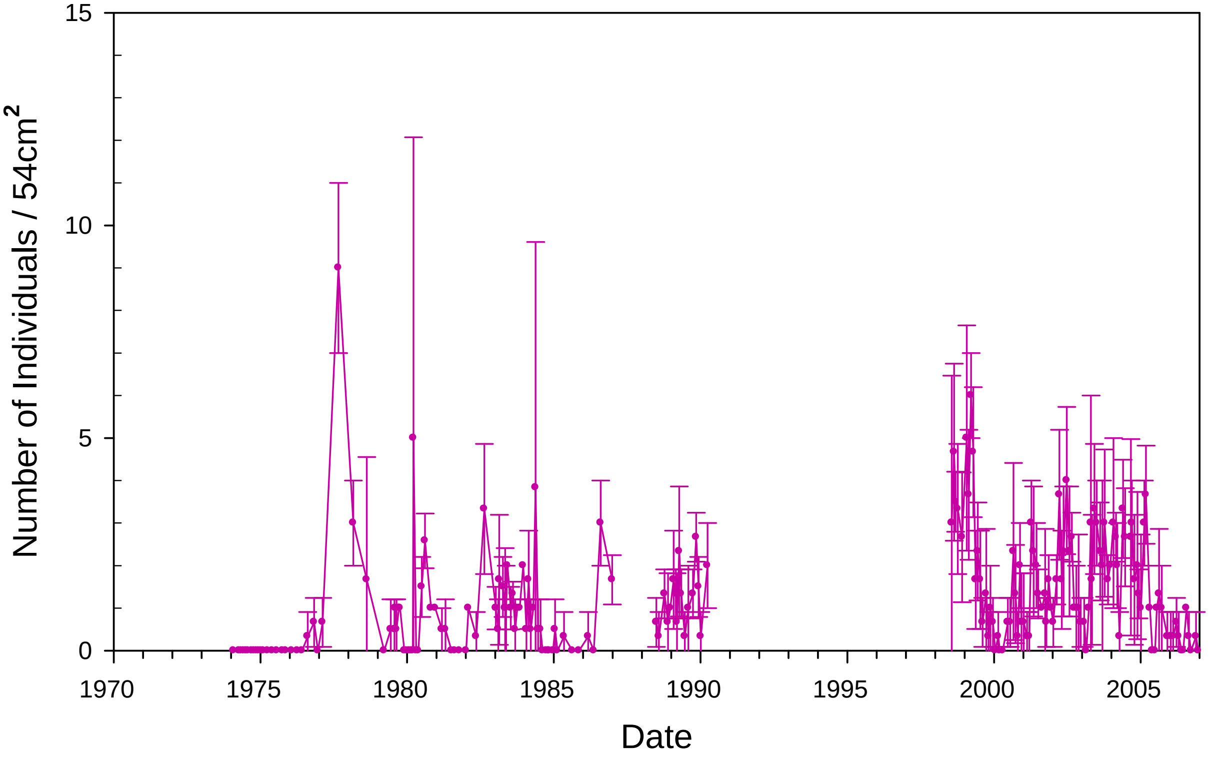


Figure 32. Average abundance of *Neanthes succinea*

Data are for the period from 1974 through 2006. Error bars represent standard deviation from 3 replicate samplings.

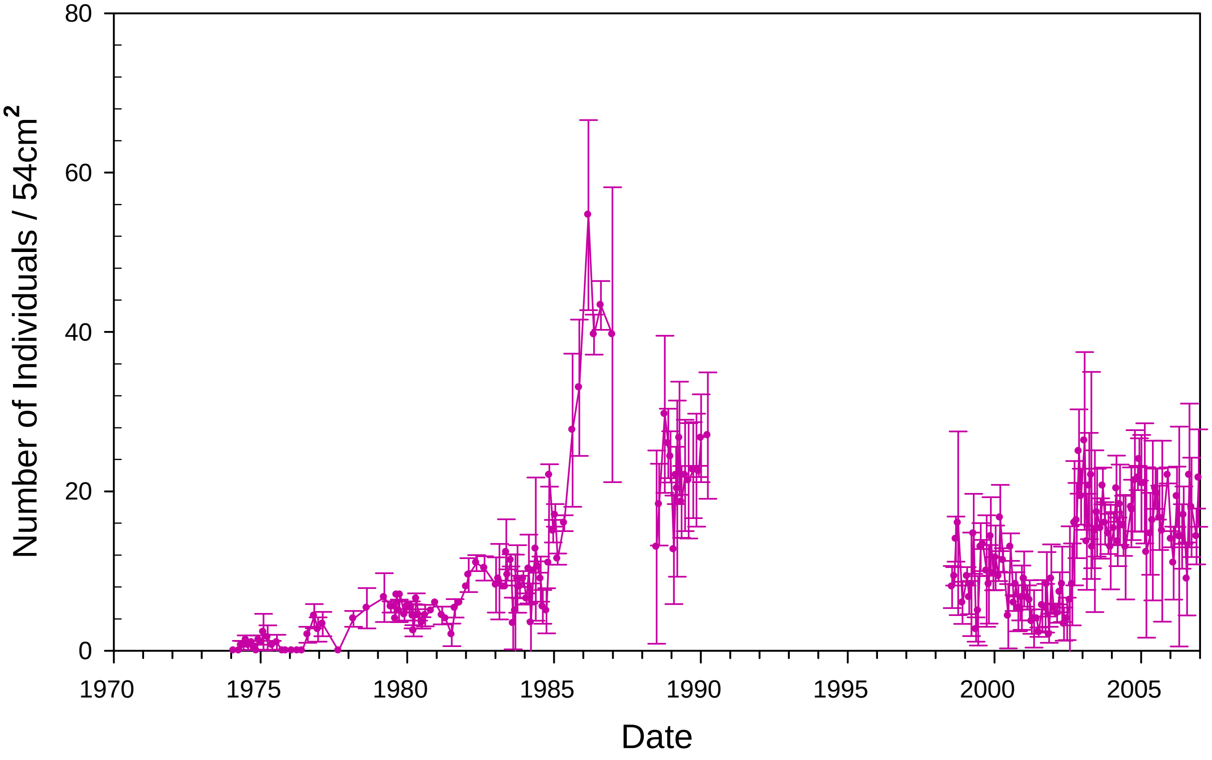


Figure 33. Average abundance of *Heteromastus filiformis*

Data are for the period from 1974 through 2006. Error bars represent standard deviation from 3 replicate samplings.

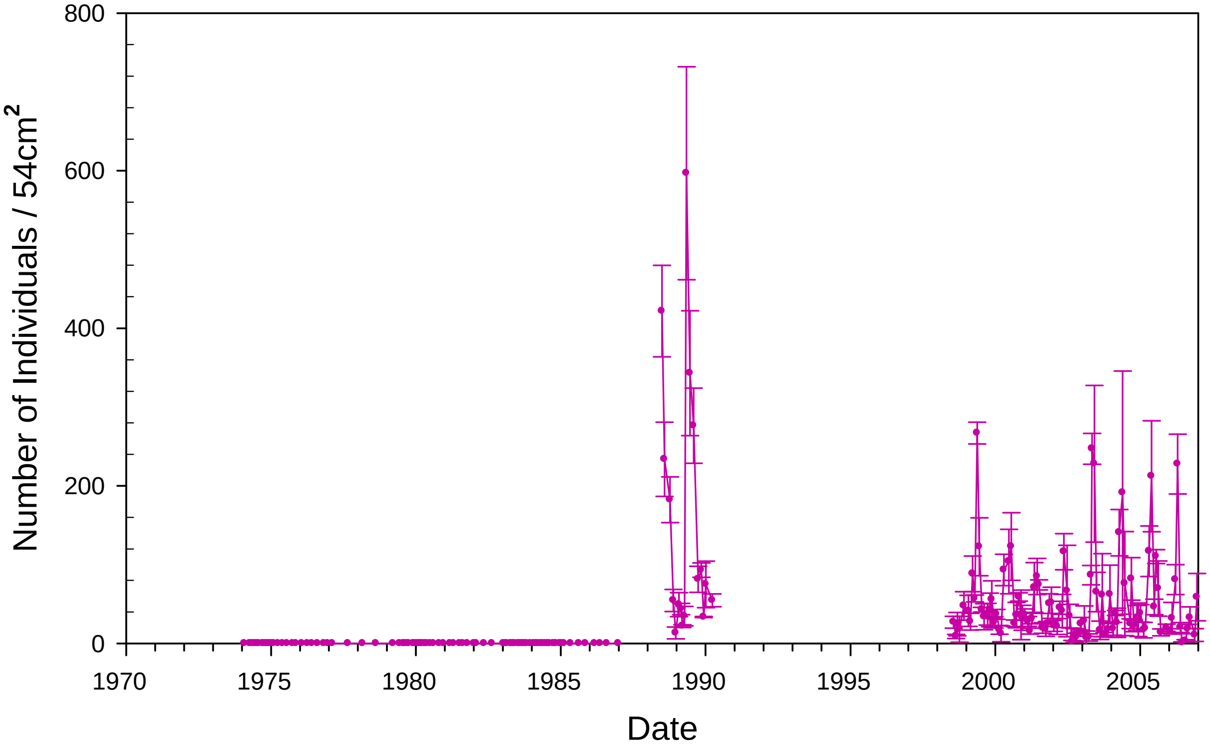


Figure 34. Average abundance of *Nippoleucon hinumensis*

Data are for the period from 1974 through 2006. Error bars represent standard deviation from 3 replicate samplings.

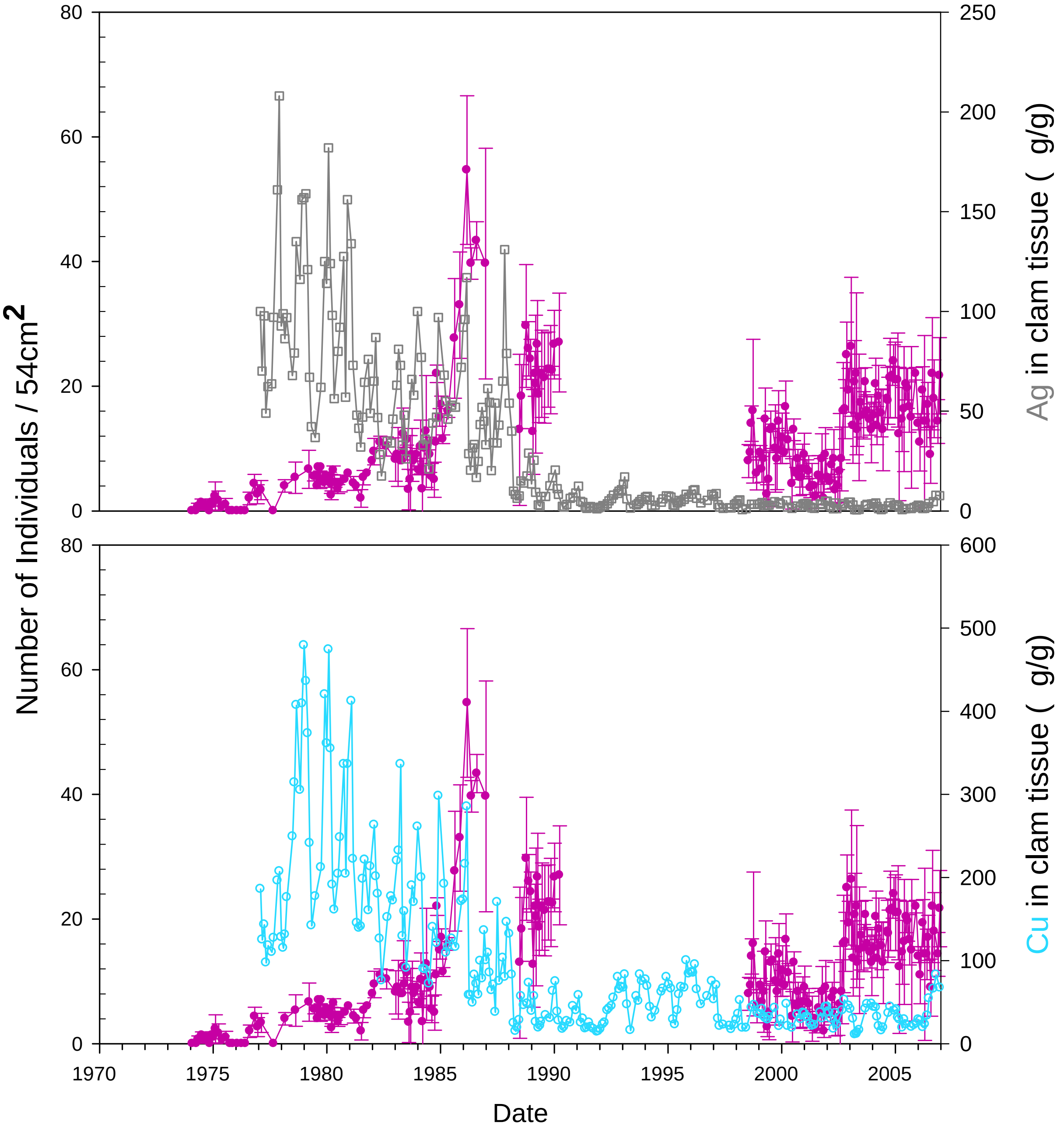


Figure 35. *Heteromastus filiformis* abundance with silver and copper in *Macoma petalum.*

Data are for the period from 1974 through 2006. Error bars represent standard deviation from 3 replicate samplings. The number of individuals (●); tissue concentration of silver (□) and copper (○) in *M. petalum.*

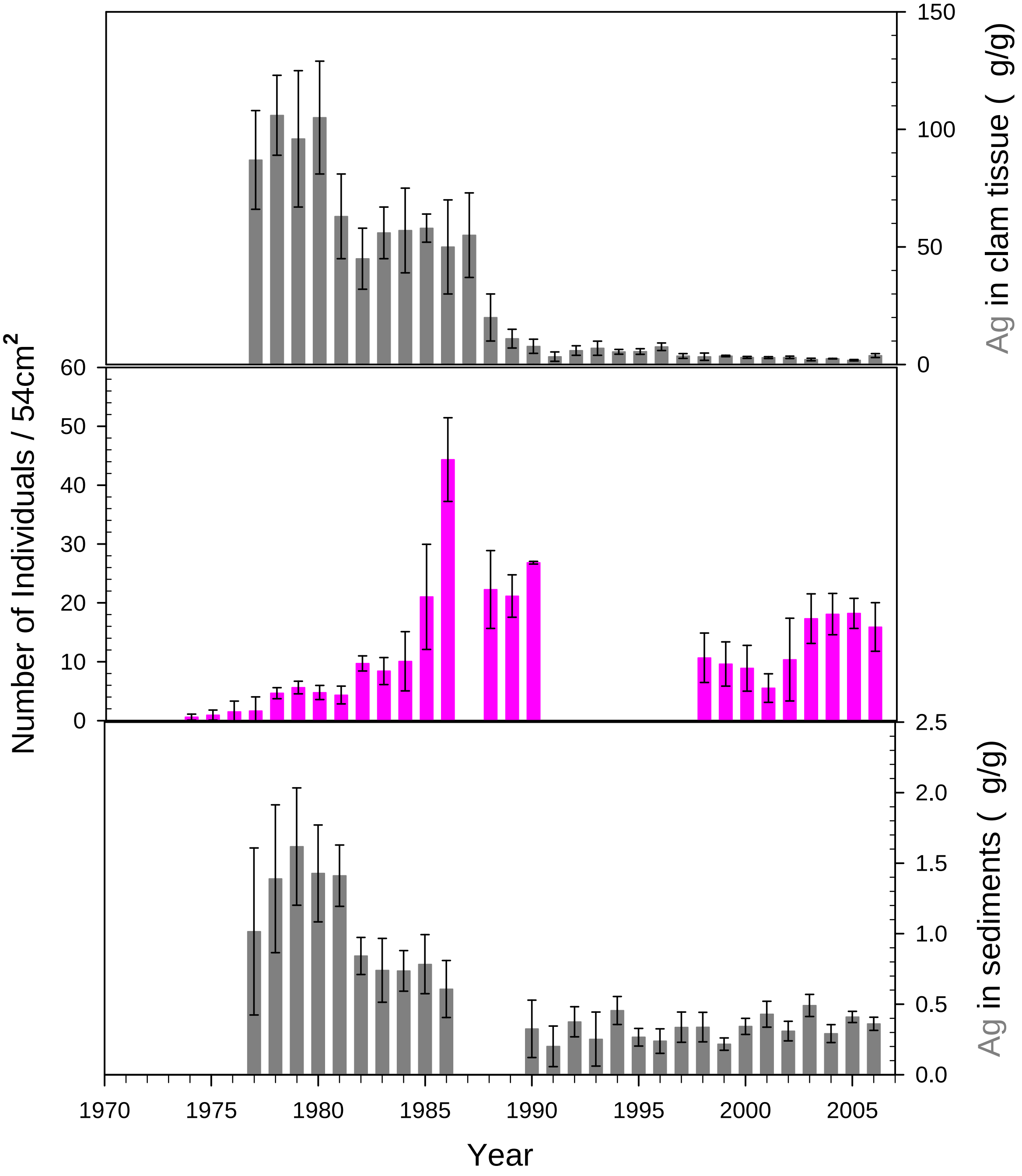


Figure 36. *Heteromastus filiformis* annual abundance with silver in *M. petalum* and sediment

Data are for the period from 1974 through 2006. Error bars for abundance and metals in sediments are the standard deviation of the means. Error bars for metals in clams are the standard error of the mean (SEM).

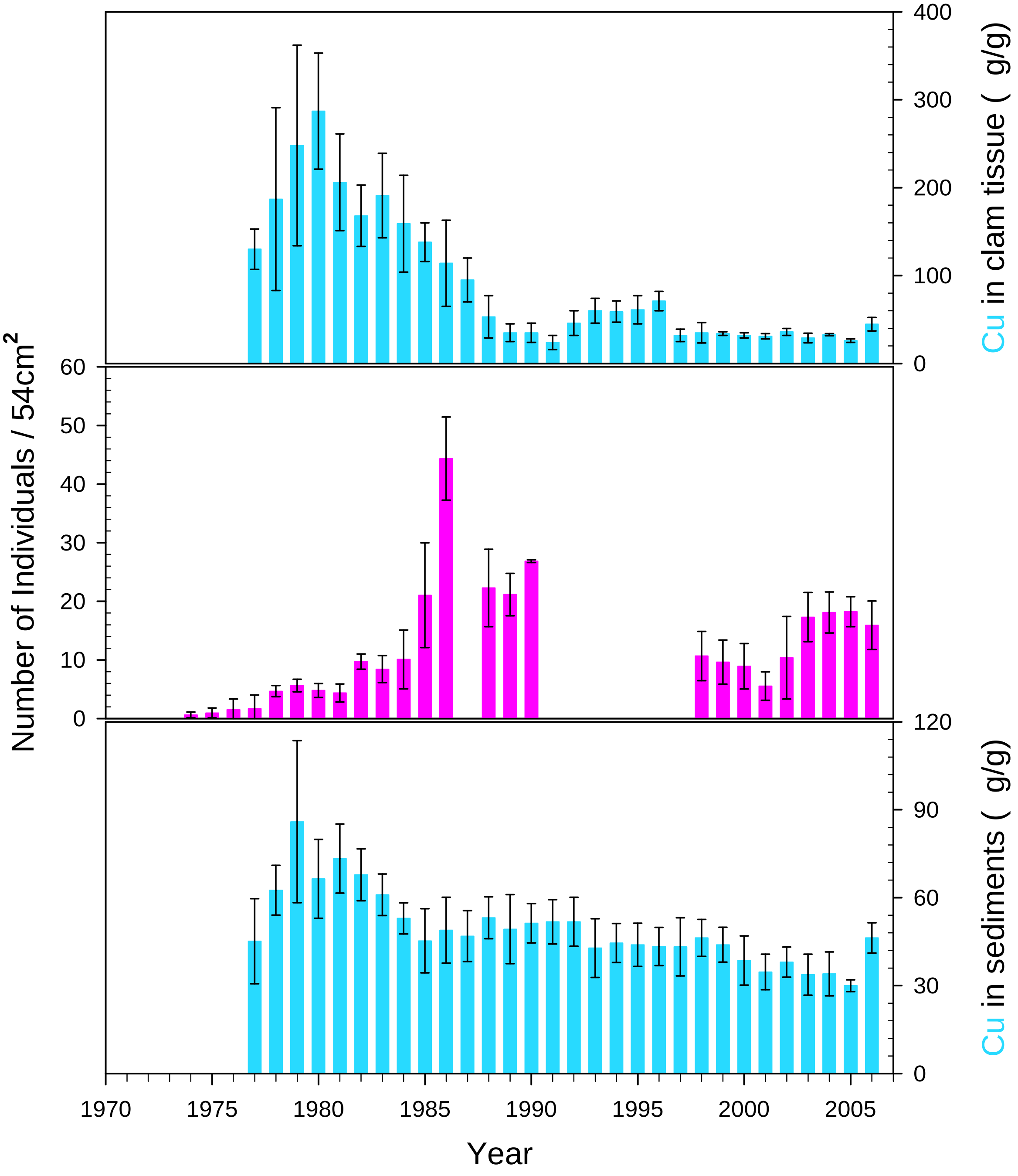


Figure 37. *Heteromastus filiformis* annual abundance with copper in *M. petalum* and sediment

Data are for the period from 1974 through 2006. Error bars for abundance and metals in sediments are the standard deviation of the means. Error bars for metals in clams are the standard error of the mean (SEM).

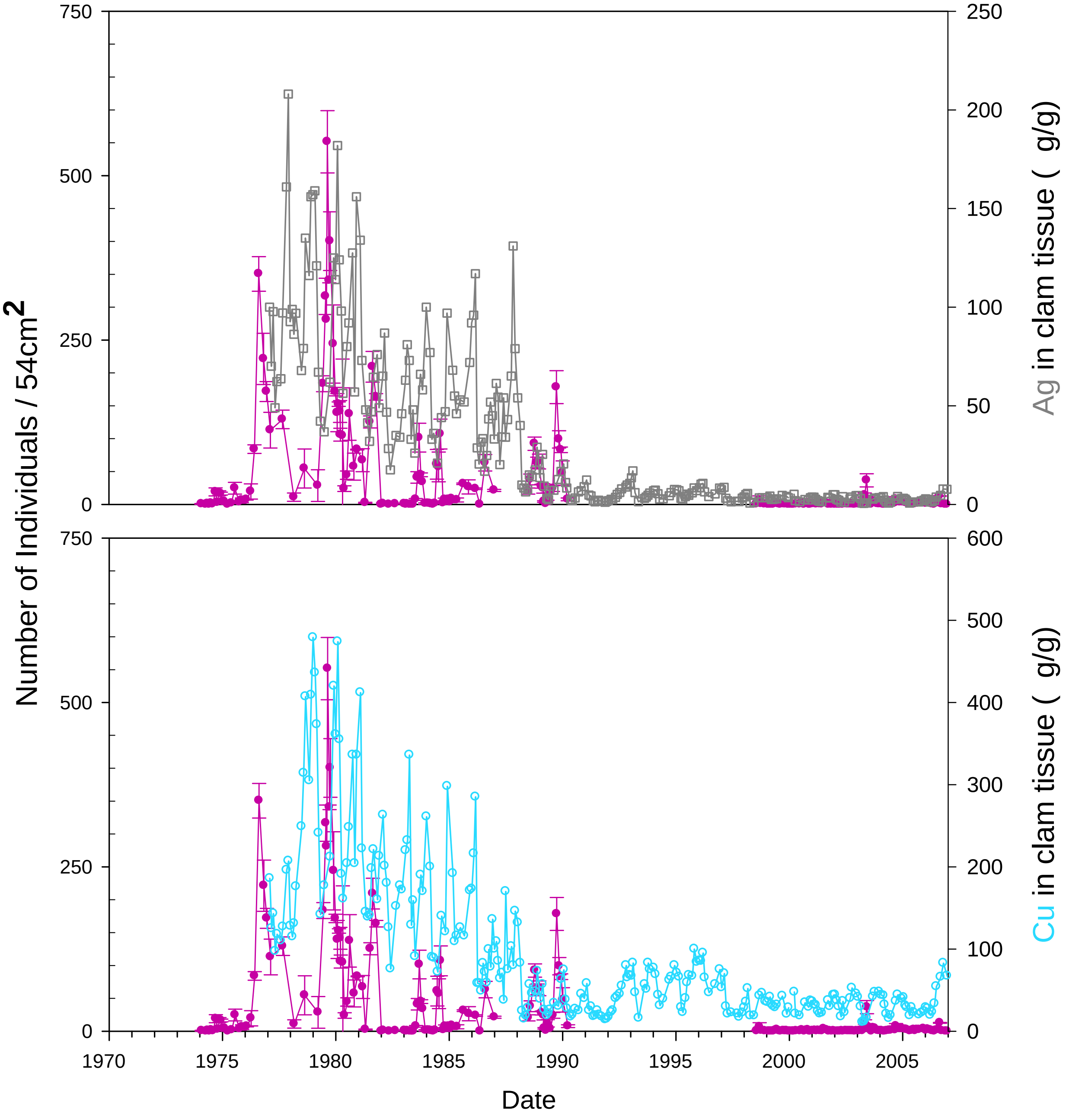


Figure 38. *Ampelisca abdita* abundance with silver and copper in *M. petalum*

Data are for the period from 1974 through 2006. Error bars represent standard deviation from 3 replicate samplings. Number of individuals (●) with silver (□) and copper (○) tissue concentrations in *Macoma petalum.*

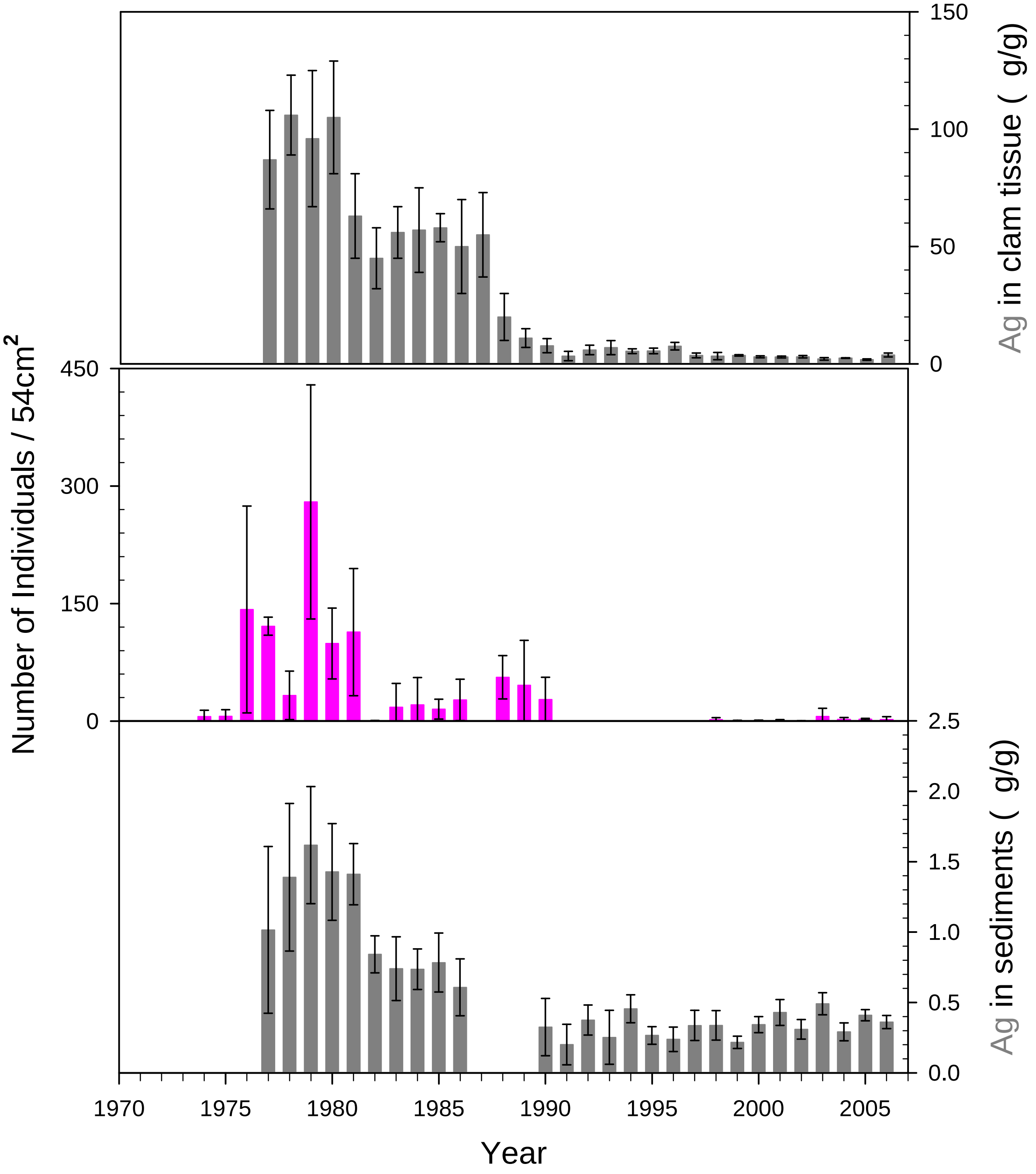


Figure 39. *Ampelisca abdita* annual abundance with silver in *M. petalum* and sediment

Data are for the period from 1974 through 2006. Error bars for abundance and metals in sediments are the standard deviation of the means. Error bars for metals in clams are the standard error of the mean (SEM).

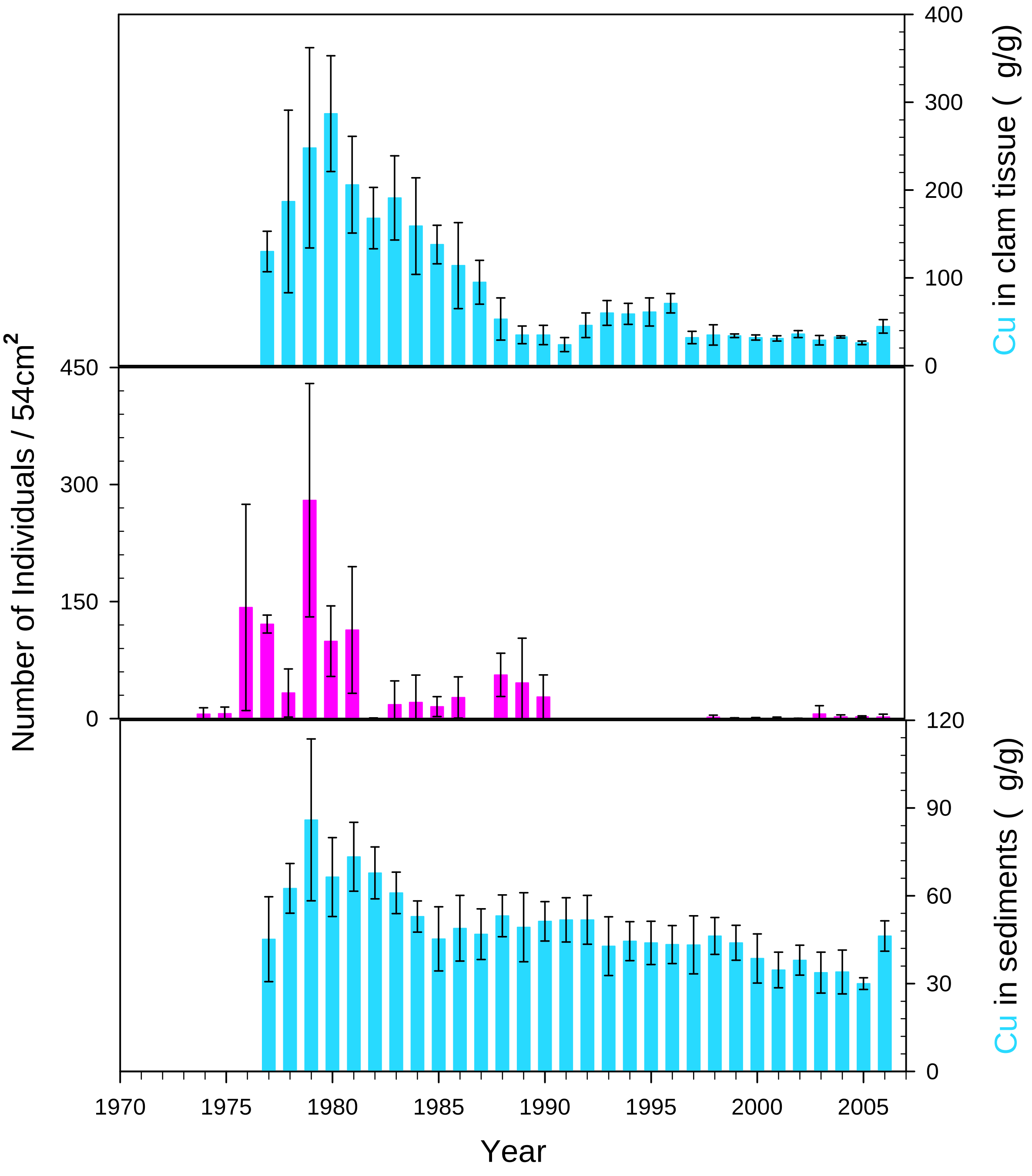


Figure 40. *Ampelisca abdita* annual abundance with copper in *M. petalum* and sediment

Data are for the period from 1974 through 2006. Error bars for abundance and metals in sediments are the standard deviation of the means. Error bars for metals in clams are the standard error of the mean (SEM).

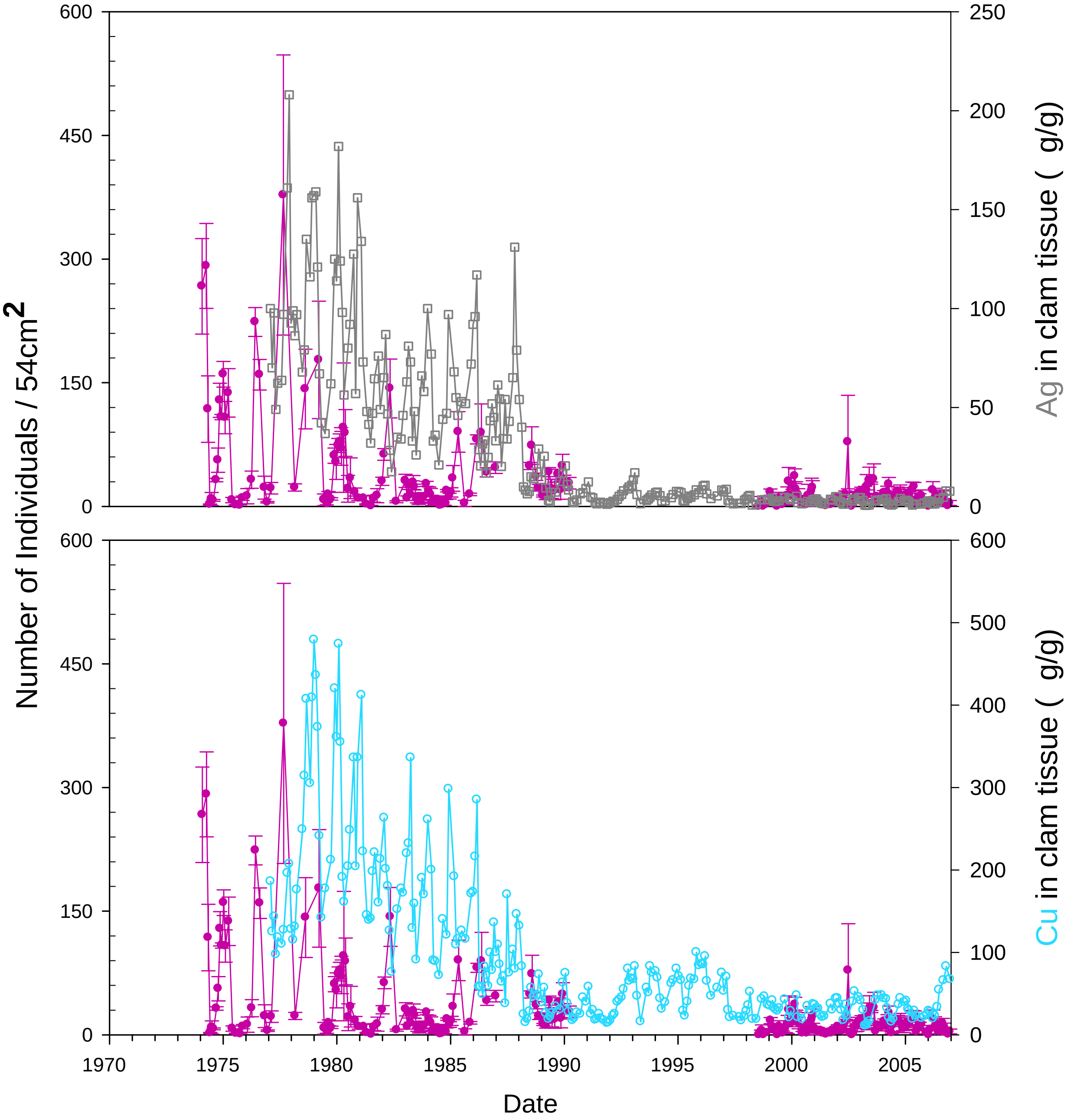


Figure 41. *Streblospio benedicti* abundance with silver and copper in *M. petalum*

Data are for the period from 1974 through 2006. Error bars represent standard deviation from 3 replicate samplings. Number of individuals (●) with silver (☐) and copper (○) tissue concentrations in *Macoma petalum*.

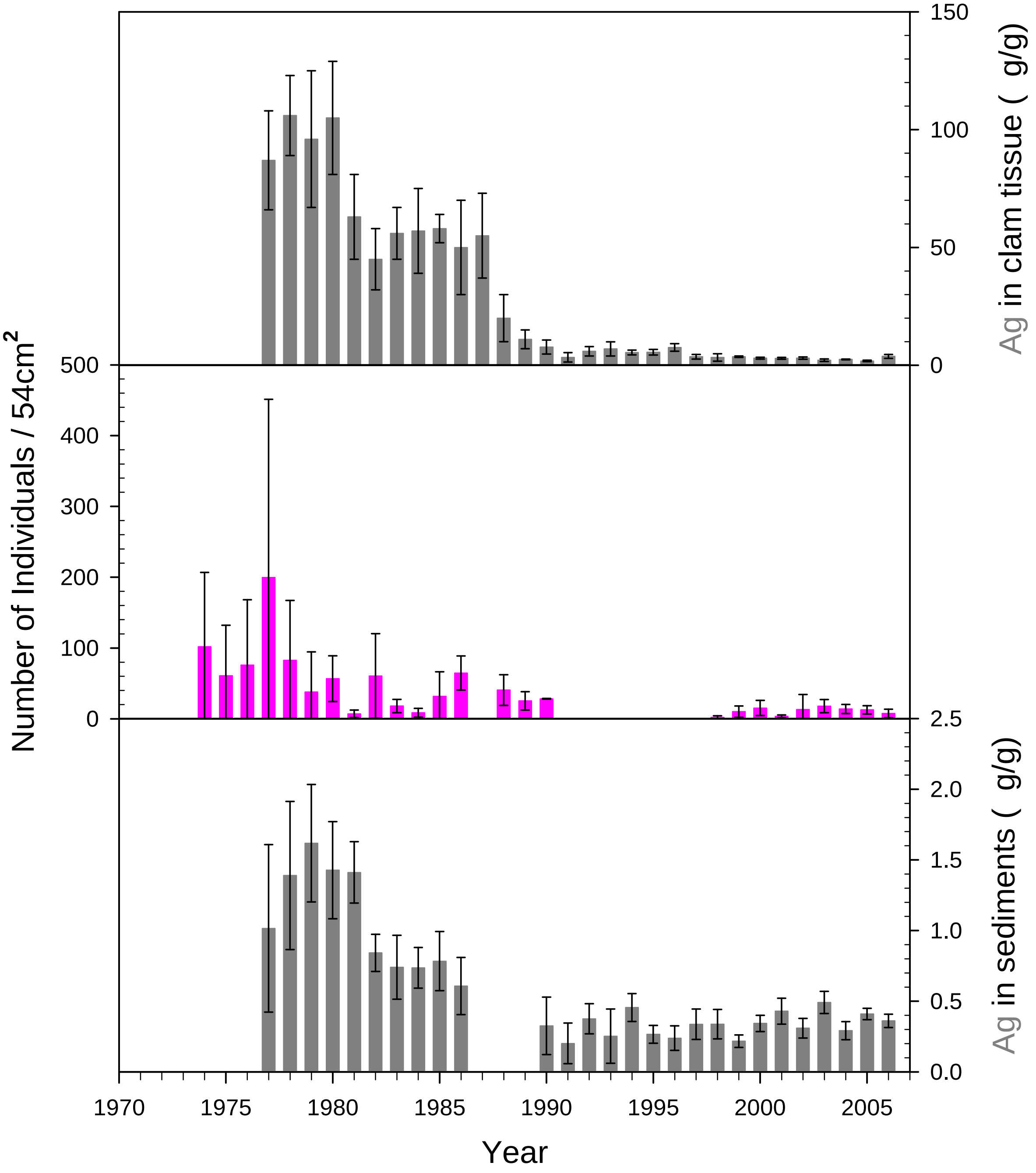


Figure 42. *Streblospio benedicti* annual abundance with silver in *M. petalum* and sediment.

Data are for the period from 1974 through 2006. Error bars for abundance and metals in sediments are the standard deviation of the means. Error bars for metals in clams are the standard error of the mean (SEM).

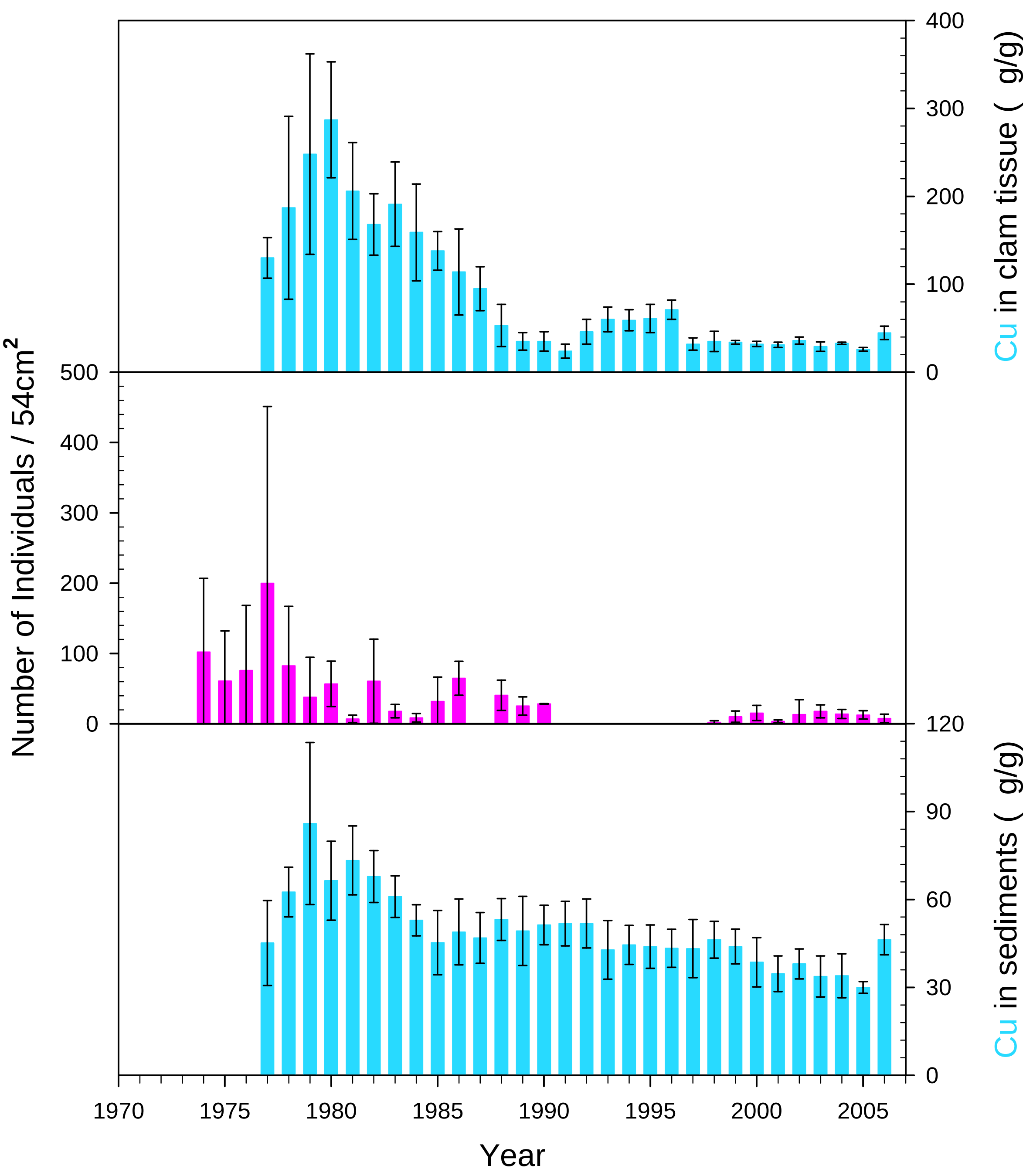


Figure 43. *Streblospio benedicti* annual abundance with copper in *M. petalum* and sediment

Data are for the period from 1974 through 2006. Error bars for abundance and metals in sediments are the standard deviation of the means. Error bars for metals in clams are the standard error of the mean (SEM).

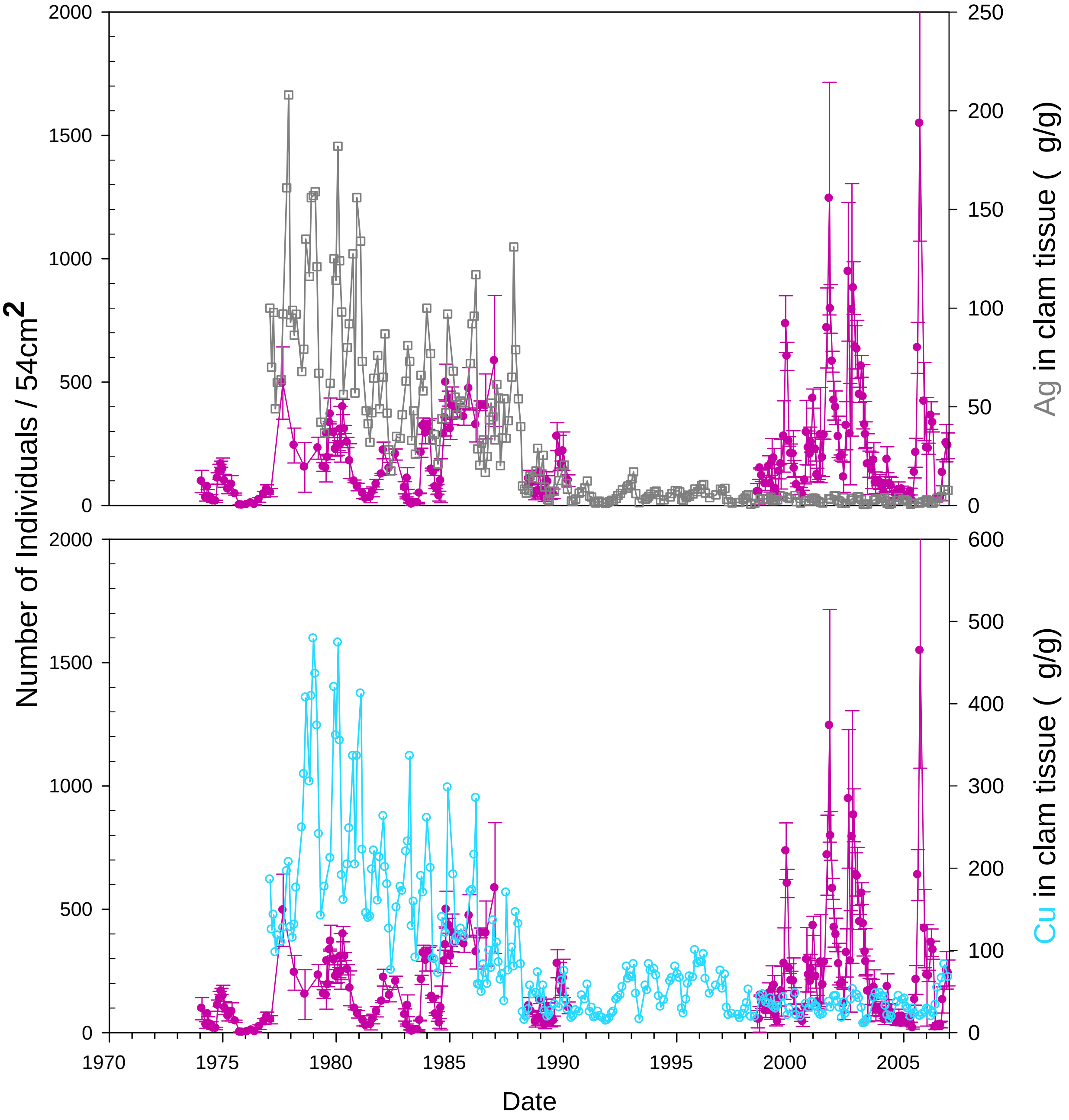


Figure 44. *Gemma gemma* abundance with silver and copper in *M. petalum*

Data are for the period from 1974 through 2006. Error bars represent standard deviation from 3 replicate samplings. Number of individuals (●) with silver (☐) and copper (○) tissue concentrations in *Macoma petalum.*

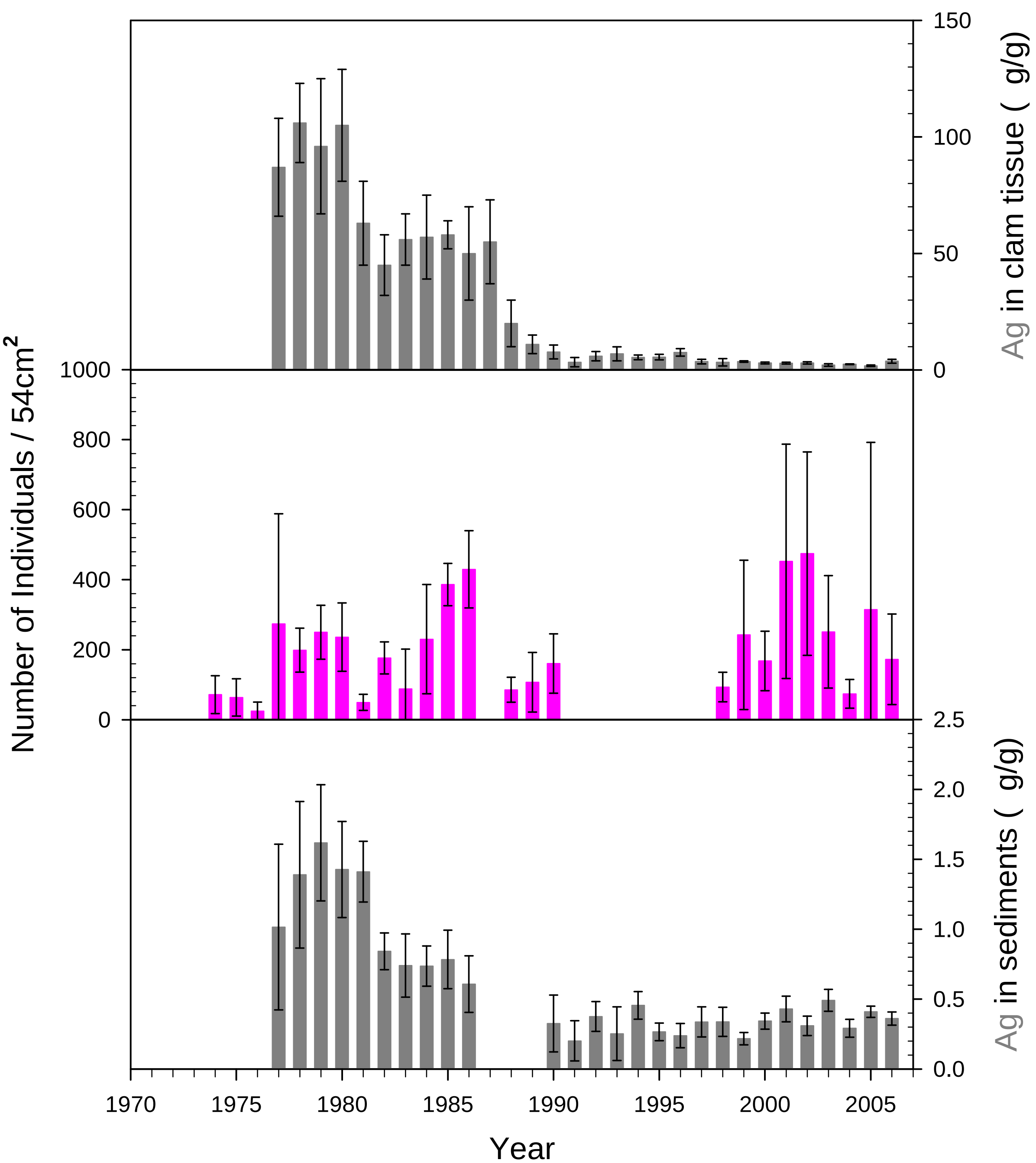


Figure 45. *Gemma gemma* annual abundance with silver in *M. petalum* and sediment.

Data are for the period from 1974 through 2006. Error bars for abundance and metals in sediments are the standard deviation of the means. Error bars for metals in clams are the standard error of the mean (SEM).

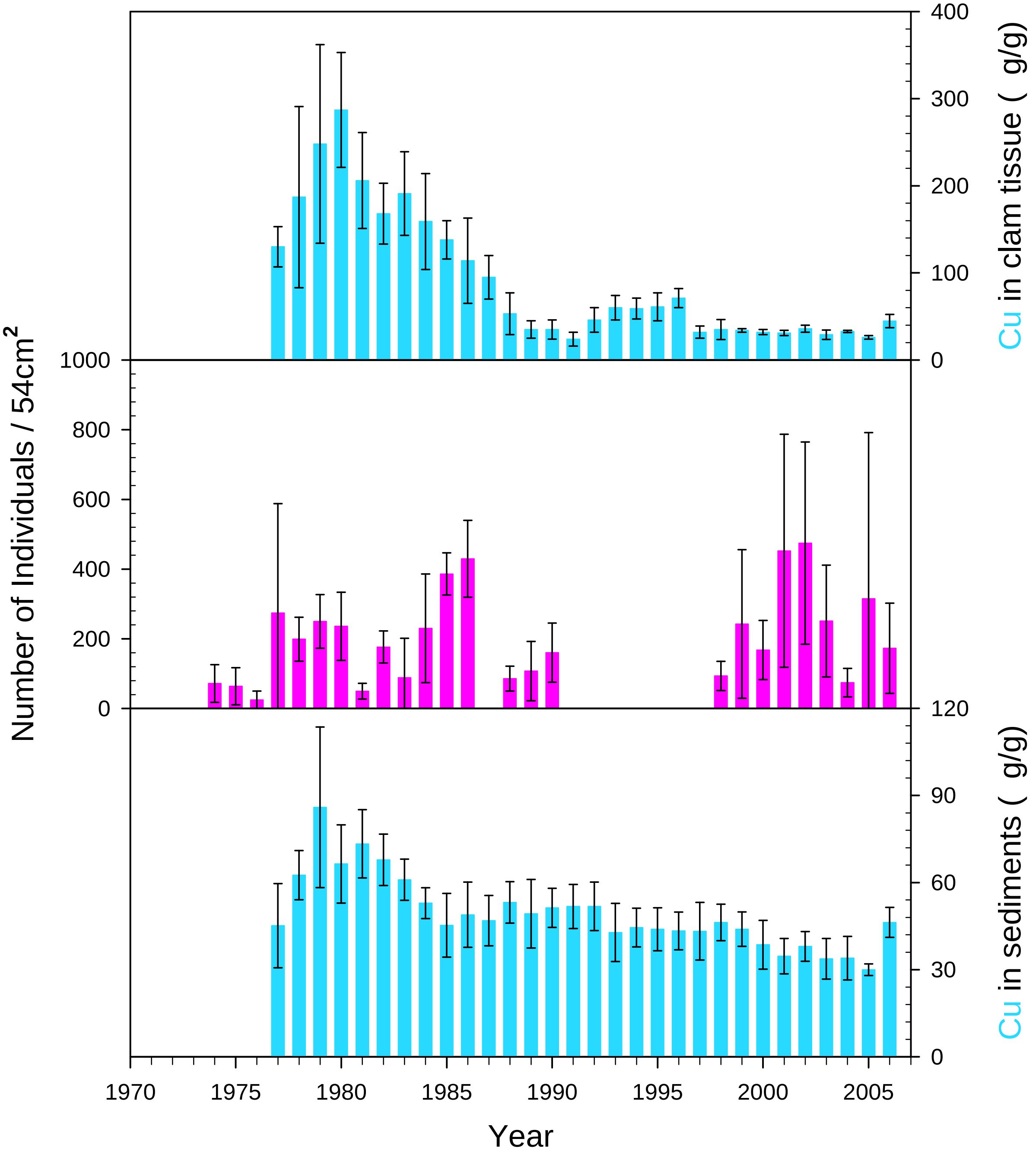


Figure 46. *Gemma gemma* annual abundance with copper in *M. petalum* and sediment

Data are for the period from 1974 through 2006. Error bars for abundance and metals in sediments are the standard deviation of the means. Error bars for metals in clams are the standard error of the mean (SEM).

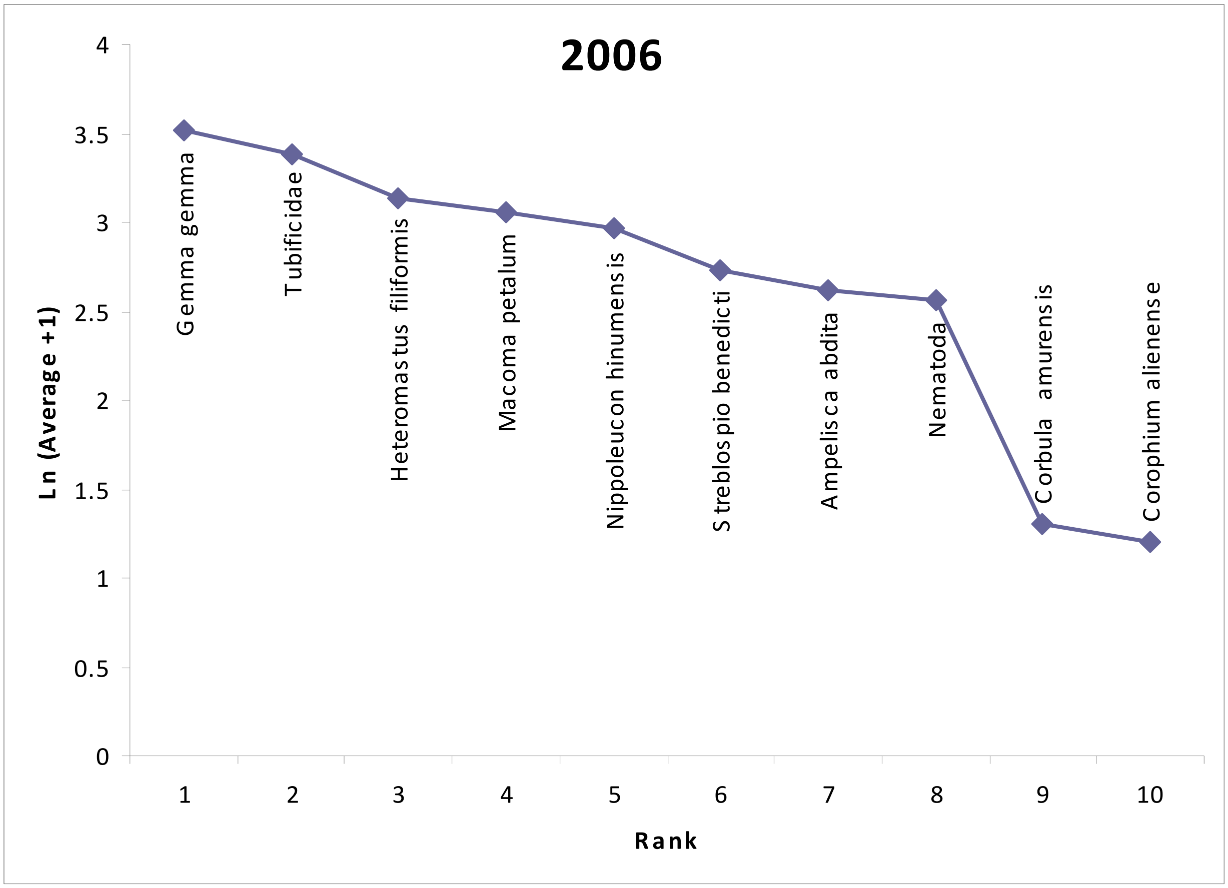


Figure 47. Benthic community rank-abundance data for 2006.

Species name for each rank is shown.

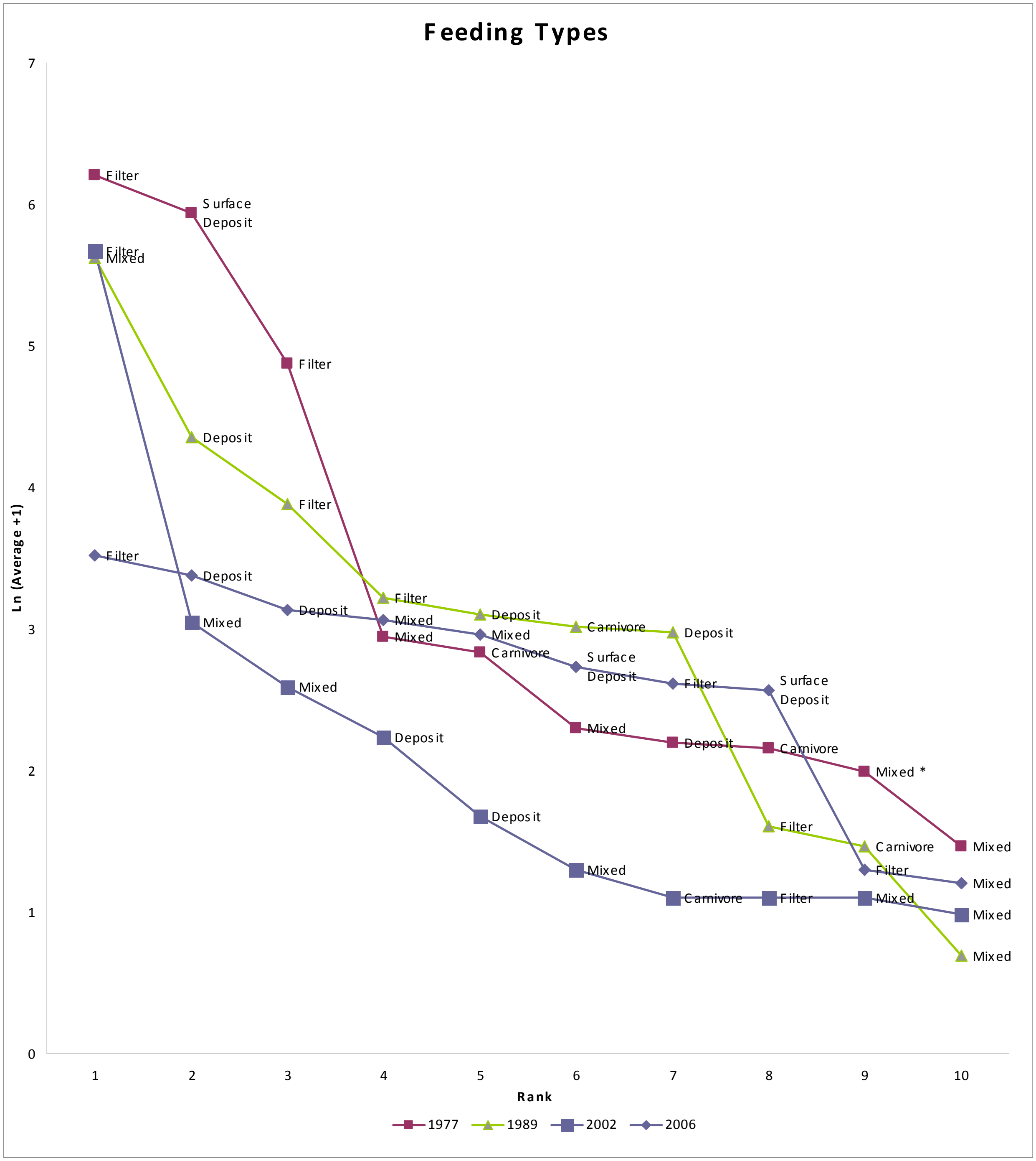


Figure 48. Benthic community rank-abundance data for 1977, 1989, 2002, and 2006. Feeding mode for each species at each rank is shown.

(Filter: filters food particles from water column; Deposit: ingests subsurface sediment and removes food from sediment in gut; Surface Deposit: ingests food particles on surface sediment; Mixed: capable of filter feeding and surface deposit feeding: Carnivore: predator on other fauna).

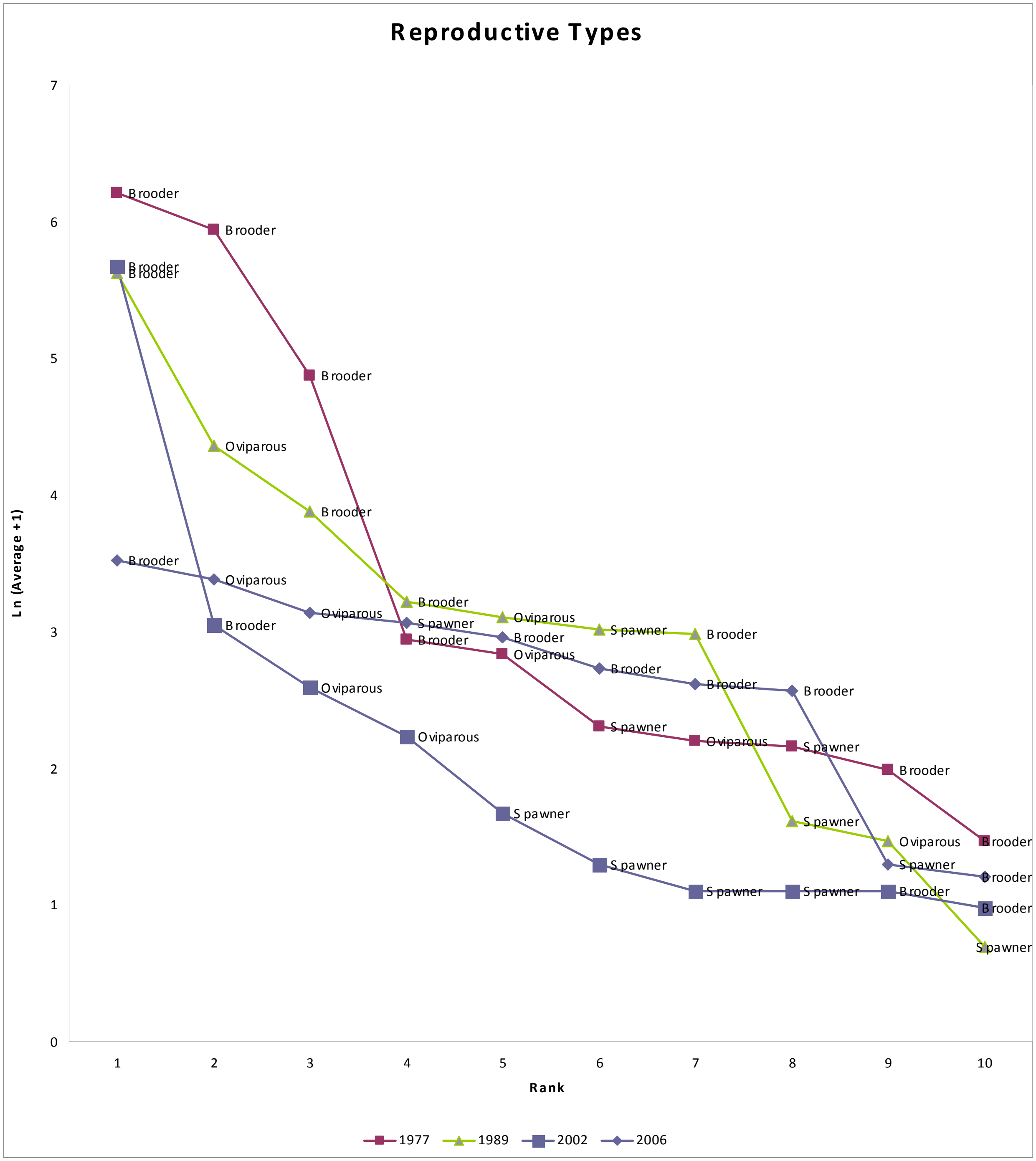


Figure 49. Benthic community rank-abundance data for 1977, 1989, 2002, and 2006.

Reproductive mode for each species at each rank is shown (Brooder: broods young and release juveniles as fully functional "miniature adults"; Oviparous: lays eggs in or on sediment; Spawner: releases gametes into water column and juveniles settle out of plankton onto sediment surface after growth in the plankton).

Tables

Table 1. Sediment characteristics and salinity in 2006

Composition of sediment and salinity of water pooled on the sediment surface. Units for Al, Fe, total organic carbon (TOC) and sand are percent of dry weight. Sand is operationally determined as ≥ 100 µm grain size. Salinity is reported in units of parts per thousand (ppt). Data for Al and Fe are reported as the mean ± 1 standard deviation (std) for replicate subsamples (n=2); results for other constituents are for a single (n=1) measurement. Means for monthly samples were summarized and reported as the annual mean ± the standard error (SEM) (n=9).

[Units are microgram per gram dry weight. STD is standard deviation of the two samples. SEM is standard error of the means for the year.]

Date	**Al** (percent)		**Fe** (percent)		**TOC** (percent)	**Sand** (percent)	**Salinity** (ppt)
	mean	std	mean	std			
January 9, 2006	5.6	0.2	4.5	0.1	1.5	26	18
February 7, 2006	5.4	0.3	4.2	0.0	1.4	14	12
March 22, 2006	4.8	0.1	3.9	0.1	1.2	33	13
April 24, 2006	5.3	0.5	4.2	0.1	1.3	13	8
May 31, 2006	5.0	0.0	3.9	0.1	1.1	65	10
June 27, 2006	3.9	0.1	3.3	0.0	1.0	33	15
September 7, 2006	4.7	0.2	4.0	0.0	1.1	24	21
October 19, 2006	4.5	0.3	4.2	0.2	1.1	16	25
December 18, 2006	4.6	0.1	4.1	0.0	1.1	37	24
Annual Mean:	**4.9**		**4.0**		**1.20**	**29**	**16**
SEM:	*0.2*		*0.1*		*0.06*	*5*	*2*

Table 2. Concentrations of trace elements in sediments in 2006

Elemental concentrations for the monthly samples are reported as the mean ± 1 standard deviation (std) for replicate subsamples (n=2). Units are micrograms per gram dry weight. Means are summarized as the annual mean (the average of monthly means) and the standard error of the monthly means (SEM) (n=9). All concentrations are based on near-total extracts, except for silver (Ag) which is based on partial extraction (See Methods).

[Units are microgram per gram dry weight. STD is standard deviation of the two samples. SEM is standard error of the means for the year.]

Date	**Ag**		**Cr**		**Cu**		**Hg**	**Ni**		**Se**	**V**		**Zn**	
	mean	***STD***	***mean***	***STD***	***mean***	***STD***	***mean***	***mean***	***STD***	***mean***	***mean***	***STD***	***mean***	***STD***
January 9, 2006	0.33	0.00	130	3	55	2	0.2	96	2	0.8	115	3	310	223
February 7, 2006	0.36	0.00	131	6	50	0	0.2	93	1	0.6	98	3	140	1
March 22, 2006	0.33	0.00	120	4	48	1	-	89	1	-	96	10	121	9
April 24, 2006	0.29	0.00	126	9	49	1	0.3	93	0	0.6	103	8	138	0
May 31, 2006	0.45	0.00	117	0	47	1	-	83	1	-	97	11	115	7
June 27, 2006	0.33	0.03	100	4	37	0	0.2	68	1	0.4	90	3	90	1
September 7, 2006	0.39	0.01	118	7	44	1	0.2	87	1	0.4	95	2	123	2
October 19, 2006	0.39	0.01	119	8	43	2	-	96	3	-	93	7	131	7
December 18, 2006	0.36	0.00	123	1	42	0	0.3	89	1	0.4	92	1	125	1
Annual Mean:	**0.36**		**120**		**46**		**0.2**	**88**		**0.5**	**98**		**144**	
SEM:	***0.02***		***3***		***2***		***0.0***	***3***		***0.1***	***2***		***21***	

Table 3. Annual mean copper in *Macoma petalum* and sediments 1977 through 2006

Values are the annual (grand) means for 7 to 12 separate samples per year and standard errors of those means. Samples were collected between January and December of each year. Units are microgram per gram dry weight of soft tissue for the clam (*Macoma petalum*) and microgram per gram dry weight for sediment. HCl refers to hydrochloric acid extractable copper.

	Copper in sediment		**Copper**
Year	**HCl**	**Total**	**in clams**
1977	28±6	45±13	130±23
1978	42±11	57±13	187±104
1979	55±13	86±18	248±114
1980	47±5	66±9	287±66
1981	48±7	57±22	206±55
1982	35±4	34±24	168±35
1983	22±9	38±21	191±48
1984	26±10	40±16	159±55
1985	27±3	45±7	138±22
1986	24±3	49±9	114±49
1987	21±3	47±6	95±25
1988	27±3	53±5	53±24
1989	23±6	44±13	35±10
1990	23±2	51±4	35±11
1991	25±2	52±5	24±8
1992	27±6	52±5	46±14
1993	21±3	43±7	60±14
1994	19±2	45±4	59±12
1995	19±2	44±5	61±16
1996	19±2	43±4	71±11
1997	18±1	43±3	32±7
1998	20±1	46±2	35±4
1999	18±1	44±2	34±2
2000	18±1	39±3	32±3
2001	17±1	35±2	31±3
2002	13±1	38±2	36±4
2003	19±4	34±8	29±16
2004	17±4	34±8	33±11
2005	16±2	30±2	26±2
2006	18±2	46±2	45±8

Table 4. Annual mean silver in *Macoma petalum* and sediments 1977 through 2006

Values are annual (grand) means for 7 to 12 separate samples per year and standard errors of those means. Samples were collected between January and December of each year. Units are microgram per gram dry weight of soft tissue for the clam (*Macoma petalum*) and microgram per gram dry weight for sediment. Sediment was extracted with 0.6 N hydrochloric acid. ND refers to No Data.

Year	**Silver in sediment**	**Silver in clams**
1977	0.65 ± 0.59	87 ± 21
1978	1.39 ± 0.35	106 ± 17
1979	1.62 ± 0.28	96 ± 29
1980	1.28 ± 0.38	105 ± 24
1981	1.41 ± 0.15	63 ± 18
1982	0.74 ± 0.21	45 ± 13
1983	0.56 ± 0.26	56 ± 11
1984	0.64 ± 0.20	57 ± 18
1985	0.78 ± 0.14	58 ± 6
1986	0.61 ± 0.14	50 ± 20
1987	ND	55 ± 18
1988	ND	20 ± 10
1989	ND	11 ± 4
1990	0.39 ± 0.09	7.7 ± 3.4
1991	0.25 ± 0.07	3.3± 2.0
1992	0.35 ± 0.11	5.9 ± 1.9
1993	0.36± 0.09	6.9 ± 3.2
1994	0.46 ± 0.07	5.4 ± 1.1
1995	0.27 ± 0.05	5.5 ± 1.2
1996	0.24 ± 0.06	7.5 ± 1.6
1997	0.34 ± 0.04	3.6 ± 1.0
1998	0.34 ± 0.04	3.3 ± 0.6
1999	0.22 ± 0.01	3.6 ± 0.3
2000	0.34 ± 0.02	3.0 ± 0.4
2001	0.43 ± 0.03	3.0 ± 0.4
2002	0.31 ± 0.02	3.0 ± 0.5
2003	0.49 ± 0.03	2.1 ± 0.5
2004	0.29 ± 0.06	2.4 ± 1.3
2005	0.41 ± 0.04	1.8 ± 0.3
2006	0.36 ± 0.05	3.8 ± 0.8

Table 5. Concentrations of trace elements in *Macoma petalum* in 2006.

Monthly data are the mean and standard error (*SEM) for replicate composites (n= 6-14). The monthly means are summarized as the grand annual mean (the average of monthly means) and the standard error (SEM) (n=9). Elemental concentrations are microgram per gram soft tissue dry weight. The condition index (CI) is the soft tissue weight in milligrams of a 25 mm shell length clam.

Date		Ag	Cr	Cu	Hg	Ni	Se	Zn	Condition Index
January 9, 2006	*mean*	2.9	3.5	29	-	5.7	-	358	83
	**SEM*	0.3	0.2	1	-	0.2	-	22	
February 7, 2006	*mean*	2.5	5.5	28	0.31	6.8	6.47	438	81
	**SEM*	0.2	0.8	2	0.02	0.5	0.14	26	
March 22, 2006	*mean*	1.2	2.9	19	-	4.4	-	311	125
	**SEM*	0.1	0.4	1	-	0.4	-	15	
April 24, 2006	*mean*	1.3	1.5	23	0.16	3.5	4.80	331	123
	**SEM*	0.1	0.1	1	0.02	0.2	0.04	7	
May 31, 2006	*mean*	2.1	1.5	34	-	4.1	-	417	102
	**SEM*	0.4	0.3	6	-	0.8	-	87	
June 27, 2006	*mean*	3.7	2.3	54	0.27	5.9	4.17	442	95
	**SEM*	0.3	0.2	3	0.02	0.5	0.04	36	
September 7, 2006	*mean*	4.6	2.3	66	0.37	6.2	4.47	383	75
	**SEM*	0.3	0.1	3	0.03	0.2	0.03	29	
October 19, 2006	*mean*	7.9	3.5	83	-	7.6	-	425	81
	**SEM*	0.9	0.4	5	-	0.6	-	32	
December 18, 2006	*mean*	7.6	4.6	67	0.49	7.9	6.27	446	89
	**SEM*	0.4	0.1	3	0.02	0.2	0.13	19	
Annual Mean:		**3.8**	**3.1**	**45**	**0.32**	**5.8**	**5.2**	**395**	**95**
SEM:		**0.8**	**0.5**	**8**	**0.05**	**0.5**	**0.5**	**17**	**6**

[All units microgram per gram soft tissue dry weight. Wt.25mm is the condition index or weight in milligrams of a 25 mm shell length clam. *SEM is standard errors of the means from 6-14 replicate analyses of composite samples.]

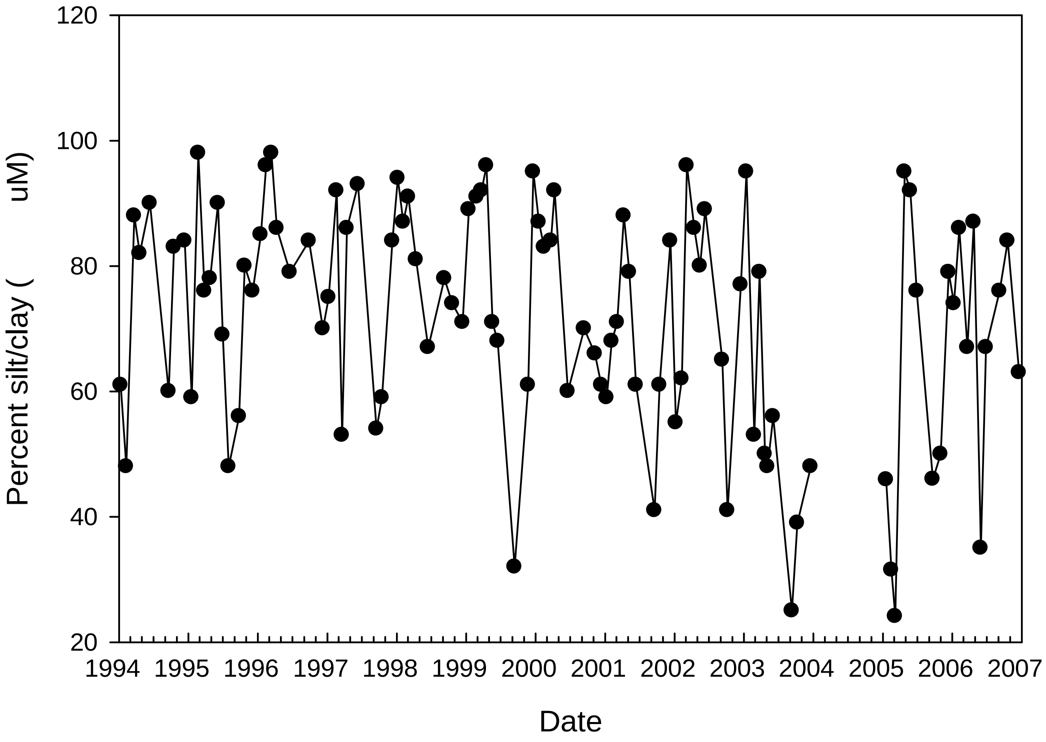
Appendix A

Sediment characteristics for samples collected between 1994 and 2006. Results are for percent fine-grained particles (silt and clay < 100 μM) (A-1, A-2), and percent organic carbon (A-3). Data for percent fines for 2004 contain unquantifiable biases due to errors in sample processing. These data are shown for qualitative purposes only.

PALTO ALTO GRAIN SIZE DATA: <100µm

Year	Date	%<100µm
1994	01/10/94	61
	02/08/94	48
	03/22/94	88
	04/20/94	82
	06/13/94	90
	09/20/94	60
	10/17/94	83
	12/12/94	84
1995	01/18/95	59
	02/22/95	98
	03/27/95	76
	04/25/95	78
	06/06/95	90
	07/01/95	69
	08/01/95	48
	09/25/95	56
	10/24/95	80
	12/05/95	76
1996	01/17/96	85
	02/13/96	96
	03/13/96	98
	04/10/96	86
	06/18/96	79
	09/26/96	84
	12/09/96	70
1997	01/08/97	75
	02/19/97	92
	03/19/97	53
	04/14/97	86
	06/11/97	93
	09/17/97	54
	10/15/97	59
	12/09/97	84
1998	01/07/98	94
	02/04/98	87
	03/03/98	91
	04/13/98	81
	06/15/98	67
	09/09/98	78
	10/20/98	74
	12/14/98	71
1999	01/15/99	89
	02/26/99	91
	03/22/99	92
	04/18/99	96
	05/19/99	71
	06/16/99	68
	09/13/99	32
	11/23/99	61
	12/20/99	95
2000	01/18/00	87
	02/15/00	83
	03/22/00	84
	04/10/00	92
	06/19/00	60
	09/13/00	70
	11/09/00	66
	12/12/00	61
2001	01/09/01	59
	02/05/01	68
	03/05/01	71
	04/10/01	88
	05/08/01	79
	06/12/01	61
	09/18/01	41
	10/15/01	61
	12/11/01	84
2002	01/08/02	55
	02/08/02	62
	03/07/02	96
	04/15/02	86
	05/15/02	80
	06/11/02	89
	09/09/02	65
	10/07/02	41
	12/16/02	77
2003	01/14/03	95
	02/24/03	53
	03/25/03	79
	04/22/03	50
	05/05/03	48
	06/04/03	56
	09/11/03	25
	10/09/03	39
	12/18/03	48
2004	01/20/04	45
	02/27/04	42
	03/16/04	49
	04/12/04	49
	05/24/04	64
	06/22/04	71
	09/13/04	24
	10/13/04	28
	12/08/04	15
2005	01/18/05	46
	02/15/05	32
	03/07/05	24
	04/25/05	95
	05/25/05	92
	06/28/05	76
	09/20/05	46
	10/01/05	50
	12/13/05	79
2006	01/09/06	74
	02/07/06	86
	03/22/06	67
	04/24/06	87
	05/31/06	35
	06/27/06	67
	09/07/06	76
	10/19/06	84
	12/18/06	63

A-2. Percent of sediment composed of silt/clay-sized particles (< 100 uM)



A-3. Total organic carbon (TOC) content (expressed as percent) of sediment collected in 2006.

Date of collection	*TOC (%)*
January 9, 2006	1.52
February 7, 2006	1.42
March 22, 2006	1.17
April 24, 2006	1.33
May 31, 2006	1.13
June 27, 2006	0.97
September 7, 2006	1.11
October 19, 2006	1.09
December 18, 2006	1.10

Appendix B

Metal concentrations in sediments collected at the Palo Alto mudflat during 2006 and determined by ICP-OES. Replicate subsamples were analyzed for each collection. The dry weight, reconstitution volume and dilution factor (if applicable) are shown for each replicate. Concentrations are reported for sample solutions (in micrograms per milliliter, µg/ml) and the calculated weight standardized concentration (reported as microgram per gram dry sediment, µg/g). The sample mean and standard deviation for the weight standardized concentration are reported, also.

Note: Appendix tables in this document may not be 508 complaint. 508 compliant Excel spreadsheet containing these 508 compliant tables may be accessed at URL: http://pubs.usgs.gov/of/2007/1199/Appendix-B.xls

Palo Alto Total Extracts: 2006

1/09/2006: 74% <100 µm

Sample	*Weight (g)*	*Recon. (ml)*	*Dil. Factor*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
Tot1	0.5012	10	10	287.90	0.66	0.27	222.40	4.17	0.47	0.22	0.58	0.76
Tot2	0.4973	10	10	273.60	0.64	0.28	227.00	4.31	0.48	0.23	0.56	2.33
			Average	**56229.62**	**130.31**	**55.34**	**45010.00**	**849.24**	**95.74**	**44.53**	**114.60**	**310.01**
			Std	**1714.77**	**3.19**	**1.59**	**900.14**	**25.51**	**2.10**	**1.10**	**2.88**	**222.76**

2/07/2006: 86% < 100 µm

Sample	*Weight (g)*	*Recon. (ml)*	*Dil. Factor*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
Tot1	0.5005	10	10	281.1	0.6744	0.2492	208.7	4.823	0.4638	0.2166	0.4836	0.6984
Tot2	0.5178	10	10	271.7	0.6563	0.2598	216.2	5.021	0.4849	0.2124	0.5194	0.7298
			Average	**54317.92**	**130.75**	**49.98**	**41725.94**	**966.66**	**93.16**	**42.15**	**98.47**	**140.24**
			Std	**2610.52**	**5.66**	**0.27**	**39.08**	**4.27**	**0.69**	**1.60**	**2.61**	**0.99**

3/22/2006: 67% <100 µm

Sample	*Weight (g)*	*Recon. (ml)*	*Dil. Factor*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
Tot1	0.5152	10	10	243.5	0.6314	0.244	199	3.956	0.4594	0.1898	0.4611	0.6527
Tot2	0.5337	10	10	259.4	0.6234	0.2596	213.8	4.351	0.47	0.1889	0.5513	0.6106
			Average	**47933.64**	**119.68**	**48.00**	**39342.87**	**791.55**	**88.62**	**36.12**	**96.40**	**120.55**
			Std	**948.15**	**4.06**	**0.91**	**1014.12**	**33.51**	**0.78**	**1.02**	**9.76**	**8.68**

4/24/2006: 87% <100 µm

Sample	*Weight (g)*	*Recon. (ml)*	*Dil. Factor*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
Tot1	0.5414	10	10	267.1	0.6456	0.2622	226	4.727	0.5034	0.209	0.5255	0.7469
Tot2	0.4941	10	10	278.8	0.6538	0.2437	212.4	4.394	0.4604	0.2096	0.537	0.6837
			Average	**52880.44**	**125.78**	**48.88**	**42365.44**	**881.20**	**93.08**	**40.51**	**102.87**	**138.16**
			Std	**5013.93**	**9.25**	**0.63**	**879.37**	**11.45**	**0.14**	**2.70**	**8.22**	**0.29**

5/31/2006: 35% < 100 µm

Sample	*Weight (g)*	*Recon. (ml)*	*Dil. Factor*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
Tot1	0.4889	10	10	243.9	0.5728	0.2262	188.2	3.785	0.4051	0.1705	0.4391	0.5894
Tot2	0.4684	10	10	236.7	0.5481	0.2235	184.7	3.68	0.3915	0.1632	0.4921	0.5151
			Average	**50210.62**	**117.09**	**46.99**	**38963.34**	**779.92**	**83.22**	**34.86**	**97.44**	**115.26**
			Std	**456.95**	**0.10**	**1.02**	**662.93**	**8.11**	**0.51**	**0.02**	**10.78**	**7.49**

6/27/2006: 67% <100 µm

Sample	*Weight (g)*	*Recon. (ml)*	*Dil. Factor*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
Tot1	0.5341	10	10	204.8	0.5211	0.1982	175.2	3.393	0.3635	0.1676	0.4728	0.475
Tot2	0.5115	10	10	205	0.5273	0.1927	171.4	3.33	0.352	0.1625	0.4712	0.4646
			Average	**39211.54**	**100.33**	**37.39**	**33156.07**	**643.15**	**68.44**	**31.57**	**90.32**	**89.88**
			Std	**1225.64**	**3.91**	**0.40**	**499.53**	**11.14**	**0.54**	**0.28**	**2.54**	**1.34**

9/7/2006: 76% <100 µm

Sample	*Weight (g)*	*Recon. (ml)*	*Dil. Factor*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
Tot1	0.4867	10	10	225.6	0.5497	0.209	196.2	4.932	0.4175	0.2133	0.4576	0.5924
Tot2	0.4882	10	10	236.8	0.602	0.2181	193.9	4.59	0.4273	0.254	0.4727	0.6105
			Average	**47428.85**	**118.13**	**43.81**	**40014.82**	**976.77**	**86.65**	**47.93**	**95.42**	**123.38**
			Std	**1521.50**	**7.33**	**1.22**	**420.71**	**51.74**	**1.23**	**5.80**	**1.98**	**2.36**

10/19/2006: 84% <100 µm

Sample	*Weight (g)*	*Recon. (ml)*	*Dil. Factor*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
Tot1	0.4816	10	10	205.4	0.5427	0.2008	196.9	5.208	0.4499	0.2485	0.4259	0.6089
Tot2	0.5183	10	10	245.8	0.645	0.2339	223.3	5.789	0.5084	0.2817	0.5088	0.7032
			Average	**45036.89**	**118.57**	**43.41**	**41983.85**	**1099.16**	**95.75**	**52.97**	**93.30**	**131.05**
			Std	**3376.27**	**8.31**	**2.43**	**1554.65**	**25.12**	**3.30**	**1.95**	**6.88**	**6.53**

12/18/2006: 63% <100 µm

Sample	*Weight (g)*	*Recon. (ml)*	*Dil. Factor*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
Tot1	0.5504	10	10	250.2	0.6826	0.232	225.1	5.779	0.4975	0.2856	0.5022	0.6915
Tot2	0.5039	10	10	238.4	0.6173	0.2157	206.5	5.286	0.445	0.2569	0.4635	0.6258
			Average	**46384.41**	**123.26**	**42.48**	**40938.94**	**1049.49**	**89.35**	**51.44**	**91.61**	**124.91**
			Std	**1310.36**	**1.07**	**0.46**	**58.57**	**0.67**	**1.47**	**0.64**	**0.52**	**1.02**

Palo Alto HCl Extracts: 2006

1/09/2006: 74% <100 µm

Sample	*Weight (g)*	*Recon. (ml)*		*Ag*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
HCl1	0.519	10		0.017	88.21	0.2162	1.089	232.7	21.67	0.5856	0.9723	0.4887	2.001
HCL2	0.5065	10		0.0168	85.21	0.205	1.064	223.8	21.11	0.5602	0.946	0.4731	1.931
			Average	**0.33**	**1690.97**	**4.11**	**20.99**	**4451.09**	**417.16**	**11.17**	**18.71**	**9.38**	**38.34**
			Std	**0.00**	**8.64**	**0.06**	**0.01**	**32.53**	**0.38**	**0.11**	**0.03**	**0.04**	**0.22**

2/07/2006: 86% < 100 µm

Sample	*Weight (g)*	*Recon. (ml)*		*Ag*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
HCl1	0.5	10		0.0181	83.13	0.2294	1.007	237.8	25.58	0.5417	0.9965	0.4637	2.019
HCL2	0.5053	10		0.018	80.26	0.2147	0.9973	231	25.53	0.5137	0.9971	0.4498	1.968
			Average	**0.36**	**1625.48**	**4.42**	**19.94**	**4663.77**	**508.42**	**10.50**	**19.83**	**9.09**	**39.66**
			Std	**0.00**	**37.12**	**0.17**	**0.20**	**92.23**	**3.18**	**0.33**	**0.10**	**0.19**	**0.72**

3/22/2006: 67% <100 µm

Sample	*Weight (g)*	*Recon. (ml)*		*Ag*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
HCl1	0.4937	10		0.0164	73.12	0.2065	0.9257	197.6	17.65	0.4839	0.9147	0.4005	1.802
HCL2	0.5066	10		0.0167	76.49	0.2206	0.9675	209.1	18.55	0.5229	0.9609	0.4178	2.021
			Average	**0.33**	**1495.47**	**4.27**	**18.92**	**4064.97**	**361.84**	**10.06**	**18.75**	**8.18**	**38.20**
			Std	**0.00**	**14.40**	**0.09**	**0.17**	**62.54**	**4.33**	**0.26**	**0.22**	**0.07**	**1.70**

4/24/2006: 87% <100 µm

Sample	*Weight (g)*	*Recon. (ml)*		*Ag*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
HCl1	0.5168	10		0.0149	84.13	0.2266	0.9961	246.1	22.54	0.568	1.021	0.4731	2.127
HCL2	0.6545	10		0.0194	103.9	0.2792	1.255	295.2	27.94	0.6967	1.277	0.5786	2.575
			Average	**0.29**	**1607.69**	**4.33**	**19.22**	**4636.16**	**431.52**	**10.82**	**19.63**	**9.00**	**40.25**
			Std	**0.00**	**20.22**	**0.06**	**0.05**	**125.84**	**4.63**	**0.17**	**0.12**	**0.16**	**0.91**

5/31/2006: 35% < 100 µm

Sample	*Weight (g)*	*Recon. (ml)*		*Ag*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
HCl1	0.3516	10		0.0159	47.29	0.1197	0.5967	121.3	12.25	0.3118	0.636	0.2418	1.102
HCL2	0.3412	10		0.0152	45.77	0.1195	0.5708	117.9	12.05	0.3052	0.6099	0.2349	1.079
			Average	**0.45**	**1343.22**	**3.45**	**16.85**	**3452.70**	**350.79**	**8.91**	**17.98**	**6.88**	**31.48**
			Std	**0.00**	**1.78**	**0.05**	**0.12**	**2.75**	**2.38**	**0.04**	**0.11**	**0.00**	**0.14**

6/27/2006: 67% <100 µm

Sample	*Weight (g)*	*Recon. (ml)*		*Ag*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
HCl1	0.6779	10		0.0206	98.9	0.2379	1.009	258.5	21.16	0.4342	0.9448	0.4281	2.072
HCl2	0.5012	10		0.0178	75.45	0.1846	0.7587	201.9	16.58	0.3379	0.7717	0.329	1.585
			Average	**0.33**	**1482.15**	**3.60**	**15.01**	**3920.79**	**321.47**	**6.57**	**14.67**	**6.44**	**31.09**
			Std	**0.03**	**23.23**	**0.09**	**0.13**	**107.54**	**9.33**	**0.17**	**0.73**	**0.12**	**0.53**

9/7/2006: 76% <100 µm

Sample	*Weight (g)*	*Recon. (ml)*		*Ag*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
HCl1	0.4869	10		0.0188	85.34	0.2096	0.7891	201.2	24.91	0.3476	0.848	0.3834	1.64
HCl2	0.4359	10		0.0174	77.81	0.1912	0.7125	186.3	22.52	0.3202	0.7599	0.3511	1.486
			Average	**0.39**	**1768.88**	**4.35**	**16.28**	**4203.09**	**514.12**	**7.24**	**17.42**	**7.96**	**33.89**
			Std	**0.01**	**16.16**	**0.04**	**0.07**	**70.83**	**2.51**	**0.10**	**0.01**	**0.09**	**0.20**

10/19/2006: 84% <100 µm

Sample	*Weight (g)*	*Recon. (ml)*		*Ag*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
HCl1	0.4432	10		0.0181	78.41	0.1927	0.7097	194.4	26.12	0.3111	0.7608	0.3497	1.532
HCl2	0.5163	10		0.0197	90.82	0.2253	0.828	222.8	30.23	0.3602	0.8876	0.4035	1.806
			Average	**0.39**	**1764.12**	**4.36**	**16.03**	**4350.80**	**587.43**	**7.00**	**17.18**	**7.85**	**34.77**
			Std	**0.01**	**5.06**	**0.01**	**0.01**	**35.48**	**1.92**	**0.02**	**0.01**	**0.04**	**0.21**

12/18/2006: 63% <100 µm

Sample	*Weight (g)*	*Recon. (ml)*		*Ag*	*AL*	*CR*	*CU*	*FE*	*MN*	*NI*	*PB*	*V*	*ZN*
HCl1	0.432	10		0.0157	78.08	0.2022	0.705	195.4	25.32	0.3231	0.7496	0.3823	1.602
HCl2	0.4514	10		0.0165	81.42	0.2079	0.7315	203.9	26.36	0.3325	0.8265	0.3966	1.558
			Average	**0.36**	**1805.56**	**4.64**	**16.26**	**4520.10**	**585.04**	**7.42**	**17.83**	**8.82**	**35.80**
			Std	**0.00**	**1.84**	**0.04**	**0.06**	**3.05**	**1.08**	**0.06**	**0.48**	**0.03**	**1.28**

Appendix C

Metal concentrations in the clam *Macoma petalum* collected at the Palo Alto Mudflat. Each monthly collection is reported on two pages. The first page contains summary statistics:

Mean concentrations in microgram per gram dry tissue weight (µg/g).

- STD is the standard deviation of the mean.
- SEM is the standard error of the mean.
- CV percent is the coefficient of variation.
- r wt x [] is the correlation coefficient for the concentration versus weight correlation for each element.
- X 100mg is the concentration interpolated from the above regression for a 100 mg animal.
- r l x [] is the correlation coefficient for the concentration versus shell length regression.
- X 20 mm and X 25 mm are concentrations interpolated from the regression for 20mm and 25 mm animals.

Condition index (CI) is an estimate of the tissue dry weight (g or mg) standardized to a constant shell length (shell length of 25 mm is used for interpretive purposes). This index, along with weights for animals of 15 mm and 20 mm shell length, was estimated from a linear regression analysis of log tissue dry weight vs. log average shell length for each monthly collection.

Content (a measure of metal bioaccumulation that is standardized to tissue mass) is show from 15 mm, 20 mm and 25 mm animals.

The second page shows the analysis of each composite within the sample, the number of animals in each composite, concentration as calculated from sample dry weight and the dilution factor and the metal content for each composite.

Note: Appendix tables in this document may not be 508 complaint. 508 compliant Excel spreadsheet containing these 508 compliant tables may be accessed at URL:
http://pubs.usgs.gov/of/2007/1199/Appendix-C.xls

Station:

Statistical Summary

Date:PA 01/09/06

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	2.8647	0.1328	3.4933	28.7805	5.7090	1.5238	4.1409	358.0370
STD	0.8272	0.0622	0.5905	2.4894	0.5895	0.2911	0.7834	70.6395
SEM	0.262	0.022	0.187	0.787	0.186	0.092	0.248	22.338
CV%	28.876	46.846	16.904	8.650	10.326	19.104	18.918	19.730
n	10	8	10	10	10	10	10	10
r wt x [ ]	0.250	0.383	0.211	0.626	0.380	0.128	0.339	0.438
X 100mg	3.686	0.044	2.999	34.956	4.821	1.376	3.087	235.450
r l x [ ]	0.300	0.341	0.239	0.628	0.381	0.105	0.379	0.483
X 20mm	3.072	0.119	3.375	30.084	5.522	1.498	3.893	329.574
X 25mm	3.392	0.091	3.193	32.102	5.232	1.459	3.509	285.499

Estimated content (ug) for 15mm and 20mm clam

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.1330	0.0046	0.1491	1.3468	0.2470	0.0662	0.1727	14.3565
25mm	0.2656	0.0072	0.2651	2.6228	0.4417	0.1206	0.2998	23.9782

Estimated weight for 15mm clam	Estimated weight for 20mm clam
0.020 gm	0.045 gm
20.265 mg	44.935 mg

Estimated weight for 25mm clam

0.083 gm
83.336 mg

Station: Palo Alto

Macoma petalum

Date:01/09/06

Sample #-n	Average Length (mm)	Total Dry Wt (gm)	Average Dry Wt (gm)	Recon Amt (ml)	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
					Concentration (ug/ml) - Blank Corrected from ICP-AES							
Mp1	11.42	0.0896	0.0090	10	0.0219	-0.0005	0.0366	0.2524	0.0574	0.0153	0.0489	3.817
Mp2	12.52	0.1892	0.0118	10	0.0532	0.0036	0.0775	0.5478	0.1192	0.0368	0.0958	7.876
Mp3	13.44	0.1675	0.0152	10	0.0319	0.0015	0.051	0.426	0.0827	0.02	0.0567	6.421
Mp4	14.31	0.2322	0.0166	10	0.0706	0.0045	0.0806	0.6211	0.1384	0.0371	0.0886	8.967
Mp5	15.60	0.1107	0.0277	10	0.0295	-0.0007	0.0318	0.2808	0.0575	0.0109	0.0379	4
Mp6	17.47	0.1333	0.0333	10	0.0313	0.0008	0.0592	0.3981	0.0878	0.0238	0.068	3.253
Mp7	18.84	0.3011	0.0376	10	0.1285	0.0056	0.0785	0.9727	0.1591	0.0409	0.1023	10.33
Mp8	20.44	0.3239	0.0463	10	0.1404	0.0062	0.1014	0.9137	0.1891	0.0546	0.1179	10.74
Mp9	21.48	0.1647	0.0549	10	0.0448	0.0014	0.0585	0.5282	0.0898	0.0228	0.068	7.364
Mp10	22.18	0.1649	0.0550	10	0.0348	0.0011	0.0599	0.506	0.0846	0.0263	0.0659	3.981

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
MDL	0.0010	0.0004	0.0026	0.0011	0.0010	0.0033	0.0012	0.0037
MRL	0.0020	0.0008	0.0052	0.0021	0.0019	0.0066	0.0024	0.0073

	Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Concentration (ug/g) ==>	Mp1	2.4442		4.0848	28.1696	6.4063	1.7076	5.4576	426.004
	Mp2	2.8118	0.1903	4.0962	28.9535	6.3002	1.9450	5.0634	416.279
	Mp3	1.9045	0.0896	3.0448	25.4328	4.9373	1.1940	3.3851	383.343
	Mp4	3.0405	0.1938	3.4711	26.7485	5.9604	1.5978	3.8157	386.176
	Mp5	2.6649		2.8726	25.3659	5.1942	0.9846	3.4237	361.337
	Mp6	2.3481	0.0600	4.4411	29.8650	6.5866	1.7854	5.1013	244.036
	Mp7	4.2677	0.1860	2.6071	32.3049	5.2840	1.3584	3.3975	343.075
	Mp8	4.3347	0.1914	3.1306	28.2093	5.8382	1.6857	3.6400	331.584
	Mp9	2.7201	0.0850	3.5519	32.0704	5.4523	1.3843	4.1287	447.116
	Mp10	2.1104	0.0667	3.6325	30.6853	5.1304	1.5949	3.9964	241.419

	Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Content (ug) ==>	Mp1	0.0219		0.0366	0.2524	0.0574	0.0153	0.0489	3.8170
	Mp2	0.0333	0.0023	0.0484	0.3424	0.0745	0.0230	0.0599	4.9225
	Mp3	0.0290	0.0014	0.0464	0.3873	0.0752	0.0182	0.0515	5.8373
	Mp4	0.0504	0.0032	0.0576	0.4436	0.0989	0.0265	0.0633	6.4050
	Mp5	0.0738		0.0795	0.7020	0.1438	0.0273	0.0948	10.0000
	Mp6	0.0783	0.0020	0.1480	0.9953	0.2195	0.0595	0.1700	8.1325
	Mp7	0.1606	0.0070	0.0981	1.2159	0.1989	0.0511	0.1279	12.9125
	Mp8	0.2006	0.0089	0.1449	1.3053	0.2701	0.0780	0.1684	15.3429
	Mp9	0.1493	0.0047	0.1950	1.7607	0.2993	0.0760	0.2267	24.5467
	Mp10	0.1160	0.0037	0.1997	1.6867	0.2820	0.0877	0.2197	13.2700

Station: Palo Alto

Statistical Summary

Date: 02/07/06

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	2.5395	0.2287	5.5210	27.5377	6.8229	1.6795	5.9233	437.7184
STD	0.5571	0.1151	2.3494	6.4175	1.5739	0.5889	2.3039	76.9485
SEM	0.186	0.047	0.783	2.139	0.525	0.196	0.768	25.649
CV%	21.938	50.351	42.554	23.304	23.068	35.062	38.895	17.579
n	9	6	9	9	9	9	9	9
r wt x [ ]	0.758	0.332	0.171	0.561	0.308	0.333	0.289	0.712
X 100mg	4.397	0.077	7.283	43.360	8.952	2.541	8.855	678.827
r l x [ ]	0.736	0.256	0.132	0.549	0.308	0.372	0.268	0.775
X 20mm	3.019	0.203	5.885	31.660	7.390	1.936	6.644	507.424
X 25mm	3.539	0.164	6.279	36.125	8.004	2.213	7.425	582.941

Estimated content (ug) for 15mm and 20mm clam

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.1405	0.0081	0.2416	1.4531	0.3280	0.0814	0.2736	23.7285
25mm	0.2807	0.0124	0.4228	2.8016	0.5909	0.1527	0.4954	46.4138

Estimated weight for 15mm clam	Estimated weight for 20mm clam
0.023 gm	0.047 gm
23.100 mg	46.873 mg

Estimated weight for 25mm clam

0.081 gm
81.149 mg

Station: Palo Alto

Date: 02/07/06

Macoma petalum

	Average	Total	Average	Recon	Concentration (ug/ml) - Blank Corrected from ICP-AES							
Sample #-n	Length (mm)	Dry Wt (gm)	Dry Wt (gm)	Amt (ml)	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mp1	10.04	0.0275	0.0092	10	0.006	-0.0027	0.0249	0.0724	0.0221	0.0045	0.0231	0.8495
Mp2	11.65	0.1000	0.0125	10	0.0169	-0.0001	0.038	0.1971	0.0566	0.0113	0.0399	3.994
Mp3	12.43	0.1330	0.0148	10	0.0296	0.0022	0.058	0.302	0.0825	0.0259	0.0678	5.46
Mp4	13.49	0.2699	0.0142	10	0.0658	0.0109	0.154	0.7219	0.1917	0.0547	0.1687	13.62
Mp5	14.55	0.2105	0.0211	10	0.0455	0.0056	0.0937	0.4877	0.1301	0.0269	0.0987	7.767
Mp6	16.32	0.1339	0.0335	10	0.0437	-0.0007	0.0306	0.398	0.0518	0.0083	0.0332	6.032
Mp7	18.70	0.0829	0.0415	10	0.0274	0.0006	0.053	0.3373	0.073	0.0201	0.0629	3.592
Mp8	19.64	0.1344	0.0448	10	0.034	0.0024	0.0593	0.4544	0.0923	0.023	0.0677	6.771
Mp9	21.64	0.1085	0.0543	10	0.0332	0.0031	0.1001	0.2708	0.0942	0.0254	0.1061	6.07

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
MDL	0.0010	0.0004	0.0026	0.0011	0.0010	0.0033	0.0012	0.0037
MRL	0.0020	0.0008	0.0052	0.0021	0.0019	0.0066	0.0024	0.0073

	Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Concentration (ug/g) ==>	Mp1	2.1818		9.0545	26.3273	8.0364	1.6364	8.4000	308.909
	Mp2	1.6900		3.8000	19.7100	5.6600	1.1300	3.9900	399.400
	Mp3	2.2256	0.1654	4.3609	22.7068	6.2030	1.9474	5.0977	410.526
	Mp4	2.4379	0.4039	5.7058	26.7469	7.1026	2.0267	6.2505	504.631
	Mp5	2.1615	0.2660	4.4513	23.1686	6.1805	1.2779	4.6888	368.979
	Mp6	3.2636		2.2853	29.7237	3.8686	0.6199	2.4795	450.485
	Mp7	3.3052	0.0724	6.3932	40.6876	8.8058	2.4246	7.5875	433.293
	Mp8	2.5298	0.1786	4.4122	33.8095	6.8676	1.7113	5.0372	503.795
	Mp9	3.0599	0.2857	9.2258	24.9585	8.6820	2.3410	9.7788	559.447

	Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Content (ug) ==>	Mp1	0.0200		0.0830	0.2413	0.0737	0.0150	0.0770	2.8317
	Mp2	0.0211		0.0475	0.2464	0.0708	0.0141	0.0499	4.9925
	Mp3	0.0329	0.0024	0.0644	0.3356	0.0917	0.0288	0.0753	6.0667
	Mp4	0.0346	0.0057	0.0811	0.3799	0.1009	0.0288	0.0888	7.1684
	Mp5	0.0455	0.0056	0.0937	0.4877	0.1301	0.0269	0.0987	7.7670
	Mp6	0.1093		0.0765	0.9950	0.1295	0.0208	0.0830	15.0800
	Mp7	0.1370	0.0030	0.2650	1.6865	0.3650	0.1005	0.3145	17.9600
	Mp8	0.1133	0.0080	0.1977	1.5147	0.3077	0.0767	0.2257	22.5700
	Mp9	0.1660	0.0155	0.5005	1.3540	0.4710	0.1270	0.5305	30.3500

Station: Palo Alto

Statistical Summary

Date: 03/22/06

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	1.2244	0.1847	2.8586	19.4769	4.4335	1.1223	3.0644	310.6788
STD	0.4249	0.0649	1.1133	3.3543	1.1864	0.4375	1.2874	45.8747
SEM	0.134	0.023	0.352	1.061	0.375	0.138	0.407	14.507
CV%	34.700	35.124	38.945	17.222	26.760	38.985	42.011	14.766
n	10	8	10	10	10	10	10	10
r wt x [ ]	0.504	0.489	0.200	0.556	0.320	0.307	0.325	0.700
X 100mg	1.591	0.251	3.239	22.670	5.083	1.352	3.780	365.658
r l x [ ]	0.627	0.536	0.368	0.693	0.495	0.480	0.486	0.752
X 20mm	1.424	0.214	3.166	21.222	4.874	1.280	3.534	336.596
X 25mm	1.786	0.270	3.722	24.377	5.671	1.565	4.382	383.431

Estimated content (ug) for 15mm and 20mm clam

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.0924	0.0137	0.1968	1.4344	0.3227	0.0823	0.2239	22.9514
25mm	0.2046	0.0320	0.4044	2.9544	0.6717	0.1833	0.5042	47.3113

Estimated weight for 15mm clam	Estimated weight for 20mm clam
0.031 gm	0.068 gm
31.253 mg	68.176 mg

Estimated weight for 25mm clam

0.125 gm
124.845 mg

Station: Palo Alto

Date: 03/22/06

Macoma petalum

Sample #-n	Average Length (mm)	Total Dry Wt (gm)	Average Dry Wt (gm)	Recon Amt (ml)	Concentration (ug/ml) - Blank Corrected from ICP-AES							
					Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mp1	11.49	0.1440	0.0160	10	0.0116	-0.0006	0.0264	0.2332	0.0473	0.0086	0.0276	3.42
Mp2	13.53	0.1661	0.0237	10	0.0186	0.0016	0.0285	0.246	0.0532	0.0108	0.022	4.365
Mp3	14.46	0.3592	0.0276	10	0.0426	0.0066	0.1279	0.6737	0.1716	0.0502	0.1354	11.17
Mp4	15.39	0.5573	0.0348	15	0.0326	0.0064	0.0974	0.7197	0.1463	0.0377	0.0949	10.85
Mp5	16.46	0.4968	0.0355	10	0.0627	0.0134	0.1829	1.077	0.2458	0.0639	0.1929	17.19
Mp6	17.51	0.4915	0.0492	10	0.0477	0.0081	0.117	0.8895	0.1784	0.0446	0.1224	15.54
Mp7	18.36	0.1891	0.0473	10	0.0265	0.0022	0.0618	0.384	0.1103	0.0285	0.0729	5.221
Mp8	20.61	0.3349	0.0837	10	0.0442	0.0065	0.1186	0.6439	0.1743	0.0484	0.1312	12.77
Mp9	21.82	0.1940	0.0970	10	0.0194	-0.0001	0.0226	0.37	0.0593	0.0112	0.0306	6.098
Mp10	22.71	0.2642	0.0881	10	0.0608	0.0074	0.1273	0.7201	0.1707	0.0486	0.1415	9.764

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
MDL	0.0010	0.0004	0.0026	0.0011	0.0010	0.0033	0.0012	0.0037
MRL	0.0020	0.0008	0.0052	0.0021	0.0019	0.0066	0.0024	0.0073

	Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Concentration (ug/g) ==>	Mp1	0.8056		1.8333	16.1944	3.2847	0.5972	1.9167	237.500
	Mp2	1.1198	0.0963	1.7158	14.8104	3.2029	0.6502	1.3245	262.793
	Mp3	1.1860	0.1837	3.5607	18.7556	4.7773	1.3976	3.7695	310.969
	Mp4	0.8774	0.1723	2.6216	19.3711	3.9377	1.0147	2.5543	292.033
	Mp5	1.2621	0.2697	3.6816	21.6787	4.9477	1.2862	3.8829	346.014
	Mp6	0.9705	0.1648	2.3805	18.0977	3.6297	0.9074	2.4903	316.175
	Mp7	1.4014	0.1163	3.2681	20.3067	5.8329	1.5071	3.8551	276.097
	Mp8	1.3198	0.1941	3.5414	19.2266	5.2045	1.4452	3.9176	381.308
	Mp9	1.0000		1.1649	19.0722	3.0567	0.5773	1.5773	314.330
	Mp10	2.3013	0.2801	4.8183	27.2559	6.4610	1.8395	5.3558	369.569

	Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Content (ug) ==>	Mp1	0.0129		0.0293	0.2591	0.0526	0.0096	0.0307	3.8000
	Mp2	0.0266	0.0023	0.0407	0.3514	0.0760	0.0154	0.0314	6.2357
	Mp3	0.0328	0.0051	0.0984	0.5182	0.1320	0.0386	0.1042	8.5923
	Mp4	0.0306	0.0060	0.0913	0.6747	0.1372	0.0353	0.0890	10.1719
	Mp5	0.0448	0.0096	0.1306	0.7693	0.1756	0.0456	0.1378	12.2786
	Mp6	0.0477	0.0081	0.1170	0.8895	0.1784	0.0446	0.1224	15.5400
	Mp7	0.0663	0.0055	0.1545	0.9600	0.2758	0.0713	0.1823	13.0525
	Mp8	0.1105	0.0163	0.2965	1.6098	0.4358	0.1210	0.3280	31.9250
	Mp9	0.0970		0.1130	1.8500	0.2965	0.0560	0.1530	30.4900
	Mp10	0.2027	0.0247	0.4243	2.4003	0.5690	0.1620	0.4717	32.5467

Station: Palo Alto

Statistical Summary

Date: 04/24/06

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	1.3328	0.1966	1.4754	23.2069	3.5382	0.4625	1.3560	330.6337
STD	0.2807	0.0562	0.3739	3.4620	0.6275	0.2178	0.4236	22.8440
SEM	0.089	0.018	0.118	1.095	0.198	0.069	0.134	7.224
CV%	21.065	28.601	25.339	14.918	17.736	47.098	31.239	6.909
n	10	10	10	10	10	10	10	10
r wt x [ ]	0.237	0.114	0.371	0.644	0.619	0.561	0.122	0.197
X 100mg	1.296	0.200	1.399	21.976	3.753	0.530	1.327	328.152
r l x [ ]	0.060	0.323	0.302	0.560	0.615	0.583	0.060	0.121
X 20mm	1.331	0.198	1.465	23.026	3.574	0.474	1.354	330.377
X 25mm	1.313	0.218	1.344	20.947	3.988	0.610	1.326	327.421

Estimated content (ug) for 15mm and 20mm clam

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.0844	0.0125	0.0915	1.4606	0.2306	0.0290	0.0843	21.3505
25mm	0.1578	0.0288	0.1592	2.5373	0.4813	0.0692	0.1564	40.2691

Estimated weight for 15mm clam	Estimated weight for 20mm clam
0.028 gm	0.065 gm
28.383 mg	64.790 mg

Estimated weight for 25mm clam

0.123 gm
122.900 mg

Station: Palo Alto

Date: 04/24/06

Macoma petalum

Sample #-n	Average Length (mm)	Total Dry Wt (gm)	Average Dry Wt (gm)	Recon Amt (ml)	Concentration (ug/ml) - Blank Corrected from ICP-AES							
					Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mp1	13.41	0.1033	0.0207	10	0.0119	0.0007	0.0157	0.2716	0.0341	0.0038	0.0153	3.319
Mp2	15.45	0.1719	0.0344	10	0.0233	0.0027	0.028	0.3991	0.059	0.0047	0.0192	6.141
Mp3	16.44	0.3050	0.0339	10	0.0385	0.0071	0.0539	0.7551	0.1017	0.0162	0.0532	10.35
Mp4	17.53	0.5489	0.0422	15	0.0421	0.0074	0.043	0.7472	0.1112	0.0117	0.0376	10.92
Mp5	18.47	0.3629	0.0518	10	0.047	0.0079	0.0448	0.7663	0.0997	0.0123	0.0365	10.98
Mp6	19.20	0.2385	0.0596	10	0.0282	0.0046	0.0345	0.5535	0.0707	0.0076	0.0289	7.82
Mp7	20.33	0.2647	0.0662	10	0.0423	0.0069	0.0348	0.7302	0.12	0.0106	0.0362	9.326
Mp8	21.63	0.2368	0.0789	10	0.0434	0.0061	0.0551	0.6348	0.0964	0.0221	0.0561	8.504
Mp9	23.30	0.2051	0.1026	10	0.0333	0.0042	0.0276	0.464	0.0707	0.0078	0.0227	7.009
Mp10	29.91	0.2090	0.2090	10	0.0183	0.0036	0.0208	0.3353	0.0943	0.0159	0.0236	6.404

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
MDL	0.0010	0.0004	0.0026	0.0011	0.0010	0.0033	0.0012	0.0037
MRL	0.0020	0.0008	0.0052	0.0021	0.0019	0.0066	0.0024	0.0073

	Sample #								
Concentration (ug/g) ==>	Mp1	1.1520	0.0678	1.5198	26.2924	3.3011	0.3679	1.4811	321.297
	Mp2	1.3554	0.1571	1.6289	23.2170	3.4322	0.2734	1.1169	357.243
	Mp3	1.2623	0.2328	1.7672	24.7574	3.3344	0.5311	1.7443	339.344
	Mp4	1.1505	0.2022	1.1751	20.4190	3.0388	0.3197	1.0275	298.415
	Mp5	1.2951	0.2177	1.2345	21.1160	2.7473	0.3389	1.0058	302.563
	Mp6	1.1824	0.1929	1.4465	23.2075	2.9644	0.3187	1.2117	327.883
	Mp7	1.5980	0.2607	1.3147	27.5859	4.5334	0.4005	1.3676	352.323
	Mp8	1.8328	0.2576	2.3269	26.8074	4.0709	0.9333	2.3691	359.122
	Mp9	1.6236	0.2048	1.3457	22.6231	3.4471	0.3803	1.1068	341.736
	Mp10	0.8756	0.1722	0.9952	16.0431	4.5120	0.7608	1.1292	306.411

	Sample #								
Content (ug) ==>	Mp1	0.0238	0.0014	0.0314	0.5432	0.0682	0.0076	0.0306	6.6380
	Mp2	0.0466	0.0054	0.0560	0.7982	0.1180	0.0094	0.0384	12.2820
	Mp3	0.0428	0.0079	0.0599	0.8390	0.1130	0.0180	0.0591	11.5000
	Mp4	0.0486	0.0085	0.0496	0.8622	0.1283	0.0135	0.0434	12.6000
	Mp5	0.0671	0.0113	0.0640	1.0947	0.1424	0.0176	0.0521	15.6857
	Mp6	0.0705	0.0115	0.0863	1.3838	0.1768	0.0190	0.0723	19.5500
	Mp7	0.1058	0.0173	0.0870	1.8255	0.3000	0.0265	0.0905	23.3150
	Mp8	0.1447	0.0203	0.1837	2.1160	0.3213	0.0737	0.1870	28.3467
	Mp9	0.1665	0.0210	0.1380	2.3200	0.3535	0.0390	0.1135	35.0450
	Mp10	0.1830	0.0360	0.2080	3.3530	0.9430	0.1590	0.2360	64.0400

Station: Palo Alto

Statistical Summary

Date: 05/24/06

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	2.0793	0.2688	1.5136	33.5604	4.1308	0.8166	1.5784	417.3716
STD	1.0704	0.1667	0.8057	17.2467	2.3461	0.4445	0.8122	246.6757
SEM	0.378	0.059	0.285	6.098	0.829	0.157	0.287	87.213
CV%	51.480	62.041	53.228	51.390	56.794	54.434	51.456	59.102
n	8	8	8	8	8	8	8	8
r wt x [ ]	0.378	0.290	0.351	0.290	0.316	0.372	0.311	0.183
X 100mg	1.055	0.146	0.798	20.903	2.252	0.398	0.939	303.077
r l x [ ]	0.040	0.113	0.014	0.049	0.063	0.065	0.051	0.172
X 20mm	2.062	0.277	1.518	33.913	4.193	0.805	1.596	435.101
X 25mm	1.979	0.313	1.540	35.553	4.482	0.748	1.677	517.490

Estimated content (ug) for 15mm and 20mm clam

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.0960	0.0124	0.0704	1.5716	0.1924	0.0366	0.0752	19.5103
25mm	0.1683	0.0236	0.1277	2.9266	0.3598	0.0612	0.1421	40.2416

Estimated weight for 15mm clam	Estimated weight for 20mm clam
0.023 gm	0.053 gm
23.181 mg	53.482 mg

Estimated weight for 25mm clam

0.102 gm
102.291 mg

Station: Palo Alto

Date: 05/24/06

Macoma petalum

Sample #-n	Average Length (mm)	Total Dry Wt (gm)	Average Dry Wt (gm)	Recon Amt (ml)	Concentration (ug/ml) - Blank Corrected from ICP-AES							
					Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mp1	15.06	0.1506	0.0215	10	0.0427	0.0039	0.0274	0.6127	0.0655	0.0179	0.0275	7.552
Mp2	16.46	0.2958	0.0329	10	0.0573	0.006	0.0382	0.9929	0.1033	0.0193	0.0394	8.682
Mp3	17.55	0.7182	0.0399	10	0.0584	0.009	0.043	0.886	0.1209	0.0252	0.0467	10.76
Mp4	18.28	0.3183	0.0455	10	0.057	0.0085	0.0505	0.9832	0.1465	0.0284	0.0548	12.59
Mp5	19.53	0.4818	0.0482	15	0.0679	0.011	0.0515	0.9978	0.1422	0.0202	0.0502	12.79
Mp6	20.33	0.2404	0.0401	10	0.1	0.0152	0.0765	1.631	0.2211	0.0395	0.079	22.13
Mp7	21.55	0.8523	0.0775	10	0.0759	0.0081	0.0553	1.213	0.147	0.0251	0.0637	13.5
Mp8	22.64	0.3185	0.0796	10	0.0667	0.0072	0.0439	1.206	0.1137	0.0281	0.0478	16.61

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
MDL	0.0010	0.0004	0.0026	0.0011	0.0010	0.0033	0.0012	0.0037
MRL	0.0020	0.0008	0.0052	0.0021	0.0019	0.0066	0.0024	0.0073

Concentration (ug/g) ==>

Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mp1	2.8353	0.2590	1.8194	40.6839	4.3493	1.1886	1.8260	501.461
Mp2	1.9371	0.2028	1.2914	33.5666	3.4922	0.6525	1.3320	293.509
Mp3	0.8131	0.1253	0.5987	12.3364	1.6834	0.3509	0.6502	149.819
Mp4	1.7908	0.2670	1.5866	30.8891	4.6026	0.8922	1.7216	395.539
Mp5	2.1139	0.3425	1.6034	31.0648	4.4271	0.6289	1.5629	398.194
Mp6	4.1597	0.6323	3.1822	67.8453	9.1972	1.6431	3.2862	920.549
Mp7	0.8905	0.0950	0.6488	14.2321	1.7247	0.2945	0.7474	158.395
Mp8	2.0942	0.2261	1.3783	37.8650	3.5699	0.8823	1.5008	521.507

Content (ug) ==>

Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mp1	0.0610	0.0056	0.0391	0.8753	0.0936	0.0256	0.0393	10.7886
Mp2	0.0637	0.0067	0.0424	1.1032	0.1148	0.0214	0.0438	9.6467
Mp3	0.0324	0.0050	0.0239	0.4922	0.0672	0.0140	0.0259	5.9778
Mp4	0.0814	0.0121	0.0721	1.4046	0.2093	0.0406	0.0783	17.9857
Mp5	0.1019	0.0165	0.0773	1.4967	0.2133	0.0303	0.0753	19.1850
Mp6	0.1667	0.0253	0.1275	2.7183	0.3685	0.0658	0.1317	36.8833
Mp7	0.0690	0.0074	0.0503	1.1027	0.1336	0.0228	0.0579	12.2727
Mp8	0.1668	0.0180	0.1098	3.0150	0.2843	0.0703	0.1195	41.5250

Station: Palo Alto

Statistical Summary

Date: 06/27/06

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	3.7417	0.4075	2.3141	54.3175	5.8938	1.2811	2.4248	441.9661
STD	0.8698	0.0954	0.6187	10.3505	1.3975	0.3945	0.6150	109.3769
SEM	0.290	0.032	0.206	3.450	0.466	0.131	0.205	36.459
CV%	23.247	23.403	26.735	19.056	23.712	30.791	25.361	24.748
n	9	9	9	9	9	9	9	9
r wt x [ ]	0.589	0.389	0.507	0.066	0.148	0.630	0.321	0.039
X 100mg	4.155	0.378	2.061	53.765	6.060	1.081	2.266	438.502
r l x [ ]	0.642	0.269	0.458	0.101	0.220	0.579	0.251	0.148
X 20mm	3.711	0.409	2.330	54.260	5.877	1.294	2.433	441.083
X 25mm	4.326	0.381	2.017	55.417	6.216	1.042	2.263	458.924

Estimated content (ug) for 15mm and 20mm clam

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.1666	0.0180	0.1013	2.4281	0.2613	0.0554	0.1068	19.5939
25mm	0.4023	0.0356	0.1865	5.2378	0.5728	0.0957	0.2092	43.0350

Estimated weight for 15mm clam	Estimated weight for 20mm clam
0.017 gm	0.045 gm
17.367 mg	45.305 mg

Estimated weight for 25mm clam

0.095 gm
95.313 mg

Station: Palo Alto

Date: 06/27/06

Macoma petalum

Sample #-n	Average Length (mm)	Total Dry Wt (gm)	Average Dry Wt (gm)	Recon Amt (ml)	Concentration (ug/ml) - Blank Corrected from ICP-AES							
					Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mp1	14.41	0.3111	0.0173	10	0.1084	0.0141	0.0941	1.679	0.1946	0.0554	0.0917	12.61
Mp2	16.51	0.7566	0.0270	15	0.1467	0.0189	0.1074	2.374	0.2518	0.0654	0.114	18.38
Mp3	17.48	0.8930	0.0271	15	0.2136	0.0245	0.1432	3.191	0.3433	0.0795	0.1413	24.98
Mp4	18.48	1.1779	0.0357	15	0.228	0.0268	0.1566	3.44	0.3609	0.0791	0.1533	28.56
Mp5	19.44	0.3576	0.0255	15	0.1184	0.0152	0.0851	1.864	0.2069	0.0478	0.0897	16.54
Mp6	20.42	0.6244	0.0568	10	0.1765	0.0219	0.1212	2.811	0.2924	0.0604	0.1236	25.26
Mp7	22.14	0.6661	0.0555	15	0.1639	0.0183	0.0997	2.666	0.2732	0.0593	0.1103	22.83
Mp8	23.57	0.3769	0.0942	10	0.1554	0.0122	0.059	1.971	0.1735	0.0354	0.0647	12.76
Mp9	29.77	0.1819	0.1819	10	0.0943	0.0066	0.0355	0.9982	0.1331	0.0157	0.0427	8.616

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
MDL	0.0010	0.0004	0.0026	0.0011	0.0010	0.0033	0.0012	0.0037
MRL	0.0020	0.0008	0.0052	0.0021	0.0019	0.0066	0.0024	0.0073

Concentration (ug/g) ==>

Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mp1	3.4844	0.4532	3.0248	53.9698	6.2552	1.7808	2.9476	405.336
Mp2	2.9084	0.3747	2.1293	47.0658	4.9921	1.2966	2.2601	364.393
Mp3	3.5879	0.4115	2.4054	53.6002	5.7665	1.3354	2.3735	419.597
Mp4	2.9035	0.3413	1.9942	43.8068	4.5959	1.0073	1.9522	363.698
Mp5	4.9664	0.6376	3.5696	78.1879	8.6787	2.0050	3.7626	693.792
Mp6	2.8267	0.3507	1.9411	45.0192	4.6829	0.9673	1.9795	404.548
Mp7	3.6909	0.4121	2.2452	60.0360	6.1522	1.3354	2.4839	514.112
Mp8	4.1231	0.3237	1.5654	52.2950	4.6033	0.9392	1.7166	338.551
Mp9	5.1842	0.3628	1.9516	54.8763	7.3172	0.8631	2.3474	473.667

Content (ug) ==>

Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mp1	0.0602	0.0078	0.0523	0.9328	0.1081	0.0308	0.0509	7.0056
Mp2	0.0786	0.0101	0.0575	1.2718	0.1349	0.0350	0.0611	9.8464
Mp3	0.0971	0.0111	0.0651	1.4505	0.1560	0.0361	0.0642	11.3545
Mp4	0.1036	0.0122	0.0712	1.5636	0.1640	0.0360	0.0697	12.9818
Mp5	0.1269	0.0163	0.0912	1.9971	0.2217	0.0512	0.0961	17.7214
Mp6	0.1605	0.0199	0.1102	2.5555	0.2658	0.0549	0.1124	22.9636
Mp7	0.2049	0.0229	0.1246	3.3325	0.3415	0.0741	0.1379	28.5375
Mp8	0.3885	0.0305	0.1475	4.9275	0.4338	0.0885	0.1618	31.9000
Mp9	0.9430	0.0660	0.3550	9.9820	1.3310	0.1570	0.4270	86.1600

Station: Palo Alto

Statistical Summary

Date: 09/7/06

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	4.5854	0.4011	2.2707	65.8289	6.2469	1.4554	2.4549	383.1770
STD	0.8410	0.0429	0.3999	8.7555	0.4864	0.2027	0.3870	90.3851
SEM	0.266	0.014	0.126	2.769	0.154	0.064	0.122	28.582
CV%	18.341	10.684	17.610	13.300	7.786	13.927	15.763	23.588
n	10	10	10	10	10	10	10	10
r wt x [ ]	0.233	0.410	0.591	0.608	0.445	0.531	0.220	0.141
X 100mg	4.987	0.365	1.785	54.897	6.691	1.234	2.280	409.417
r l x [ ]	0.188	0.342	0.530	0.721	0.484	0.551	0.164	0.234
X 20mm	4.565	0.403	2.298	66.655	6.216	1.470	2.463	380.409
X 25mm	4.767	0.384	2.027	58.576	6.517	1.327	2.382	407.484

Estimated content (ug) for 15mm and 20mm clam

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.1712	0.0152	0.0854	2.4914	0.2362	0.0549	0.0923	14.1686
25mm	0.3486	0.0285	0.1502	4.3664	0.4855	0.0982	0.1764	29.4213

Estimated weight for 15mm clam	Estimated weight for 20mm clam
0.016 gm	0.038 gm
15.885 mg	37.984 mg

Estimated weight for 25mm clam

0.075 gm
74.693 mg

Station: Palo Alto

Macoma petalum

Date: 09/7/06

Sample #-n	Average Length (mm)	Total Dry Wt (gm)	Average Dry Wt (gm)	Recon Amt (ml)	Concentration (ug/ml) - Blank Corrected from ICP-AES Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mp1	14.65	0.3433	0.0172	10	0.1766	0.0144	0.0834	2.8	0.2086	0.0563	0.084	11.83
Mp2	16.52	0.4439	0.0202	10	0.2283	0.0189	0.1053	3.274	0.2734	0.0681	0.1106	13.01
Mp3	17.52	0.5716	0.0229	10	0.1886	0.0216	0.1284	4.074	0.3142	0.0851	0.1274	22.38
Mp4	18.42	0.7265	0.0303	15	0.1819	0.0176	0.1041	3.103	0.2679	0.0669	0.1032	15.36
Mp5	19.44	0.4044	0.0337	10	0.1815	0.018	0.1197	2.53	0.2642	0.0651	0.1289	15.91
Mp6	20.54	0.2295	0.0383	10	0.0871	0.0097	0.0607	1.467	0.1622	0.0379	0.0614	9.698
Mp7	22.35	0.4266	0.0533	10	0.2346	0.0184	0.106	2.853	0.2592	0.0646	0.1239	23.22
Mp8	24.07	0.2619	0.0655	10	0.1506	0.0103	0.0428	1.353	0.1715	0.0252	0.0492	9.622
Mp9	25.24	0.1633	0.0817	10	0.0647	0.007	0.0287	0.8917	0.1042	0.0234	0.0358	8.239
Mp10	26.36	0.1844	0.0922	10	0.0925	0.0056	0.0374	1.254	0.1217	0.0247	0.0445	4.669

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
MDL	0.0015	0.0002	0.0026	0.0012	0.0008	0.0027	0.0266	0.0012
MRL	0.0029	0.0003	0.0090	0.0023	0.0011	0.0072	0.0532	0.0024

Concentration (ug/g) ==>

Sample #								
Mp1	5.1442	0.4195	2.4294	81.5613	6.0763	1.6400	2.4468	344.597
Mp2	5.1431	0.4258	2.3722	73.7554	6.1590	1.5341	2.4916	293.084
Mp3	3.2995	0.3779	2.2463	71.2736	5.4969	1.4888	2.2288	391.533
Mp4	3.7557	0.3634	2.1493	64.0674	5.5313	1.3813	2.1308	317.137
Mp5	4.4881	0.4451	2.9599	62.5618	6.5331	1.6098	3.1874	393.422
Mp6	3.7952	0.4227	2.6449	63.9216	7.0675	1.6514	2.6754	422.571
Mp7	5.4993	0.4313	2.4848	66.8776	6.0759	1.5143	2.9044	544.304
Mp8	5.7503	0.3933	1.6342	51.6609	6.5483	0.9622	1.8786	367.392
Mp9	3.9620	0.4287	1.7575	54.6050	6.3809	1.4329	2.1923	504.532
Mp10	5.0163	0.3037	2.0282	68.0043	6.5998	1.3395	2.4132	253.200

Content (ug) ==>

Sample #								
Mp1	0.0883	0.0072	0.0417	1.4000	0.1043	0.0282	0.0420	5.9150
Mp2	0.1038	0.0086	0.0479	1.4882	0.1243	0.0310	0.0503	5.9136
Mp3	0.0754	0.0086	0.0514	1.6296	0.1257	0.0340	0.0510	8.9520
Mp4	0.1137	0.0110	0.0651	1.9394	0.1674	0.0418	0.0645	9.6000
Mp5	0.1513	0.0150	0.0998	2.1083	0.2202	0.0543	0.1074	13.2583
Mp6	0.1452	0.0162	0.1012	2.4450	0.2703	0.0632	0.1023	16.1633
Mp7	0.2933	0.0230	0.1325	3.5663	0.3240	0.0808	0.1549	29.0250
Mp8	0.3765	0.0258	0.1070	3.3825	0.4288	0.0630	0.1230	24.0550
Mp9	0.3235	0.0350	0.1435	4.4585	0.5210	0.1170	0.1790	41.1950
Mp10	0.4625	0.0280	0.1870	6.2700	0.6085	0.1235	0.2225	23.3450

Station: Palo Alto

Statistical Summary

Date: 10/19/06

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	7.8588	0.4774	3.5447	82.7916	7.5848	1.9702	3.9238	425.3945
STD	2.8262	0.0819	1.1570	15.9100	1.8535	0.5410	1.0835	96.6388
SEM	0.942	0.027	0.386	5.303	0.618	0.180	0.361	32.213
CV%	35.963	17.150	32.641	19.217	24.437	27.456	27.614	22.717
n	9	9	9	9	9	9	9	9
r wt x [ ]	0.502	0.590	0.254	0.566	0.291	0.115	0.178	0.738
X 100mg	11.012	0.370	2.892	102.807	8.784	1.832	4.353	266.852
r l x [ ]	0.459	0.542	0.209	0.395	0.333	0.133	0.229	0.621
X 20mm	7.878	0.477	3.541	82.883	7.594	1.969	3.927	424.521
X 25mm	9.695	0.415	3.202	91.697	8.459	1.868	4.275	340.458

Estimated content (ug) for 15mm and 20mm clam

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.2981	0.0184	0.1323	3.2270	0.2927	0.0746	0.1500	16.0711
25mm	0.7002	0.0340	0.2461	7.1933	0.6486	0.1446	0.3261	27.3144

Estimated weight for 15mm clam	Estimated weight for 20mm clam
0.015 gm	0.039 gm
15.446 mg	39.363 mg

Estimated weight for 25mm clam

0.081 gm
81.327 mg

Station: Palo Alto

Date: 10/19/06

Macoma petalum

Sample #-n	Average Length (mm)	Total Dry Wt (gm)	Average Dry Wt (gm)	Recon Amt (ml)	Concentration (ug/ml) - Blank Corrected from ICP-AES Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mp1	14.61	0.1139	0.0127	10	0.1105	0.0073	0.0525	1.106	0.1072	0.0315	0.0502	6.293
Mp2	16.51	0.2439	0.0244	10	0.1562	0.012	0.0832	1.675	0.1485	0.0419	0.0845	10.55
Mp3	17.80	0.3341	0.0304	10	0.184	0.0134	0.0964	2.281	0.1927	0.0527	0.0932	13.12
Mp4	18.50	0.3022	0.0302	10	0.1858	0.0128	0.0893	2.16	0.199	0.0544	0.1031	11.4
Mp5	19.48	0.3470	0.0347	10	0.257	0.0166	0.1282	2.803	0.242	0.0684	0.1438	17.36
Mp6	20.96	0.1953	0.0391	10	0.1195	0.011	0.1161	1.563	0.1692	0.0526	0.1137	9.297
Mp7	22.36	0.1539	0.0513	10	0.1381	0.0075	0.0288	1.053	0.124	0.0176	0.0403	7.861
Mp8	23.35	0.2334	0.0778	10	0.1424	0.0096	0.073	2.584	0.1319	0.0392	0.0794	7.977
Mp9	25.96	0.0902	0.0902	10	0.1296	0.0036	0.0307	0.8989	0.0998	0.0215	0.0474	2.207
				MDL	0.0015	0.0002	0.0026	0.0012	0.0008	0.0027	0.0266	0.0012
				MRL	0.0029	0.0003	0.0090	0.0023	0.0011	0.0072	0.0532	0.0024

	Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Concentration (ug/g) ==>	Mp1	9.7015	0.6409	4.6093	97.1027	9.4118	2.7656	4.4074	552.502
	Mp2	6.4043	0.4920	3.4112	68.6757	6.0886	1.7179	3.4645	432.554
	Mp3	5.5073	0.4011	2.8854	68.2730	5.7677	1.5774	2.7896	392.697
	Mp4	6.1482	0.4236	2.9550	71.4758	6.5850	1.8001	3.4116	377.234
	Mp5	7.4063	0.4784	3.6945	80.7781	6.9741	1.9712	4.1441	500.288
	Mp6	6.1188	0.5632	5.9447	80.0307	8.6636	2.6933	5.8218	476.037
	Mp7	8.9734	0.4873	1.8713	68.4211	8.0572	1.1436	2.6186	510.786
	Mp8	6.1011	0.4113	3.1277	110.7112	5.6512	1.6795	3.4019	341.774
	Mp9	14.3681	0.3991	3.4035	99.6563	11.0643	2.3836	5.2550	244.678

	Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Content (ug) ==>	Mp1	0.1228	0.0081	0.0583	1.2289	0.1191	0.0350	0.0558	6.9922
	Mp2	0.1562	0.0120	0.0832	1.6750	0.1485	0.0419	0.0845	10.5500
	Mp3	0.1673	0.0122	0.0876	2.0736	0.1752	0.0479	0.0847	11.9273
	Mp4	0.1858	0.0128	0.0893	2.1600	0.1990	0.0544	0.1031	11.4000
	Mp5	0.2570	0.0166	0.1282	2.8030	0.2420	0.0684	0.1438	17.3600
	Mp6	0.2390	0.0220	0.2322	3.1260	0.3384	0.1052	0.2274	18.5940
	Mp7	0.4603	0.0250	0.0960	3.5100	0.4133	0.0587	0.1343	26.2033
	Mp8	0.4747	0.0320	0.2433	8.6133	0.4397	0.1307	0.2647	26.5900
	Mp9	1.2960	0.0360	0.3070	8.9890	0.9980	0.2150	0.4740	22.0700

Station: Palo Alto

Statistical Summary

Date: 12/18/06

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	7.6356	0.5702	4.6043	67.0780	7.8999	2.4053	5.4801	445.9620
STD	1.4641	0.0687	0.5151	10.5804	0.7377	0.2338	1.1216	66.7346
SEM	0.423	0.020	0.149	3.054	0.213	0.067	0.324	19.265
CV%	19.175	12.052	11.187	15.773	9.338	9.719	20.468	14.964
n	12	12	12	12	12	12	12	12
r wt x [ ]	0.485	0.843	0.142	0.613	0.534	0.441	0.288	0.876
X 100mg	5.681	0.411	4.805	49.240	6.817	2.121	6.369	285.168
r l x [ ]	0.594	0.888	0.076	0.689	0.695	0.573	0.038	0.892
X 20mm	7.258	0.544	4.587	63.910	7.677	2.347	5.499	420.118
X 25mm	5.693	0.434	4.517	50.787	6.754	2.106	5.576	313.055

Estimated content (ug) for 15mm and 20mm clam

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.2874	0.0219	0.1854	2.5636	0.3107	0.0950	0.2178	16.7812
25mm	0.5196	0.0404	0.3965	4.7373	0.6137	0.1903	0.4694	29.5528

Estimated weight for 15mm clam	Estimated weight for 20mm clam
0.015 gm	0.041 gm
14.864 mg	40.832 mg

Estimated weight for 25mm clam

0.089 gm
89.417 mg

Station: Palo Alto

Date: 12/18/06

Macoma petalum

Sample #-n	Average Length (mm)	Total Dry Wt (gm)	Average Dry Wt (gm)	Recon Amt (ml)	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
					Concentration (ug/ml) - Blank Corrected from ICP-AES							
Mp1	14.31	0.1581	0.0144	10	0.1394	0.0098	0.0782	1.372	0.1414	0.0421	0.1017	7.624
Mp2	16.50	0.1767	0.0196	10	0.1498	0.0112	0.0817	1.229	0.1567	0.0446	0.1131	9.207
Mp3	16.51	0.2077	0.0208	10	0.1801	0.0133	0.1056	1.567	0.1719	0.0539	0.13	10.45
Mp4	17.51	0.2944	0.0268	10	0.2274	0.0187	0.1345	1.587	0.2348	0.0719	0.1676	14.57
Mp5	17.56	0.2751	0.0250	10	0.2321	0.0174	0.1383	1.912	0.2407	0.074	0.1597	13.73
Mp6	18.43	0.2527	0.0316	10	0.2068	0.0146	0.1092	1.719	0.1859	0.0574	0.1221	11.32
Mp7	18.48	0.1901	0.0272	10	0.1853	0.0117	0.0778	1.461	0.1573	0.0486	0.0626	8.718
Mp8	19.55	0.2718	0.0388	10	0.1728	0.0143	0.1433	1.674	0.2122	0.0679	0.1323	11.41
Mp9	19.41	0.2721	0.0340	10	0.2117	0.014	0.0976	2.055	0.1863	0.0516	0.1033	13.04
Mp10	20.40	0.2988	0.0427	10	0.133	0.0149	0.1306	1.607	0.2051	0.0643	0.1716	11.74
Mp11	21.94	0.3236	0.0539	10	0.1927	0.0163	0.1352	1.914	0.2401	0.075	0.1771	10.84
Mp12	24.92	0.3035	0.1012	10	0.2132	0.0135	0.1572	1.664	0.2251	0.0685	0.2175	9.641

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
MDL	0.0015	0.0002	0.0026	0.0012	0.0008	0.0027	0.0266	0.0012
MRL	0.0029	0.0003	0.0090	0.0023	0.0011	0.0072	0.0532	0.0024

Concentration (ug/g) ==>

Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mp1	8.8172	0.6199	4.9462	86.7805	8.9437	2.6629	6.4326	482.226
Mp2	8.4776	0.6338	4.6237	69.5529	8.8681	2.5241	6.4007	521.053
Mp3	8.6712	0.6403	5.0843	75.4454	8.2764	2.5951	6.2590	503.130
Mp4	7.7242	0.6352	4.5686	53.9063	7.9755	2.4423	5.6929	494.905
Mp5	8.4369	0.6325	5.0273	69.5020	8.7495	2.6899	5.8052	499.091
Mp6	8.1836	0.5778	4.3213	68.0253	7.3565	2.2715	4.8318	447.962
Mp7	9.7475	0.6155	4.0926	76.8543	8.2746	2.5565	3.2930	458.601
Mp8	6.3576	0.5261	5.2723	61.5894	7.8072	2.4982	4.8675	419.794
Mp9	7.7802	0.5145	3.5869	75.5237	6.8467	1.8964	3.7964	479.236
Mp10	4.4511	0.4987	4.3708	53.7818	6.8641	2.1519	5.7430	392.905
Mp11	5.9549	0.5037	4.1780	59.1471	7.4197	2.3177	5.4728	334.981
Mp12	7.0247	0.4448	5.1796	54.8270	7.4168	2.2570	7.1664	317.661

Content (ug) ==>

Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mp1	0.1267	0.0089	0.0711	1.2473	0.1285	0.0383	0.0925	6.9309
Mp2	0.1664	0.0124	0.0908	1.3656	0.1741	0.0496	0.1257	10.2300
Mp3	0.1801	0.0133	0.1056	1.5670	0.1719	0.0539	0.1300	10.4500
Mp4	0.2067	0.0170	0.1223	1.4427	0.2135	0.0654	0.1524	13.2455
Mp5	0.2110	0.0158	0.1257	1.7382	0.2188	0.0673	0.1452	12.4818
Mp6	0.2585	0.0183	0.1365	2.1488	0.2324	0.0718	0.1526	14.1500
Mp7	0.2647	0.0167	0.1111	2.0871	0.2247	0.0694	0.0894	12.4543
Mp8	0.2469	0.0204	0.2047	2.3914	0.3031	0.0970	0.1890	16.3000
Mp9	0.2646	0.0175	0.1220	2.5688	0.2329	0.0645	0.1291	16.3000
Mp10	0.1900	0.0213	0.1866	2.2957	0.2930	0.0919	0.2451	16.7714
Mp11	0.3212	0.0272	0.2253	3.1900	0.4002	0.1250	0.2952	18.0667
Mp12	0.7107	0.0450	0.5240	5.5467	0.7503	0.2283	0.7250	32.1367

Appendix D

Concentrations of Hg and Se in surface sediments and the clam *Macoma petalum* from Palo Alto (D-1a, D-1b) and in standard reference materials (D-2).

Note: Appendix tables in this document may not be 508 complaint. 508 compliant Excel spreadsheet containing these tables may be access at URL: http://pubs.usgs.gov/of/2007/1199/Appendix-D.xls

D-1a. Mercury and selenium concentrations (µg/g dry weight) determined in surface sediments and *M. petalum* in 2006. One analysis was conducted on homogenized sediment. Values for *M. petalum* are the mean and 95% confidence interval (n=3). Not analyzed (NA).

Date	***Sediment***		***M. petalum***	
	mercury	***selenium***	***mercury***	***selenium***
1/9/2006	0.21	0.84	NA	NA
2/7/2006	0.22	0.62	0.31±0.02	6.47±0.14
4/24/2006	0.25	0.57	0.16±0.02	4.80±0.04
6/27/2006	0.2	0.4	0.27±0.02	4.17±0.03
9/7/2006	0.24	0.42	0.37±0.03	4.47±0.03
12/18/2006	0.3	0.4	0.49±0.02	6.27±0.03

D-1b. Mercury and selenium concentrations (µg/g dry weight) determined in sample splits of surface sediments and *M. petalum* collected in April and June 2006.

Date	***Sediment***		**M. petalum**	
	mercury	***selenium***	***mercury***	***selenium***
4/24/2006	NA	NA	0.22/0.22	NA
6/27/2006	0.19/0.21	0.4/0.4	NA	4.1/4.2

D-2. Observed and certified concentrations of mercury and selenium in standard reference materials analyzed in 2006. Certified concentrations as reported by National Research Council Canada are the mean and 95% confidence interval. The five materials are oyster tissue (NIST 1566b), lobster hepatopancreas (TORT-2), dogfish muscle (DORM-2), San Joaquin soil (NIST 2709), and marine sediment (USGS MAG-1). Split values indicate standard was used more than once during the year for sample analysis

SRM	***Mercury***		***Selenium***	
	Observed	***Certified***	***Observed***	***Certified***
NIST 1566B	0.03/0.05	0.04±0.01	2.2/1.9	2.06±0.15
TORT-2	0.3	0.27±0.06	6.3	5.6±0.7
DORM-2	4.4	4.64±0.26	1.5	1.4±0.1
NIST 2709	1.3	1.4±0.1	1.6	1.5±0.1
USGS MAG-1	0.03	0.02	1.3	1.2±0.1

Appendix E

Results of the analyses of National Institute of Science and Technology (NIST) standard reference materials for elements, excluding selenium and mercury. Recoveries are reported as the observed concentrations and the percent recoveries relative to the certified values for the standard. Results for SRM 2709 (San Joaquin Soil) are shown in E-1, for SRM 2976 (mussel tissue) in E-2, and E-3, respectively.

Note: Appendix tables in this document may not be 508 complaint. 508 compliant Excel spreadsheet containing these 5 08 compliant tables may be accessed at URL:
http://pubs.usgs.gov/of/2007/1199/Appendix-E.xls

E1. Observed and certified concentrations in SRM 2709. Units in upper table are µg/mL. The lower table reports the percent recovery.

Month	***Rep***	***AG***	***AL***	***AS***	***CD***	***CR***	***CU***	***FE***	***MN***	***NI***	***PB***	***V***	***ZN***
January	1	1.097115	43823.65	15.52215	1.970744	101.4019	34.43722	35432.8	542.87	88.1349	39.43519	95.55059	107.6392
	2	1.183915	43988.57	13.67626	2.122882	96.97898	34.23148	31741.2	496.43	78.1384	26.18902	88.65075	96.61155
February	1	0.983343	43668.47	13.16476	2.127233	99.39795	34.59763	32450.3	498.09	80.91511	26.47	95.36424	101.8663
	2	0.971644	44457.66	14.11858	2.300218	99.74222	36.12929	33670.4	524.69	84.87012	27.26552	95.43922	107.7732
March	1	1.147306	44376.15	13.39889	2.110223	97.00881	34.2143	32001.6	499.49	78.56997	26.55194	88.54743	98.03319
	2	1.097645	44729.02	13.26321	2.195289	98.12486	34.94169	32997.9	514.75	80.58541	26.45781	92.31649	100.6174
April	1	1.03912	43663.41	12.87694	2.03749	98.55338	34.51508	32722.1	500.61	80.70497	26.22249	94.2339	101.4874
	2	0.859207	42804.14	13.66921	2.479984	96.85608	34.99317	33372.4	522.94	85.78403	28.13904	87.13142	102.9291
May	1	0.915157	42306.96	14.90944	2.669209	95.99619	34.85224	34070.5	530.79	88.54147	29.09438	87.87417	104.4042
	2	0.883179	43837.82	13.04697	2.067443	98.21357	34.40385	32356.5	502.21	80.28904	26.71618	91.77037	100.3011
June	1	1.010101	46187.36	15.58724	2.040008	104.3177	36.52208	36878.6	565.66	91.06754	40.22579	98.3363	113.3096
	2	1.053887	45675.08	16.84231	3.221316	107.5363	38.19845	37462.7	582.22	96.59972	31.27858	101.2527	105.6671
September	1	0.909971	41548.89	15.12101	2.14908	96.18587	34.77251	35547	561.67	88.49952	38.8577	90.08712	109.0416
	2	1.27501	42546.1	14.79011	1.824245	97.76383	34.89604	34778.3	535.7	85.17066	37.21067	91.58494	105.8847
October	1	1.28808	47066.04	17.82866	2.412595	111.1634	38.00859	40012.3	615.82	101.8197	45.77796	103.7007	122.5516
	2	0.986114	43650.63	14.81183	1.77098	99.47676	34.87623	34393.2	533.71	82.59207	35.9831	97.26303	119.2795
December	1	1.151981	46645.11	16.6734	2.12207	108.9733	37.14632	38156.8	584.88	94.96766	42.34034	101.0711	120.6548
		1.715593	43290.13	16.4125	2.230271	103.1453	36.59931	37590.5	577.2	95.84445	42.77545	101.3534	118.2234
	Cert. Value	0.41	75000	17.70	0.38	130.00	34.60	35000	538	88.0	18.9	112.0	106.0
	Std	0.03	0.06	0.80	0.01	4.00	0.70	0.11	17.00	5.00	0.50	5.00	3.00

Month	***Rep***	***AG***	***AL***	***AS***	***CD***	***CR***	***CU***	***FE***	***MN***	***NI***	***PB***	***V***	***ZN***
January	1	267.6	58.43	87.70	518.6	78.00	99.53	101.24	100.90	100.15	208.65	85.31	101.55
	2	288.8	58.65	77.27	558.7	74.60	98.93	90.69	92.27	88.79	138.57	79.15	91.14
February	1	239.8	58.22	74.38	559.8	76.46	99.99	92.72	92.58	91.95	140.05	85.15	96.10
	2	237.0	59.28	79.77	605.3	76.72	104.42	96.20	97.53	96.44	144.26	85.21	101.67
March	1	279.8	59.17	75.70	555.3	74.62	98.89	91.43	92.84	89.28	140.49	79.06	92.48
	2	267.7	59.64	74.93	577.7	75.48	100.99	94.28	95.68	91.57	139.99	82.43	94.92
April	1	253.4	58.22	72.75	536.2	75.81	99.75	93.49	93.05	91.71	138.74	84.14	95.74
	2	209.6	57.07	77.23	652.6	74.50	101.14	95.35	97.20	97.48	148.88	77.80	97.10
May	1	223.2	56.41	84.2	702.4	73.8	100.7	97.34	98.66	100.6	153.9	78.5	98.5
	2	215.4	58.45	73.7	544.1	75.5	99.4	92.45	93.35	91.2	141.4	81.9	94.6
June	1	246.4	61.58	88.06	536.8	80.24	105.56	105.37	105.14	103.49	212.83	87.80	106.90
	2	257.0	60.90	95.15	847.7	82.72	110.40	107.04	108.22	109.77	165.50	90.40	99.69
September	1	221.9	55.40	85.43	565.5	73.99	100.50	101.56	104.40	100.57	205.60	80.43	102.87
	2	311.0	56.73	83.56	480.1	75.20	100.86	99.37	99.57	96.78	196.88	81.77	99.89
October	1	314.2	62.75	100.73	634.9	85.51	109.85	114.32	114.47	115.70	242.21	92.59	115.61
	2	240.5	58.20	83.68	466.0	76.52	100.80	98.27	99.20	93.85	190.39	86.84	112.53
December	1	281.0	62.19	94.20	558.4	83.83	107.36	109.02	108.71	107.92	224.02	90.24	113.83
	AVG	**256.1**	**58.90**	**82.85**	**582.4**	**77.27**	**102.30**	**98.83**	**99.63**	**98.08**	**172.49**	**84.04**	**100.89**
	STDEV	**31.6**	**2.03**	**8.31**	**90.0**	**3.61**	**3.77**	**6.79**	**6.57**	**7.68**	**35.88**	**4.49**	**7.39**

E-2. Observed and certified values for inorganic elements in NIST Standard Reference Material 2976 (mussel tissue) and DOLT-3 (dogfish liver) prepared in 2006. Values for different dates are the observed mean concentrations and 1 standard deviation for either replicate or triplicates of the standard (n=2-3). The mean values are summarized as the median. The certified values for the standard reference material are shown below the observed values (vanadium is not certified for this material). All values are reported as μg/g dry weight. Two different SRMs were used this year due insufficient amount of material during time of processing.

NIST 2976

Date	*Cadmium*	*Chromium*	*Copper*	*Lead*	*Nickel*	*Silver*	*Vanadium*	*Zinc*
January 9, 2006	0.65	0.72	4.48	1.05	0.63	0.03	0.76	138.01
February 7, 2006	0.66	0.48	4.29	0.94	0.63	0.02	0.71	135.74

Mean	0.65	0.60	4.38	1.00	0.63	0.03	0.74	136.88
STD	0.01	0.17	0.14	0.08	0.00	0.01	0.03	1.61

Certified Values

Mean	0.82	0.5	4.02	1.19	0.93	0.011	not certified	137
Max.	0.98	0.66	4.35	1.37	1.05	0.016		150
Min.	0.66	0.37	3.69	1.01	0.81	0.006		124

DOLT-3

Date	*Cadmium*	*Chromium*	*Copper*	*Lead*	*Nickel*	*Silver*	*Vanadium*	*Zinc*
March 22, 2006	19.83	4.27	34.63	0.13	3.04	1.34	0.32	94.32
April 24, 2006	19.41	4.05	33.17	0.20	2.86	1.16	0.32	92.70
May 31, 2006	19.36	3.68	33.33	0.22	2.35	1.12	0.33	93.11
June 27, 2006	19.89	4.39	35.75	0.23	3.03	1.39	0.36	94.87
September 7, 2006	19.29	5.40	35.30	0.26	3.90	1.38	0.34	92.89
October 19, 2006	19.15	4.40	35.35	0.27	3.27	1.37	0.34	92.31
December 18, 2006	19.12	4.27	36.31	0.24	3.31	1.41	0.76	93.88

Mean	19.44	4.35	34.83	0.22	3.11	1.31	0.40	93.44
STD	0.31	0.53	1.20	0.05	0.47	0.12	0.16	0.93

Certified Values

Mean	19.4	not certified	31.2	0.319	2.72	1.2	not certified	86.6
Max.	20		32.2	0.364	3.07	1.27		89
Min.	18.8		30.2	0.274	2.37	1.13		84.2

Appendix F

Method detection limits (MDL) and reporting levels (MRL) for the analysis of sediment and tissue samples by ICP-OES (F-1). Values are in units of μg/mL.

Note: Appendix tables in this document may not be 508 complaint. 508 compliant Excel spreadsheet containing these 5 08 compliant tables may be accessed at URL: http://pubs.usgs.gov/of/2007/1199/Appendix-F.xls

F-1. Method detection limits and reporting levels for ICP-OES methods. Concentration markers are method detection limit (MDL) and method reporting level (MRL). All units are μg/mL.

Method	*marker*	*Ag*	*Al*	*Cd*	*Cr*	*Cu*	*Fe*	*Mn*	*Ni*	*Pb*	*V*	*Zn*
Sediment	MDL	0.0015	0.4500	0.0005	0.0031	0.0028	0.055	0.0058	0.0008	0.0081	0.011	0.006
	MRL	0.0031	0.8900	0.001	0.0064	0.0055	0.108	0.0116	0.0015	0.0163	0.0219	0.012
Tissue	MDL	0.0015	0.1399	0.0002	0.0045	0.0012	0.0056	0.0003	0.0006	0.0036	0.0266	0.0012
	MRL	0.0029	0.2798	0.0003	0.009	0.0023	0.0111	0.0006	0.0011	0.0072	0.0532	0.0024

Appendix G

Reproduction data for the year 2006 (G-1).

Note: Appendix tables in this document may not be 508 complaint. 508 compliant Excel spreadsheet containing these 508 compliant tables may be accessed at URL: http://pubs.usgs.gov/of/2007/1199/Appendix-G.xls

G-1. Reproductive stage of *M. petalum* sampled from Palo Alto during 2006.

Date	***Inactive***	***Active***	***Ripe***	***Spawning***	***Spent***	***Spawned***	***N***	***Reproductive***	***Non-Reproductive***
1/9/06	0	0	100	0	0		10	100	0
2/7/06	0	0	60	40	0		10	100	0
3/1/06	0	0	100	0	0		10	100	0
4/24/06	0	0	50	40	10		10	90	-10
5/31/06	0	0	0	0	100		10	0	-100
6/27/06	80	0	0	0	20		10	0	-100
9/7/06	60	10	0	0	30		10	10	-90
12/18/06	0	33.3	66.7	0	0		9	100	0

Appendix H

Complete list of benthic species found at Palo Alto in the year 2006.

Note: Appendix tables in this document may not be 508 complaint. 508 compliant Excel spreadsheet containing these tables may be accessed at URL: http://pubs.usgs.gov/of/2007/1199/Appendix-H.xls

	09-Jan-06		07-Feb-06		22-Mar-06		18-Apr-06		25-May-06		14-Jun-06		25-Jul-06		23-Aug-06		21-Sep-06		21-Nov-06		18-Dec-06	
Species	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**
Acari	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Actiniaria	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.0
Ampelisca abdita	1.3	0.6	3.0	1.7	1.7	1.2	0.7	0.6	0.0	0.0	1.0	1.0	2.3	1.5	12.7	0.6	0.7	1.2	0.0	0.0	0.0	0.0
Ampithoe spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anthozoa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Balanus ?aquila	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Balanus improvisus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Balanus spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.7	13.2	0.3	0.6	1.7	2.1	0.0	0.0	0.7	1.2	0.0	0.0
Boonea bisuturalis	0.0	0.0	0.3	0.6	0.3	0.6	0.3	0.6	0.3	0.6	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	0.0	0.0
Calinoida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Callianassidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capitella "capitata"	0.0	0.0	0.0	0.0	0.7	0.6	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.3	0.6	0.0	0.0
Caprella californica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cirratulidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cirripedia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Corbula amurensis	0.3	0.6	0.0	0.0	24.7	3.1	7.7	2.1	4.3	1.2	3.3	1.2	4.3	2.1	2.7	1.5	8.0	1.7	2.0	0.0	2.3	1.2
Corophium ?insidiosum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Corophium alienense	1.3	1.2	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0	2.0	2.6	3.3	2.9	2.3	1.2	2.7	2.9	17.0	4.0	2.0	1.7
Corophium spinicorne	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	3.5	0.0	0.0
Cumella vulgaris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprideis spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dynamenella spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eogammarus confervicolus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eteone ?californica	2.3	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eteone lighti	5.3	5.5	2.3	1.5	5.7	0.6	4.3	4.0	1.3	0.6	0.3	0.6	2.0	1.7	1.7	2.9	7.7	3.1	7.7	2.1	8.3	4.2
Eteone spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euchone limnicola	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euchone spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eusarsiella zostericola	5.3	4.9	5.0	2.0	5.0	3.6	2.7	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gemma gemma	232.3	205.5	230.0	22.5	364.3	55.8	334.3	36.5	22.0	9.6	23.0	4.6	32.0	10.0	32.7	13.6	132.7	53.0	252.7	76.3	242.0	52.1
Glycera spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glycinde armigera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glycinde polygnatha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glycinde spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gnorisphaeroma oregonensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	1.3	1.5	0.7	0.6	0.3	0.6	0.0	0.0	0.7	0.6	0.0	0.0
Grandidierella japonica	5.3	1.5	1.3	0.6	6.0	5.0	0.3	0.6	9.7	6.4	21.7	10.3	17.0	11.5	1.7	0.6	6.7	1.5	1.3	1.2	1.0	1.0

	09-Jan-06		07-Feb-06		22-Mar-06		18-Apr-06		25-May-06		14-Jun-06		25-Jul-06		23-Aug-06		21-Sep-06		21-Nov-06		18-Dec-06	
Species	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**
Harmothoe imbricata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Harpacticoida	0.0	0.0	0.0	0.0	0.0	0.0	5.7	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6
Hemigrapsus oregonensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heteromastus filiformis	14.0	1.0	11.0	4.6	19.3	3.8	14.3	13.8	14.3	4.0	17.0	3.6	9.0	4.6	22.0	9.0	18.0	6.2	14.3	3.5	21.7	6.1
Ilyanassa obsoleta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Macoma petalum	3.0	2.6	2.0	1.0	1.7	2.1	4.0	4.0	21.3	7.1	18.0	1.7	17.3	2.3	20.3	2.3	18.3	3.8	12.7	4.2	8.7	3.5
Macoma spp.	0.0	0.0	0.0	0.0	3.0	1.0	6.7	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Marphysa sanguinea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Melita nitida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Moncorophium acherusicum	0.3	0.6	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0	1.7	2.9	0.0	0.0	37.0	20.5	4.3	2.1	0.0	0.0
Moncorophium insidiosum	1.7	1.5	0.0	0.0	0.3	0.6	0.0	0.0	0.7	1.2	0.0	0.0	0.0	0.0	0.7	1.2	0.0	0.0	1.3	1.2	0.7	1.2
Moncorophium spp.	0.7	1.2	1.3	0.6	1.7	2.1	0.0	0.0	0.7	0.6	0.0	0.0	0.3	0.6	0.0	0.0	3.7	3.1	3.3	2.1	0.7	1.2
Musculista senhousia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6
Mya arenaria	0.0	0.0	0.0	0.0	1.0	0.0	2.3	1.2	0.0	0.0	1.0	1.0	0.3	0.6	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.0
Mysidacea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Naididae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neanthes succinea	0.3	0.6	0.3	0.6	0.7	0.6	0.3	0.6	0.0	0.0	0.0	0.0	1.0	0.0	0.3	0.6	0.0	0.0	0.3	0.6	0.0	0.0
Nematoda	23.0	13.1	0.0	0.0	1.7	2.1	1.3	2.3	18.0	26.0	16.3	23.2	7.7	12.4	12.0	13.1	14.7	6.8	0.3	0.6	2.0	3.5
Nippoleucon hinumensis	16.0	2.6	32.0	20.1	81.0	19.0	227.7	37.9	20.3	6.4	1.0	1.0	3.3	1.5	18.3	6.0	32.7	13.7	10.7	8.1	58.7	30.0
Odostomia fetella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Odostomia spp.	1.7	2.1	0.7	0.6	1.0	0.0	2.3	2.1	0.3	0.6	0.3	0.6	0.0	0.0	0.0	0.0	1.3	1.2	1.0	1.0	0.0	0.0
Oligochaeta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Planariidae A	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6
Polydora cornuta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.7	0.6	0.0	0.0	0.3	0.6	0.0	0.0
Polydora spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pseudopolydora kempi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rochefortia grippi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rochefortia spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sabaco elongatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphaeromatidae (juv.)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphaerosyllis californiensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphaerosyllis erinaceus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Streblospio benedicti	0.0	0.0	6.3	5.0	19.7	10.5	8.3	13.6	13.0	4.4	4.0	6.1	4.0	4.0	14.3	5.5	9.3	4.9	0.7	0.6	4.0	3.0
Synidotea laevidorsalis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.6	0.0	0.0	0.0	0.0	4.3	3.2	0.3	0.6	0.0	0.0
Tellinidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tharyx spp. ?	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tubificidae	56.7	24.9	21.7	19.7	23.7	11.0	27.3	17.5	37.3	19.3	23.0	7.2	27.3	32.3	28.3	9.9	38.7	25.3	13.0	6.2	52.7	37.6
Turbellaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	09-Jan-06		07-Feb-06		22-Mar-06		18-Apr-06		25-May-06		14-Jun-06		25-Jul-06		23-Aug-06		21-Sep-06		21-Nov-06		18-Dec-06	
Species	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**
Unid. Amphipod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unid. Balanomorpha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unid. Bivalvia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unid. Cumacea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unid. Gastropoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unid. Isopoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unid. Nudibranchia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unid. Ostracoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unid. Polychaeta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unid. Spionidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unid. Syllidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unid. Tanaidacea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Urosalpinx cinerea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0