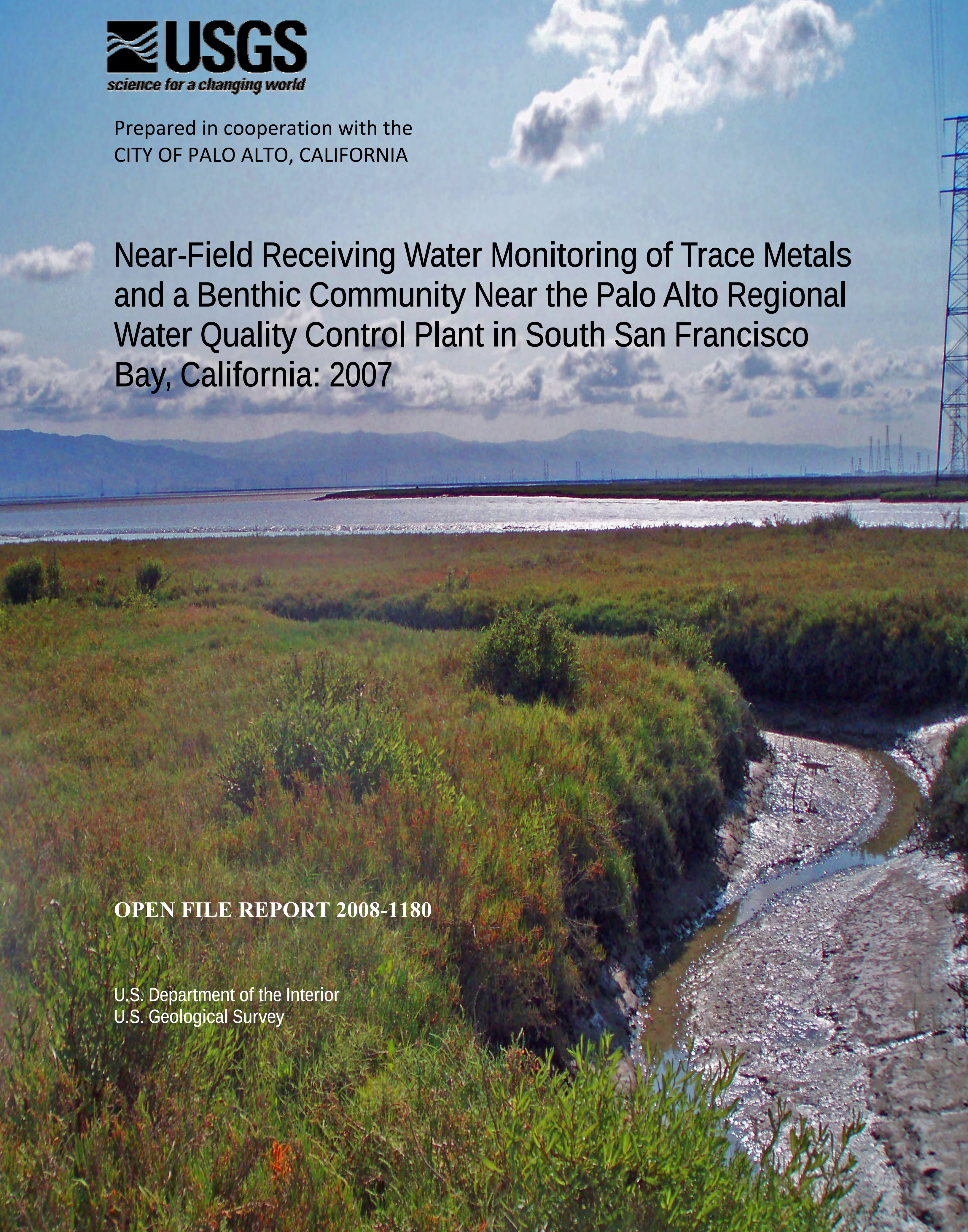

Prepared in cooperation with the
CITY OF PALO ALTO, CALIFORNIA

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: 2007

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

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Allison H. Lorenzi, Daniel J. Cain, Francis Parchaso, Janet K. Thompson, Samuel N. Luoma, Michelle I. Hornberger, and Jessica L. Dyke

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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 (º C) is converted to degrees Fahrenheit (º F) with the following equation:

$°F = (1.8 \times °C) + 32$

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 2007 to December 2007, 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 2007 remained consistent with results observed since 1990. Most notably, copper and silver concentrations in sediment and clam tissue are elevated for the second consecutive year, but the values remain well within the range of past findings. Other metals such as chromium, nickel, vanadium, and zinc remained relatively constant throughout the year except for maximum values that generally occur in winter months (January-March). Mercury levels in sediment and clam tissue were some of the lowest seen on record. Last year's elevated selenium levels appear to be transient, and selenium concentrations have returned to background levels. Overall, metal concentrations in sediments and tissue remain within past findings.

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 and is now showing signs of population stability. 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.

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 impact 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; Lorenzi and others 2007) 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 clam species, *Macoma 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 (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; Lorenzi and others 2007). 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 controls 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 2007, 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 San Francisco Bay 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 2007. 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 layer (top 1-2 cm) of mud. This surface layer represents recently deposited sediments and detritus, or sediments affected by recent chemical reactions 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 the 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 60º C, weighed, and then subsampled to provide replicates weighing 0.4 to 0.6 g. These were re-dried (60º 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 (12º 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. 10.00-10.99 mm, 11.00-11.99mm, 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 acid. 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 Se and Hg 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 Spectrophotometry (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 MΩ 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 Se and Hg) 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 Se and Hg. 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 2007.

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. In 2007, precipitation was well below average with annual rainfall measuring 14.1 inches. The magnitude of rain events for the 2007 rainy season was much lower compared to previous years. The maximum average monthly rainfall in 2007 occurred in February (4.8 inches compared to 8.7 inches in March 2006).

Surface-water salinity typically exhibits a seasonal pattern that is generally the inverse of regional rainfall (*Figure 3*, *Table 1*). This general pattern was again observed in 2007. Because of the small amount of local rainfall in 2007, the winter-spring decline in salinity was minimal, similar to other years of below average rainfall (e.g. 2002). The salinity minimum of 23 parts per thousand (ppt) occurred in April, and subsequently began to climb. Salinities remained high during the dry season and reached their maximum (30 ppt) in June (0.0 inches of rainfall).

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, 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 2007 (*Figure 4*, *Appendix A*).

The percentage of silt/clay in the sediment reached its maximum (87%) in February and March coinciding with maximum rainfall and declined to 52% in October. Aluminum and Fe concentrations changed directly in response to the proportion of silt/clay size (maximum values recorded February through June) (*Figure 4*, *Table 1*), as described above, reflecting the contribution of clays composed of Al and Fe. Total organic carbon content (TOC) of the sediments varied slightly during the year (0.7 to 1.5%). Changes were coincident with sedimentary constituents (*Table 1*). TOC content was highest during winter and spring (values from January through June averaged 1.3%) compared with fall and winter (average 0.9%).

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 occurred in the fall of 2007 (74 µg/g in September) and the maximum in winter (113 µg/g in February). This range is 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 (an average of 138 µg/g for Cr and 117 µg/g for V).

Copper concentrations in sediments are shown with sediment guidelines set by the National Oceanic and Atmospheric Administration (Long and others, 1995) (*Figure 6*, *Table 2*). 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 site-specific sediment toxicity. In 2006, Cu concentrations increased to concentrations similar to those observed before 2000, apparently reversing a trend of declining concentrations during the intervening years. In 2007, Cu concentrations remained above the ERL (34 µg/g) for the entire year. The typical seasonal pattern was evident as, Cu concentrations peaked in February (53 µg/g) and then gradually declined throughout the year reaching their minimum concentration (34 µg/g) in September (*Figure 6*, *Table 2*). The partial-extractable concentrations have generally remained relatively constant outside of the typical seasonal variation and in particular, did not increase during 2006-2008.

Near-total and partial-extractable Zn concentrations were below the Zn ERL (150 µg/g) (*Figure 7*, *Table 2*) for the majority of the year with the exception of February through April 2007 which were slightly above the limit (average of 155 µg/g).

Concentrations of partial-extractable Ag in Palo Alto sediments were 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 8*, *Table 2*). In 2006, Ag concentrations were exceptionally stable. The seasonal pattern missing from the previous year returned in 2007 with peaks in Ag concentrations occurring in spring (March and April 2007; 0.4 and 0.5 µg/g, respectively). Long-term directional trends in the annual mean concentrations were not evident.

Mercury concentrations in sediment during 2007 ranged between 0.18 µg/g (April) to 0.3 µg/g (December) (*Figure 9*, *Table 2*). Hg concentrations were within the range usually observed within San Francisco Bay (0.2 - 0.4 µg/g) throughout the entire year.

Selenium concentrations in 2007 remained relatively stable (range of 0.2 – 0.4 µg/g) with little variation the entire year (*Figure 9*, *Table 2*). Increasing concentrations of selenium vary in magnitude from year to year but these results remain within the overall range of data since analysis of this element began in 1994.

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 10* and *Figure 11*, *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 2007 were, respectively, 43 ± 7 and 4.5 ± 0.9 µg/g, essentially unchanged from 2006 when concentrations of both elements increased slightly. However, concentrations during the past two years still fall within the error of means from recent years (2002-2004 for copper and 1997-2002 for silver).

Intra-annual variations in Ag and Cu concentrations in clam soft tissues display a consistent seasonal signal characterized by, 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 1997 than in subsequent 8 years (*Figure 12*, *Figure 13*). 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). The maximum concentrations reached during the fall/winter of 2006-7 had not been observed since 1996-1997. In 2006, concentrations increased steadily throughout the year and reached their maximum in November (83 µg/g for Cu and 7.9 µg/g for Ag). In January 2007, Cu and Ag concentrations were respectively, 72 µg/g and 8.6 µg/g, but thereafter started falling.

As with Cu and Ag, tissue concentrations of Cr (*Figure 14*, *Table 5*), Ni (*Figure 15*, *Table 5*) and Zn (*Figure 16*, *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 - 2007). 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 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, the seasonal cycle was weakly expressed and concentrations increased notably to values comparable to those observed in the mid- to late-90s. A strong seasonal pattern was evident in 2007. Maximum Zn concentrations occurred in winter (average of 486 µg/g for January-April) and decreased through May (a summer-winter average of 245 µg/g). Cr concentrations for 2007 were similar in magnitude and timing to the previous year. The maximum Cr concentrations were comparable to concentrations observed in 1996-1997 (10.6 µg/g in February). 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.

Mercury concentrations in 2007 returned to levels not observed since 1994. Maximum concentrations in January were 0.58 µg/g, comparable to concentrations observed in September

1994 and during the winters of 1995 and 1996 (all 0.5 µg/g). Moreover, the minimum concentration observed in 2007 was higher than the minimum concentrations observed in most years of the record. The increase in Hg during the winter of 2006-7appeared to mark the end of a slight overall downward trend in concentrations during the period 1994 and 2005 (*Figure 17*).

Selenium concentrations in *M. petalum* varied seasonally like other elements (*Figure 18*, *Table 5*). Long-term trends in the data are not evident. Although in 2007, the annual minimum concentrations (during summer/fall) have decreased somewhat to minima last observed in 2002.

The condition index for *M. petalum* at Palo Alto extends back to 1988 (*Figure 19*). 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. In 2006, the maximum CI was one of the lowest observed (81 mg) but in 2007, the maximum CI (187mg) returned to values consistently found since 2000.

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 (*Figure 20*). Furthermore, the low reproductive activity observed during the late 1970s has not been observed during the entire period of reduced metal exposures. Data for 2007 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 cycling of reproduction, beginning in fall and spawning during the following spring (see *Appendix G* for detailed reproduction data for 2007 and *Figure 21* 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 and decreases as seen in 2006 and 2007 *(Figure 22)*. Total animal abundance follows the same trend *(Figure 23).* The difficulty with these types of metrics is that they do not consider the possibility that one species can take the place of another or that high abundance is based on one species. Depending on the characteristics of a species new to the community or newly dominant in the community, the community structure and function may change as a result of this change of species composition or dominance. 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 since 2004 although there have been seasonal eruptions of several species in some years.

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 2007 (*Figure 24*, *Figure 25*, and *Figure 26*). There was significant seasonal and inter-annual variability in species abundances for all species and that is well illustrated in these three bivalves: *Gemma gemma* has been particularly volatile since 2005. There were six species that did show trends in their abundance since the 1970s and these trends continued through 2007. 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; *Figure 27*) between 1990 and 1998 and that pattern continues through today. 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 28)*. 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 29)* and has shown a consistent peak in abundance in fall since 1999. *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 30)* remained relatively stable until 2005 when the abundance decreased. Two species showed an increase in abundance within the time series. The first was the polychaete worm *Heteromastus filiformis (Figure 31),* 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 a second increase in abundance in 2003 has been followed by a maintained average of 15-20 individuals/core through 2007. The second species showing an increase was *Nippoleucon hinumensis*, a small burrowing crustacean, that appeared in the dataset in 1988 *(Figure 32)* following its introduction into the bay in 1986 (Cohen and Carlton 1995). Another non-indigenous species, *Corbula amurensis*, a filter feeding bivalve that 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, has since declined to background levels of <2 individuals/core *(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 33)*. 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 34* and *Figure 35*). 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). Future sampling will tell if the most recent plateau in abundance of *H. filiformis* is a sign that has established a stable abundance.

The two species that have declined in abundance coincident with the decline in metals, the crustacean *A. abdita (Figure 36*, *Figure 37*, and *Figure 38)* and the worm *S. benedicti (Figure 39, Figure 40*, and *Figure 41)* 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. The abundance of a third common species in the 1970s and 1980s, *G. gemma* has, unlike *A. abdita* and *S. benedicti*, not shown a significant decline in abundance *(Figure 42, Figure 43*, and *Figure 44).* This small clam reproduces by brooding their young and lives on the sediment surface which makes them fairly resistant to sediment-borne stresses. *Gemma gemma* abundance has been variable throughout the study and the high peak seen in 2005, followed by a decline in 2006, has remained in the moderate range in 2007. 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 *(Figure 45)*. The plot for 2007 is indicative of a healthy benthic community with species dominance as revealed by abundance being spread over a range of species. If we examine similar plots for August of four years during our study (1977, 1989, 2002, and 2007), we can see that the shape of the curve has changed greatly between 1977 and 2007 *(Figure 46)*. 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 2007 community plot is similar to that seen in 2002, although with higher abundances. Both of these plots show four gradually declining abundant species followed by a leveling off within the rest of the community which is indicative of a more evenly diverse community than was seen in the 1970s and 1980s.

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 *(Figure 46)* and reproductive mode (*Figure 47)*. 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 *(Figure 47)*. 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 brooding species remain in the ten most abundant species in the 2002 and 2007 plots, the reproductive mode of the dominant species has shifted to include 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 1970s 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; Lorenzi and others 2007) with additional data from January 2007 through December 2007, to create a record spanning 34 years. This long-term dataset includes sediment chemistry, tissue concentrations of metals, condition index and reproductive activity in the clam, *Macoma 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.

The ecology of the mudflats in Palo Alto are part of the larger south bay which has been undergoing some changes in recent years. In 1999-2005, USGS scientists noticed an increase in phytoplankton biomass in the southern bay. Sampling in the deeper water of the southern bay showed that the bivalves were mostly absent from the system during the increase in primary production. Cloern and others (2007) show that the cause of the decline in bivalves was due to an increase in fish predators resulting from increased offshore upwelling activity. The higher reproductive stress of demersal fish, crabs, and shrimp during this period resulted in a higher number of juveniles moving into the south bay to grow. Since 2005, we have seen the large bivalve populations fluctuate more than in previous years and these fluctuations have been reflected in changes in phytoplankton biomass in the system. The value of these findings in greater South Bay to our study is two fold. First, it reinforces the importance of the benthic community in structuring the ecosystem function. Second, it shows that the community in the high intertidal has not been demonstrably affected by these greater south bay influences during these years. This finding solidifies our confidence that the changes we have observed on the benthic community are in large part due to local factors.

2007

Copper and silver concentrations in sediments and soft tissues of the clam, *M. petalum*, throughout 2007 remain representative of the concentrations observed since 1991 following the significant reductions in concentrations during the 1980s that coincided with reductions in the discharge of these elements from PARWQCP. Though copper and silver concentrations have risen slightly since 2005, the increase in annual mean concentrations is modest and consistent with the inter-annual variation observed since 1994. This is also true for Hg and Se concentrations. Inter-annual variation during the 15 years since 1991 did not correlate with discharge of Cu and Ag from PARWQCP (Lorenzi and others 2007), 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). These factors include variables such as precipitation and accelerated erosion of salt marsh banks in recent years, which 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 2007. The abundances of individual species showed no remarkable variability during 2007 and the continued stability in abundance of *H. filiformis* may indicate some shift to increased stability in the benthic community. The distribution of species abundances for the 2007 community were similar to those seen in 2002 reflecting a diverse community but not one as evenly diverse as was seen in 2006. The interpretation that shifts in species abundance at the Palo Alto sampling site 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. We saw a return to a community in 2006 and 2007 with more brooding species than in the recent past, which may be a non-consequential variation in the data or one that is the beginning of a trend that needs to be closely monitored. Future data will help determine the significance of this new finding.

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

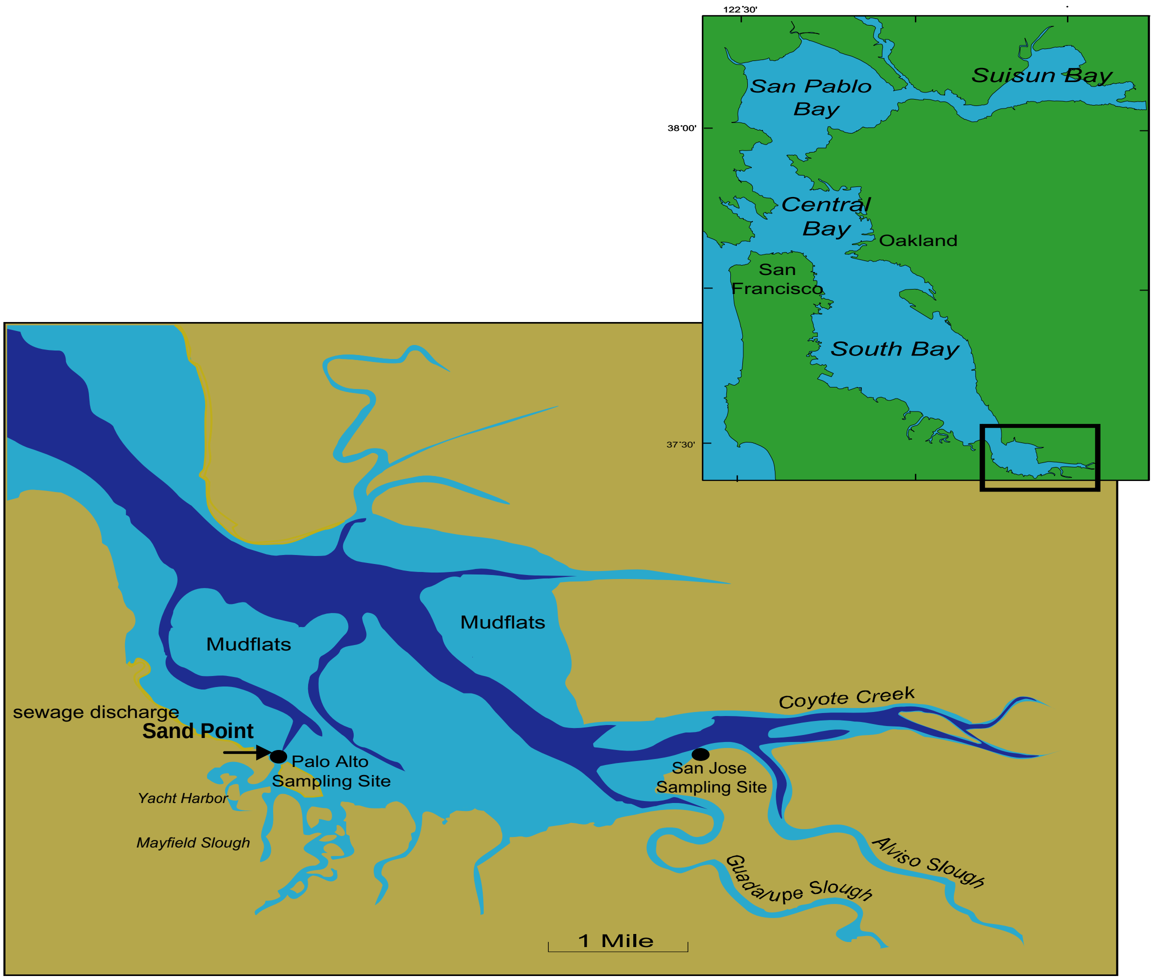


Figure 1. Location of the Palo Alto sampling site in South San Francisco Bay.

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) is also shown for reference.

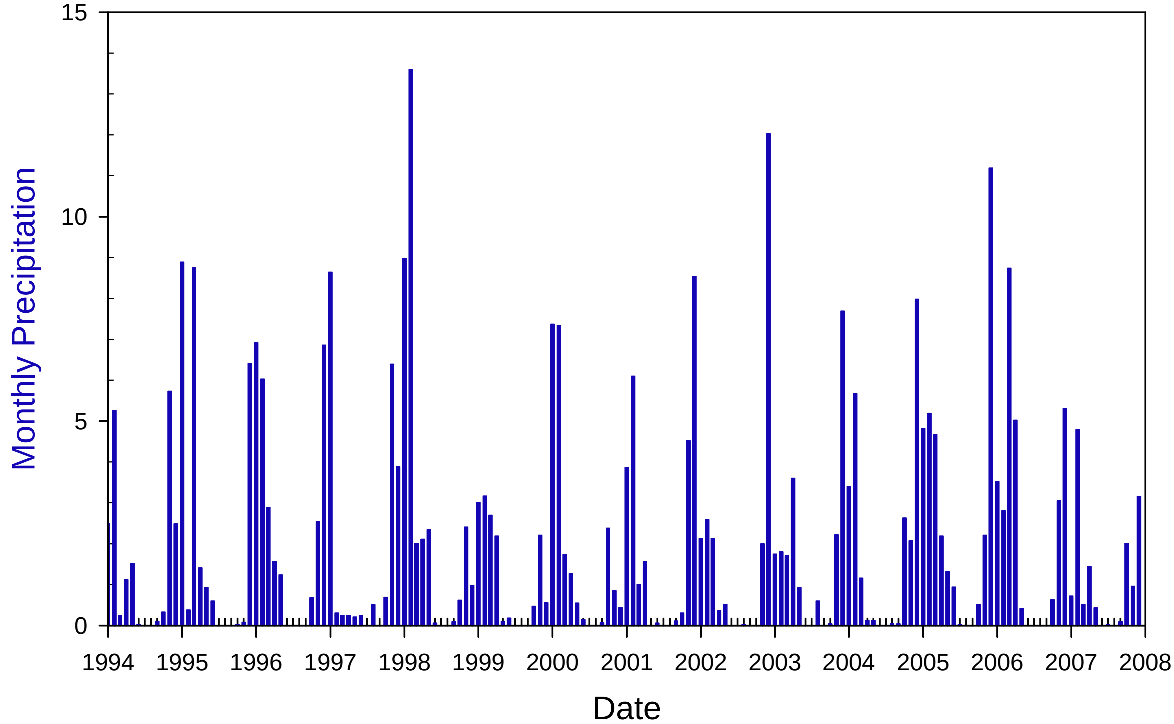


Figure 2. Precipitation

Data from San Mateo gauge station from 1994 through 2007. Precipitation is in inches.

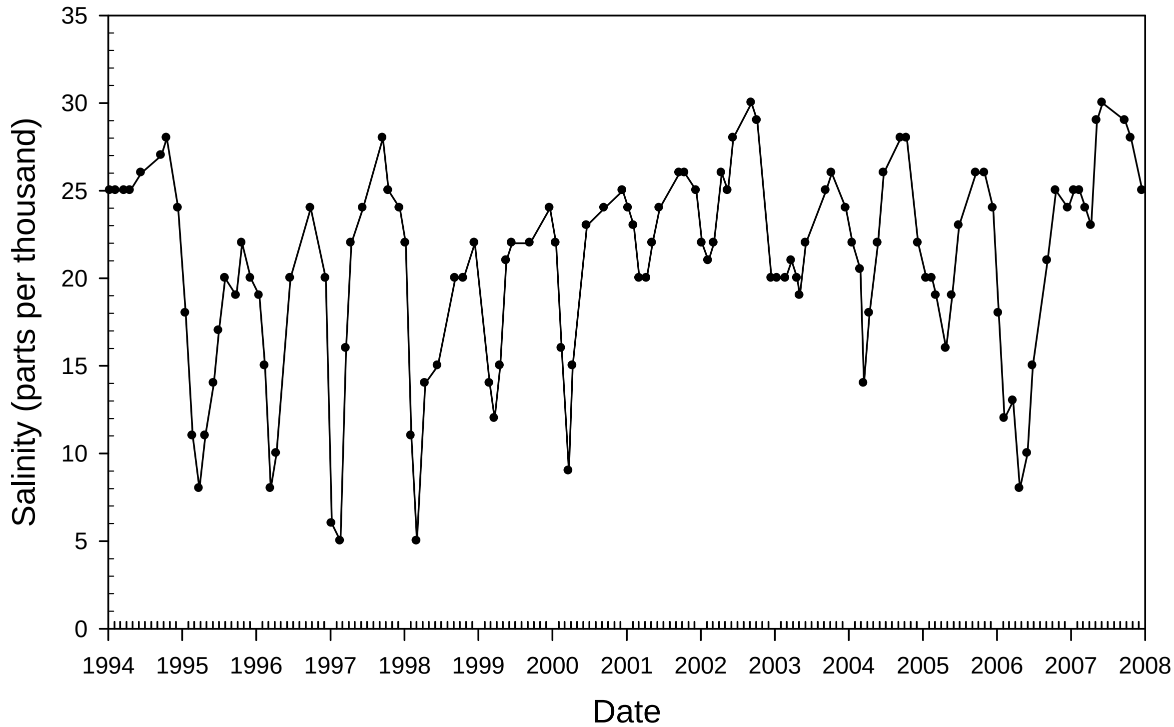


Figure 3. Water column salinity

Data from Palo Alto site from 1994 through 2007.

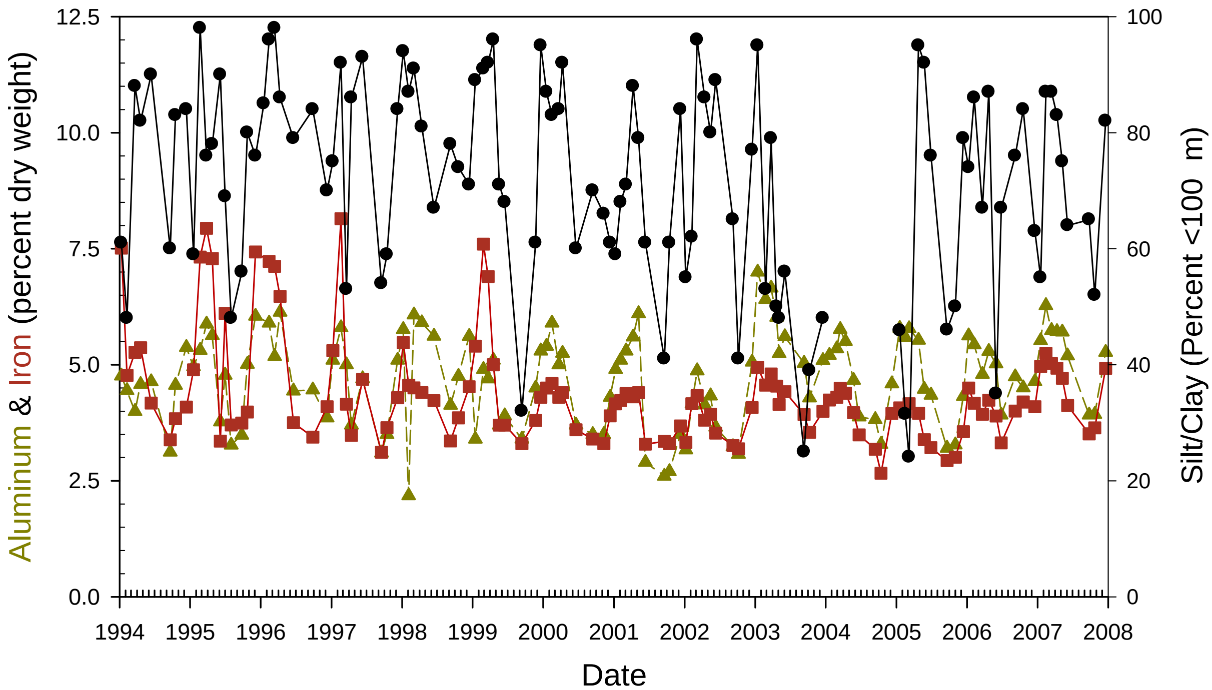


Figure 4. Aluminum, iron and silt/clay in sediments

Data are for the period from 1994 through 2007. Percent aluminum (▲) iron (■) (extracted by near-total digest) and silt/clay (<100µm) (●). 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.

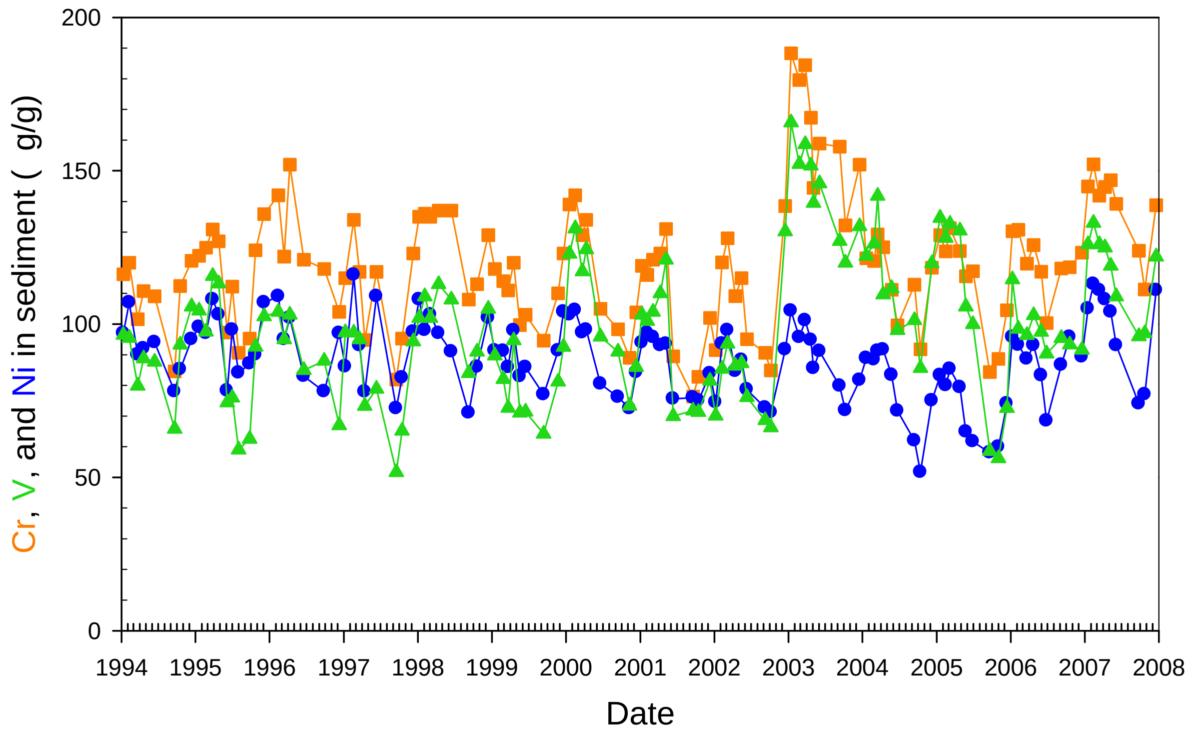


Figure 5. Chromium, nickel and vanadium in sediments

Data are for the period from 1994 through 2007. Concentrations of chromium (Cr) (■), nickel (Ni) (●) and vanadium (V) (▲) extracted by near-total digest.

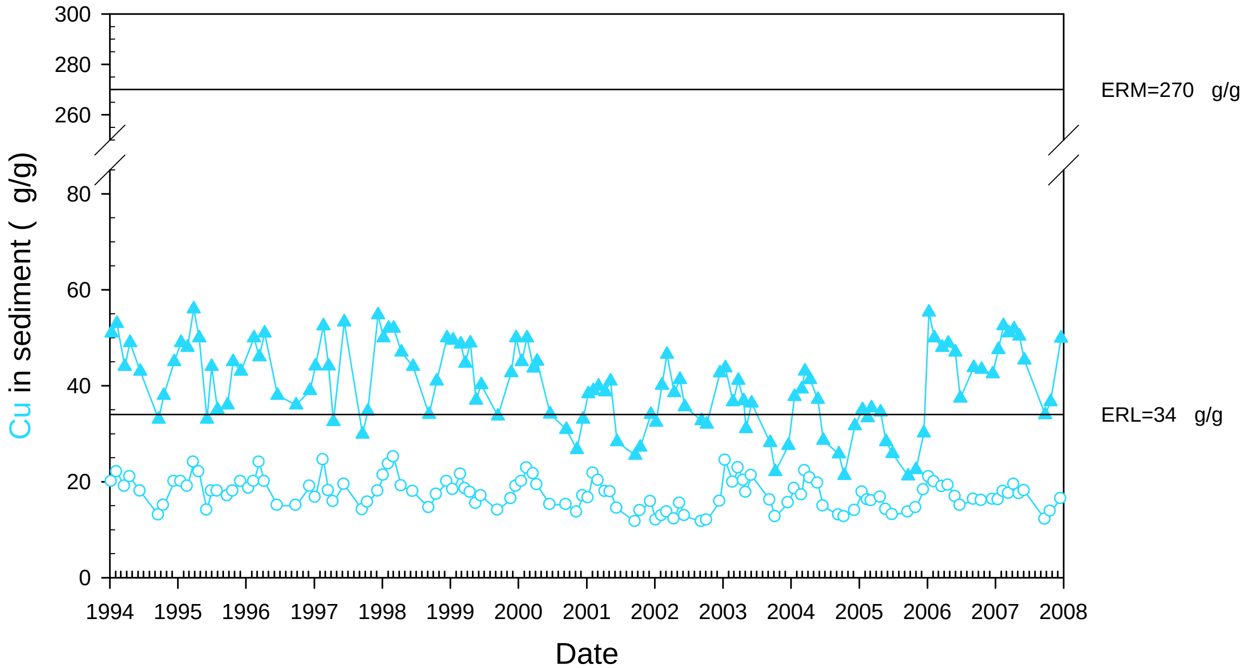


Figure 6. Copper in sediments

Data are for the period from 1994 through 2007. Near-total (▲) and partial-extractable (○) copper.

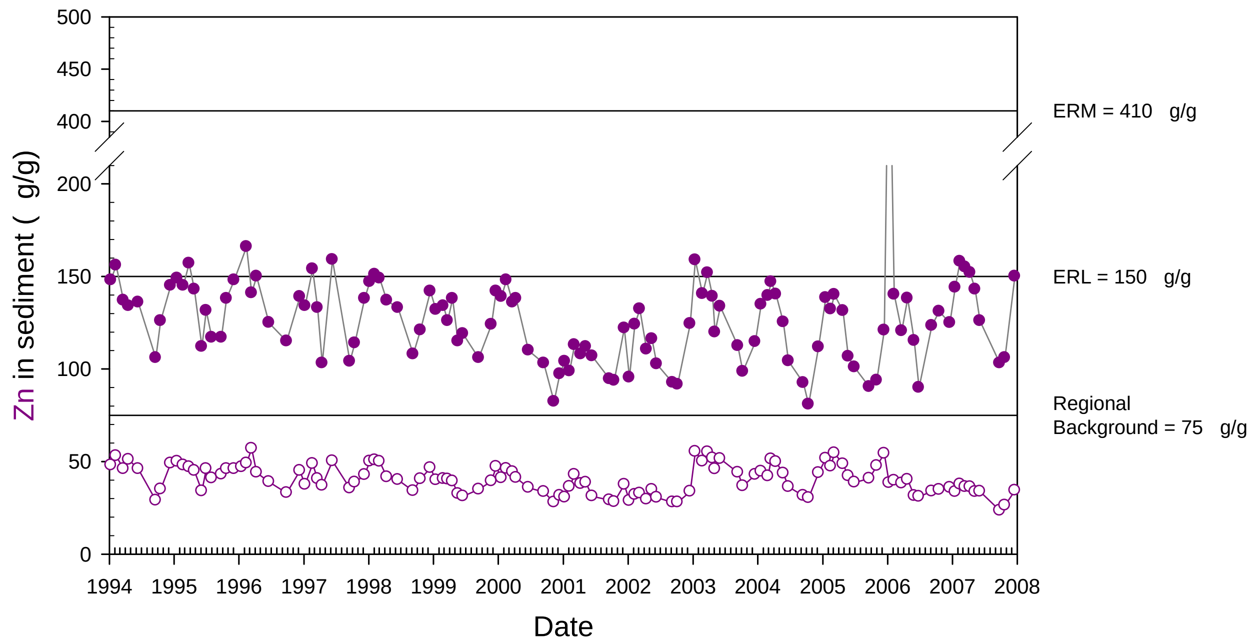


Figure 7. Zinc in sediments

Data are for the period from 1994 through 2007. Near-total (●) and partial-extractable (○) zinc.

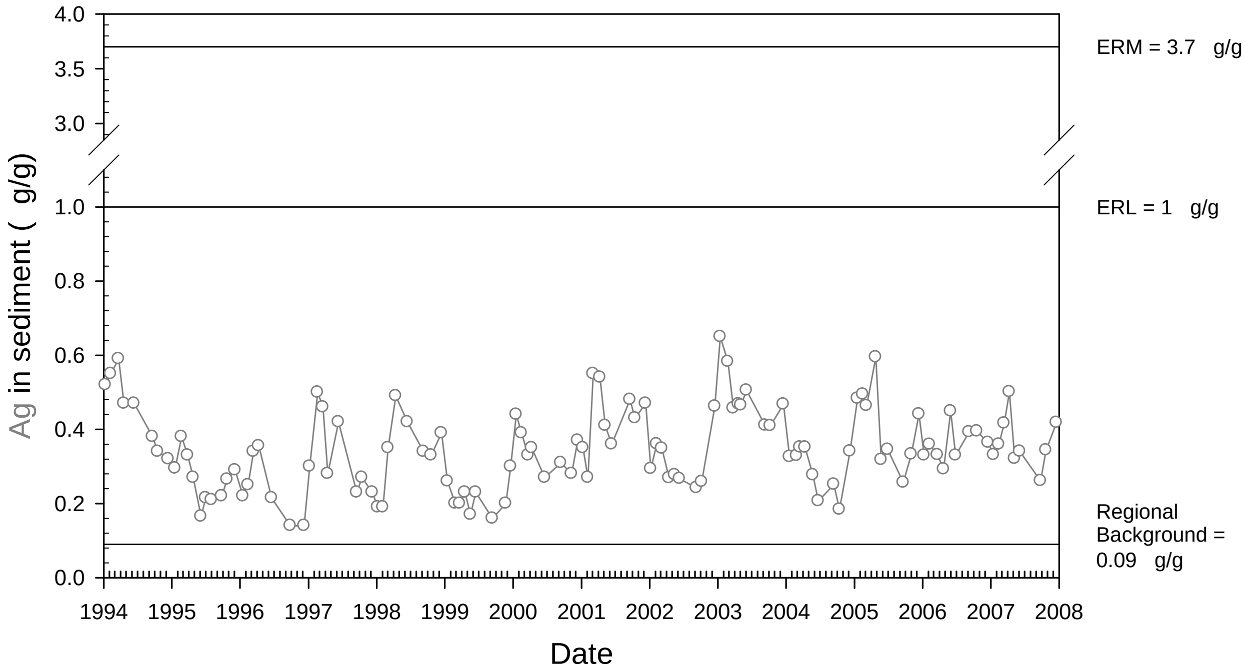


Figure 8. Silver in sediments

Data are for the period from 1994 through 2007. Data represent partial-extractable silver (treatment with 0.6 N hydrochloric acid).

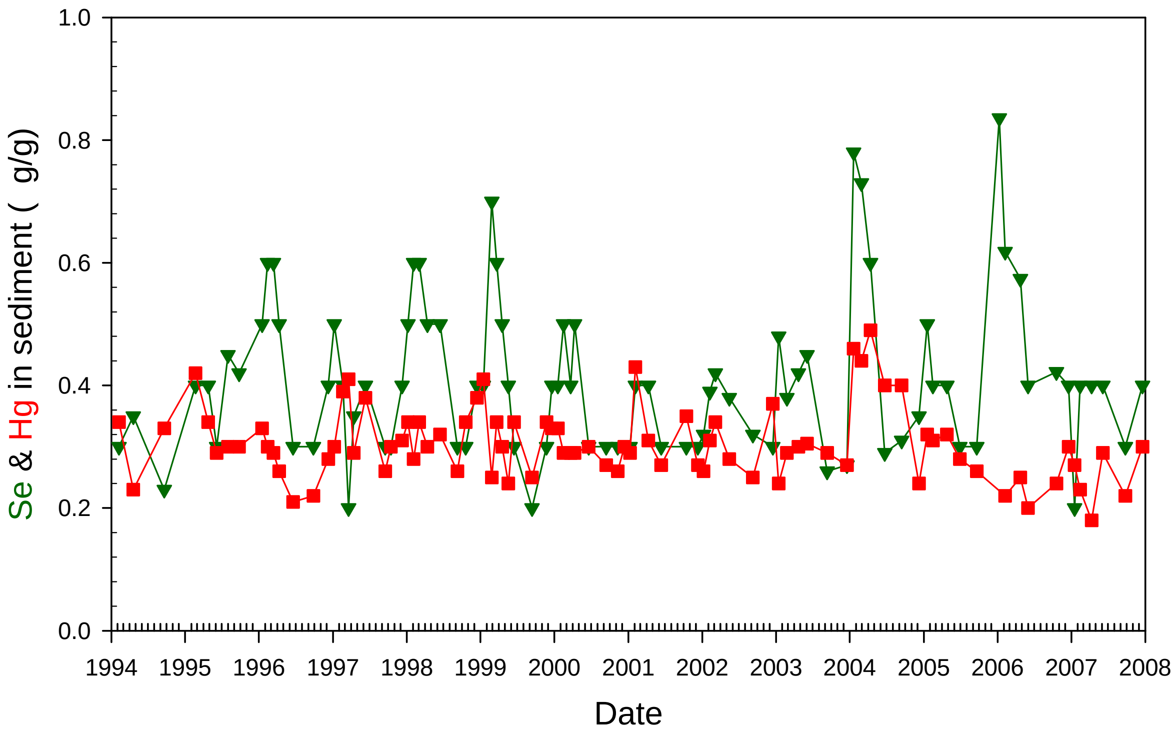


Figure 9. Selenium and mercury in sediments

Data are for the period from 1994 through 2007. Selenium (▼); mercury (■).

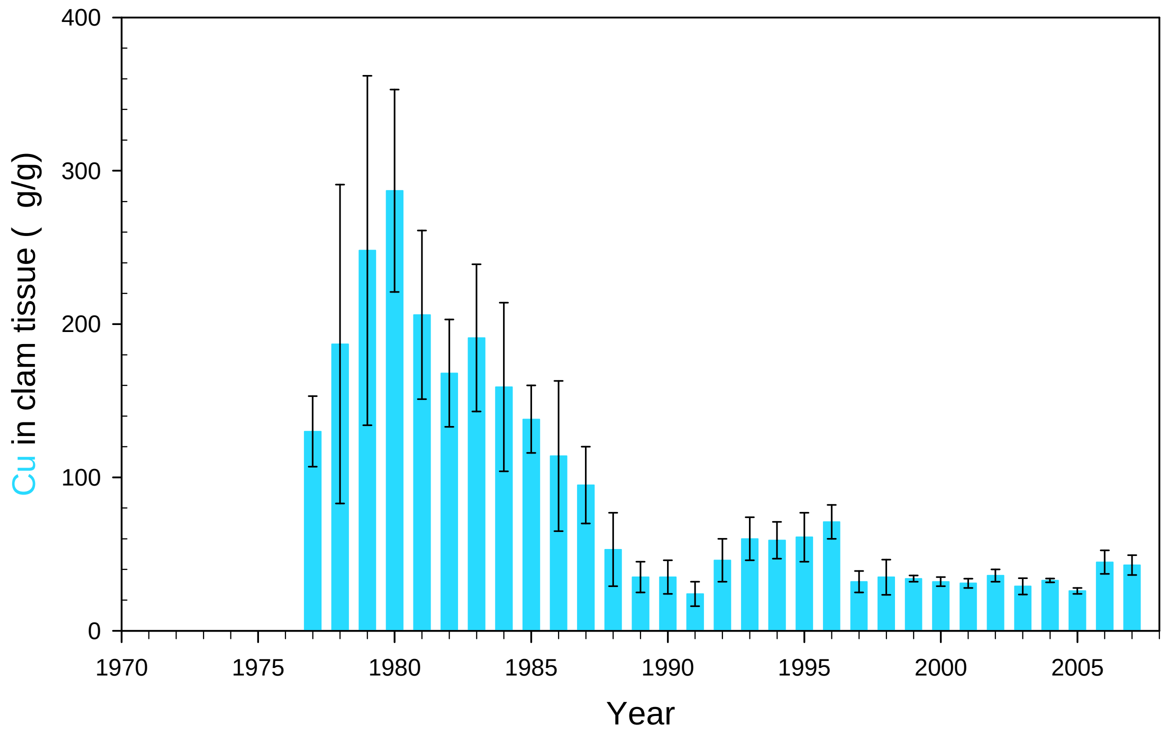


Figure 10. Annual mean copper in *Macoma petalum*

Data are for the period from 1977 through 2007. The error bars are the standard error of the mean (SEM).

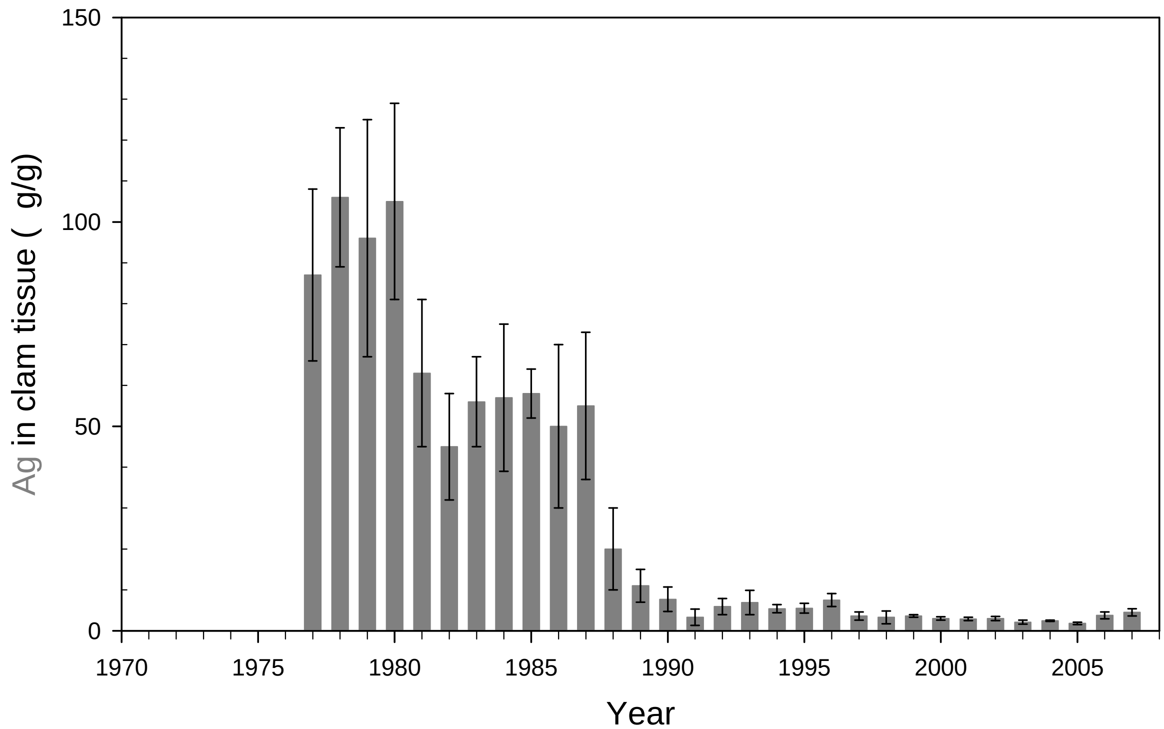


Figure 11. Annual mean silver in *Macoma petalum*

Data are for the period from 1977 through 2007. The error bars are the standard error of the mean (SEM).

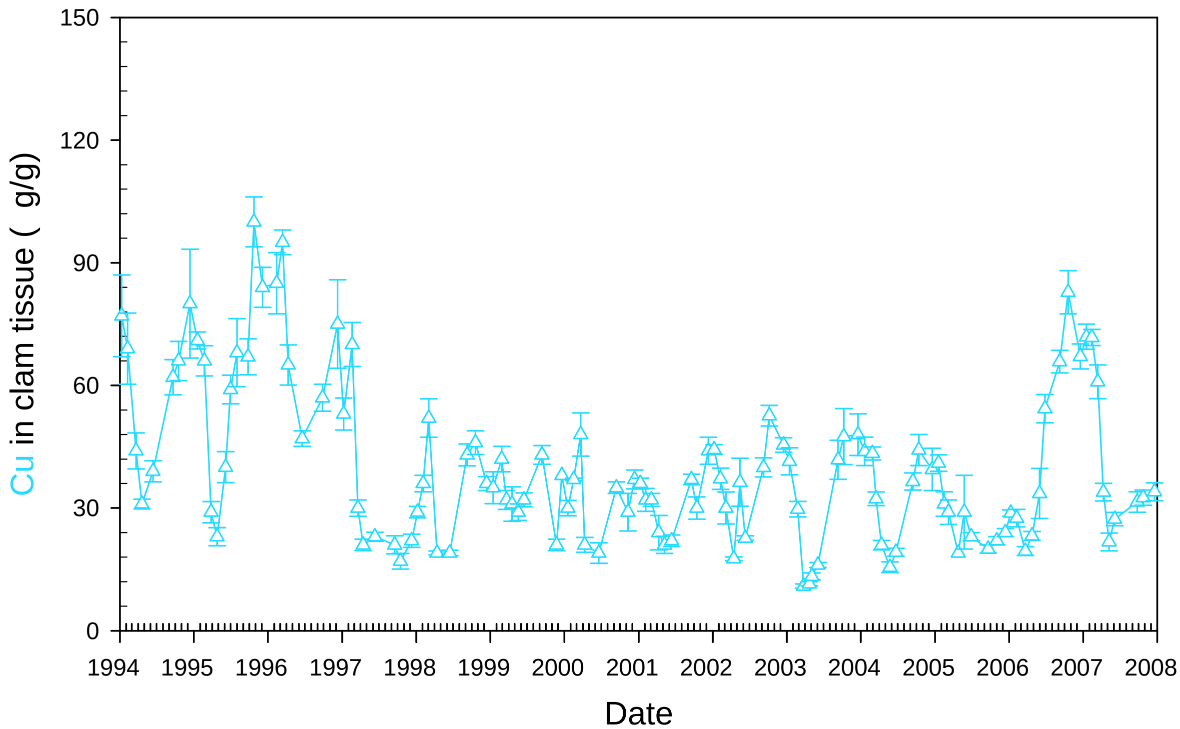


Figure 12. Copper in *Macoma petalum*

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).

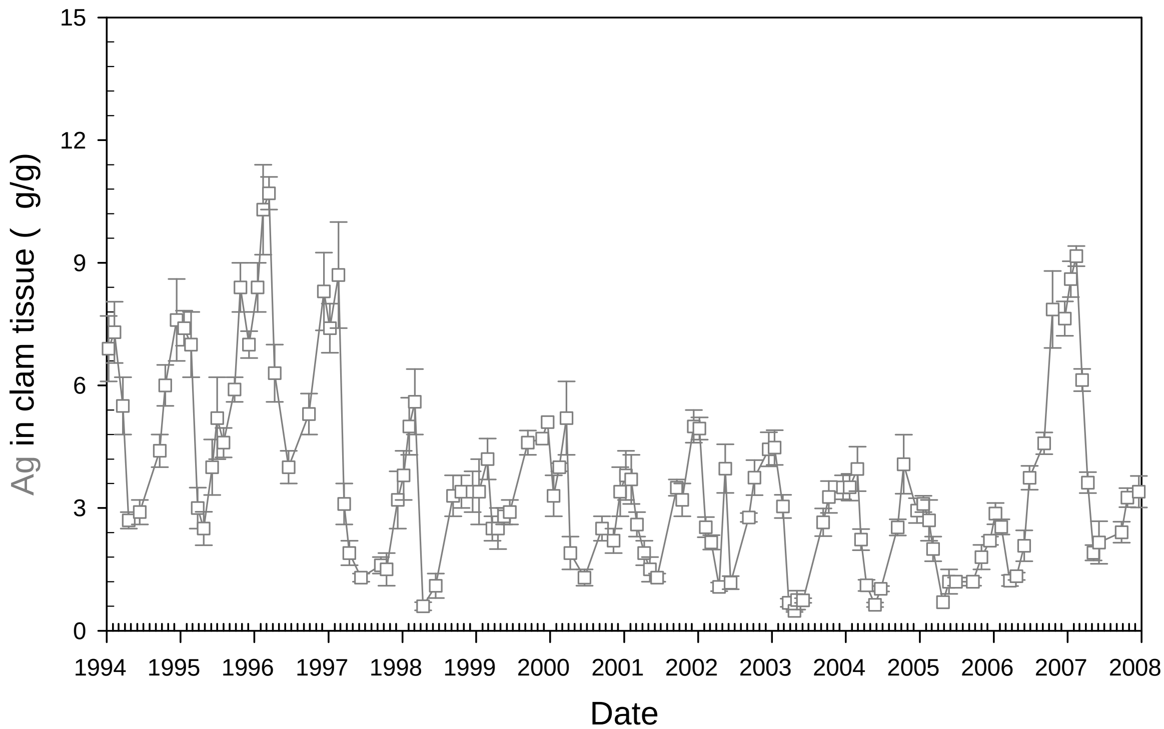


Figure 13. Silver in *Macoma petalum*

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).

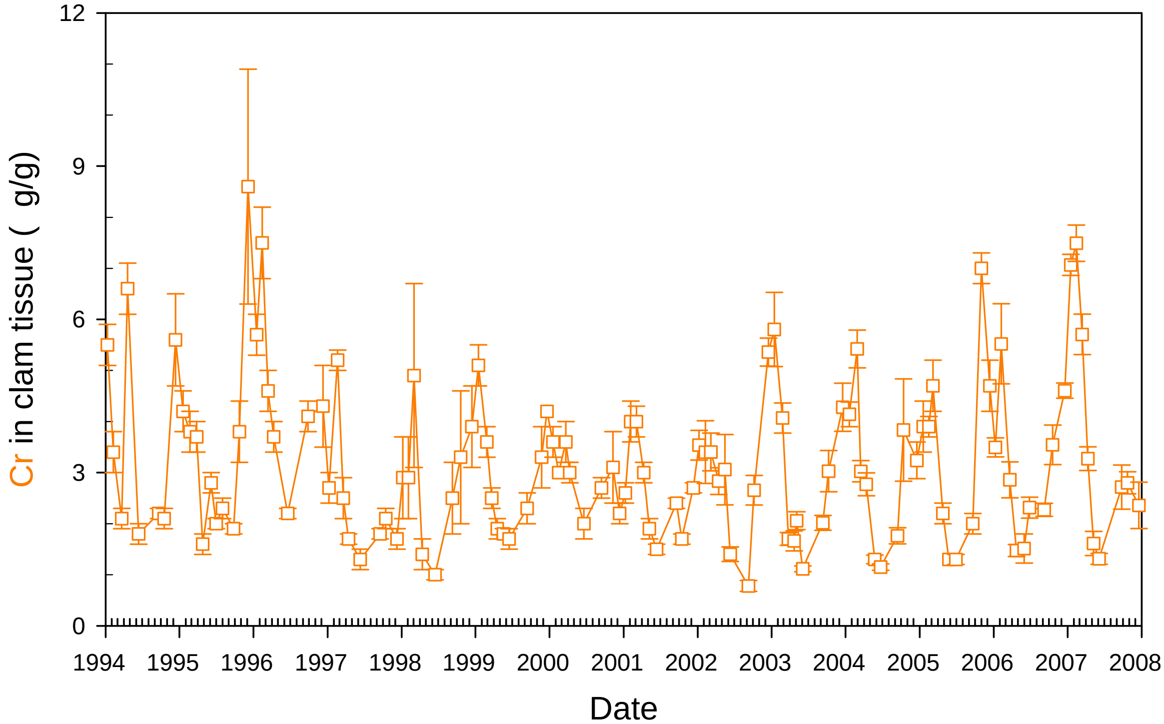


Figure 14. Chromium in *Macoma petalum*

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).

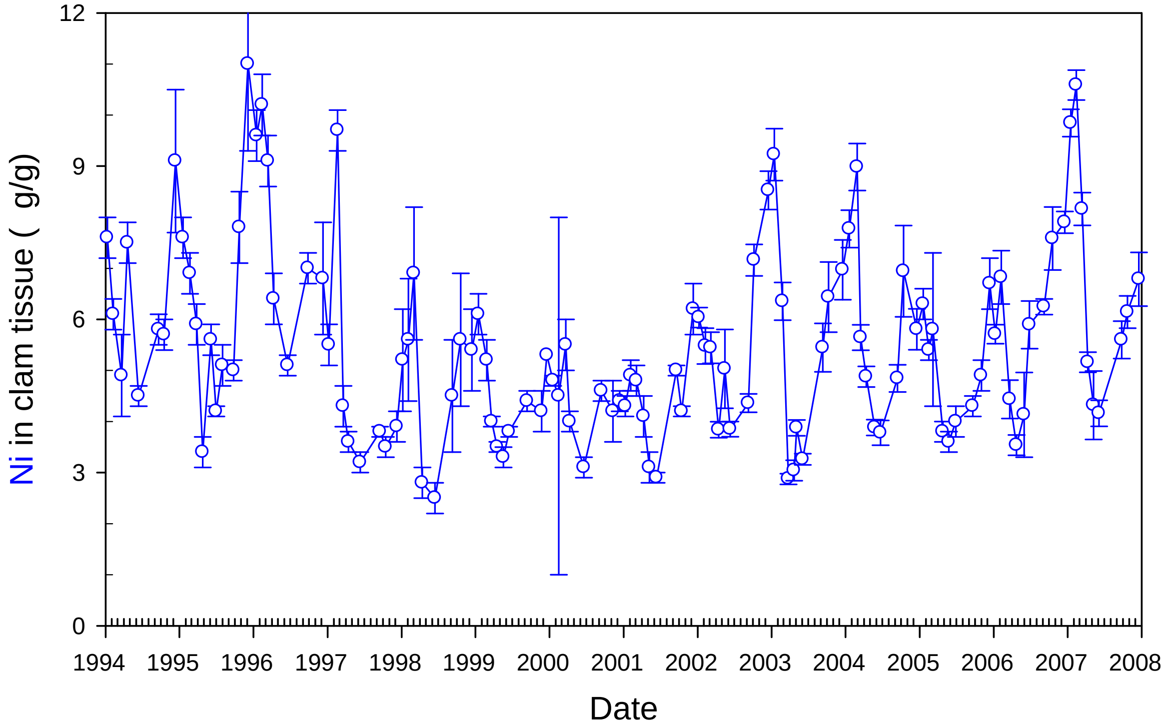


Figure 15. Nickel in *Macoma petalum*

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).

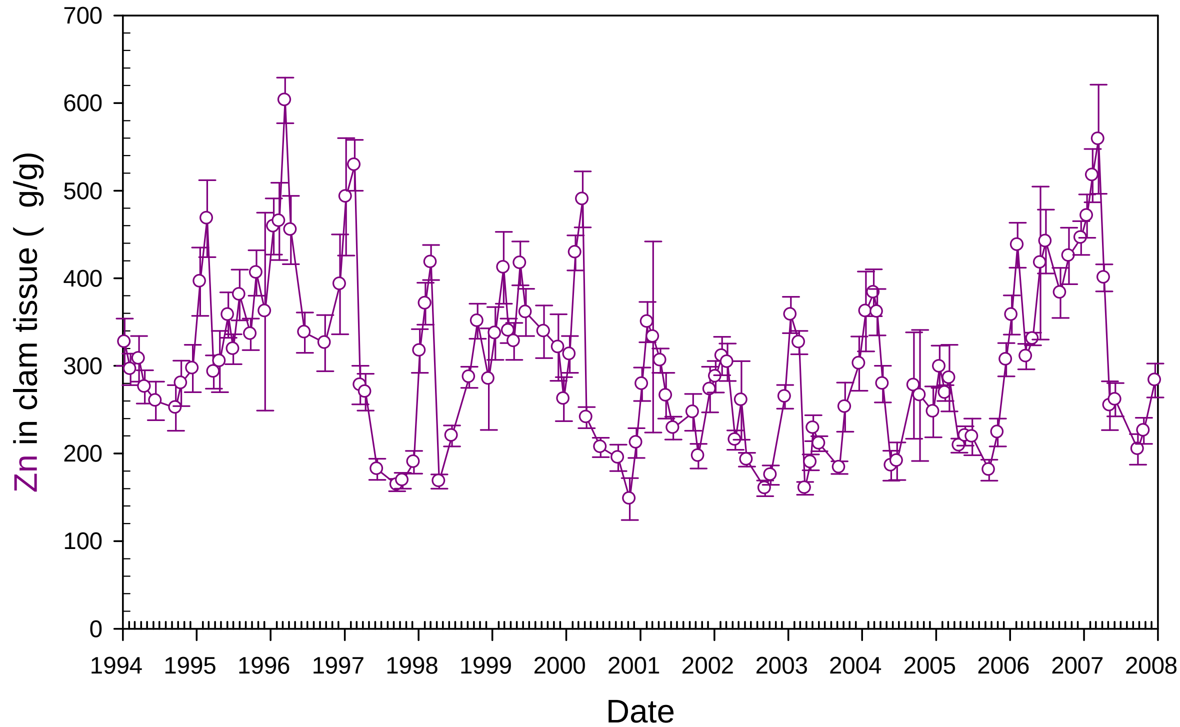


Figure 16. Zinc in *Macoma petalum*

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).

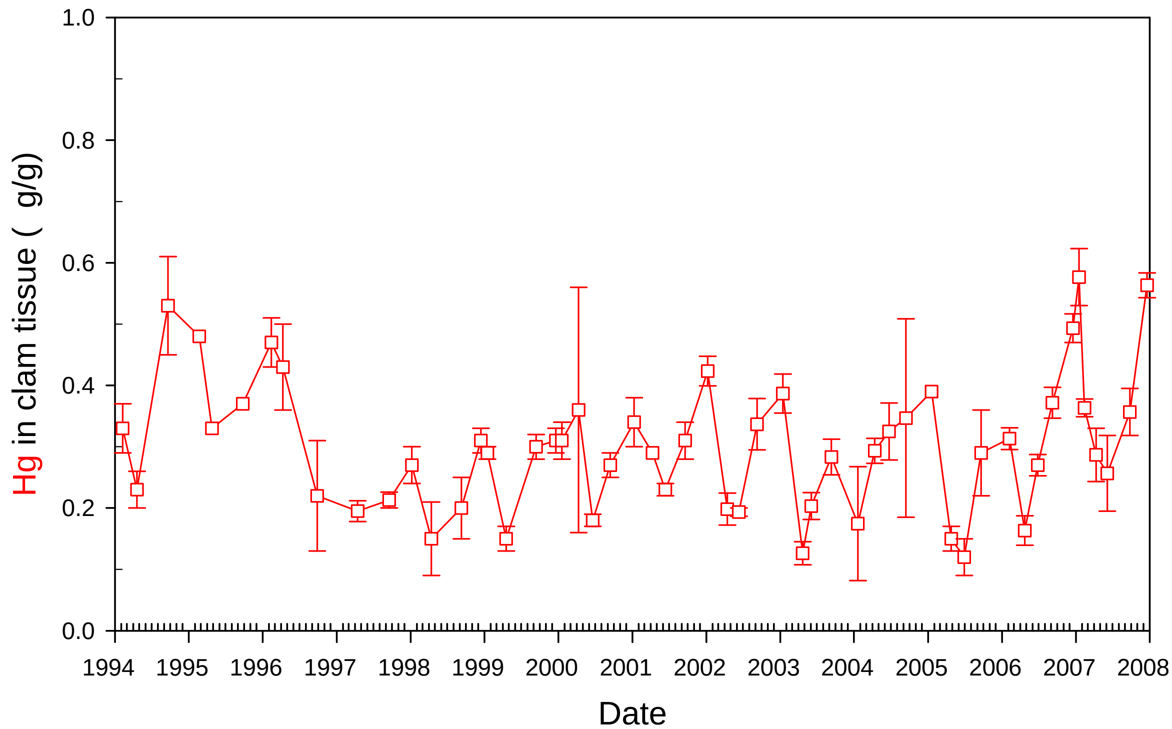


Figure 17. Mercury in *Macoma petalum*

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).

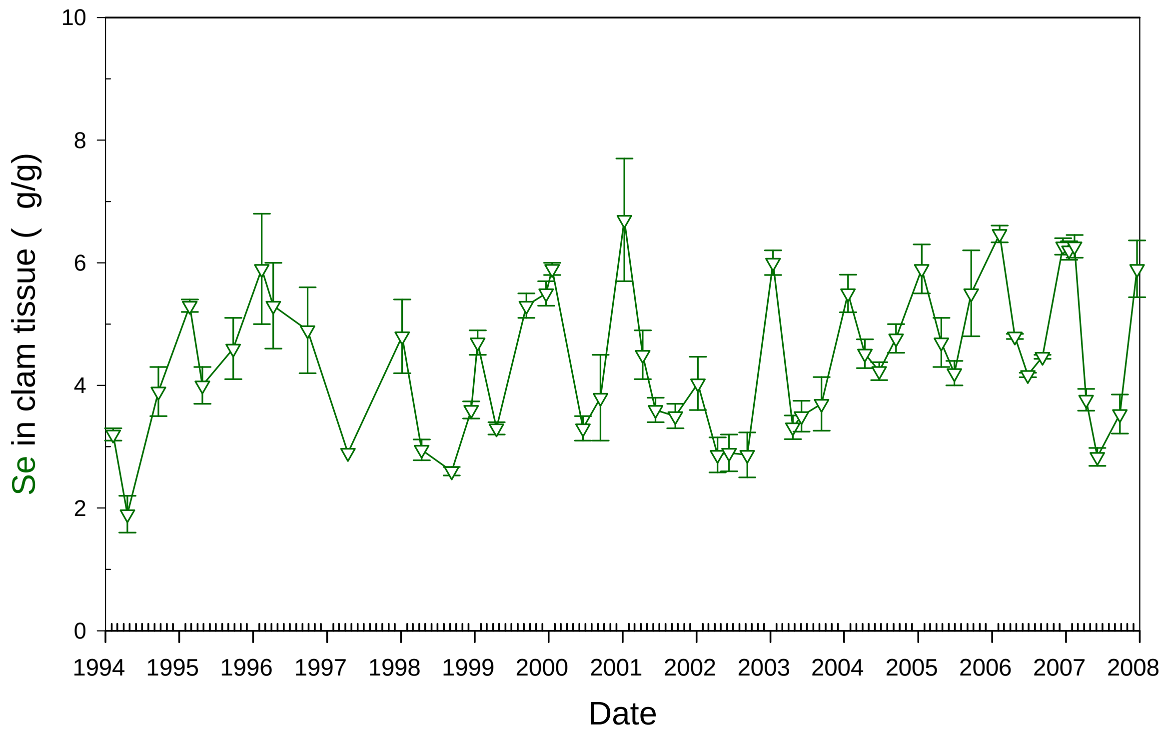


Figure 18. Selenium in *Macoma petalum*

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).

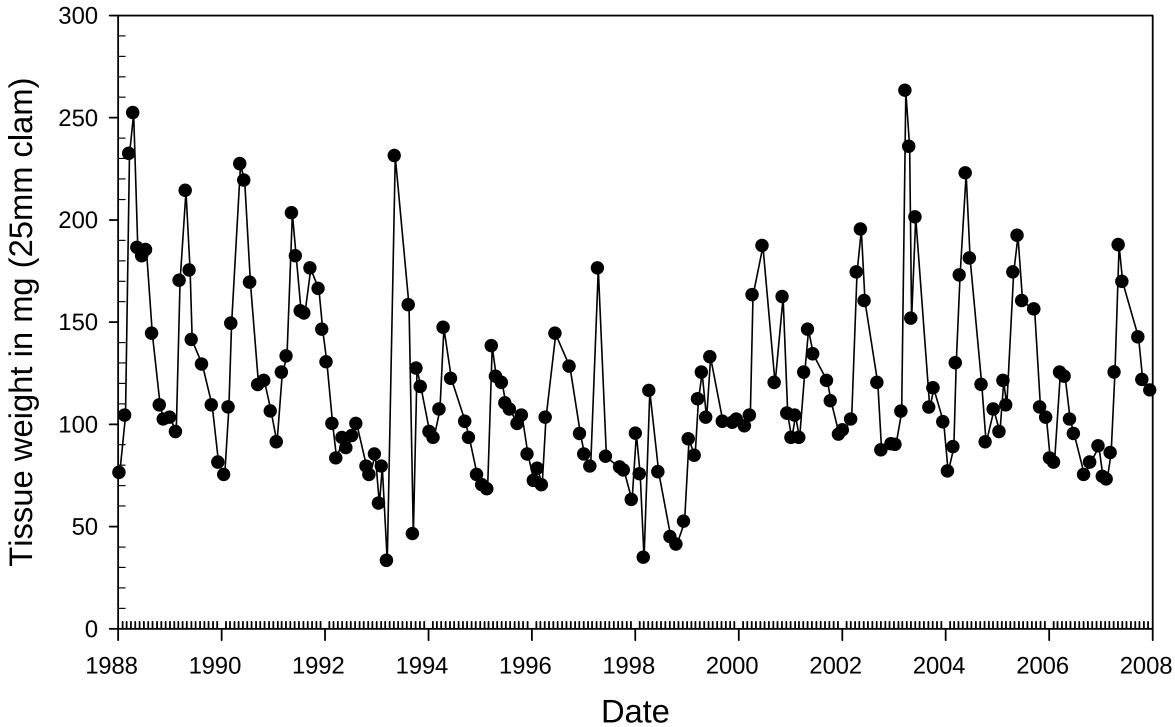


Figure 19. Condition index of *Macoma petalum*

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

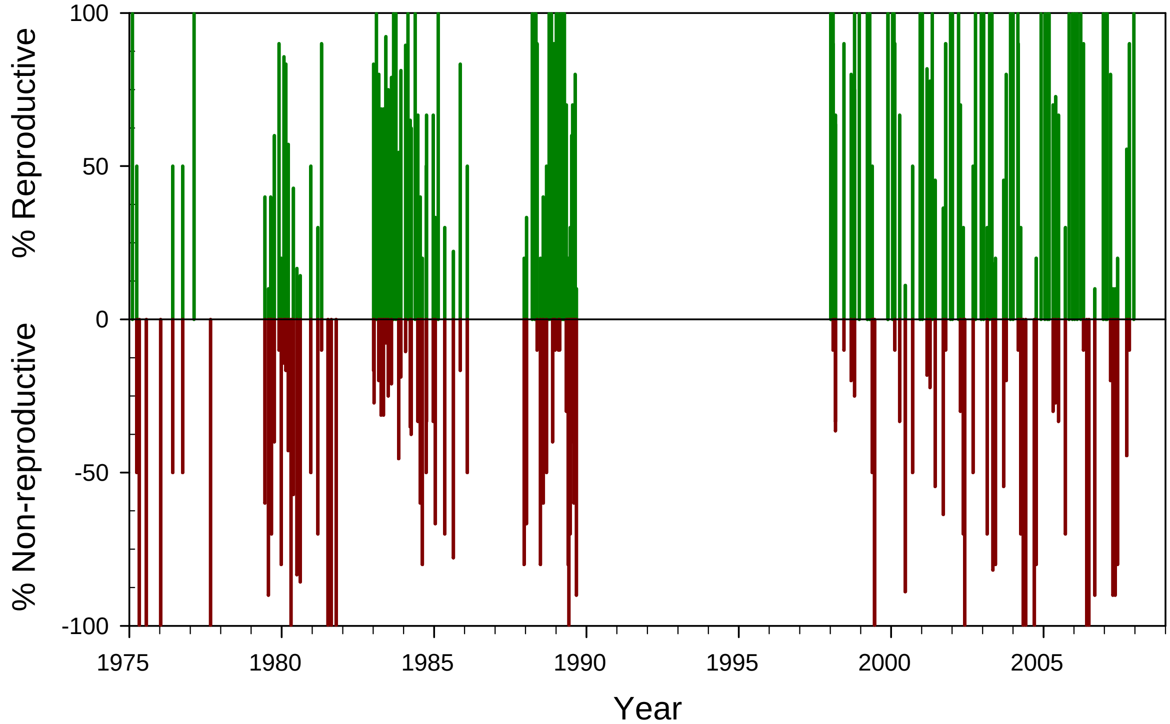


Figure 20. Reproductive activity of *Macoma petalum*

Data are for the period from 1974 through 2007.

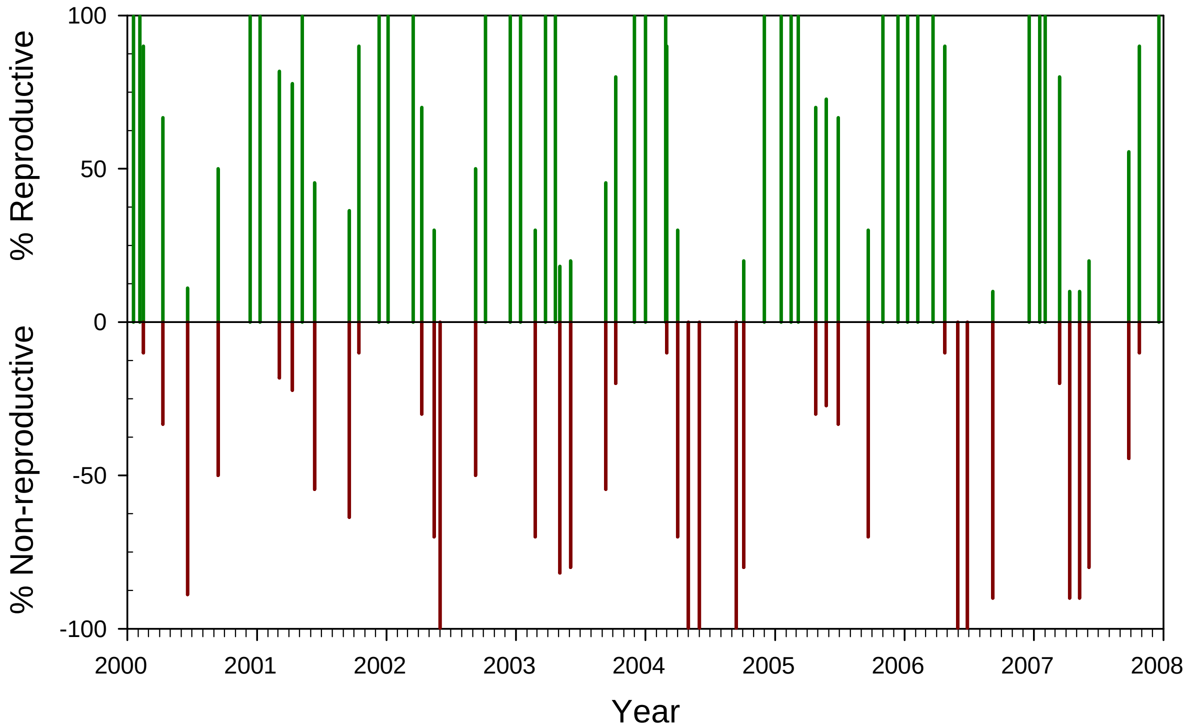


Figure 21. Reproductive activity of *Macoma petalum* 2000 through 2007.

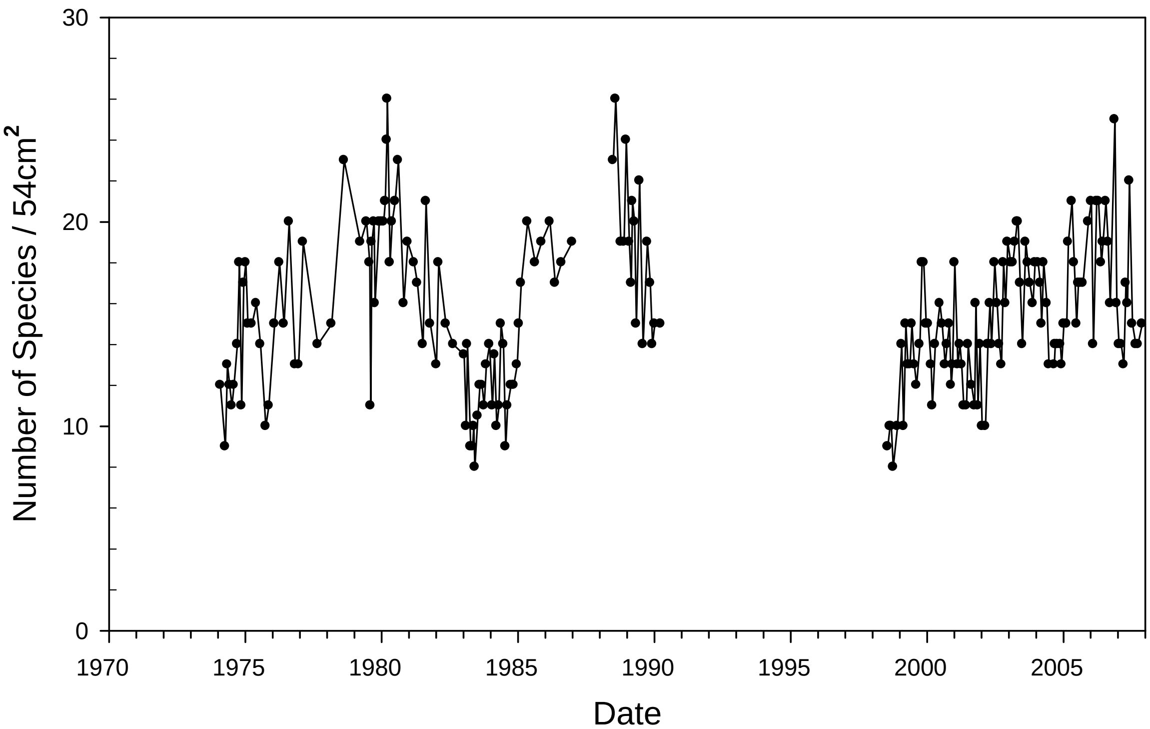


Figure 22. Total number of species present

Data are for the period from 1974 through 2007.

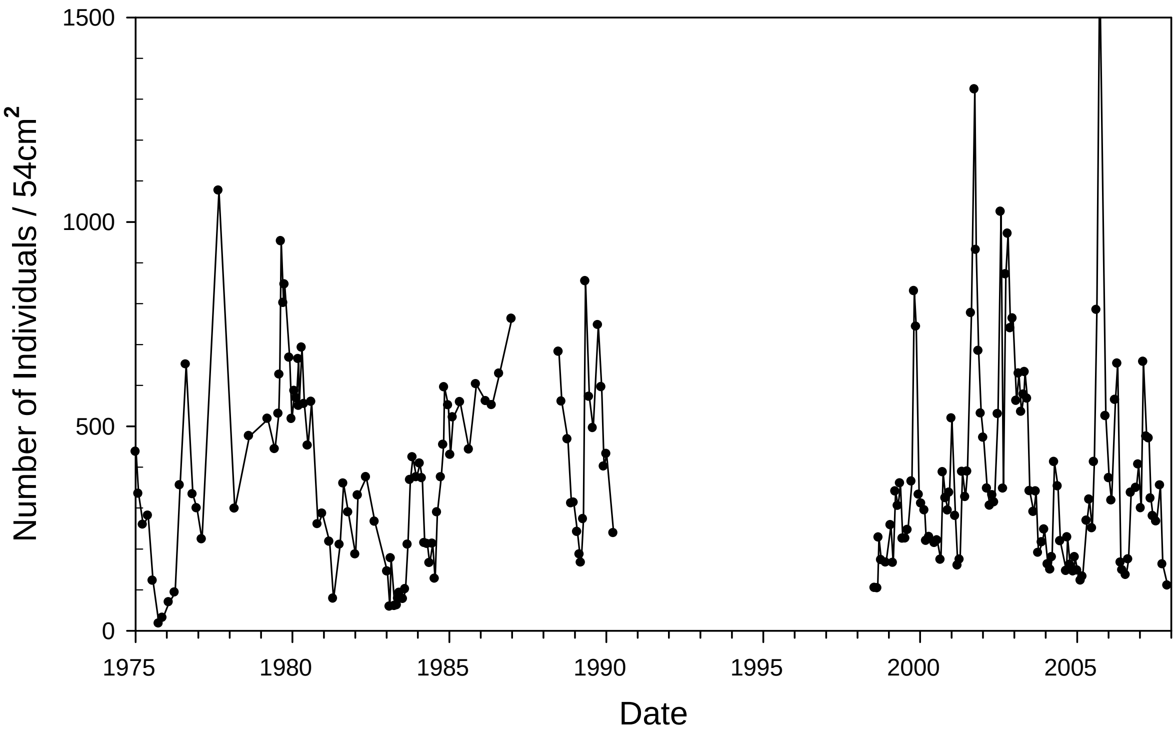


Figure 23. Total average number of individuals present

Data are for the period from 1974 through 2007.

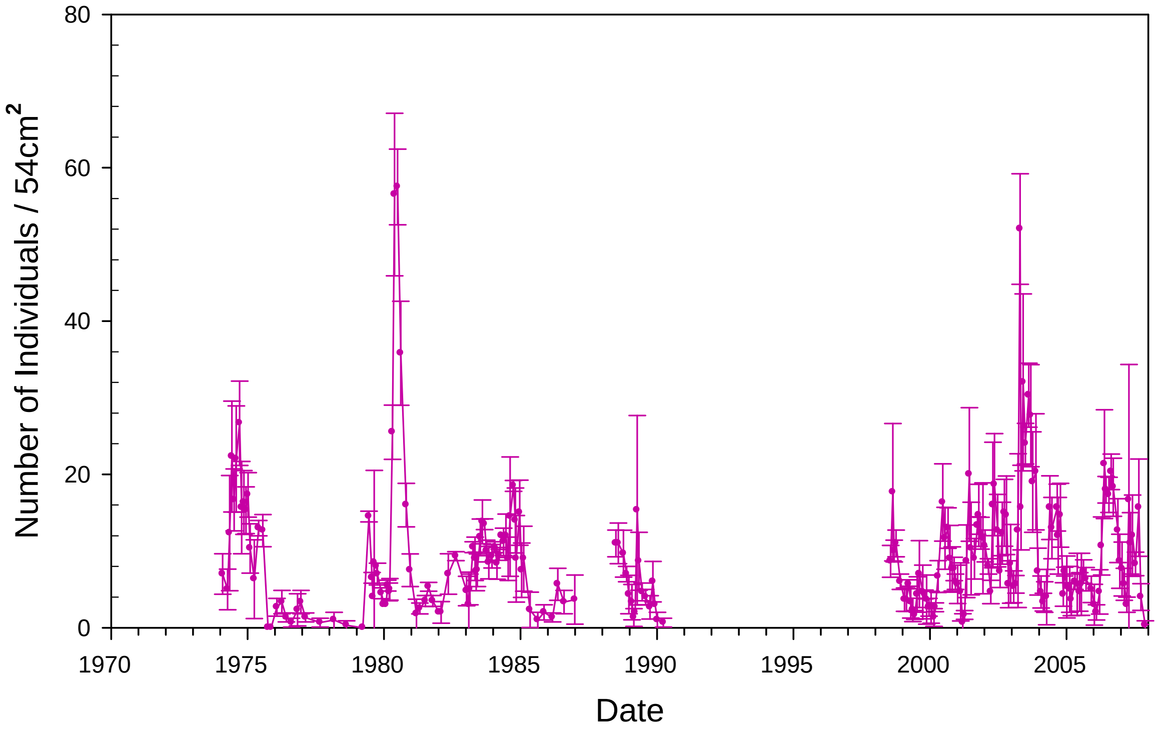


Figure 24. Average abundance of *Macoma petalum*

Data are for the period from 1974 through 2007. Error bars represent standard deviation from 3 replicate samplings.

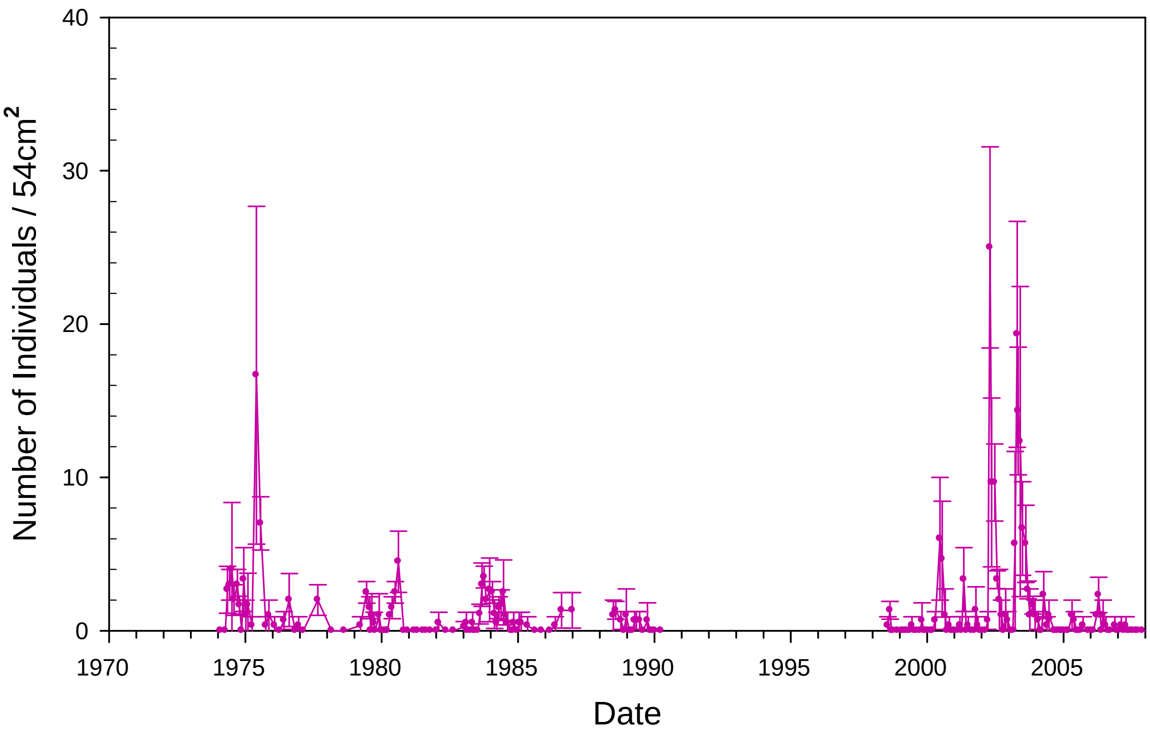


Figure 25. Average abundance of *Mya arenaria*

Data are for the period from 1974 through 2007. Error bars represent standard deviation from 3 replicate samplings.

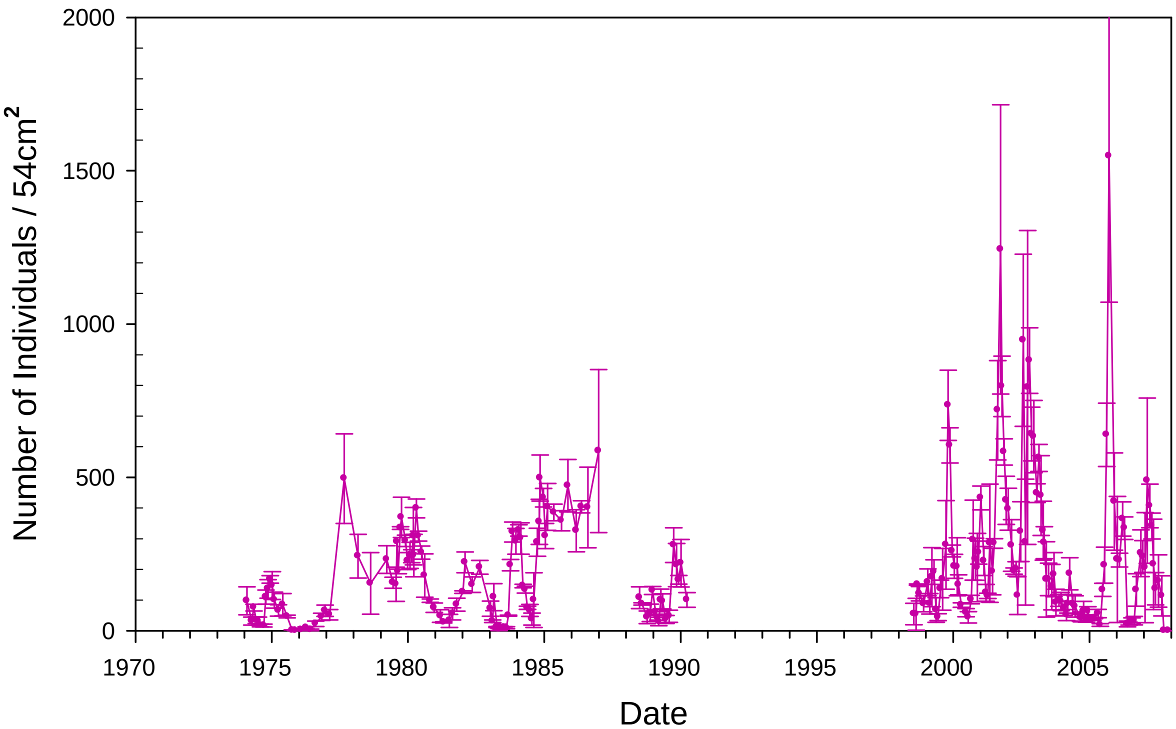


Figure 26. Average abundance of *Gemma gemma*

Data are for the period from 1974 through 2007. Error bars represent standard deviation from 3 replicate samplings.

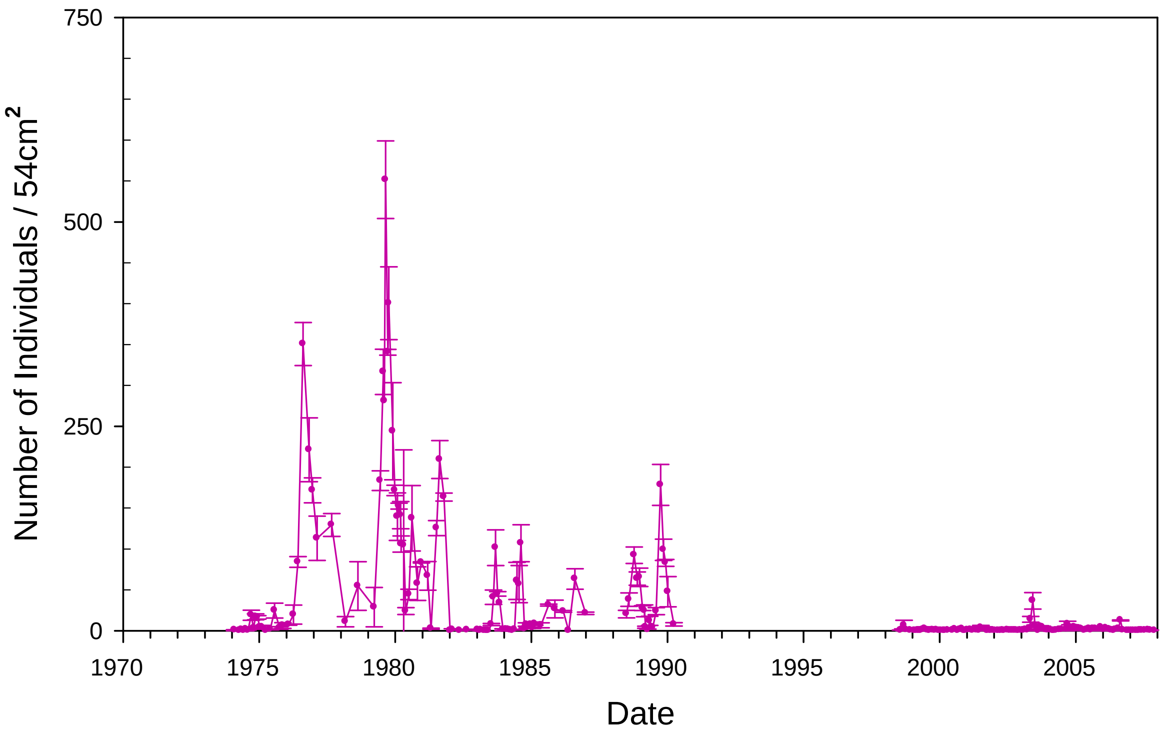


Figure 27. Average abundance of *Ampelisca abdita*

Data are for the period from 1974 through 2007. Error bars represent standard deviation from 3 replicate samplings.

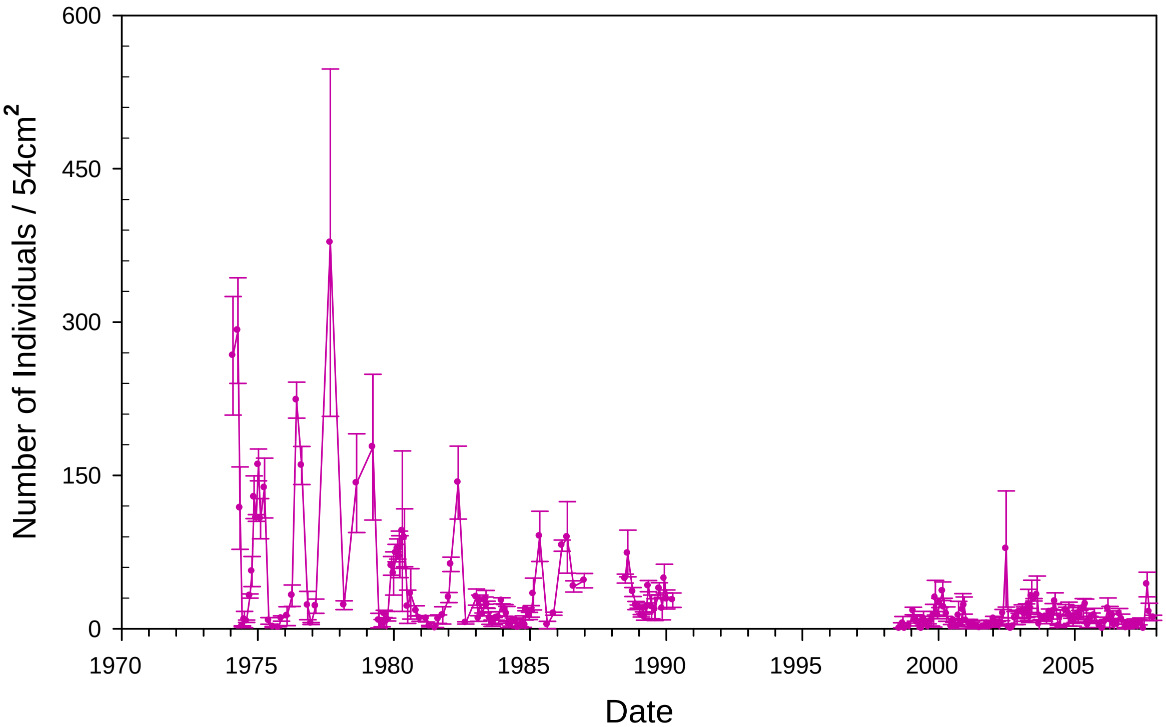


Figure 28. Average abundance of *Streblospio benedicti*

Data are for the period from 1974 through 2007. Error bars represent standard deviation from 3 replicate samplings.

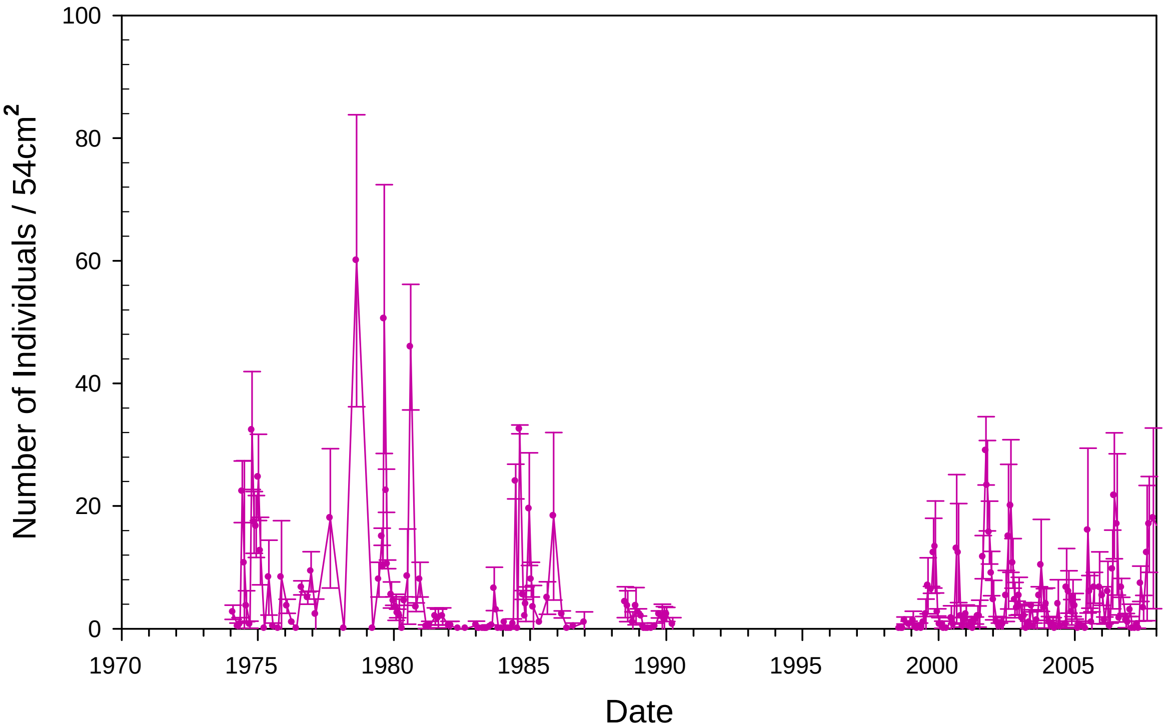


Figure 29. Average abundance of *Grandiderella japonica*

Data are for the period from 1974 through 2007. Error bars represent standard deviation from 3 replicate samplings.

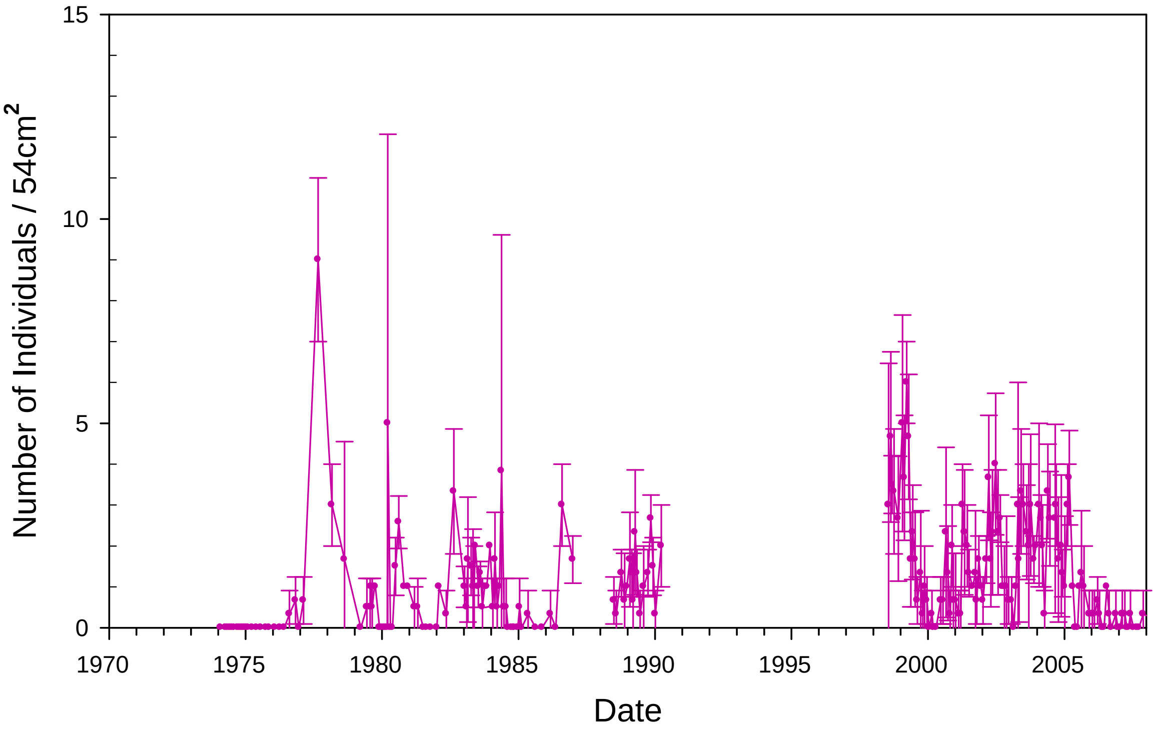


Figure 30. Average abundance of *Neanthes succinea*

Data are for the period from 1974 through 2007. Error bars represent standard deviation from 3 replicate samplings.

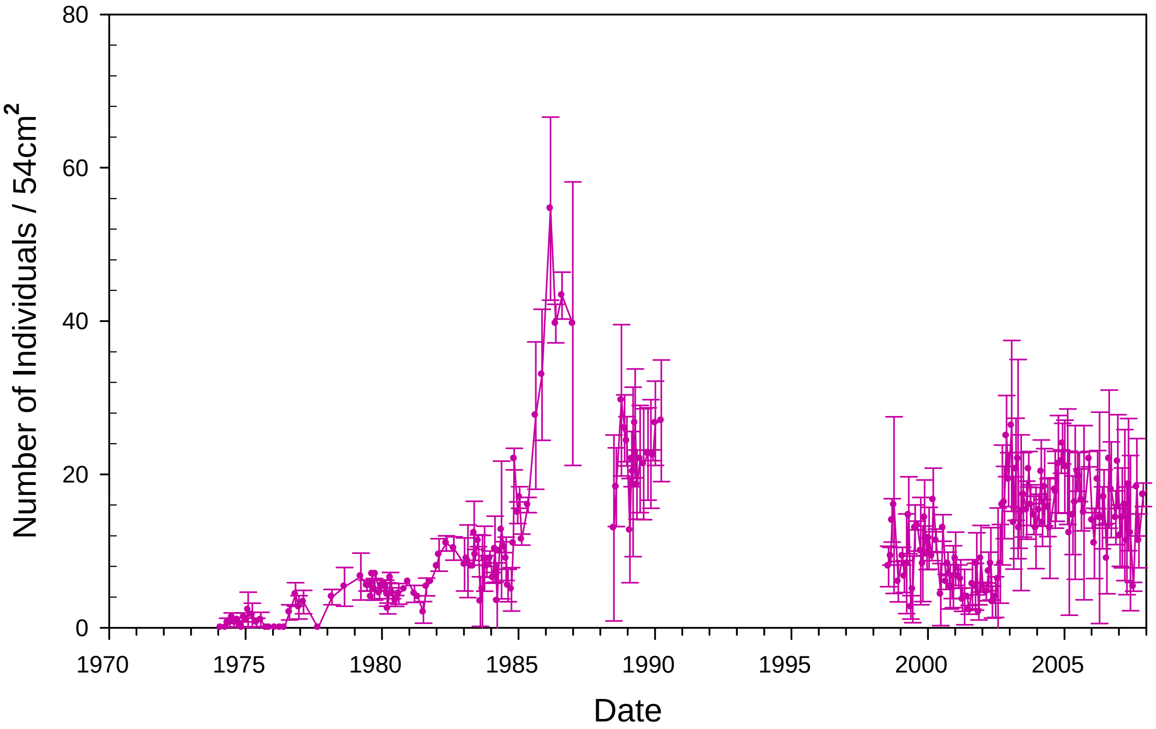


Figure 31. Average abundance of *Heteromastus filiformis*

Data are for the period from 1974 through 2007. Error bars represent standard deviation from 3 replicate samplings.

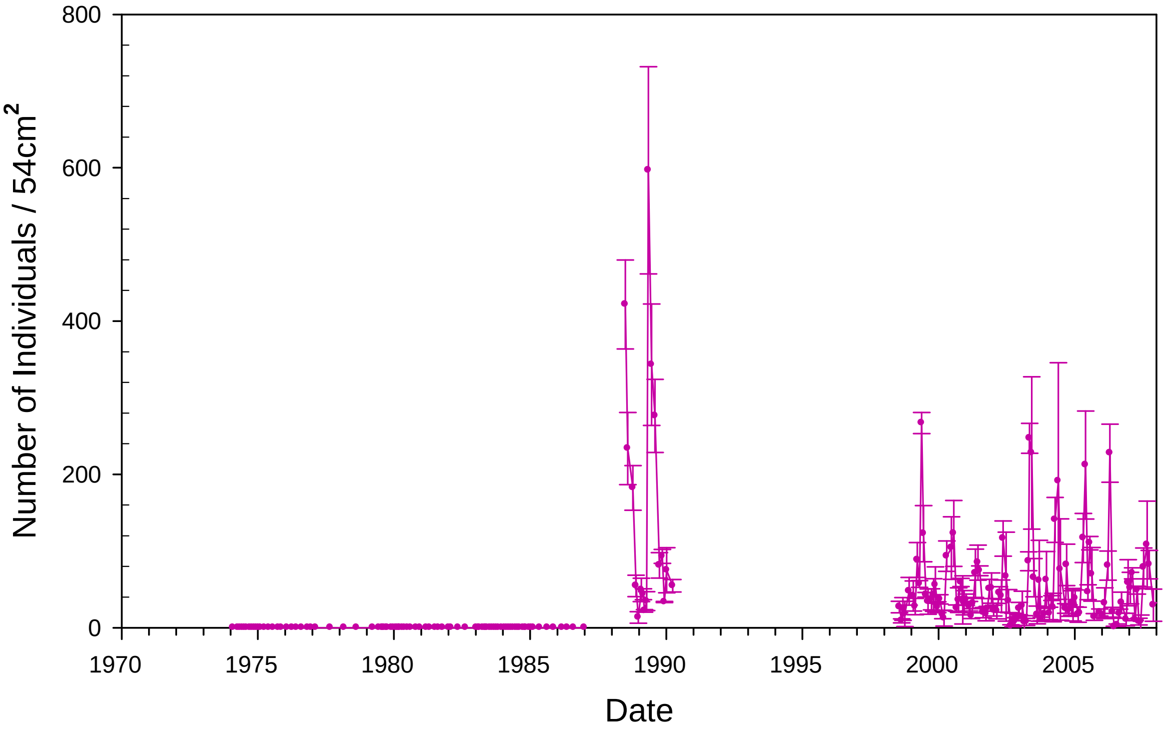


Figure 32. Average abundance of *Nippoleucon hinumensis*

Data are for the period from 1974 through 2007. Error bars represent standard deviation from 3 replicate samplings.

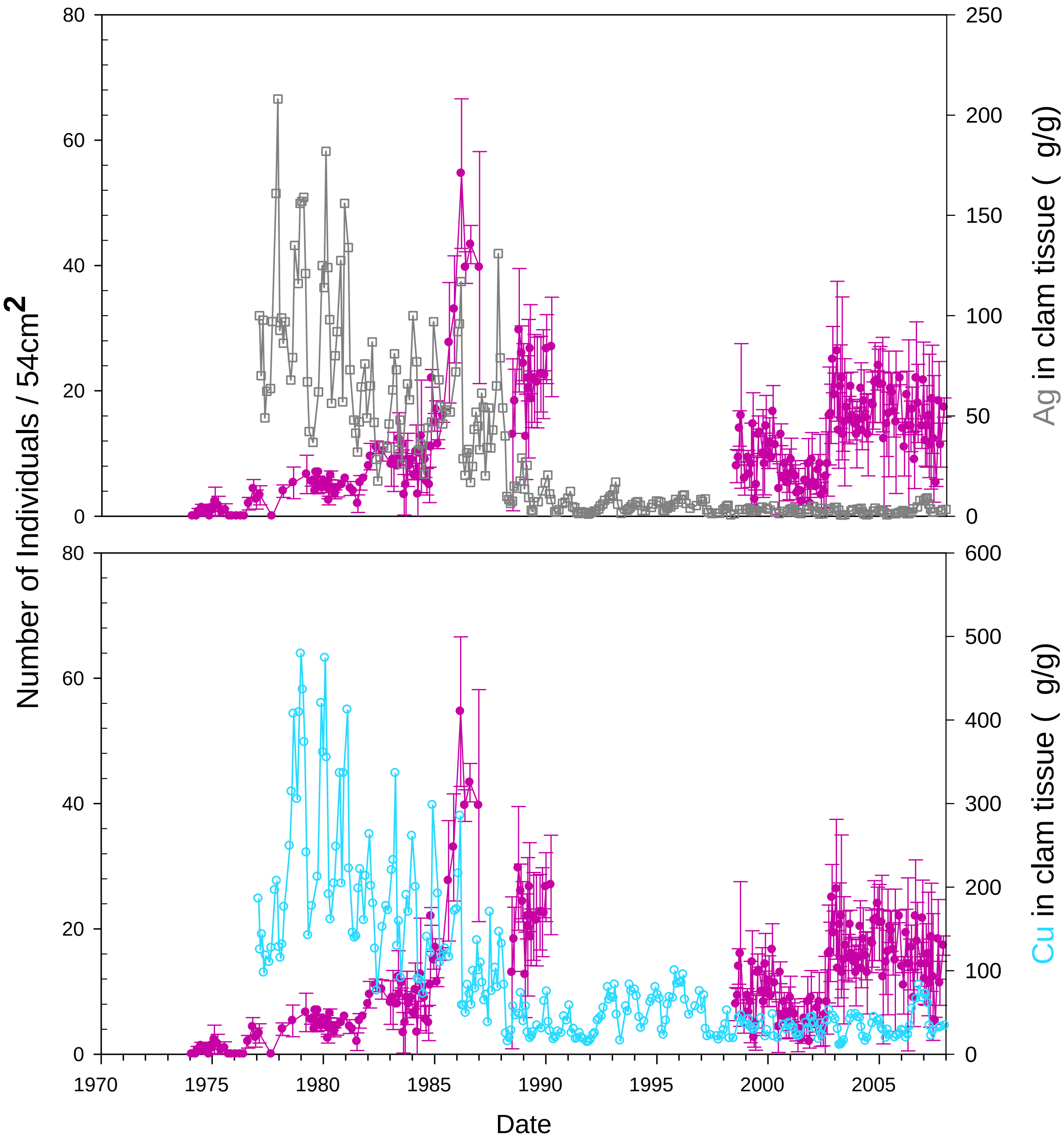


Figure 33. *Heteromastus filiformis* abundance with silver and copper in *Macoma petalum.*

Data are for the period from 1974 through 2007. Error bars represent standard deviation from 3 replicate samplings. The number of individuals (●); tissue concentration of silver (□) and copper (○) in *M. petalum.*

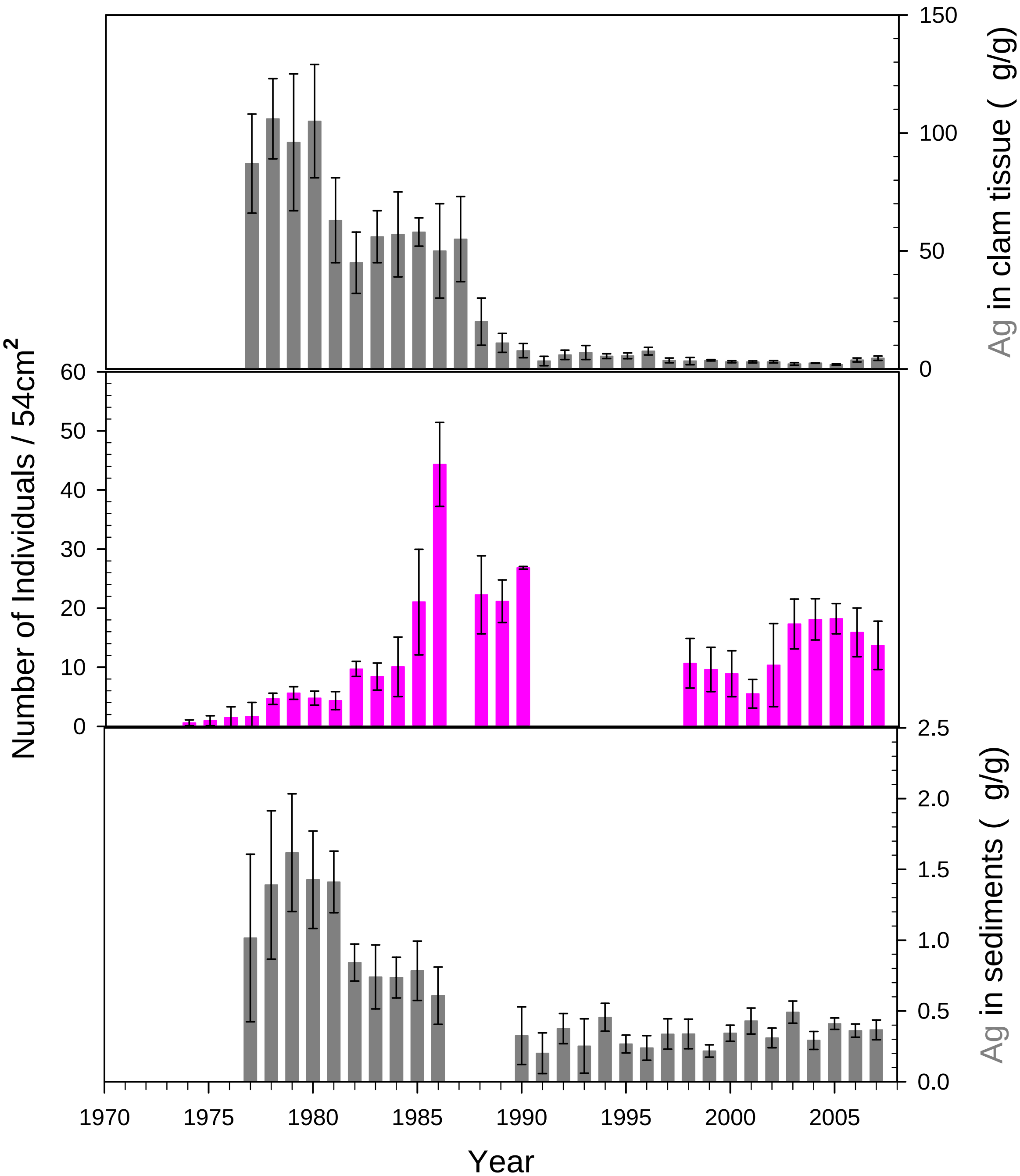


Figure 34. *Heteromastus filiformis* annual abundance with silver in *Macoma petalum* and sediment

Data are for the period from 1974 through 2007. 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).

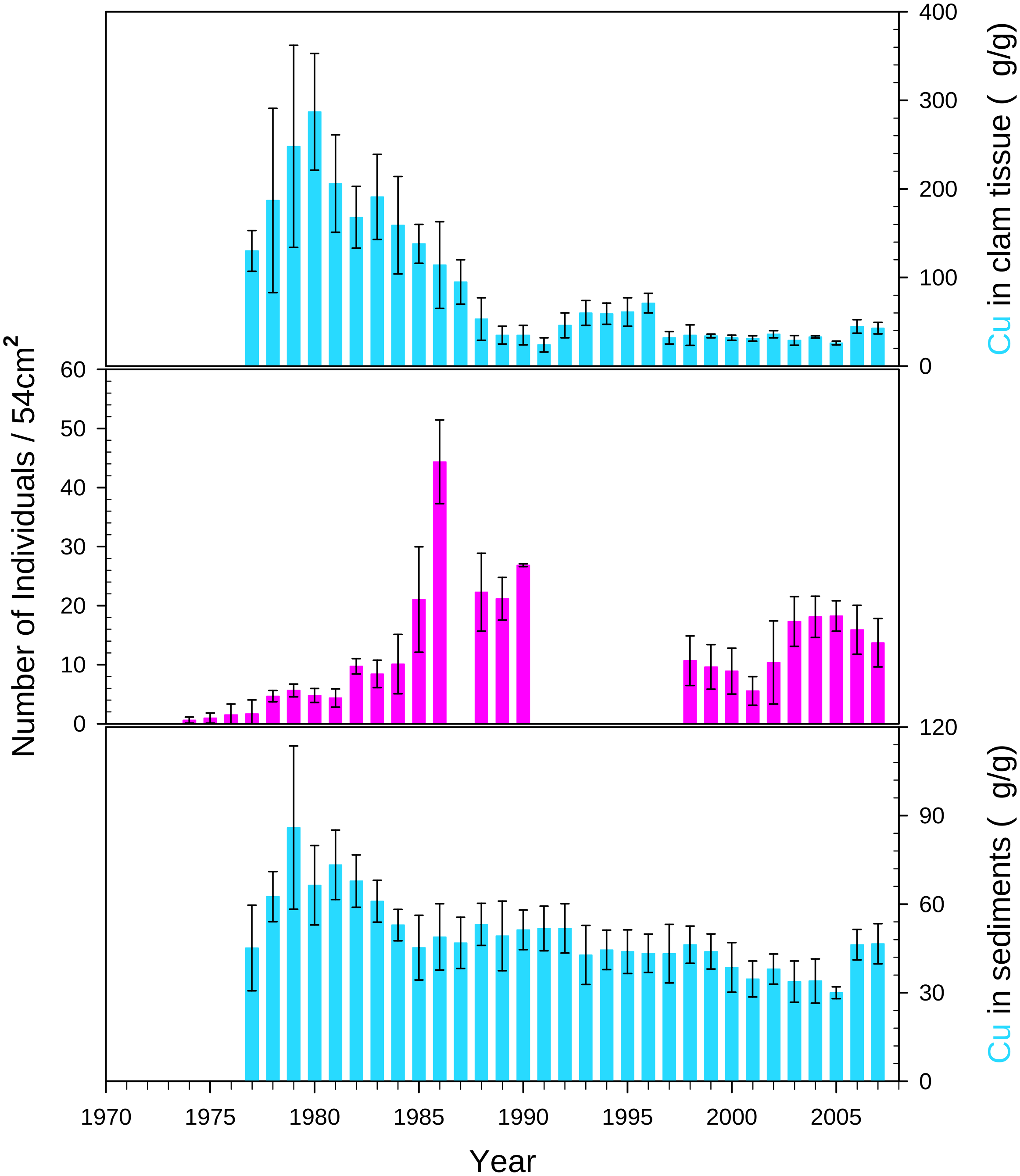


Figure 35. *Heteromastus filiformis* annual abundance with copper in *Macoma petalum* and sediment

Data are for the period from 1974 through 2007. 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).

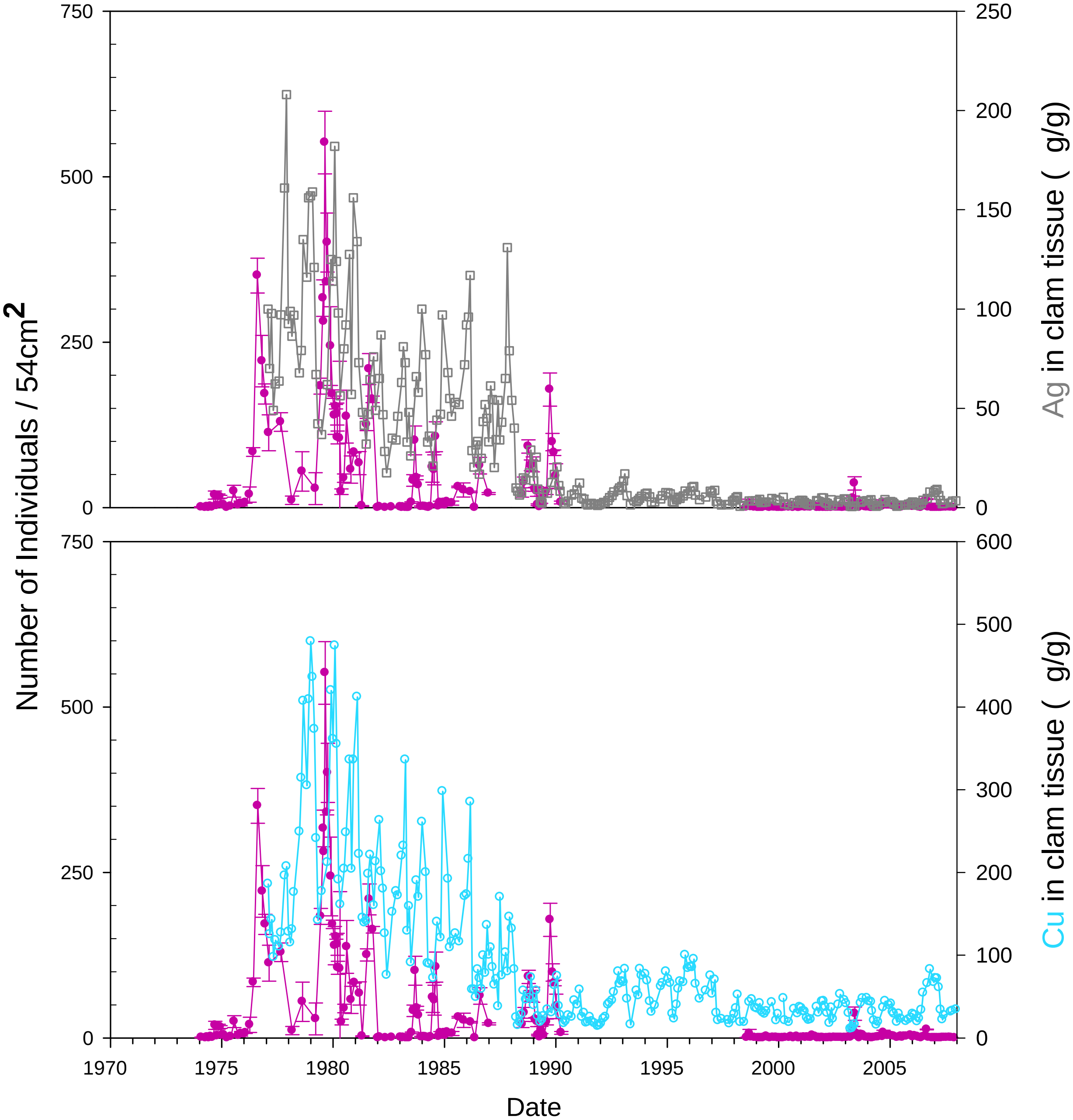


Figure 36. *Ampelisca abdita* abundance with silver and copper in *Macoma petalum*

Data are for the period from 1974 through 2007. Error bars represent standard deviation from 3 replicate samplings. Number of individuals (●) with silver (□) and copper (○) tissue concentrations in *Macoma petalum.*

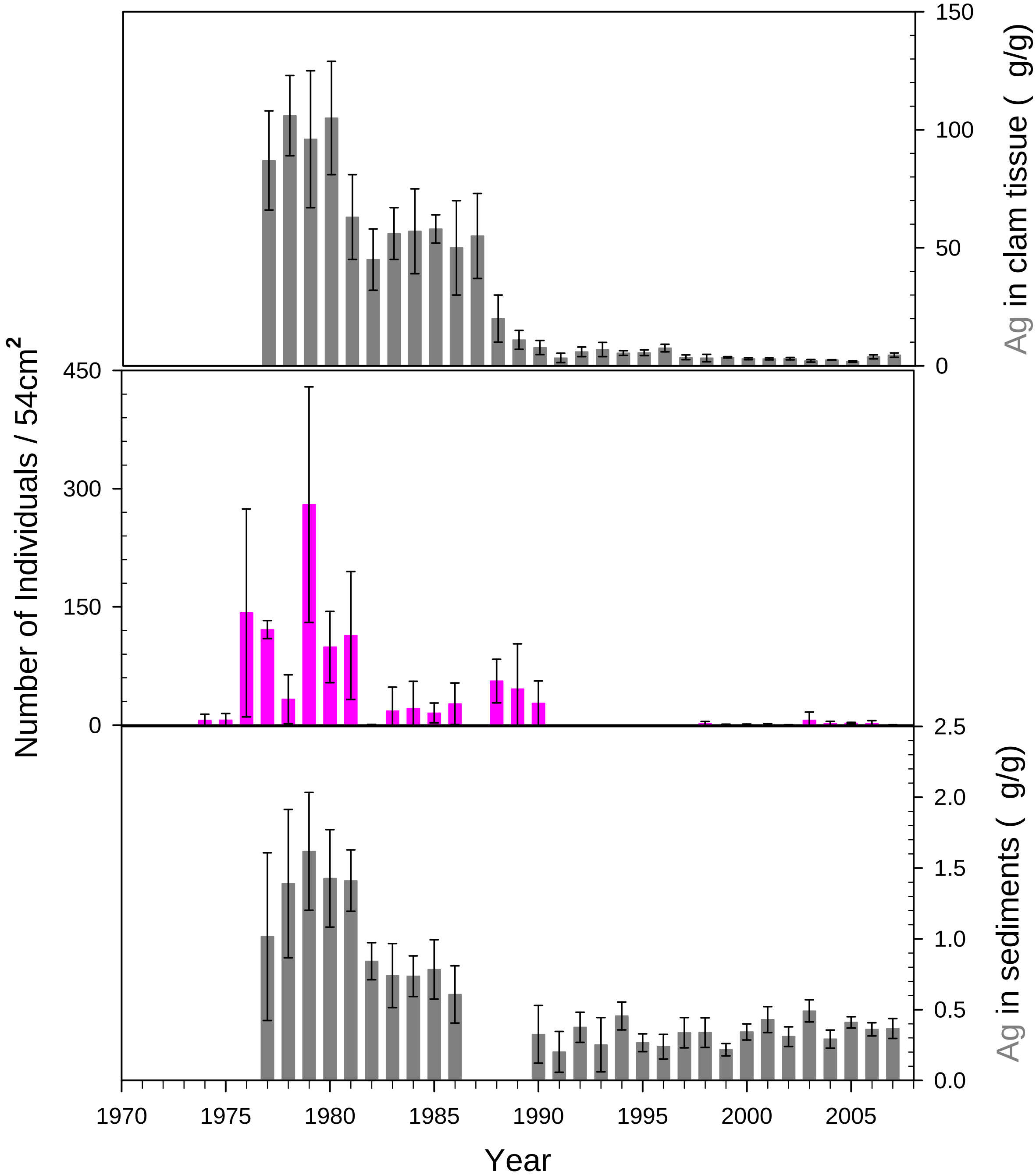


Figure 37. *Ampelisca abdita* annual abundance with silver in *Macoma petalum* and sediment

Data are for the period from 1974 through 2007. 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).

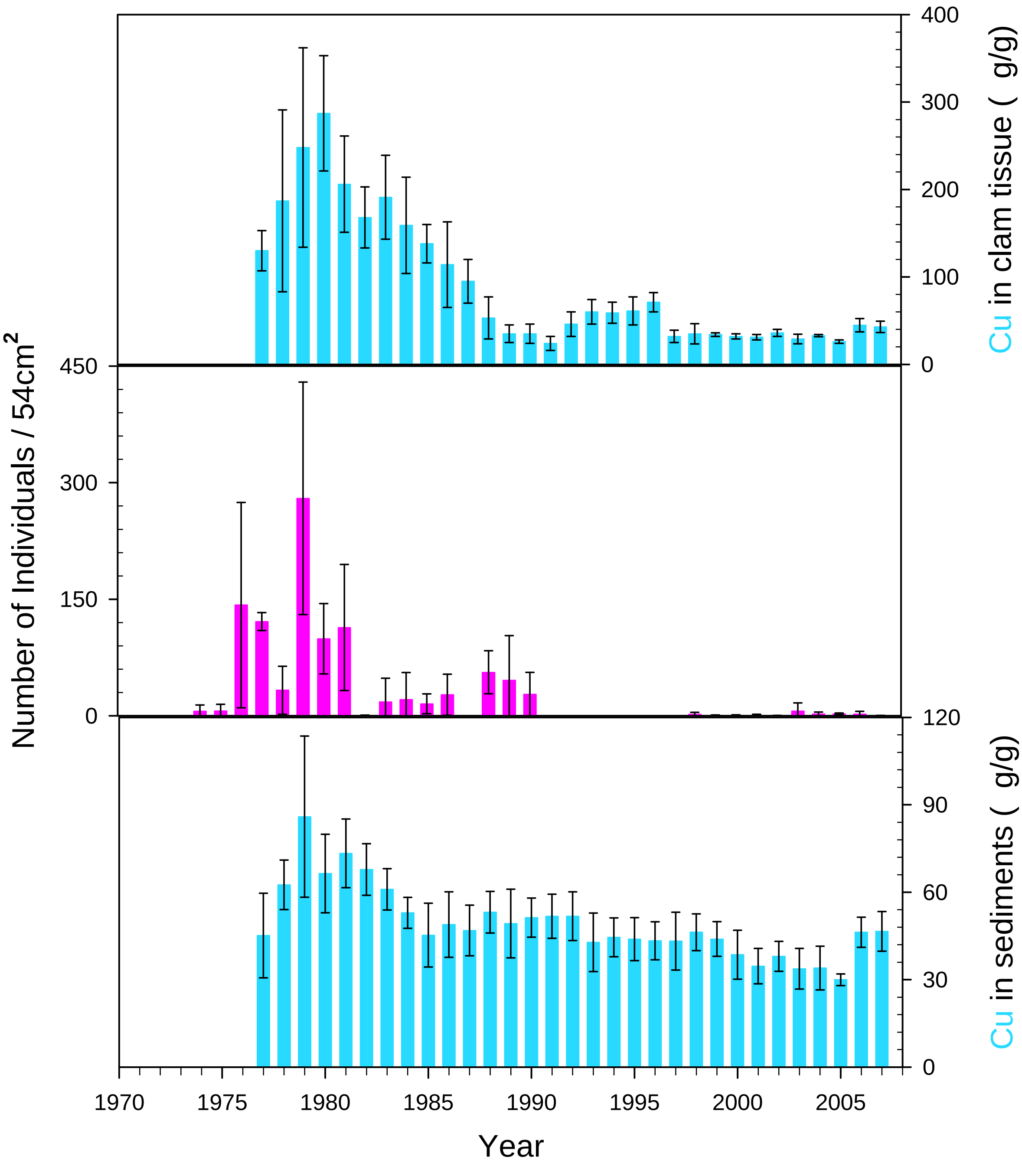


Figure 38. *Ampelisca abdita* annual abundance with copper in *Macoma petalum* and sediment

Data are for the period from 1974 through 2007. 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).

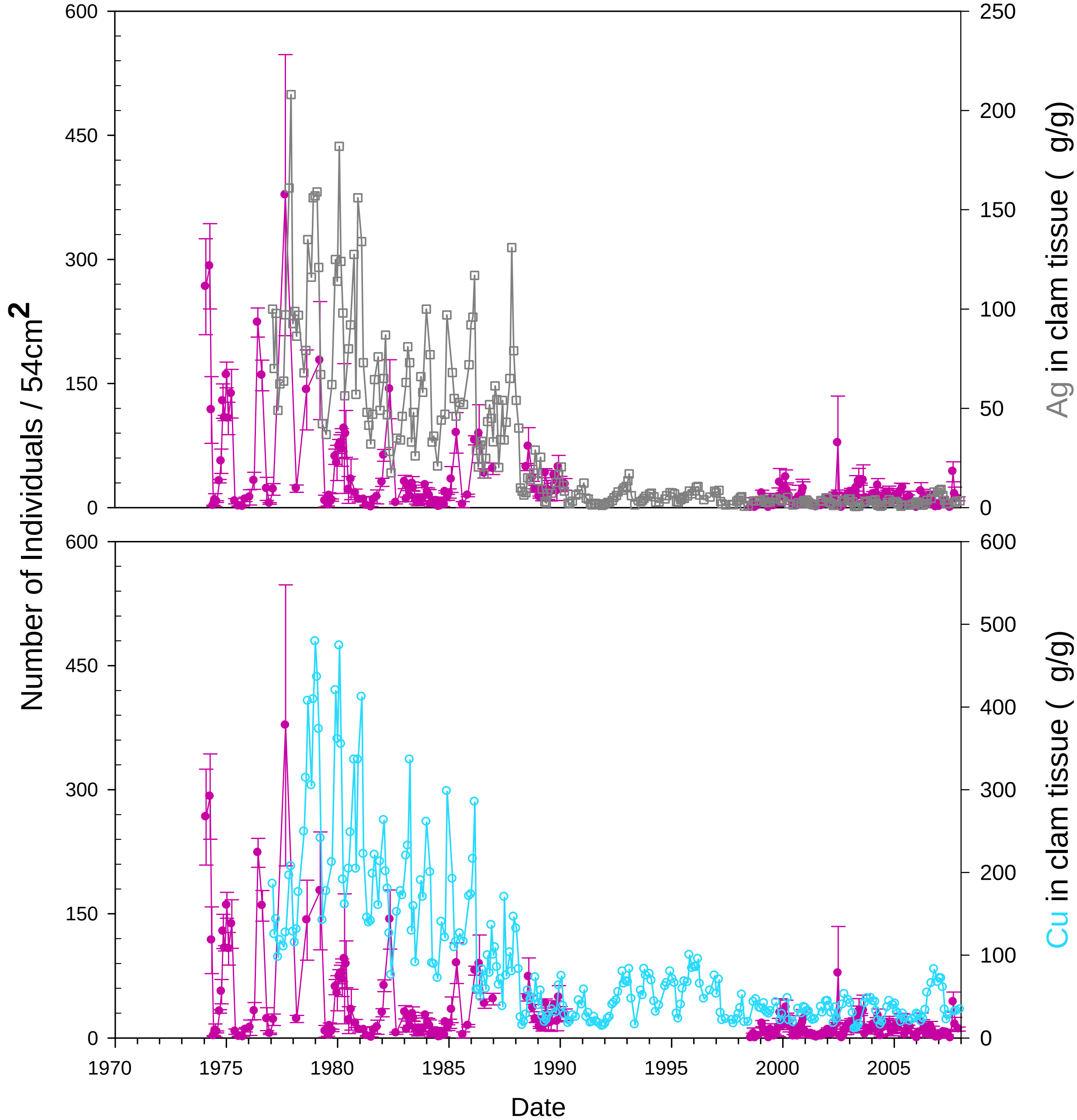


Figure 39. *Streblospio benedicti* abundance with silver and copper in *Macoma petalum*

Data are for the period from 1974 through 2007. Error bars represent standard deviation from 3 replicate samplings. Number of individuals (●) with silver (□) and copper (○) tissue concentrations in *Macoma petalum.*

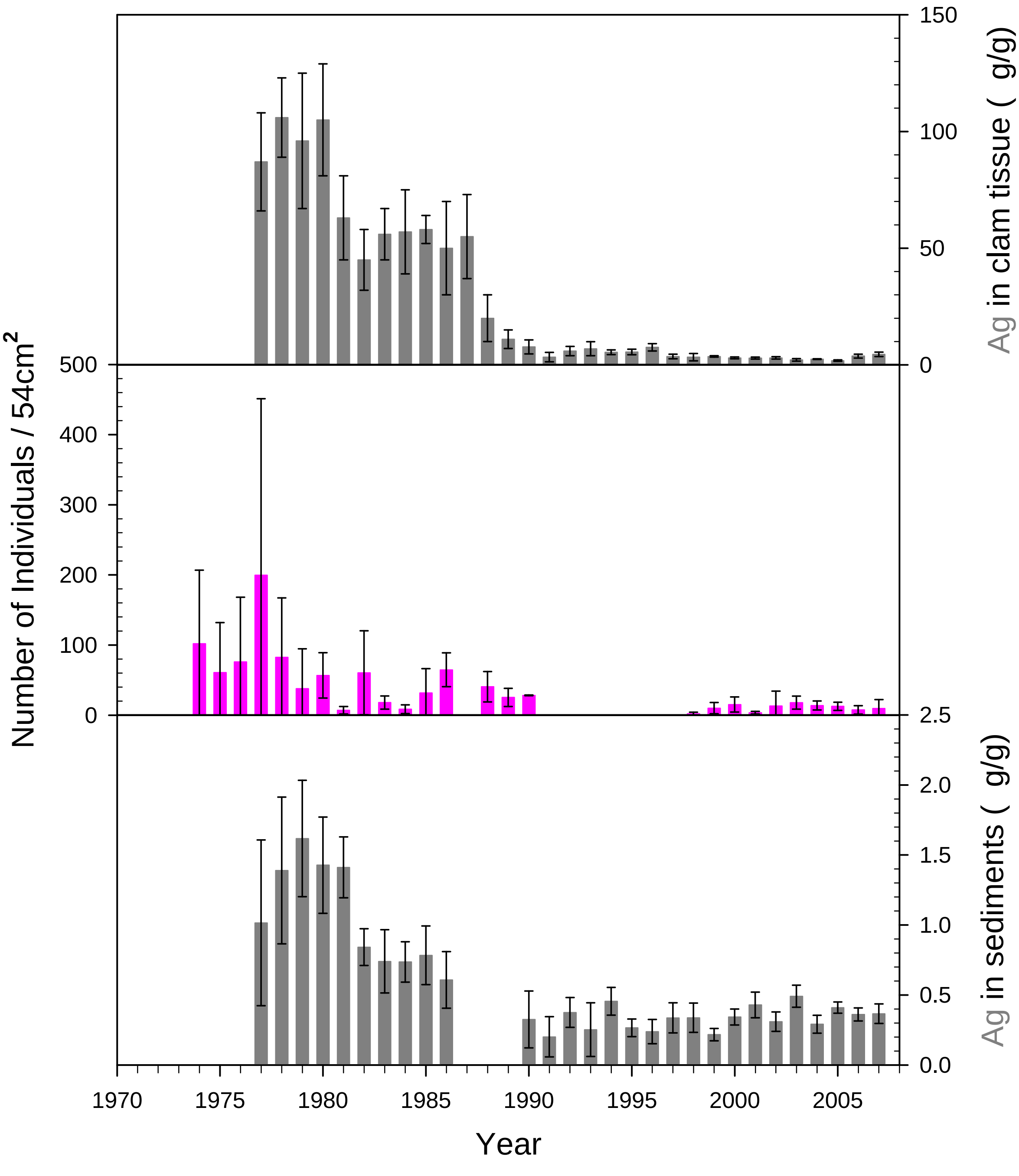


Figure 40. *Streblospio benedicti* annual abundance with silver in *Macoma petalum* and sediment.

Data are for the period from 1974 through 2007. 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).

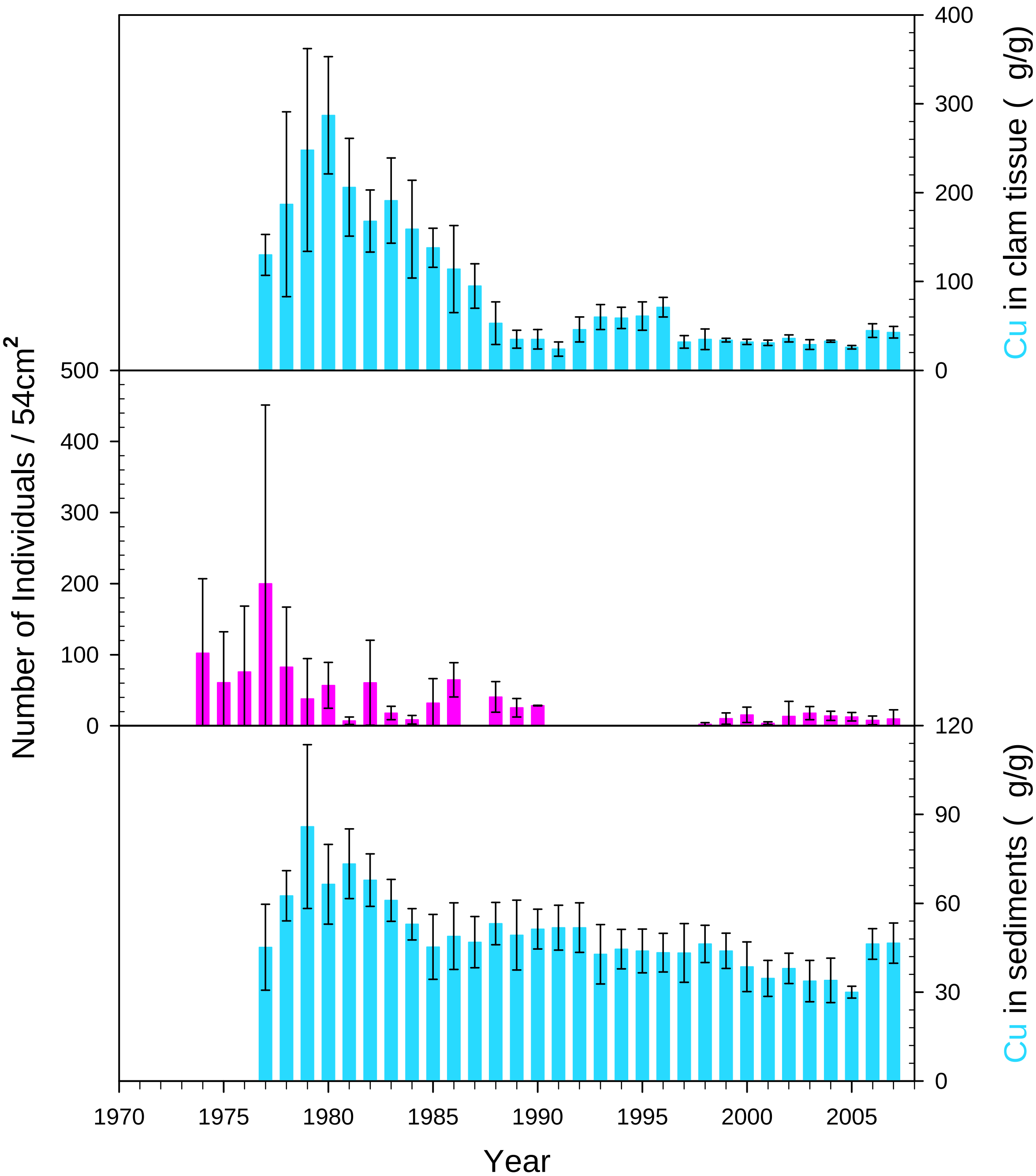


Figure 41. *Streblospio benedicti* annual abundance with copper in *Macoma petalum* and sediment

Data are for the period from 1974 through 2007. 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).

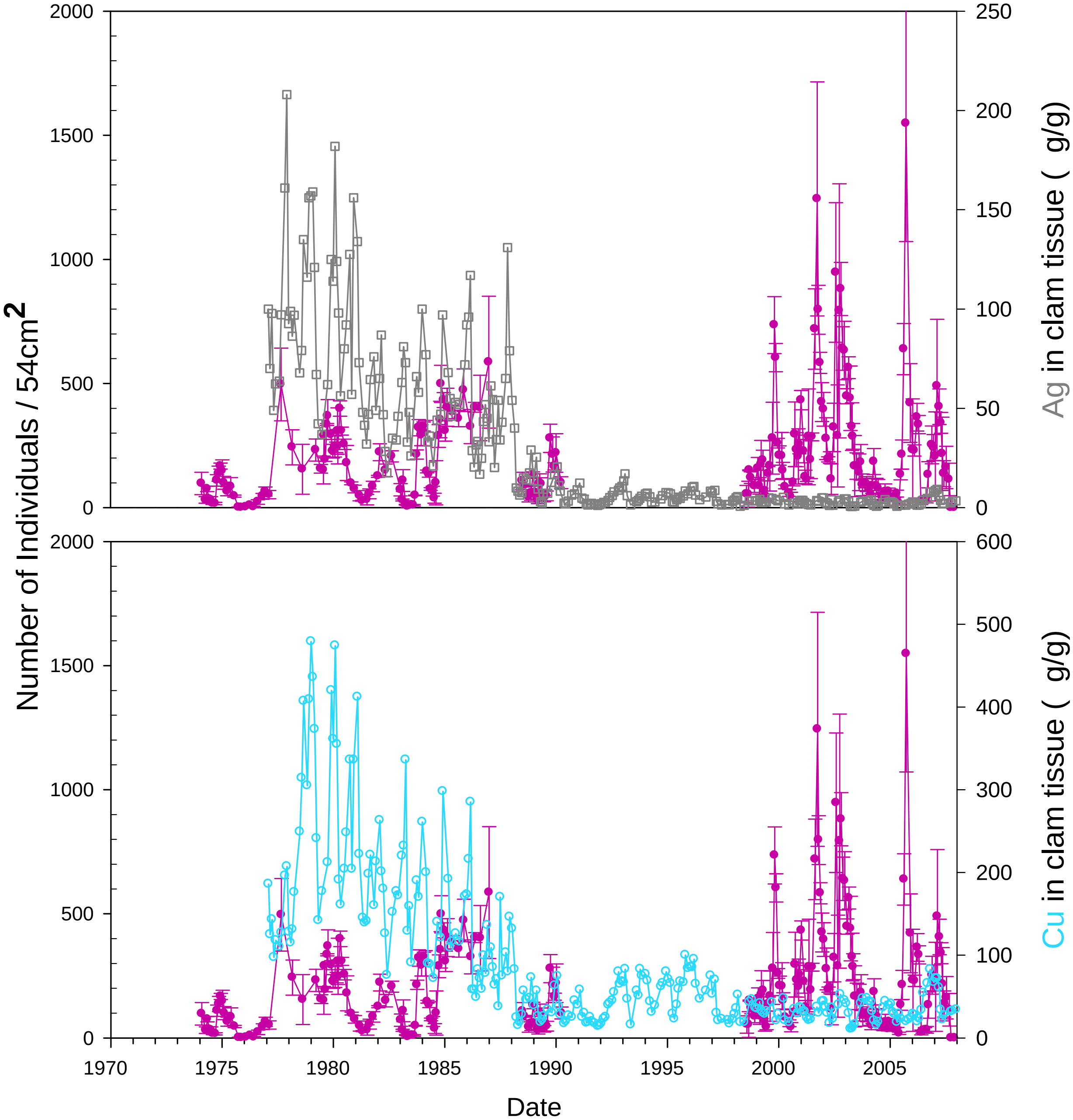


Figure 42. *Gemma gemma* abundance with silver and copper in *Macoma petalum*

Data are for the period from 1974 through 2007. Error bars represent standard deviation from 3 replicate samplings. Number of individuals (●) with silver (□) and copper (○) tissue concentrations in *Macoma petalum.*

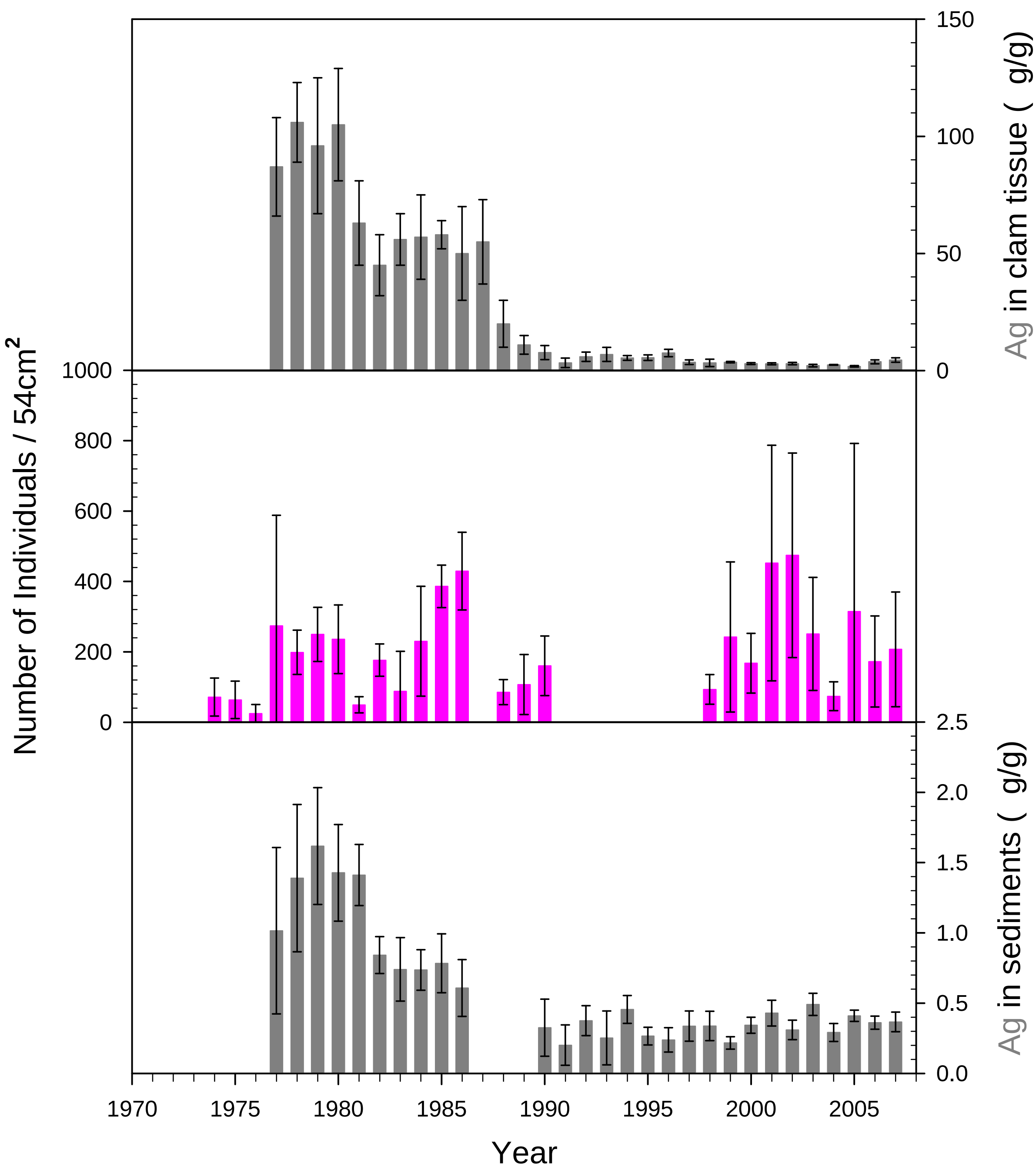


Figure 43. *Gemma gemma* annual abundance with silver in *Macoma petalum* and sediment.

Data are for the period from 1974 through 2007. 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).

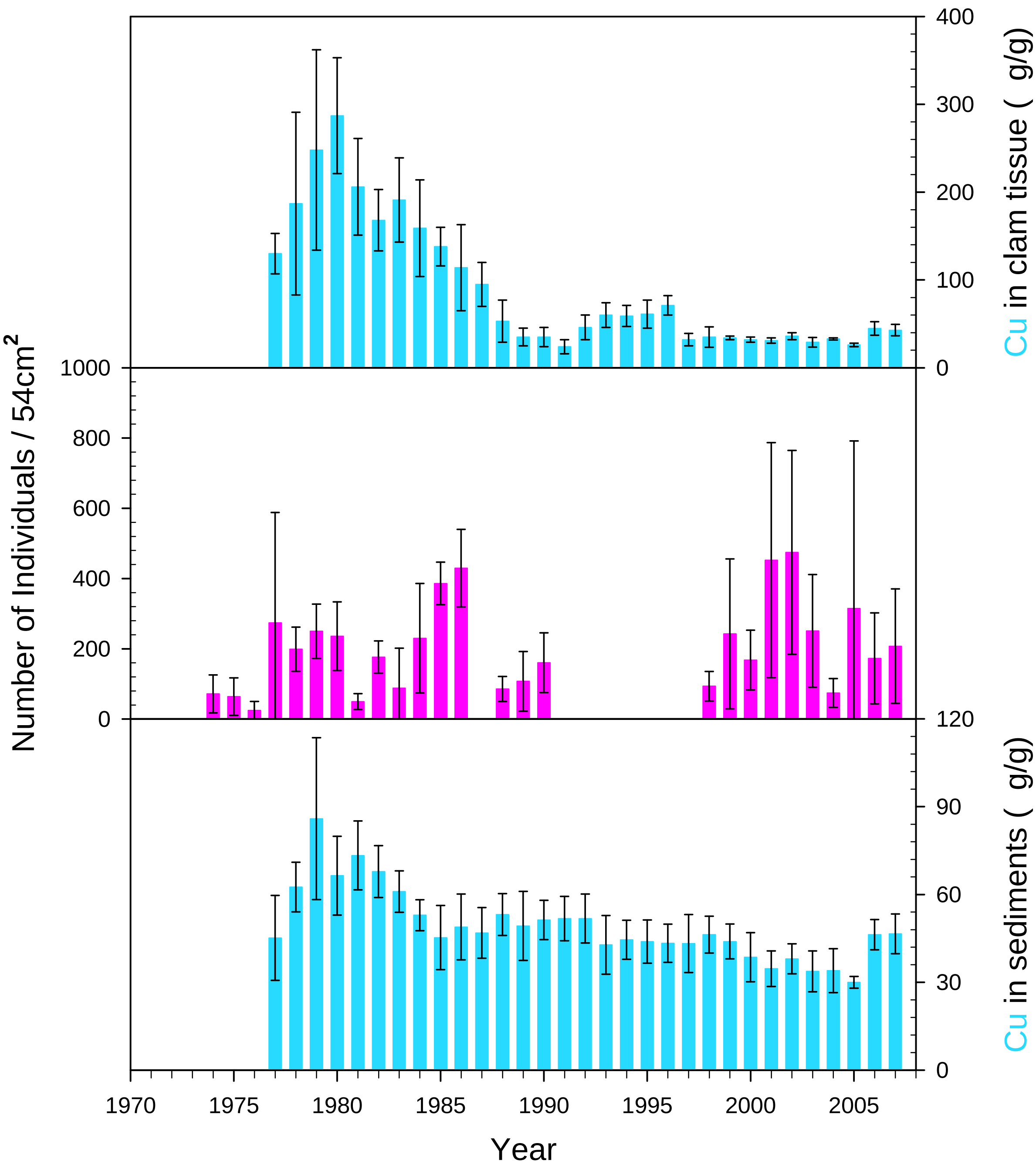


Figure 44. *Gemma gemma* annual abundance with copper in *Macoma petalum* and sediment

Data are for the period from 1974 through 2007. 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).

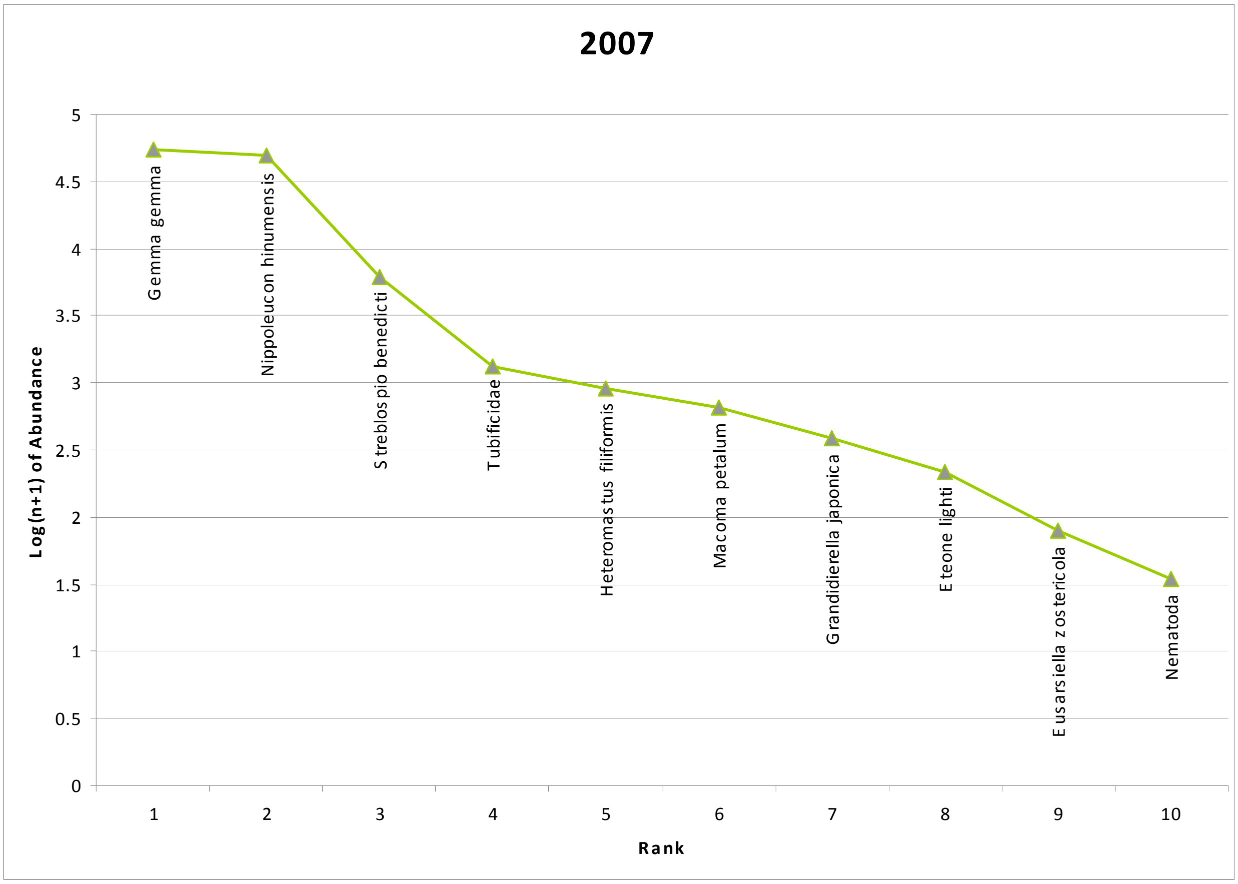


Figure 45. Benthic community rank-abundance data for 2007.

Species name for each rank is shown.

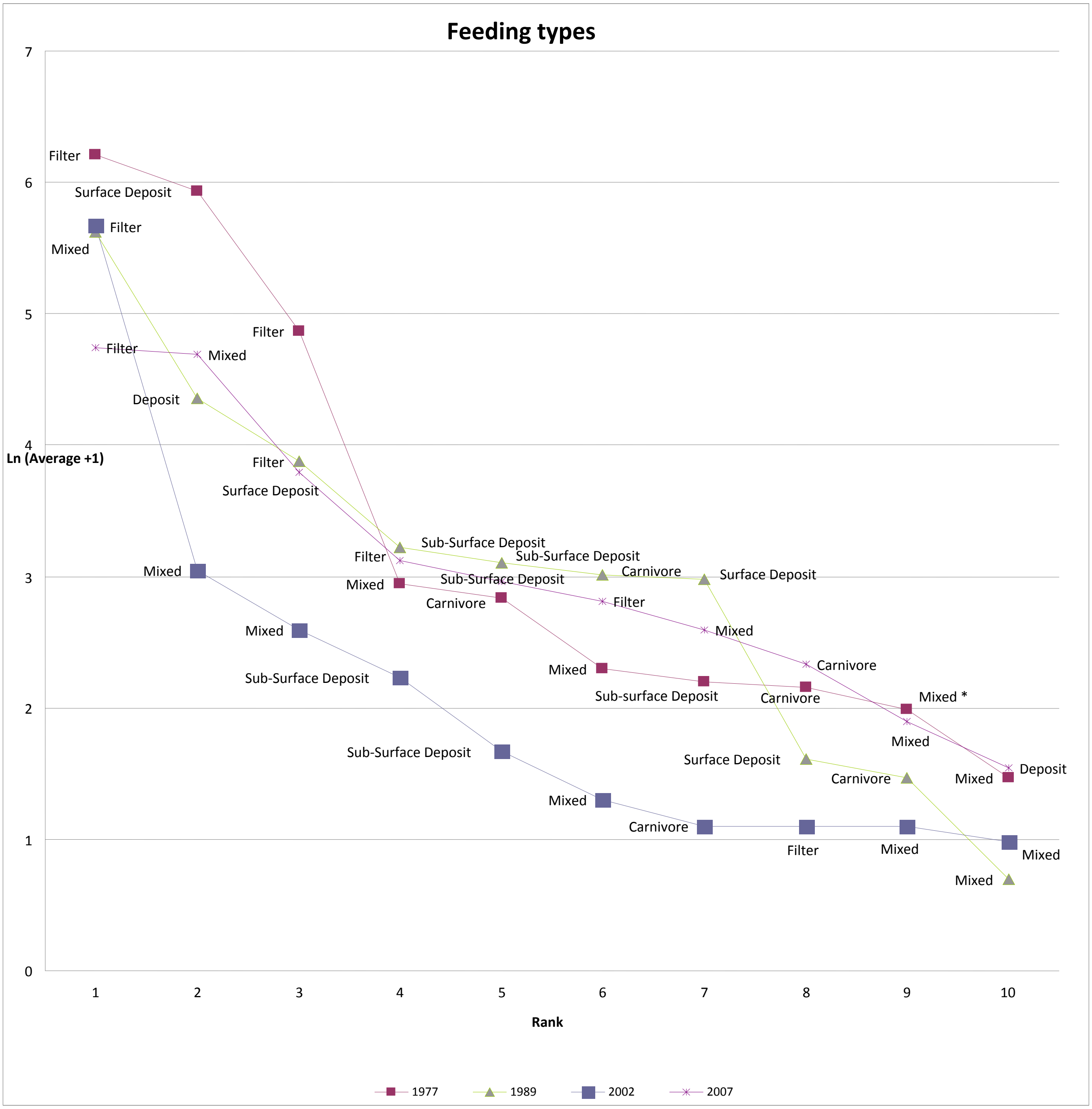


Figure 46. Benthic community rank-abundance data for 1977, 1989, 2002, and 2007. Feeding mode for each species at each rank is shown.

(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).

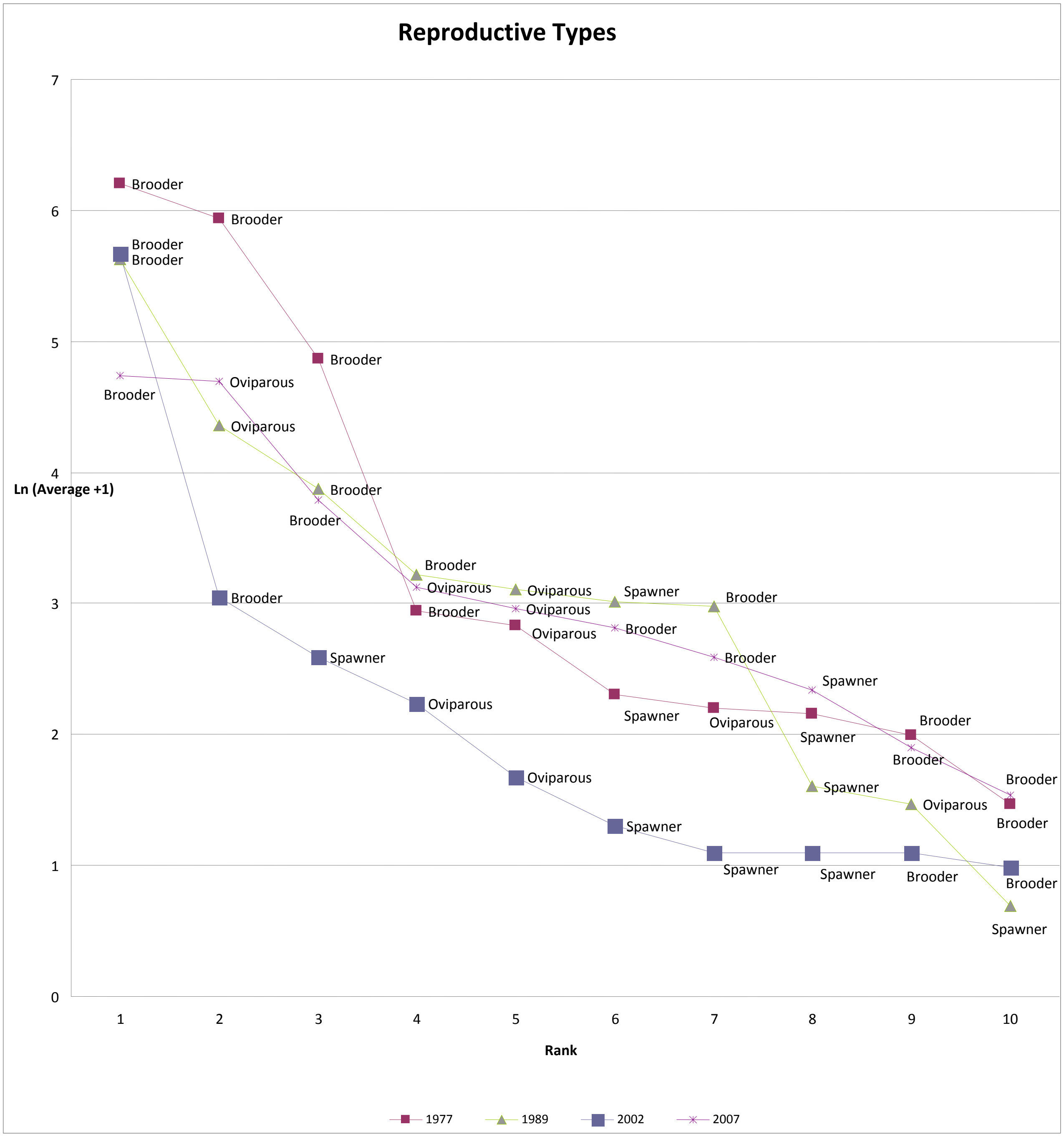


Figure 47. Benthic community rank-abundance data for 1977, 1989, 2002, and 2007.

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 2007

Table comprised of 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 17, 2007	5.5	0.1	5.0	0.2	1.2	45	25
February 13, 2007	6.3	0.0	5.2	0.2	1.4	13	25
March 14, 2007	5.7	0.3	5.0	0.4	1.5	13	24
April 11, 2007	5.7	0.3	4.9	0.2	1.2	17	23
May 9, 2007	5.7	0.0	4.7	0.2	1.4	25	29
June 5, 2007	5.2	0.2	4.1	0.3	1.2	36	30
September 25, 2007	3.9	0.1	3.5	0.1	0.7	35	29
October 24, 2007	3.9	0.2	3.6	0.1	0.8	48	28
December 19, 2007	5.3	0.0	4.9	0.1	1.1	18	25
Annual Mean:	**5.3**		**4.6**		**1.18**	**28**	**26**
SEM:	*0.3*		*0.2*		*0.08*	*5*	*1*

Table 2. Concentrations of trace elements in sediments in 2007

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 17, 2007	0.33	0.00	145	3	48	1	0.27	105	5	0.2	126	3	144	6
February 13, 2007	0.36	0.01	152	1	53	1	0.23	113	3	0.4	133	1	158	7
March 14, 2007	0.42	0.01	142	9	51	3	-	111	11	-	126	6	155	13
April 11, 2007	0.50	0.02	145	11	52	3	0.18	108	8	0.4	125	6	152	11
May 9, 2007	0.32	0.02	147	2	50	0	-	104	3	-	119	0	143	4
June 5, 2007	0.34	0.00	139	6	45	3	0.29	93	12	0.4	109	10	126	12
September 25, 2007	0.26	0.01	124	13	34	1	0.22	74	0	0.3	96	1	103	2
October 24, 2007	0.34	0.00	111	9	37	1	-	77	2	-	97	5	106	2
December 19, 2007	0.42	0.01	139	1	50	1	0.30	111	3	0.4	122	2	150	4
Annual Mean:	**0.37**		**138**		**47**		**0.2**	**100**		**0.4**	**117**		**137**	
SEM:	***0.02***		***4***		***2***		***0.0***	***5***		***0.0***	***4***		***7***	

Table 3. Annual mean copper in *Macoma petalum* and sediments, 1977 through 2007

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
2007	17±1	47±2	43±7

Table 4. Annual mean silver in *Macoma petalum* and sediments, 1977 through 2007

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
2007	0.37 ± 0.02	4.5 ± 0.9

Table 5. Concentrations of trace elements in *Macoma petalum* in 2007.

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 17, 2007	*mean*	8.6	7.1	72	0.58	9.8	6.20	471	74
	**SEM*	0.4	0.2	3	0.05	0.3	0.15	25	
February 13, 2007	*mean*	9.2	7.5	72	0.36	10.6	6.27	517	73
	**SEM*	0.2	0.4	2	0.01	0.3	0.19	30	
March 14, 2007	*mean*	6.1	5.7	61	-	8.2	-	559	86
	**SEM*	0.3	0.4	4	-	0.3	-	62	
April 11, 2007	*mean*	3.6	3.3	34	0.29	5.2	3.77	400	125
	**SEM*	0.3	0.2	2	0.04	0.2	0.18	15	
May 9, 2007	*mean*	1.9	1.6	22	-	4.3	-	255	187
	**SEM*	0.2	0.2	2	-	0.7	-	28	
June 5, 2007	*mean*	2.2	1.3	27	0.26	4.2	2.83	261	169
	**SEM*	0.5	0.1	2	0.06	0.3	0.15	19	
September 25, 2007	*mean*	2.4	2.7	31	0.36	5.6	3.53	205	142
	**SEM*	0.3	0.4	3	0.04	0.4	0.32	17	
October 24, 2007	*mean*	3.3	2.8	33	-	6.1	-	226	121
	**SEM*	0.2	0.2	2	-	0.3	-	15	
December 19, 2007	*mean*	3.4	2.4	34	0.56	6.8	5.90	283	116
	**SEM*	0.4	0.5	2	0.02	0.5	0.46	19	
Annual Mean:		**4.5**	**3.8**	**43**	**0.40**	**6.8**	**4.8**	**353**	**122**
SEM:		**0.9**	**0.8**	**7**	**0.06**	**0.8**	**0.6**	**45**	**13**

[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 error of the mean from 9-13 replicate analyses of composite samples.]

Appendix A

Sediment characteristics for samples collected between 1994 and 2007. 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.

Note: Appendix tables in this document may not be 508 compliant. A 508 compliant Excel spreadsheet containing these 508 compliant tables may be accessed at URL: *http://pubs.usgs.gov/of/2008/1180/Appendix-A.xls*

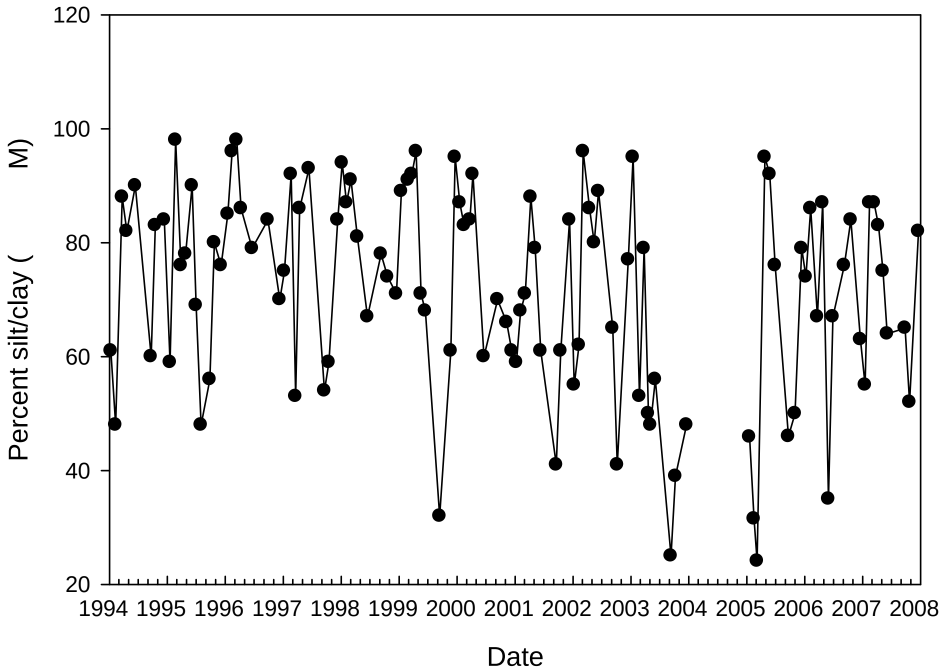
PALTO ALTO GRAIN SIZE DATA: <100µm

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

Year	Date	%<100µm
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

Year	Date	%<100µm
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
2007	01/17/07	55
	02/13/07	87
	03/14/07	87
	04/11/07	83
	05/09/07	75
	06/05/07	64
	09/25/07	65
	10/24/07	52
	12/19/07	82

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



A-3. Total organic carbon (TOC) content (expressed as percent) of sediment collected in 2007.

Date of collection	*TOC (%)*
January 17, 2007	1.20
February 13, 2007	1.36
March 14, 2007	1.49
April 11, 2007	1.25
May 9, 2007	1.37
June 5, 2007	1.22
September 25, 2007	0.70
October 24, 2007	0.84
December 19, 2007	1.14

Appendix B

Metal concentrations in sediments collected at the Palo Alto mudflat during 2007 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 also reported.

Note: Appendix tables in this document may not be 508 compliant. A 508 compliant Excel spreadsheet containing these 508 compliant tables may be accessed at URL: *http://pubs.usgs.gov/of/2008/1180/Appendix-B.xls*

Palo Alto Total Extracts: 2007

1/17/2007: 55% <100 µm

Sample	Weight (g)	Recon. (ml)	Dil. Factor	AL	CR	CU	FE	MN	NI	PB	V	ZN
Tot1	0.4949	10	10	270.9	0.7058	0.2387	251.9	6.07	0.5368	0.2362	0.6323	0.7339
Tot2	0.4971	10	10	276.8	0.7312	0.2328	240.6	5.779	0.502	0.217	0.615	0.6951
			Average	**55211**	**144.85**	**47.53**	**49650**	**1195**	**104.73**	**45.69**	**125.74**	**144.06**
			Std	**668**	**3.17**	**0.99**	**1767**	**45**	**5.29**	**2.88**	**2.86**	**5.98**

2/13/2007: 87% < 100 µm

Sample	Weight (g)	Recon. (ml)	Dil. Factor	AL	CR	CU	FE	MN	NI	PB	V	ZN
Tot1	0.4913	10	10	309.4	0.7503	0.261	263.7	6.461	0.5683	0.2491	0.659	0.7992
Tot2	0.5034	10	10	314.8	0.7623	0.2612	257.8	6.349	0.5603	0.2457	0.6674	0.7721
			Average	**62755**	**152.07**	**52.51**	**52443**	**1288**	**113.49**	**49.76**	**133.36**	**158.02**
			Std	**312**	**0.91**	**0.87**	**1741**	**38**	**3.09**	**1.34**	**1.10**	**6.57**

3/14/2007: 87% <100 µm

Sample	Weight (g)	Recon. (ml)	Dil. Factor	AL	CR	CU	FE	MN	NI	PB	V	ZN
Tot1	0.5047	10	10	280.5	0.6847	0.2456	240.1	8.501	0.5215	0.2237	0.6145	0.7372
Tot2	0.5255	10	10	311.1	0.7785	0.2805	278.6	9.803	0.6243	0.2718	0.6852	0.8637
			Average	**57389**	**141.90**	**51.02**	**50294**	**1775**	**111.06**	**48.02**	**126.07**	**155.21**
			Std	**2562**	**8.82**	**3.33**	**3849**	**128**	**10.94**	**5.23**	**6.11**	**12.93**

4/11/2007: 83% <100 µm

Sample	Weight (g)	Recon. (ml)	Dil. Factor	AL	CR	CU	FE	MN	NI	PB	V	ZN
Tot1	0.6227	10	10	369.6	0.9475	0.3379	317.4	12.36	0.7078	0.3043	0.8027	0.9912
Tot2	0.5709	10	10	313.8	0.7838	0.2819	271.8	10.99	0.5844	0.2532	0.6892	0.8221
			Average	**57160**	**144.73**	**51.82**	**49290**	**1955**	**108.02**	**46.61**	**124.81**	**151.59**
			Std	**3103**	**10.51**	**3.45**	**2378**	**42**	**7.99**	**3.19**	**5.79**	**10.73**

5/09/2007: 75% < 100 µm

Sample	Weight (g)	Recon. (ml)	Dil. Factor	AL	CR	CU	FE	MN	NI	PB	V	ZN
Tot1	0.4929	10	10	280	0.7185	0.2485	237.8	4.795	0.5238	0.2331	0.5856	0.7158
Tot2	0.5093	10	10	292	0.7541	0.2558	233.9	4.728	0.5198	0.2259	0.6025	0.7141
			Average	**57070**	**146.92**	**50.32**	**47085**	**951**	**104.17**	**45.82**	**118.55**	**142.72**
			Std	**373**	**1.62**	**0.13**	**1640**	**31**	**2.98**	**2.08**	**0.36**	**3.54**

6/05/2007: 64% <100 µm

Sample	Weight (g)	Recon. (ml)	Dil. Factor	AL	CR	CU	FE	MN	NI	PB	V	ZN
Tot1	0.5104	10	10	272.2	0.7321	0.244	222.6	3.905	0.5154	0.2156	0.5924	0.6882
Tot2	0.5604	10	10	283.2	0.7562	0.2404	217.6	3.821	0.4735	0.1965	0.5749	0.6595
			Average	**51933**	**139.19**	**45.35**	**41221**	**723**	**92.74**	**38.65**	**109.33**	**126.26**
			Std	**1977**	**6.01**	**3.47**	**3382**	**59**	**11.66**	**5.08**	**9.53**	**12.13**

9/25/2007: 65% <100 µm

Sample	Weight (g)	Recon. (ml)	Dil. Factor	AL	CR	CU	FE	MN	NI	PB	V	ZN
Tot1	0.5319	10	10	204.6	0.6112	0.1774	184.3	3.737	0.3932	0.1681	0.5062	0.5392
Tot2	0.5417	10	10	216.4	0.7201	0.1871	192.7	3.871	0.4042	0.17	0.521	0.566
			Average	**39207**	**123.92**	**33.95**	**35111**	**709**	**74.27**	**31.49**	**95.67**	**102.93**
			Std	**1048**	**12.75**	**0.84**	**653**	**9**	**0.49**	**0.16**	**0.71**	**2.20**

10/24/2007: 52% <100 µm

Sample	Weight (g)	Recon. (ml)	Dil. Factor	AL	CR	CU	FE	MN	NI	PB	V	ZN
Tot1	0.6157	10	10	233.5	0.6474	0.2222	219.2	5.305	0.4674	0.1818	0.5756	0.641
Tot2	0.5885	10	10	239.9	0.6912	0.2191	219.2	5.271	0.4608	0.1943	0.5888	0.6331
			Average	**39344**	**111.30**	**36.66**	**36424**	**879**	**77.11**	**31.27**	**96.77**	**105.84**
			Std	**2008**	**8.70**	**0.81**	**1164**	**24**	**1.69**	**2.47**	**4.64**	**2.45**

12/19/2007: 82% <100 µm

Sample	Weight (g)	Recon. (ml)	Dil. Factor	AL	CR	CU	FE	MN	NI	PB	V	ZN
Tot1	0.5064	10	10	268	0.7058	0.2563	253.1	7.662	0.5752	0.2467	0.6243	0.774
Tot2	0.5355	10	10	280.9	0.7397	0.2638	259.6	7.889	0.5856	0.2499	0.6485	0.7885
			Average	**52689**	**138.75**	**49.94**	**49229**	**1493**	**111.47**	**47.69**	**122.19**	**150.04**
			Std	**330**	**0.88**	**0.95**	**1062**	**28**	**2.99**	**1.45**	**1.54**	**3.96**

Palo Alto HCl Extracts: 2007

1/17/2007: 55% <100 µm

Sample	Weight (g)	Recon. (ml)		Ag	AL	CR	CU	FE	MN	NI	PB	V	ZN
HCl1	0.4918	10		0.0164	84.24	0.2042	0.7937	206	27.04	0.3288	0.8817	0.4561	1.652
HCL2	0.5600	10		0.0184	95.57	0.2376	0.9142	228.5	30.18	0.3682	1.006	0.5198	1.866
			Average	**0.33**	**1710**	**4.20**	**16.23**	**4135**	**544**	**6.63**	**17.95**	**9.28**	**33.46**
			Std	**0.00**	**3**	**0.05**	**0.09**	**54**	**5**	**0.06**	**0.02**	**0.00**	**0.13**

2/13/2007: 87% < 100 µm

Sample	Weight (g)	Recon. (ml)		Ag	AL	CR	CU	FE	MN	NI	PB	V	ZN
HCl1	0.4803	10		0.0169	94.37	0.2201	0.8552	229.7	29.73	0.3387	0.9818	0.4835	1.797
HCL2	0.4742	10		0.0174	95.42	0.2215	0.8562	230.7	31.24	0.3378	0.977	0.4853	1.802
			Average	**0.36**	**1989**	**4.63**	**17.93**	**4824**	**639**	**7.09**	**20.52**	**10.15**	**37.71**
			Std	**0.01**	**24**	**0.04**	**0.13**	**41**	**20**	**0.04**	**0.08**	**0.08**	**0.29**

3/14/2007: 87% <100 µm

Sample	Weight (g)	Recon. (ml)		Ag	AL	CR	CU	FE	MN	NI	PB	V	ZN
HCl1	0.5108	10		0.0218	89.96	0.2201	0.9035	224.7	46.03	0.3244	0.9525	0.5023	1.883
HCL2	0.5416	10		0.022	93.28	0.233	0.9393	231.6	48.86	0.3365	1.011	0.5209	1.937
			Average	**0.42**	**1742**	**4.31**	**17.52**	**4338**	**902**	**6.28**	**18.66**	**9.73**	**36.31**
			Std	**0.01**	**19**	**0.00**	**0.17**	**61**	**1**	**0.07**	**0.01**	**0.11**	**0.55**

4/11/2007: 83% <100 µm

Sample	Weight (g)	Recon. (ml)		Ag	AL	CR	CU	FE	MN	NI	PB	V	ZN
HCl1	0.5826	10		0.0281	97.94	0.2601	1.127	243	59.54	0.3997	1.106	0.561	2.057
HCL2	0.4596	10		0.0239	82.41	0.2127	0.8942	207	48.74	0.3393	0.8956	0.4631	1.701
			Average	**0.50**	**1737**	**4.55**	**19.40**	**4337**	**1041**	**7.12**	**19.24**	**9.85**	**36.16**
			Std	**0.02**	**56**	**0.08**	**0.06**	**166**	**19**	**0.26**	**0.25**	**0.22**	**0.85**

5/09/2007: 75% < 100 µm

Sample	Weight (g)	Recon. (ml)		Ag	AL	CR	CU	FE	MN	NI	PB	V	ZN
HCl1	0.5305	10		0.016	78.02	0.1931	0.8736	206.6	20.96	0.3146	0.921	0.4238	1.684
HCL2	0.4964	10		0.0169	85.63	0.2303	0.9077	223.8	21.72	0.3326	0.9723	0.4515	1.763
			Average	**0.32**	**1598**	**4.14**	**17.38**	**4201**	**416**	**6.32**	**18.47**	**8.54**	**33.63**
			Std	**0.02**	**127**	**0.50**	**0.91**	**307**	**21**	**0.38**	**1.11**	**0.55**	**1.89**

6/05/2007: 64% <100 µm

Sample	Weight (g)	Recon. (ml)		Ag	AL	CR	CU	FE	MN	NI	PB	V	ZN
HCl1	0.5431	10		0.0184	82.82	0.2098	0.9417	214.7	17.32	0.334	0.9938	0.4562	1.789
HCl2	0.5704	10		0.0195	95.58	0.2543	1.071	243.7	19	0.3709	1.065	0.5124	1.979
			Average	**0.34**	**1600**	**4.16**	**18.06**	**4113**	**326**	**6.33**	**18.48**	**8.69**	**33.82**
			Std	**0.00**	**75**	**0.30**	**0.72**	**160**	**7**	**0.18**	**0.19**	**0.29**	**0.88**

9/25/2007: 65% <100 µm

Sample	Weight (g)	Recon. (ml)		Ag	AL	CR	CU	FE	MN	NI	PB	V	ZN
HCl1	0.497	10		0.0137	54.61	0.1369	0.6115	125.4	14.75	0.2222	0.6645	0.2595	1.194
HCl2	0.5631	10		0.0139	57.47	0.1393	0.6647	130.8	15.95	0.2368	0.719	0.2806	1.292
			Average	**0.26**	**1060**	**2.61**	**12.05**	**2423**	**290**	**4.34**	**13.07**	**5.10**	**23.48**
			Std	**0.01**	**39**	**0.14**	**0.25**	**100**	**7**	**0.13**	**0.30**	**0.12**	**0.54**

10/24/2007: 52% <100 µm

Sample	Weight (g)	Recon. (ml)		Ag	AL	CR	CU	FE	MN	NI	PB	V	ZN
HCl1	0.5231	10		0.0182	62.4	0.1609	0.7134	162	22.46	0.261	0.7368	0.3152	1.392
HCl2	0.5177	10		0.0176	60.56	0.1507	0.7213	156.2	22.31	0.2571	0.7326	0.3131	1.343
			Average	**0.34**	**1181**	**2.99**	**13.79**	**3057**	**430**	**4.98**	**14.12**	**6.04**	**26.28**
			Std	**0.00**	**12**	**0.08**	**0.15**	**40**	**1**	**0.01**	**0.03**	**0.01**	**0.33**

12/19/2007: 82% <100 µm

Sample	Weight (g)	Recon. (ml)		Ag	AL	CR	CU	FE	MN	NI	PB	V	ZN
HCl1	0.5365	10		0.023	94.98	0.2415	0.8752	225	40.73	0.3337	0.9462	0.4656	1.836
HCl2	0.5306	10		0.0216	94.78	0.243	0.8753	222.5	40.19	0.3302	0.9338	0.4655	1.829
			Average	**0.42**	**1778**	**4.54**	**16.40**	**4194**	**758**	**6.22**	**17.62**	**8.73**	**34.35**
			Std	**0.01**	**8**	**0.04**	**0.09**	**0**	**1**	**0.00**	**0.02**	**0.05**	**0.12**

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, respectively.

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 shown for 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 compliant. A 508 compliant Excel spreadsheet containing these 508 compliant tables may be accessed at URL: *http://pubs.usgs.gov/of/2008/1180/Appendix-C.xls*

Station:Palo Alto

Date:01/17/07

Statistical Summary

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	8.5999	0.5530	7.0658	71.9161	9.8452	3.0663	7.4270	470.9563
STD	1.3859	0.0545	0.6579	9.7548	0.8529	0.3453	0.9338	78.3058
SEM	0.438	0.017	0.208	3.085	0.270	0.109	0.295	24.762
CV%	16.116	9.854	9.311	13.564	8.663	11.259	12.573	16.627
n	10	10	10	10	10	10	10	10
r wt x [ ]	0.467	0.137	0.517	0.553	0.487	0.754	0.656	0.245
X 100mg	6.150	0.525	5.780	51.518	8.273	2.082	5.112	398.361
r l x [ ]	0.567	0.127	0.566	0.677	0.567	0.692	0.689	0.288
X 20mm	8.319	0.551	6.932	69.554	9.672	2.981	7.197	462.881
X 25mm	7.214	0.541	6.409	60.281	8.993	2.645	6.293	431.177

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

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.3327	0.0223	0.2797	2.7923	0.3903	0.1199	0.2891	18.4629
25mm	0.5495	0.0401	0.4814	4.6164	0.6738	0.2013	0.4802	31.7078

Estimated weight for 15mm clam	Estimated weight for 20mm clam
0.019 gm	0.041 gm
18.716 mg	40.600 mg

Estimated weight for 25mm clam

0.074 gm
74.029 mg

Station:Palo Alto Macoma petalum

Date:01/17/07

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	11.55	0.0913	0.0091	10	0.1024	0.0053	0.0755	0.8402	0.1064	0.032	0.0842	5.188
Mp2	15.86	0.0913	0.0228	10	0.0813	0.0041	0.0618	0.6422	0.0909	0.0285	0.073	4.089
Mp3	16.55	0.2519	0.0252	10	0.2337	0.015	0.1951	2.129	0.2463	0.0823	0.1845	11.97
Mp4	17.48	0.2963	0.0296	10	0.2383	0.0176	0.1972	2.079	0.2752	0.093	0.2122	14.09
Mp5	18.48	0.4054	0.0290	15	0.185	0.0138	0.1892	1.764	0.2583	0.0899	0.1997	10.91
Mp6	19.47	0.3564	0.0356	10	0.2922	0.0215	0.2357	2.423	0.3384	0.1114	0.2501	20.14
Mp7	20.47	0.2298	0.0460	10	0.1821	0.014	0.1494	1.483	0.2101	0.0582	0.1478	8.267
Mp8	21.49	0.2932	0.0489	10	0.3081	0.0157	0.2317	2.016	0.325	0.099	0.2506	11.39
Mp9	22.24	0.2156	0.0539	10	0.1631	0.0121	0.1463	1.288	0.1994	0.0581	0.1518	12.51
Mp10	23.66	0.2606	0.0652	10	0.1959	0.0128	0.1672	1.976	0.241	0.0671	0.16	11.61
				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	11.2158	0.5805	8.2694	92.0263	11.6539	3.5049	9.2223	568.237
	Mp2	8.9047	0.4491	6.7689	70.3395	9.9562	3.1216	7.9956	447.864
	Mp3	9.2775	0.5955	7.7451	84.5177	9.7777	3.2672	7.3243	475.189
	Mp4	8.0425	0.5940	6.6554	70.1654	9.2879	3.1387	7.1617	475.532
	Mp5	6.8451	0.5106	7.0005	65.2689	9.5572	3.3263	7.3890	403.675
	Mp6	8.1987	0.6033	6.6134	67.9854	9.4949	3.1257	7.0174	565.095
	Mp7	7.9243	0.6092	6.5013	64.5344	9.1427	2.5326	6.4317	359.748
	Mp8	10.5082	0.5355	7.9025	68.7585	11.0846	3.3765	8.5471	388.472
	Mp9	7.5649	0.5612	6.7857	59.7403	9.2486	2.6948	7.0408	580.241
	Mp10	7.5173	0.4912	6.4160	75.8250	9.2479	2.5748	6.1397	445.510

	Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Content (ug) ==>	Mp1	0.1024	0.0053	0.0755	0.8402	0.1064	0.0320	0.0842	5.1880
	Mp2	0.2033	0.0103	0.1545	1.6055	0.2273	0.0713	0.1825	10.2225
	Mp3	0.2337	0.0150	0.1951	2.1290	0.2463	0.0823	0.1845	11.9700
	Mp4	0.2383	0.0176	0.1972	2.0790	0.2752	0.0930	0.2122	14.0900
	Mp5	0.1982	0.0148	0.2027	1.8900	0.2768	0.0963	0.2140	11.6893
	Mp6	0.2922	0.0215	0.2357	2.4230	0.3384	0.1114	0.2501	20.1400
	Mp7	0.3642	0.0280	0.2988	2.9660	0.4202	0.1164	0.2956	16.5340
	Mp8	0.5135	0.0262	0.3862	3.3600	0.5417	0.1650	0.4177	18.9833
	Mp9	0.4078	0.0303	0.3658	3.2200	0.4985	0.1453	0.3795	31.2750
	Mp10	0.4898	0.0320	0.4180	4.9400	0.6025	0.1678	0.4000	29.0250

Station:Palo Alto

Date:02/13/07

Statistical Summary

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	9.1626	0.6327	7.4915	71.7267	10.5889	3.1498	7.7735	517.1676
STD	0.8881	0.0569	1.2827	7.0991	1.0599	0.4424	1.0314	109.6044
SEM	0.246	0.016	0.356	1.969	0.294	0.123	0.286	30.399
CV%	9.693	8.998	17.123	9.897	10.010	14.044	13.268	21.193
n	13	13	13	13	13	13	13	13
r wt x [ ]	0.166	0.566	0.450	0.754	0.591	0.437	0.174	0.747
X 100mg	8.717	0.535	5.747	55.558	8.698	2.566	7.230	269.916
r l x [ ]	0.177	0.572	0.469	0.728	0.604	0.497	0.222	0.673
X 20mm	9.184	0.637	7.573	72.423	10.675	3.179	7.804	527.111
X 25mm	8.909	0.580	6.519	63.381	9.555	2.794	7.403	398.016

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

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.3226	0.0223	0.2622	2.5356	0.3738	0.1108	0.2730	17.9679
25mm	0.6449	0.0424	0.4620	4.6408	0.6935	0.2015	0.5299	27.9215

Estimated weight for 15mm clam

0.014 gm
13.915 mg

Estimated weight for 20mm clam

0.035 gm
35.318 mg

Estimated weight for 25mm clam

0.073 gm
72.739 mg

Station:Palo Alto

Date:02/13/07

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	16.39	0.2563	0.0214	10	0.2506	0.0186	0.2071	2.015	0.2999	0.0882	0.2076	14.87
Mp2	17.40	0.2666	0.0242	10	0.2203	0.0167	0.1897	1.989	0.2722	0.0796	0.1848	16.4
Mp3	17.57	0.2593	0.0185	10	0.2621	0.0168	0.1908	2.062	0.2825	0.0856	0.2002	15.11
Mp4	18.43	0.2926	0.0293	10	0.2489	0.0181	0.2589	2.125	0.3209	0.1046	0.261	16.1
Mp5	18.50	0.2453	0.0273	10	0.2441	0.0149	0.2015	1.772	0.2775	0.0889	0.2062	13.5
Mp6	19.59	0.3708	0.0285	10	0.3706	0.0267	0.2854	3.202	0.4196	0.1188	0.2788	20.74
Mp7	19.43	0.3923	0.0327	10	0.3625	0.0273	0.3518	2.909	0.4418	0.1404	0.3389	24.93
Mp8	20.47	0.4058	0.0406	15	0.2079	0.0153	0.2035	1.836	0.2855	0.0815	0.203	10.77
Mp9	21.50	0.3136	0.0448	10	0.308	0.0204	0.2245	2.036	0.3299	0.0894	0.2366	15.83
Mp10	22.59	0.1064	0.0532	10	0.1025	0.007	0.0724	0.7088	0.1135	0.0278	0.0812	4.83
Mp11	23.20	0.2938	0.0490	10	0.236	0.0165	0.1827	1.99	0.2668	0.0783	0.1937	16.68
Mp12	24.65	0.2233	0.0744	10	0.1828	0.0127	0.2025	1.331	0.2529	0.0836	0.2179	11.24
Mp13	25.28	0.0812	0.0812	10	0.0805	0.0047	0.0352	0.5488	0.0637	0.0191	0.047	1.801
				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	9.7776	0.7257	8.0804	78.6188	11.7011	3.4413	8.0999	580.179
	Mp2	8.2633	0.6264	7.1155	74.6062	10.2101	2.9857	6.9317	615.154
	Mp3	10.1080	0.6479	7.3583	79.5218	10.8947	3.3012	7.7208	582.723
	Mp4	8.5065	0.6186	8.8483	72.6247	10.9672	3.5748	8.9200	550.239
	Mp5	9.9511	0.6074	8.2144	72.2381	11.3127	3.6241	8.4060	550.347
	Mp6	9.9946	0.7201	7.6969	86.3538	11.3161	3.2039	7.5189	559.331
	Mp7	9.2404	0.6959	8.9676	74.1524	11.2618	3.5789	8.6388	635.483
	Mp8	7.6848	0.5655	7.5222	67.8659	10.5532	3.0126	7.5037	398.103
	Mp9	9.8214	0.6505	7.1588	64.9235	10.5198	2.8508	7.5446	504.783
	Mp10	9.6335	0.6579	6.8045	66.6165	10.6673	2.6128	7.6316	453.947
	Mp11	8.0327	0.5616	6.2185	67.7332	9.0810	2.6651	6.5929	567.733
	Mp12	8.1863	0.5687	9.0685	59.6059	11.3256	3.7438	9.7582	503.359
	Mp13	9.9138	0.5788	4.3350	67.5862	7.8448	2.3522	5.7882	221.798

	Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Content (ug) ==>	Mp1	0.2088	0.0155	0.1726	1.6792	0.2499	0.0735	0.1730	12.3917
	Mp2	0.2003	0.0152	0.1725	1.8082	0.2475	0.0724	0.1680	14.9091
	Mp3	0.1872	0.0120	0.1363	1.4729	0.2018	0.0611	0.1430	10.7929
	Mp4	0.2489	0.0181	0.2589	2.1250	0.3209	0.1046	0.2610	16.1000
	Mp5	0.2712	0.0166	0.2239	1.9689	0.3083	0.0988	0.2291	15.0000
	Mp6	0.2851	0.0205	0.2195	2.4631	0.3228	0.0914	0.2145	15.9538
	Mp7	0.3021	0.0228	0.2932	2.4242	0.3682	0.1170	0.2824	20.7750
	Mp8	0.3119	0.0230	0.3053	2.7540	0.4283	0.1223	0.3045	16.1550
	Mp9	0.4400	0.0291	0.3207	2.9086	0.4713	0.1277	0.3380	22.6143
	Mp10	0.5125	0.0350	0.3620	3.5440	0.5675	0.1390	0.4060	24.1500
	Mp11	0.3933	0.0275	0.3045	3.3167	0.4447	0.1305	0.3228	27.8000
	Mp12	0.6093	0.0423	0.6750	4.4367	0.8430	0.2787	0.7263	37.4667
	Mp13	0.8050	0.0470	0.3520	5.4880	0.6370	0.1910	0.4700	18.0100

Station:Palo Alto

Statistical Summary

Date:03/14/07

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	6.1318	0.5118	5.7052	60.8723	8.1607	2.2422	5.8032	558.6722
STD	0.9809	0.0774	1.4247	14.9196	1.1572	0.5498	1.6759	224.4498
SEM	0.272	0.021	0.395	4.138	0.321	0.152	0.465	62.251
CV%	15.997	15.119	24.972	24.510	14.180	24.520	28.878	40.176
n	13	13	13	13	13	13	13	13
r wt x [ ]	0.077	0.489	0.132	0.850	0.355	0.125	0.100	0.193
X 100mg	6.236	0.564	5.447	78.280	8.725	2.336	6.032	618.038
r l x [ ]	0.099	0.404	0.132	0.800	0.307	0.156	0.069	0.143
X 20mm	6.121	0.509	5.725	59.606	8.123	2.233	5.791	555.262
X 25mm	6.235	0.545	5.505	73.556	8.538	2.333	5.925	592.828

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

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.2912	0.0244	0.2657	2.8556	0.3891	0.1050	0.2696	25.2570
25mm	0.5283	0.0459	0.4364	6.0279	0.7207	0.1916	0.4689	43.3020

Estimated weight for 15mm clam	Estimated weight for 20mm clam
0.023 gm	0.048 gm
22.857 mg	48.104 mg

Estimated weight for 25mm clam

0.086 gm
85.675 mg

Station:Palo Alto

Date:03/14/07

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	13.93	0.1637	0.0182	10	0.1078	0.0088	0.091	0.8832	0.1303	0.0307	0.0861	9.081
Mp2	16.34	0.1497	0.0299	10	0.0993	0.0074	0.0872	0.7787	0.1261	0.0316	0.0926	8.4
Mp3	17.51	0.2747	0.0343	10	0.1108	0.0116	0.1311	1.474	0.19	0.0461	0.1267	12.67
Mp4	17.59	0.2517	0.0360	10	0.1723	0.0134	0.1529	1.585	0.2106	0.0607	0.1473	12.2
Mp5	18.29	0.3184	0.0398	10	0.1786	0.0145	0.201	1.715	0.2508	0.0736	0.1932	14.35
Mp6	18.67	0.3018	0.0431	10	0.1614	0.0144	0.1686	1.467	0.2291	0.0616	0.1661	16.02
Mp7	19.46	0.4614	0.0419	15	0.2114	0.015	0.2048	1.76	0.2574	0.0833	0.2045	17.9
Mp8	20.49	0.1992	0.0498	10	0.1129	0.009	0.0881	0.9104	0.133	0.0368	0.0932	10.04
Mp9	21.49	0.479	0.0532	15	0.1818	0.0158	0.1752	1.869	0.2562	0.0738	0.1667	17.57
Mp10	22.51	0.289	0.0578	10	0.2306	0.0151	0.1947	1.978	0.2581	0.0797	0.1867	15.32
Mp11	23.63	0.2304	0.0768	10	0.1301	0.0125	0.1233	1.329	0.1875	0.0504	0.1266	13.98
Mp12	26.33	0.1094	0.1094	10	0.0757	0.0081	0.0961	0.8326	0.1248	0.0387	0.1139	13.47
Mp13	29.65	0.1313	0.1313	10	0.0772	0.0065	0.0341	1.347	0.0973	0.018	0.04	2.825
				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	6.5852	0.5376	5.5589	53.9524	7.9597	1.8754	5.2596	554.734
	Mp2	6.6333	0.4943	5.8250	52.0174	8.4235	2.1109	6.1857	561.122
	Mp3	4.0335	0.4223	4.7725	53.6585	6.9166	1.6782	4.6123	461.230
	Mp4	6.8455	0.5324	6.0747	62.9718	8.3671	2.4116	5.8522	484.704
	Mp5	5.6093	0.4554	6.3128	53.8631	7.8769	2.3116	6.0678	450.691
	Mp6	5.3479	0.4771	5.5865	48.6083	7.5911	2.0411	5.5036	530.815
	Mp7	6.8726	0.4876	6.6580	57.2172	8.3680	2.7081	6.6482	581.925
	Mp8	5.6677	0.4518	4.4227	45.7028	6.6767	1.8474	4.6787	504.016
	Mp9	5.6931	0.4948	5.4864	58.5282	8.0230	2.3111	5.2203	550.209
	Mp10	7.9792	0.5225	6.7370	68.4429	8.9308	2.7578	6.4602	530.104
	Mp11	5.6467	0.5425	5.3516	57.6823	8.1380	2.1875	5.4948	606.771
	Mp12	6.9196	0.7404	8.7843	76.1060	11.4077	3.5375	10.4113	1231.261
	Mp13	5.8797	0.4950	2.5971	102.5895	7.4105	1.3709	3.0465	215.156

	Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Content (ug) ==>	Mp1	0.1198	0.0098	0.1011	0.9813	0.1448	0.0341	0.0957	10.0900
	Mp2	0.1986	0.0148	0.1744	1.5574	0.2522	0.0632	0.1852	16.8000
	Mp3	0.1385	0.0145	0.1639	1.8425	0.2375	0.0576	0.1584	15.8375
	Mp4	0.2461	0.0191	0.2184	2.2643	0.3009	0.0867	0.2104	17.4286
	Mp5	0.2233	0.0181	0.2513	2.1438	0.3135	0.0920	0.2415	17.9375
	Mp6	0.2306	0.0206	0.2409	2.0957	0.3273	0.0880	0.2373	22.8857
	Mp7	0.2883	0.0205	0.2793	2.4000	0.3510	0.1136	0.2789	24.4091
	Mp8	0.2823	0.0225	0.2203	2.2760	0.3325	0.0920	0.2330	25.1000
	Mp9	0.3030	0.0263	0.2920	3.1150	0.4270	0.1230	0.2778	29.2833
	Mp10	0.4612	0.0302	0.3894	3.9560	0.5162	0.1594	0.3734	30.6400
	Mp11	0.4337	0.0417	0.4110	4.4300	0.6250	0.1680	0.4220	46.6000
	Mp12	0.7570	0.0810	0.9610	8.3260	1.2480	0.3870	1.1390	134.7000
	Mp13	0.7720	0.0650	0.3410	13.4700	0.9730	0.1800	0.4000	28.2500

Station:Palo Alto

Date:04/11/07

Statistical Summary

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	3.6226	0.3643	3.2721	33.9139	5.1594	1.2625	3.4948	400.4898
STD	0.8540	0.0351	0.7694	7.1438	0.6541	0.2037	0.7977	51.3427
SEM	0.257	0.011	0.232	2.154	0.197	0.061	0.252	15.480
CV%	23.574	9.634	23.513	21.064	12.677	16.138	22.825	12.820
n	11	11	11	11	11	11	10	11
r wt x [ ]	0.117	0.208	0.239	0.549	0.046	0.257	0.001	0.640
X 100mg	3.750	0.374	3.036	38.938	5.198	1.195	3.496	442.585
r l x [ ]	0.284	0.264	0.241	0.438	0.176	0.214	0.072	0.606
X 20mm	3.655	0.366	3.247	34.331	5.175	1.257	3.514	404.642
X 25mm	4.120	0.383	2.892	40.325	5.396	1.173	3.638	464.273

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

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.2541	0.0259	0.2243	2.4062	0.3653	0.0878	0.2468	28.6615
25mm	0.5023	0.0478	0.3590	4.8429	0.6607	0.1452	0.4522	56.8871

Estimated weight for 15mm clam	Estimated weight for 20mm clam
0.034 gm	0.071 gm
34.314 mg	71.101 mg

Estimated weight for 25mm clam

0.125 gm
125.113 mg

Station:Palo Alto | Macoma petalum

Date:04/11/07

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	14.06	0.2717	0.0302	10	0.0725	0.0088	0.1071	0.7573	0.1431	0.0386	0.1046	9.317
Mp2	17.45	0.4677	0.0468	15	0.1337	0.0121	0.0937	1.103	0.1622	0.041	0.0958	14.29
Mp3	18.71	0.3647	0.0608	10	0.0907	0.0119	0.0904	0.91	0.1464	0.0399	0.0876	11.63
Mp4	18.71	0.3385	0.0564	10	0.1401	0.0118	0.0903	1.08	0.1606	0.0436	0.1019	12.85
Mp5	19.43	0.5607	0.0701	15	0.1603	0.0138	0.1373	1.364	0.2091	0.0549	0.1415	14.05
Mp6	19.26	0.5028	0.0629	15	0.1544	0.0114	0.149	1.193	0.1823	0.0454	0.1429	12.11
Mp7	20.30	0.4009	0.0802	15	0.0646	0.0117	0.0594	0.7385	0.119	0.0196	0.0625	11.57
Mp8	20.55	0.2732	0.0683	10	0.0955	0.0112	0.1045	0.9307	0.1727	0.0389	0.1327	10.34
Mp9	21.34	0.3519	0.0880	10	0.125	0.0123	0.1482	1.23	0.1761	0.0438	0.1354	15.08
Mp10	22.50	0.2175	0.1088	10	0.0686	0.0078	0.0637	1.135	0.105	0.0281	0.0766	10.09
Mp11	23.86	0.1014	0.1014	10	0.0482	0.0036	0.0263	0.3248	0.0597	0.0127	0.0244	4.712
				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	2.6684	0.3239	3.9418	27.8727	5.2668	1.4207	3.8498	342.915
	Mp2	4.2880	0.3881	3.0051	35.3752	5.2021	1.3149	3.0725	458.307
	Mp3	2.4870	0.3263	2.4787	24.9520	4.0143	1.0940	2.4020	318.892
	Mp4	4.1388	0.3486	2.6677	31.9055	4.7445	1.2880	3.0103	379.616
	Mp5	4.2884	0.3692	3.6731	36.4901	5.5939	1.4687	3.7854	375.869
	Mp6	4.6062	0.3401	4.4451	35.5907	5.4385	1.3544	4.2631	361.277
	Mp7	2.4171	0.4378	2.2225	27.6316	4.4525	0.7333	2.3385	432.901
	Mp8	3.4956	0.4100	3.8250	34.0666	6.3214	1.4239	4.8572	378.477
	Mp9	3.5521	0.3495	4.2114	34.9531	5.0043	1.2447	3.8477	428.531
	Mp10	3.1540	0.3586	2.9287	52.1839	4.8276	1.2920	3.5218	463.908
	Mp11	4.7535	0.3550	2.5937	32.0316	5.8876	1.2525		464.694

	Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Content (ug) ==>	Mp1	0.0806	0.0098	0.1190	0.8414	0.1590	0.0429	0.1162	10.3522
	Mp2	0.2006	0.0182	0.1406	1.6545	0.2433	0.0615	0.1437	21.4350
	Mp3	0.1512	0.0198	0.1507	1.5167	0.2440	0.0665	0.1460	19.3833
	Mp4	0.2335	0.0197	0.1505	1.8000	0.2677	0.0727	0.1698	21.4167
	Mp5	0.3006	0.0259	0.2574	2.5575	0.3921	0.1029	0.2653	26.3438
	Mp6	0.2895	0.0214	0.2794	2.2369	0.3418	0.0851	0.2679	22.7063
	Mp7	0.1938	0.0351	0.1782	2.2155	0.3570	0.0588	0.1875	34.7100
	Mp8	0.2388	0.0280	0.2613	2.3268	0.4318	0.0973	0.3318	25.8500
	Mp9	0.3125	0.0308	0.3705	3.0750	0.4403	0.1095	0.3385	37.7000
	Mp10	0.3430	0.0390	0.3185	5.6750	0.5250	0.1405	0.3830	50.4500
	Mp11	0.4820	0.0360	0.2630	3.2480	0.5970	0.1270		47.1200

Station:Palo Alto

Date:05/09/07

Statistical Summary

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	1.9068	0.3128	1.6115	21.7215	4.3188	0.9503	1.5712	254.5888
STD	0.6170	0.1033	0.7798	7.1491	2.2246	0.3508	0.8065	92.6368
SEM	0.186	0.031	0.235	2.156	0.671	0.106	0.243	27.931
CV%	32.357	33.025	48.387	32.913	51.511	36.911	51.331	36.387
n	11	11	11	11	11	11	11	11
r wt x [ ]	0.486	0.666	0.847	0.678	0.451	0.882	0.868	0.370
X 100mg	1.965	0.300	1.484	20.790	4.512	0.891	1.437	247.999
r l x [ ]	0.546	0.494	0.833	0.508	0.269	0.797	0.847	0.176
X 20mm	1.962	0.304	1.506	21.132	4.416	0.905	1.460	251.940
X 25mm	2.438	0.232	0.587	15.993	5.263	0.509	0.494	228.852

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

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.1719	0.0193	0.0415	1.3529	0.3612	0.0679	0.0668	15.3584
25mm	0.4460	0.0229	0.0153	1.6135	0.7693	0.0886	0.0445	19.3941

Estimated weight for 15mm clam	Estimated weight for 20mm clam
0.035 gm	0.090 gm
34.971 mg	90.014 mg

Estimated weight for 25mm clam

0.187 gm
187.411 mg

Station:Palo Alto

Date:05/09/07

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	12.29	0.2402	0.0185	10	0.0289	0.0083	0.0671	0.5772	0.1148	0.0302	0.0629	5.621
Mp2	15.05	0.3574	0.0357	10	0.045	0.0122	0.1012	0.8772	0.1723	0.0534	0.1098	7.823
Mp3	17.12	0.6584	0.0549	15	0.066	0.0142	0.0631	0.9726	0.137	0.0402	0.0599	10.34
Mp4	18.57	0.4843	0.0605	15	0.1031	0.0124	0.0588	0.8709	0.1363	0.0355	0.0592	10.4
Mp5	19.46	0.5803	0.0829	15	0.0701	0.0139	0.0639	0.9041	0.1431	0.0446	0.0615	11.77
Mp6	20.39	0.6007	0.1001	15	0.0705	0.0136	0.0442	0.9469	0.109	0.0343	0.0387	11.21
Mp7	20.49	0.6249	0.1042	15	0.0806	0.0129	0.061	0.9141	0.1538	0.0434	0.0727	10.89
Mp8	21.52	0.8245	0.1178	15	0.1015	0.0189	0.0752	1.331	0.1686	0.0424	0.0716	19.31
Mp9	21.67	0.8965	0.1121	15	0.0858	0.0196	0.0792	1.402	0.2034	0.0575	0.0931	16.37
Mp10	22.43	0.6445	0.1289	15	0.0993	0.0154	0.0829	1.034	0.1408	0.0339	0.0528	13.53
Mp12	24.72	0.5540	0.1847	15	0.1003	0.0131	0.0607	0.8852	0.1584	0.0434	0.075	8.934
				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	1.2032	0.3455	2.7935	24.0300	4.7794	1.2573	2.6187	234.013
	Mp2	1.2591	0.3414	2.8316	24.5439	4.8209	1.4941	3.0722	218.886
	Mp3	1.5036	0.3235	1.4376	22.1583	3.1212	0.9159	1.3647	235.571
	Mp4	3.1933	0.3841	1.8212	26.9740	4.2216	1.0995	1.8336	322.114
	Mp5	1.8120	0.3593	1.6517	23.3698	3.6989	1.1529	1.5897	304.239
	Mp6	1.7604	0.3396	1.1037	23.6449	2.7218	0.8565	0.9664	279.923
	Mp7	1.9347	0.3096	1.4642	21.9419	3.6918	1.0418	1.7451	261.402
	Mp8	1.8466	0.3438	1.3681	24.2147	3.0673	0.7714	1.3026	351.304
	Mp9	1.4356	0.3279	1.3252	23.4579	3.4032	0.9621	1.5577	273.898
	Mp10	2.3111	0.3584	1.9294	24.0652	3.2770	0.7890	1.2289	314.895
	Mp12	2.7157	0.0071	0.0001	0.5357	10.7035	0.1133	0.0037	4.2301

	Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Content (ug) ==>	Mp1	0.0222	0.0064	0.0516	0.4440	0.0883	0.0232	0.0484	4.3238
	Mp2	0.0450	0.0122	0.1012	0.8772	0.1723	0.0534	0.1098	7.8230
	Mp3	0.0825	0.0178	0.0789	1.2158	0.1713	0.0503	0.0749	12.9250
	Mp4	0.1933	0.0233	0.1103	1.6329	0.2556	0.0666	0.1110	19.5000
	Mp5	0.1502	0.0298	0.1369	1.9374	0.3066	0.0956	0.1318	25.2214
	Mp6	0.1763	0.0340	0.1105	2.3673	0.2725	0.0858	0.0968	28.0250
	Mp7	0.2015	0.0323	0.1525	2.2853	0.3845	0.1085	0.1818	27.2250
	Mp8	0.2175	0.0405	0.1611	2.8521	0.3613	0.0909	0.1534	41.3786
	Mp9	0.1609	0.0368	0.1485	2.6288	0.3814	0.1078	0.1746	30.6938
	Mp10	0.2979	0.0462	0.2487	3.1020	0.4224	0.1017	0.1584	40.5900
	Mp12	0.5015	0.0013	0.0000	0.0989	1.9766	0.0209	0.0007	0.7812

Station:Palo Alto

Date:06/05/07

Statistical Summary

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	2.1593	0.3414	1.3115	27.3155	4.1596	1.2165	1.3307	261.3300
STD	1.6466	0.0345	0.3394	5.1341	0.8038	0.3165	0.4000	59.9913
SEM	0.521	0.011	0.107	1.624	0.254	0.100	0.126	18.971
CV%	76.256	10.114	25.881	18.796	19.324	26.013	30.058	22.956
n	10	10	10	10	10	10	10	10
r wt x [ ]	0.646	0.426	0.055	0.263	0.308	0.397	0.199	0.653
X 100mg	1.975	0.344	1.315	27.081	4.203	1.238	1.344	254.532
r l x [ ]	0.719	0.388	0.016	0.269	0.211	0.314	0.099	0.725
X 20mm	1.817	0.345	1.310	26.917	4.209	1.245	1.342	248.760
X 25mm	3.411	0.327	1.317	28.776	3.980	1.111	1.289	307.365

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

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.1488	0.0294	0.1103	2.2965	0.3550	0.1036	0.1116	21.2382
25mm	0.4394	0.0550	0.2071	4.6977	0.6550	0.1804	0.2016	50.4278

Estimated weight for 15mm clam	Estimated weight for 20mm clam
0.036 gm	0.086 gm
35.674 mg	85.787 mg

Estimated weight for 25mm clam

0.169 gm
169.434 mg

Station:Palo Alto

Date:06/05/07

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	15.01	0.4423	0.0316	10	0.0851	0.0188	0.0723	1.555	0.228	0.0743	0.0793	10.25
Mp2	17.57	0.3485	0.0498	10	0.0364	0.0119	0.0551	0.8023	0.1842	0.0593	0.0633	6.292
Mp3	18.71	0.3802	0.0760	10	0.0534	0.0127	0.0519	0.9851	0.1728	0.0452	0.0485	8.487
Mp4	19.64	0.5763	0.0823	10	0.1143	0.0186	0.0662	1.399	0.2122	0.0637	0.0745	16.77
Mp5	20.73	0.6597	0.1100	15	0.066	0.0139	0.0579	0.99	0.1362	0.0486	0.0516	10.43
Mp6	21.30	0.783	0.1119	15	0.0796	0.0187	0.0563	1.355	0.1856	0.0521	0.0504	15.63
Mp7	22.76	0.5664	0.1416	10	0.0844	0.0181	0.0554	1.505	0.1855	0.0506	0.0522	14.67
Mp8	22.87	0.5945	0.1486	10	0.0936	0.0179	0.0658	1.618	0.2247	0.058	0.0596	12.21
Mp9	23.71	0.8231	0.1372	15	0.1331	0.0185	0.0501	1.349	0.23	0.0512	0.0575	16.31
Mp10	28.43	0.1982	0.1982	10	0.1332	0.0071	0.0395	0.7522	0.0997	0.0314	0.04	7.702
				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	1.9240	0.4251	1.6346	35.1571	5.1549	1.6799	1.7929	231.743
	Mp2	1.0445	0.3415	1.5811	23.0215	5.2855	1.7016	1.8164	180.545
	Mp3	1.4045	0.3340	1.3651	25.9100	4.5450	1.1888	1.2756	223.225
	Mp4	1.9833	0.3227	1.1487	24.2756	3.6821	1.1053	1.2927	290.994
	Mp5	1.5007	0.3161	1.3165	22.5102	3.0969	1.1050	1.1733	237.153
	Mp6	1.5249	0.3582	1.0785	25.9579	3.5556	0.9981	0.9655	299.425
	Mp7	1.4901	0.3196	0.9781	26.5713	3.2751	0.8934	0.9216	259.004
	Mp8	1.5744	0.3011	1.1068	27.2161	3.7796	0.9756	1.0025	205.383
	Mp9	2.4256	0.3371	0.9130	24.5839	4.1915	0.9331	1.0479	297.230
	Mp10	6.7205	0.3582	1.9929	37.9516	5.0303	1.5843	2.0182	388.597

	Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Content (ug) ==>	Mp1	0.0608	0.0134	0.0516	1.1107	0.1629	0.0531	0.0566	7.3214
	Mp2	0.0520	0.0170	0.0787	1.1461	0.2631	0.0847	0.0904	8.9886
	Mp3	0.1068	0.0254	0.1038	1.9702	0.3456	0.0904	0.0970	16.9740
	Mp4	0.1633	0.0266	0.0946	1.9986	0.3031	0.0910	0.1064	23.9571
	Mp5	0.1650	0.0348	0.1448	2.4750	0.3405	0.1215	0.1290	26.0750
	Mp6	0.1706	0.0401	0.1206	2.9036	0.3977	0.1116	0.1080	33.4929
	Mp7	0.2110	0.0453	0.1385	3.7625	0.4638	0.1265	0.1305	36.6750
	Mp8	0.2340	0.0448	0.1645	4.0450	0.5618	0.1450	0.1490	30.5250
	Mp9	0.3328	0.0463	0.1253	3.3725	0.5750	0.1280	0.1438	40.7750
	Mp10	1.3320	0.0710	0.3950	7.5220	0.9970	0.3140	0.4000	77.0200

Station:Palo Alto

Date:09/25/07

Statistical Summary

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	2.4094	0.3746	2.7162	31.4927	5.5995	1.9556	2.6346	204.6653
STD	0.8134	0.0576	1.3718	7.9112	1.1600	0.7584	1.2389	55.2115
SEM	0.257	0.018	0.434	2.502	0.367	0.240	0.392	17.459
CV%	33.757	15.367	50.503	25.121	20.716	38.781	47.024	26.976
n	10	10	10	10	10	10	10	10
r wt x [ ]	0.219	0.779	0.841	0.283	0.805	0.902	0.869	0.283
X 100mg	2.477	0.357	2.276	30.639	5.243	1.695	2.224	198.715
r l x [ ]	0.538	0.565	0.939	0.056	0.719	0.952	0.941	0.121
X 20mm	2.519	0.366	2.393	31.605	5.390	1.774	2.342	202.985
X 25mm	2.881	0.339	1.326	31.974	4.699	1.176	1.377	197.445

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

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.1709	0.0248	0.1425	2.1329	0.3567	0.1104	0.1405	13.3800
25mm	0.4011	0.0487	0.2237	4.4679	0.6694	0.1833	0.2237	26.5756

Estimated weight for 15mm clam	Estimated weight for 20mm clam
0.027 gm	0.069 gm
27.195 mg	69.065 mg

Estimated weight for 25mm clam

0.142 gm
142.308 mg

Station:Palo Alto Macoma petalum

Date:09/25/07

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	8.71	0.1068	0.0056	10	0.0124	0.004	0.0604	0.2322	0.0774	0.0353	0.0542	2.376
Mp2	10.99	0.1791	0.0094	10	0.0357	0.0078	0.0723	0.6505	0.1144	0.0512	0.0704	4.127
Mp3	12.84	0.1759	0.0147	10	0.0419	0.0078	0.058	0.5715	0.1129	0.0429	0.0572	3.858
Mp4	16.05	0.2704	0.0338	10	0.0511	0.0096	0.0797	0.8016	0.1522	0.0556	0.0773	4.635
Mp5	18.80	0.3128	0.0447	10	0.0796	0.0135	0.0925	1.1150	0.1895	0.0694	0.0958	4.848
Mp6	21.33	0.5036	0.0719	10	0.1775	0.0207	0.1026	1.900	0.2943	0.0771	0.1035	12.49
Mp7	22.30	0.2834	0.0945	10	0.0823	0.01	0.0503	1.305	0.1368	0.0403	0.0445	5.574
Mp8	23.52	0.7392	0.1848	15	0.1027	0.0127	0.0549	0.953	0.1483	0.0486	0.0534	6.122
Mp9	24.29	0.2369	0.1185	10	0.0903	0.0079	0.0407	0.6696	0.1156	0.0386	0.0447	7.496
Mp10	26.01	0.1712	0.1712	10	0.0308	0.006	0.0278	0.4743	0.0975	0.019	0.0269	2.785
				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	1.1610	0.3745	5.6554	21.7416	7.2472	3.3052	5.0749	222.472
Mp2	1.9933	0.4355	4.0369	36.3205	6.3875	2.8587	3.9308	230.430
Mp3	2.3820	0.4434	3.2973	32.4901	6.4184	2.4389	3.2518	219.329
Mp4	1.8898	0.3550	2.9475	29.6450	5.6287	2.0562	2.8587	171.413
Mp5	2.5448	0.4316	2.9572	35.6458	6.0582	2.2187	3.0627	154.987
Mp6	3.5246	0.4110	2.0373	37.7284	5.8439	1.5310	2.0552	248.014
Mp7	2.9040	0.3529	1.7749	46.0480	4.8271	1.4220	1.5702	196.683
Mp8	2.0840	0.2577	1.1140	19.3385	3.0093	0.9862	1.0836	124.229
Mp9	3.8117	0.3335	1.7180	28.2651	4.8797	1.6294	1.8869	316.420
Mp10	1.7991	0.3505	1.6238	27.7044	5.6951	1.1098	1.5713	162.675

Content (ug) ==>

Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mp1	0.0065	0.0021	0.0318	0.1222	0.0407	0.0186	0.0285	1.2505
Mp2	0.0188	0.0041	0.0381	0.3424	0.0602	0.0269	0.0371	2.1721
Mp3	0.0349	0.0065	0.0483	0.4763	0.0941	0.0358	0.0477	3.2150
Mp4	0.0639	0.0120	0.0996	1.0020	0.1903	0.0695	0.0966	5.7938
Mp5	0.1137	0.0193	0.1321	1.5929	0.2707	0.0991	0.1369	6.9257
Mp6	0.2536	0.0296	0.1466	2.7143	0.4204	0.1101	0.1479	17.8429
Mp7	0.2743	0.0333	0.1677	4.3500	0.4560	0.1343	0.1483	18.5800
Mp8	0.3851	0.0476	0.2059	3.5738	0.5561	0.1823	0.2003	22.9575
Mp9	0.4515	0.0395	0.2035	3.3480	0.5780	0.1930	0.2235	37.4800
Mp10	0.3080	0.0600	0.2780	4.7430	0.9750	0.1900	0.2690	27.8500

Station:Palo Alto

Date:10/24/07

Statistical Summary

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	3.2540	0.2543	2.7989	32.5530	6.1447	1.7685	4.2577	225.8488
STD	0.8037	0.0311	0.7128	6.5207	1.0989	0.4392	1.4650	51.8716
SEM	0.232	0.009	0.215	1.882	0.317	0.127	0.423	14.974
CV%	24.697	12.227	25.469	20.031	17.883	24.837	34.408	22.967
n	12	12	11	12	12	12	12	12
r wt x [ ]	0.752	0.008	0.364	0.663	0.743	0.718	0.736	0.374
X 100mg	3.436	0.254	2.633	33.855	5.899	1.673	3.933	231.695
r l x [ ]	0.803	0.145	0.422	0.513	0.812	0.849	0.807	0.222
X 20mm	3.021	0.256	2.873	31.345	6.467	1.903	4.685	221.696
X 25mm	3.760	0.251	2.504	35.176	5.445	1.476	3.330	234.865

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

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.1706	0.0145	0.1560	1.7967	0.3572	0.1029	0.2444	12.5599
25mm	0.4488	0.0301	0.2958	4.1235	0.6654	0.1821	0.4039	27.2505

Estimated weight for 15mm clam	Estimated weight for 20mm clam
0.022 gm	0.057 gm
21.616 mg	57.143 mg

Estimated weight for 25mm clam

0.121 gm
121.459 mg

Station:Palo Alto

Date:10/24/07

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	11.82	0.1629	0.0102	10	0.0384	0.0049	0.0529	0.5202	0.1355	0.0437	0.1103	4.085
Mp2	16.06	0.2186	0.0273	10	0.0339	0.0048	0.0848	0.5223	0.1661	0.0526	0.1471	3.786
Mp3	18.85	0.3053	0.0436	10	0.071	0.0081	0.1128	0.8601	0.2135	0.068	0.1673	6.111
Mp4	20.63	0.2479	0.0620	10	0.0788	0.0058	0.0449	0.8213	0.1237	0.0346	0.0758	5.831
Mp5	21.52	0.7134	0.0793	15	0.1768	0.0122	0.0943	1.578	0.2471	0.0708	0.1447	11.18
Mp6	22.52	0.5486	0.0784	10	0.2281	0.0136	0.172	1.762	0.3381	0.0958	0.2301	14.17
Mp7	22.60	0.6642	0.0830	10	0.2341	0.0173	0.1832	2.248	0.4175	0.1143	0.2777	14.37
Mp8	23.43	0.4795	0.0959	10	0.1459	0.0117	0.0921	1.265	0.2571	0.0646	0.1488	10.47
Mp9	23.29	0.3768	0.0942	10	0.1392	0.0092	0.086	1.171	0.2299	0.0558	0.1483	6.866
Mp10	24.25	0.6364	0.1061	10	0.2328	0.0182	0.1913	2.4	0.405	0.108	0.261	14.7
Mp11	26.07	0.5952	0.1488	10	0.2178	0.0116	0.1827	1.755	0.3497	0.1	0.2694	9.129
Mp12	27.89	0.1913	0.1913	10	0.08	0.0057	-0.007	0.9509	0.0859	0.0258	0.0377	6.814
				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	2.3573	0.3008	3.2474	31.9337	8.3180	2.6826	6.7710	250.767
	Mp2	1.5508	0.2196	3.8792	23.8930	7.5984	2.4062	6.7292	173.193
	Mp3	2.3256	0.2653	3.6947	28.1723	6.9931	2.2273	5.4799	200.164
	Mp4	3.1787	0.2340	1.8112	33.1303	4.9899	1.3957	3.0577	235.216
	Mp5	3.7174	0.2565	1.9828	33.1791	5.1955	1.4886	3.0425	235.071
	Mp6	4.1579	0.2479	3.1353	32.1181	6.1630	1.7463	4.1943	258.294
	Mp7	3.5245	0.2605	2.7582	33.8452	6.2858	1.7209	4.1810	216.350
	Mp8	3.0428	0.2440	1.9208	26.3816	5.3618	1.3472	3.1032	218.352
	Mp9	3.6943	0.2442	2.2824	31.0775	6.1014	1.4809	3.9358	182.219
	Mp10	3.6581	0.2860	3.0060	37.7121	6.3639	1.6970	4.1012	230.987
	Mp11	3.6593	0.1949	3.0696	29.4859	5.8753	1.6801	4.5262	153.377
	Mp12	4.1819	0.2980		49.7073	4.4903	1.3487	1.9707	356.194

	Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Content (ug) ==>	Mp1	0.0240	0.0031	0.0331	0.3251	0.0847	0.0273	0.0689	2.5531
	Mp2	0.0424	0.0060	0.1060	0.6529	0.2076	0.0658	0.1839	4.7325
	Mp3	0.1014	0.0116	0.1611	1.2287	0.3050	0.0971	0.2390	8.7300
	Mp4	0.1970	0.0145	0.1123	2.0533	0.3093	0.0865	0.1895	14.5775
	Mp5	0.2947	0.0203	0.1572	2.6300	0.4118	0.1180	0.2412	18.6333
	Mp6	0.3259	0.0194	0.2457	2.5171	0.4830	0.1369	0.3287	20.2429
	Mp7	0.2926	0.0216	0.2290	2.8100	0.5219	0.1429	0.3471	17.9625
	Mp8	0.2918	0.0234	0.1842	2.5300	0.5142	0.1292	0.2976	20.9400
	Mp9	0.3480	0.0230	0.2150	2.9275	0.5748	0.1395	0.3708	17.1650
	Mp10	0.3880	0.0303	0.3188	4.0000	0.6750	0.1800	0.4350	24.5000
	Mp11	0.5445	0.0290	0.4568	4.3875	0.8743	0.2500	0.6735	22.8225
	Mp12	0.8000	0.0570		9.5090	0.8590	0.2580	0.3770	68.1400

Station:Palo Alto

Statistical Summary

Date:12/19/07

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Mean(ug/g)	3.3982	0.2623	2.3579	33.9945	6.7864	1.7157	4.6051	283.3877
STD	1.2232	0.0231	1.4353	6.8804	1.6586	0.5519	1.9026	60.9284
SEM	0.387	0.007	0.454	2.176	0.524	0.175	0.602	19.267
CV%	35.996	8.809	60.873	20.240	24.440	32.167	41.315	21.500
n	10	10	10	10	10	10	10	10
r wt x [ ]	0.103	0.122	0.850	0.214	0.872	0.886	0.856	0.222
X 100mg	3.474	0.264	1.627	34.875	5.920	1.423	3.629	275.267
r l x [ ]	0.400	0.099	0.862	0.416	0.781	0.870	0.867	0.289
X 20mm	3.424	0.262	2.292	34.147	6.717	1.690	4.517	282.448
X 25mm	3.852	0.260	1.210	36.652	5.584	1.270	3.074	267.042

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

	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
20mm	0.1903	0.0150	0.0968	1.9607	0.3664	0.0894	0.2296	15.7032
25mm	0.4320	0.0300	0.1305	4.2009	0.6509	0.1502	0.3666	30.0509

Estimated weight for 15mm clam

0.023 gm
23.357 mg

Estimated weight for 20mm clam

0.058 gm
57.669 mg

Estimated weight for 25mm clam

0.116 gm
116.255 mg

Station:Palo Alto

Date:12/19/07

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	9.82	0.103	0.0064	10	0.0279	0.003	0.0382	0.289	0.0837	0.0235	0.0657	3.482
Mp2	12.04	0.2174	0.0114	10	0.0368	0.0057	0.1172	0.6265	0.2032	0.0595	0.1825	7.361
Mp3	14.38	0.1659	0.0207	10	0.0388	0.0041	0.0481	0.465	0.1181	0.0306	0.0903	4.017
Mp4	19.94	0.1689	0.0563	10	0.0675	0.0044	0.0254	0.6144	0.1198	0.0298	0.0711	4.842
Mp5	21.37	0.22	0.0733	10	0.1032	0.006	0.0528	0.8126	0.1735	0.0426	0.1133	5.402
Mp6	22.46	0.3732	0.0746	10	0.1958	0.0099	0.0939	1.844	0.2802	0.0679	0.1833	12.92
Mp7	22.32	0.2984	0.0746	10	0.1425	0.0079	0.0574	1.008	0.1861	0.0412	0.106	9.386
Mp8	23.43	0.3506	0.0877	10	0.1165	0.0082	0.0672	1.016	0.2165	0.0481	0.128	8.999
Mp9	23.51	0.4261	0.1065	10	0.1289	0.0096	0.0451	1.695	0.1943	0.0513	0.0991	6.42
Mp11	27.67	0.1799	0.1799	10	0.0393	0.0054	0.0047	0.5357	0.0686	0.0147	0.0366	5.663
				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	2.7087	0.2913	3.7087	28.0583	8.1262	2.2816	6.3786	338.058
	Mp2	1.6927	0.2622	5.3910	28.8178	9.3468	2.7369	8.3947	338.592
	Mp3	2.3388	0.2471	2.8993	28.0289	7.1187	1.8445	5.4430	242.134
	Mp4	3.9964	0.2605	1.5038	36.3766	7.0930	1.7644	4.2096	286.679
	Mp5	4.6909	0.2727	2.4000	36.9364	7.8864	1.9364	5.1500	245.545
	Mp6	5.2465	0.2653	2.5161	49.4105	7.5080	1.8194	4.9116	346.195
	Mp7	4.7755	0.2647	1.9236	33.7802	6.2366	1.3807	3.5523	314.544
	Mp8	3.3229	0.2339	1.9167	28.9789	6.1751	1.3719	3.6509	256.674
	Mp9	3.0251	0.2253	1.0584	39.7794	4.5600	1.2039	2.3257	150.669
	Mp11	2.1845	0.3002	0.2613	29.7777	3.8132	0.8171	2.0345	314.786

	Sample #	Ag	Cd	Cr	Cu	Ni	Pb	V	Zn
Content (ug) ==>	Mp1	0.0174	0.0019	0.0239	0.1806	0.0523	0.0147	0.0411	2.1763
	Mp2	0.0194	0.0030	0.0617	0.3297	0.1069	0.0313	0.0961	3.8742
	Mp3	0.0485	0.0051	0.0601	0.5813	0.1476	0.0383	0.1129	5.0213
	Mp4	0.2250	0.0147	0.0847	2.0480	0.3993	0.0993	0.2370	16.1400
	Mp5	0.3440	0.0200	0.1760	2.7087	0.5783	0.1420	0.3777	18.0067
	Mp6	0.3916	0.0198	0.1878	3.6880	0.5604	0.1358	0.3666	25.8400
	Mp7	0.3563	0.0198	0.1435	2.5200	0.4653	0.1030	0.2650	23.4650
	Mp8	0.2913	0.0205	0.1680	2.5400	0.5413	0.1203	0.3200	22.4975
	Mp9	0.3223	0.0240	0.1128	4.2375	0.4858	0.1283	0.2478	16.0500
	Mp11	0.3930	0.0540	0.0470	5.3570	0.6860	0.1470	0.3660	56.6300

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 compliant. A 508 compliant Excel spreadsheet containing these 508 compliant tables may be accessed at URL: *http://pubs.usgs.gov/of/2008/1180/Appendix-D.xls*

D-1a. Mercury and selenium concentrations (µg/g dry weight) determined in surface sediments and *M. petalum* in 2007. Analyses 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***
1/17/2007	0.27	0.2	NA	NA
2/13/2007	0.23	0.4	0.31±0.02	6.47±0.14
4/11/2007	0.18	0.4	0.16±0.02	4.80±0.04
6/5/2007	0.29	0.4	0.27±0.02	4.17±0.03
9/25/2007	0.22	0.3	0.37±0.03	4.47±0.03
12/19/2007	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 June and September 2007.

Date	***Sediment***		**M. petalum**	
	mercury	***selenium***	***mercury***	***selenium***
6/5/2007	0.26/0.32	0.4/0.4	0.41/0.34	2.7/2.5
9/25/2007	NA	NA	0.42/0.37	2.9/3.1

D-2. Observed and certified concentrations of mercury and selenium in standard reference materials analyzed in 2007. Certified concentrations as reported by National Research Council Canada are the mean and 95% confidence interval. The seven materials are Montana soil (NIST 2711), estuarine sediment (NIST 1646a), mussel tissue (NIST 2976), dogfish liver (CRC DOLT-3), oyster tissue (NIST 1566b), San Joaquin soil (NIST 2709), and marine sediment (USGS MAG-1).

SRM	***Mercury***		***Selenium***	
	Observed	***Certified***	***Observed***	***Certified***
NIST 2711	6.0	6.25±0.19	1.4	1.52±0.14
NIST 1646A	0.04	0.04	0.2	0.19±0.03
NIST 2976	0.07	0.061±0.004	1.8	1.8±0.2
CRC DOLT-3	3.5	3.4±0.1	6.6	7.1±0.5
NIST 1566B	0.05	0.037±0.013	1.2	2.06±0.15
NIST 2709	1.5	1.40±0.08	1.5	1.57±0.08
USGS MAG-1	0.018	0.018	1.2	1.16±0.12

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-1and SRM 2976 (mussel tissue) in E-2.

Note: Appendix tables in this document may not be 508 compliant. A 508 compliant Excel spreadsheet containing these 508 compliant tables may be accessed at URL: *http://pubs.usgs.gov/of/2008/1180/Appendix-E.xls*

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

Month	Rep	AL	AS	CD	CR	CU	FE	MN	NI	PB	V	ZN
January	1	43228	12.56	0.65	99.10	33.42	32611	510.28	78.84	25.25	94.37	98.10
	2	43883	13.12	0.73	102.76	34.02	34272	540.14	83.91	27.19	94.31	101.58
February	1	43459	13.49	0.80	102.83	34.05	34453	540.95	85.23	28.01	100.04	103.69
	2	44744	12.32	0.67	104.17	34.43	33400	526.28	79.38	25.30	93.02	99.38
March	1	42638	14.23	0.75	98.32	33.23	34517	542.89	83.86	25.88	100.10	103.28
	2	43694	13.34	0.67	99.65	33.56	34188	534.71	80.57	24.87	100.29	100.71
April	1	44847	15.63	0.95	106.38	35.47	36291	565.29	87.56	28.20	103.42	107.01
	2	46317	15.05	0.99	111.16	37.01	36799	577.72	88.93	29.01	105.53	110.24
May	1	42788	14.04	0.82	100.66	33.32	34604	547.64	83.79	25.90	102.65	101.10
	2	43147	14.42	0.81	101.68	34.20	34525	541.47	83.38	26.48	100.70	101.72
June	1	43697	13.86	0.83	105.33	34.66	34151	541.75	83.99	26.33	102.98	102.55
	2	43850	15.02	0.84	104.38	34.83	34398	546.83	86.99	27.36	104.21	102.76
September	1	44414	14.51	0.96	106.12	35.36	34084	539.70	86.25	27.81	100.74	104.11
	2	44616	12.87	0.84	107.88	34.61	32765	514.34	82.27	26.31	99.90	99.46
October	1	44952	13.49	0.81	107.25	34.86	32452	519.08	80.96	25.81	101.77	99.42
	2	45331	12.61	0.75	109.93	35.04	32684	517.26	81.36	25.70	101.40	99.29
December	1	41741	14.05	0.95	97.98	33.67	32194	518.31	83.31	26.36	100.00	99.50
		42077	12.94	0.81	97.84	33.58	32262	516.95	81.45	24.78	99.69	97.32
	Cert. Value	75000	17.70	0.38	130.00	34.60	35000	538	88.0	18.9	112.0	106.0
	Std	0.06	0.80	0.01	4.00	0.70	0.11	17.00	5.00	0.50	5.00	3.00

Month	Rep	AL	AS	CD	CR	CU	FE	MN	NI	PB	V	ZN
January	1	57.64	70.98	170.72	76.23	96.58	93.17	94.85	89.60	133.61	84.26	92.55
	2	58.51	74.14	192.98	79.05	98.33	97.92	100.40	95.35	143.86	84.20	95.83
February	1	57.95	76.21	209.42	79.10	98.40	98.44	100.55	96.85	148.19	89.32	97.82
	2	59.66	69.62	176.46	80.13	99.52	95.43	97.82	90.20	133.86	83.06	93.76
March	1	56.85	80.38	196.75	75.63	96.04	98.62	100.91	95.30	136.92	89.38	97.44
	2	58.26	75.38	175.55	76.65	97.00	97.68	99.39	91.56	131.59	89.55	95.01
April	1	59.80	88.28	249.65	81.83	102.52	103.69	105.07	99.50	149.20	92.34	100.96
	2	61.76	85.03	259.73	85.50	106.97	105.14	107.38	101.06	153.49	94.23	104.00
May	1	57.05	79.3	216.44	77.4	96.3	98.87	101.79	95.2	137.0	91.6	95.4
	2	57.53	81.5	213.66	78.2	98.8	98.64	100.64	94.7	140.1	89.9	96.0
June	1	58.26	78.32	218.68	81.02	100.17	97.57	100.70	95.44	139.30	91.95	96.75
	2	58.47	84.86	221.48	80.29	100.66	98.28	101.64	98.85	144.78	93.04	96.95
September	1	59.22	81.96	253.30	81.63	102.18	97.38	100.32	98.01	147.14	89.95	98.22
	2	59.49	72.73	221.63	82.98	100.03	93.61	95.60	93.49	139.20	89.20	93.83
October	1	59.94	76.24	214.42	82.50	100.74	92.72	96.48	92.00	136.59	90.86	93.80
	2	60.44	71.22	197.66	84.56	101.27	93.38	96.14	92.46	135.98	90.54	93.67
December	1	55.66	79.38	250.77	75.37	97.31	91.98	96.34	94.68	139.49	89.29	93.86
	AVG	**58.6**	**78.0**	**214**	**79.9**	**99.6**	**97.2**	**99.8**	**95.0**	**141**	**89.6**	**96.2**
	STDEV	**1.5**	**5.4**	**28**	**3.1**	**2.8**	**3.6**	**3.3**	**3.2**	**6.2**	**3.1**	**2.9**

E-2. Observed and certified values for inorganic elements in NIST Standard Reference Material 2976 (mussel tissue) prepared in 2007. 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.

Date prepared	*Cadmium*	*Chromium*	*Copper*	*Lead*	*Nickel*	*Silver*	*Vanadium*	*Zinc*
January 17, 2007	0.80±0.05	0.70±0.17	4.88±0.07	0.97±0.07	0.82±0.02	0.047±0.01	0.91±0.1	137±5
February 13, 2007	0.81±0.01	0.60±0.06	4.61±0.01	1.04±0.07	0.83±0.06	0.013±0.02	0.79±0.01	140±1
March 14, 2007	0.82±0.01	0.59±0.09	4.67±0.04	1.03±0.08	0.82±0.02	0.006±0.02	0.78±0.05	140±2
April 11, 2007	0.84±0.01	0.90±0.48	4.83±0.04	1.08±0.08	0.83±0.03	0.034±0.01	0.82±0.00	142±2
May 9, 2007	0.81±0.01	0.75±0.08	4.73±0.01	1±0.05	0.78±0.04	0.022±0.03	0.82±0.08	138±1
June 5, 2007	0.79±0.01	1.36±0.11	4.84±0.02	1.03±0.02	0.81±0.02	0.023±0.01	0.84±0.00	136±2
September 25, 2007	0.78±0.01	1.01±0.30	4.92±0.12	1.03±0.03	0.78±0.02	0.016±0.01	0.82±0.03	136±2
October 24, 2007	0.76±0.00	0.44±0.15	4.44±0.01	1.04±0.03	0.76±0.00	<MDL	0.83±0.01	142±2
December 19, 2007	0.75±0.00	0.29±0.20	4.24±0.07	1.05±0.04	0.73±0.01	<MDL	0.81±0.02	139±1
Median	0.80	0.70	4.73	1.03	0.81	0.022	0.82	139
Certified Value Mean	0.82	0.5	4.02	0.93	1.19	0.011	Not certified	137
95% CI	0.16	0.02	0.33	0.12	0.18	0.005		13

Appendix F

Method detection limits (MDL) and reporting levels (MRL) for the analyses 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 compliant. A 508 compliant Excel spreadsheet containing these 508 compliant tables may be accessed at URL: *http://pubs.usgs.gov/of/2008/1180/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 2007 (G-1).

Note: Appendix tables in this document may not be 508 compliant. A 508 compliant Excel spreadsheet containing these 508 compliant tables may be accessed at URL: *http://pubs.usgs.gov/of/2008/1180/Appendix-G.xls*

G-1. Reproductive stage of *M. petalum* sampled from Palo Alto during 2007.

Date	***Inactive***	***Active***	***Ripe***	***Spawning***	***Spent***	***Spawned***	***N***	***Reproductive***	***Non-Reproductive***
01/17/07	0	0	100	0	0		10	100	0
02/01/07	0	0	90	10	0		10	100	0
03/14/07	0	0	30	50	20		10	80	-20
04/11/07	0	0	0	10	90		10	10	-90
05/09/07	0	0	0	10	90		10	10	-90
06/05/07	80	20	0	0	0		10	20	-80
09/25/07	44.4	55.6	0	0	0		9	56	-44
10/25/07	10	80	10	0	0		10	90	-10
12/19/07	0	70	30	0	0		10	100	0

Appendix H

Complete list of benthic species found at Palo Alto in the year 2007.

Note: Appendix tables in this document may not be 508 compliant. A 508 compliant Excel spreadsheet containing these 508 compliant tables may be accessed at URL: *http://pubs.usgs.gov/of/2008/1180//Appendix-H.xls*

	1/17/2007		2/13/2007		3/21/2007		4/18/2007		5/10/2007		6/5/2007		7/13/2007		8/29/2007		9/26/2007		11/21/2007	
Species	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std 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
Actiniaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.3	0.6
Ampelisca abdita	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.3	0.6	0.3	0.6	0.7	1.2	0.3	0.6	0.0	0.0
Ampithoe 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
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
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
Balanus 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
Boonea bisuturalis	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	0.0	0.0	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
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
Capitella "capitata"	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	1.0	1.7	1.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	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
Chironomidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	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
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
Corbula amurensis	0.0	0.0	0.7	0.6	0.3	0.6	1.7	1.5	1.0	1.0	1.3	1.5	1.0	1.0	0.7	0.6	0.0	0.0	0.0	0.0
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	1.7	2.9
Corophium alienense	0.7	1.2	0.0	0.0	0.7	1.2	0.0	0.0	0.0	0.0	0.7	0.6	0.3	0.6	0.0	0.0	0.7	0.6	0.3	0.6
Corophium spp.	1.3	0.6	0.3	0.6	0.3	0.6	1.3	1.5	0.7	1.2	9.7	6.7	0.0	0.0	0.0	0.0	0.0	0.0	3.0	2.6
Corophium spp. (female & juvenile)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	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 spp. (male)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	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
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
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
Eogammarus confervicolus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	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	0.3	0.6	0.0	0.0	0.0	0.0	0.7	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 lighti	5.3	1.5	4.0	2.0	0.0	0.0	20.7	11.6	31.3	8.7	41.7	10.4	2.0	1.7	9.3	1.5	4.7	2.1	4.3	0.6
Eteone 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
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
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
Eusarsiella zostericola	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	1.7	0.6	5.7	3.1	2.7	0.6	1.7	0.6
Gemma gemma	206.0	179.5	489.3	269.5	406.7	71.2	341.3	42.1	216.7	147.6	136.7	52.8	162.0	85.3	113.7	65.4	0.0	0.0	0.0	0.0
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
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
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
Glycinde 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
Gnorisphaeroma 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
Grandidierella japonica	3.0	1.0	0.0	0.0	0.0	0.0	0.7	0.6	0.0	0.0	7.3	2.9	3.3	2.1	12.3	11.0	17.0	7.8	18.0	14.7

	1/17/2007		2/13/2007		3/21/2007		4/18/2007		5/10/2007		6/5/2007		7/13/2007		8/29/2007		9/26/2007		11/21/2007	
Species	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std 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
Harpacticoida	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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
Heteromastus filiformis	12.0	4.0	14.3	6.5	16.0	9.8	11.3	7.0	18.7	8.6	12.3	10.1	5.3	0.6	18.3	6.4	11.3	3.5	17.3	1.5
Ilyanassa obsoleta	0.0	0.0	0.0	0.0	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
Macoma petalum	6.3	3.5	5.7	2.1	2.7	1.5	13.7	17.7	2.7	1.2	11.0	5.2	1.7	0.6	15.7	6.4	4.0	1.7	0.3	0.6
Macoma spp.	1.3	0.6	0.0	0.0	0.3	0.6	3.0	0.0	8.3	4.2	1.0	1.0	6.7	1.5	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
Melita nitida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monocorophium acherusicum	0.0	0.0	0.0	0.0	0.0	0.0	10.3	12.1	0.7	1.2	6.3	4.2	0.0	0.0	0.0	0.0	0.0	0.0	11.0	4.4
Monocorophium insidiosum	0.3	0.6	0.0	0.0	0.0	0.0	1.3	2.3	0.0	0.0	22.3	8.1	0.7	1.2	0.0	0.0	0.3	0.6	7.3	4.2
Monocorophium 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	0.0	0.0
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
Mya arenaria	0.0	0.0	0.3	0.6	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
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
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
Neanthes succinea	0.0	0.0	0.3	0.6	0.3	0.6	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6
Nematoda	1.7	1.5	11.0	16.5	2.0	2.0	0.0	0.0	0.7	1.2	3.3	3.1	1.0	1.0	3.7	3.8	0.7	1.2	0.0	0.0
Nippoleucon hinumensis	51.7	20.6	71.0	7.2	10.3	1.2	49.0	5.3	8.0	4.4	7.7	9.0	78.7	25.4	108.0	57.1	82.3	18.6	29.3	21.0
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	1.0	1.0	0.3	0.6	0.0	0.0	0.0	0.0
Odostomia spp.	0.0	0.0	1.3	2.3	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
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
Philine 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	0.7	1.2	0.0	0.0
Planariidae A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polydora cornuta	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	0.0	0.0	0.0	0.0	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pseudopolydora kempi	0.0	0.0	0.0	0.0	0.3	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
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
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
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
Sinelobus stanfordi	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
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
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
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
Streblospio benedicti	1.0	1.7	3.3	2.5	7.0	2.6	3.0	5.2	6.3	2.5	5.0	5.6	0.0	0.0	43.3	12.0	16.3	8.5	10.7	2.5
Synidotea laevidorsalis	0.0	0.0	0.0	0.0	0.0	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
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
Tharyx 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
Tubificidae	7.7	6.4	54.7	47.8	27.0	10.5	9.7	4.6	25.3	26.4	9.3	8.1	0.0	0.0	21.7	7.4	20.0	21.0	4.0	5.2
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

	1/17/2007		2/13/2007		3/21/2007		4/18/2007		5/10/2007		6/5/2007		7/13/2007		8/29/2007		9/26/2007		11/21/2007	
Species	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Unid. Actiniaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	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
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
Unid. Copepod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	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
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
Unid. Malanidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	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
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
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
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
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
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	0.0	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