SELECTED MOLLUSCS
AS MONITORS OF METAL POLLUTION
IN COASTAL MARINE ENVIRONMENTS

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by

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SUMMARY

The potential of bivalve molluscs as monitors of metal pollution in South African coastal marine environments has been investigated using the species Crassostrea gigas, Crassostrea margaritacea, Perna perna and Choromytilus meridionalis.

Metal concentrations in these and other species living along an unpolluted coast have been determined by atomic absorption spectrometry following chemical oxidation of the biological tissues. Variations in concentrations within a population may depend upon the size or sex of the individual and on the season during which the sample is collected.

Metal accumulation by the four study species has been investigated under controlled laboratory conditions for the elements zinc, cadmium, copper, lead, iron, manganese, nickel, cobalt and chromium. Rates of accumulation differ between species and for each element. Some of the factors affecting cadmium uptake have been studied. Rates of accumulation depend greatly upon the form of the cadmium in solution but are also affected by changes in environmental parameters. The accumulation rates of other elements are probably also affected by these factors, not necessarily in the same way.

The solution concentrations tested for these accumulation experiments, and also those tested for their effects on the filtering rates of adults or on the development of larvae, are higher than those normally found in polluted areas. This implies that these species are sufficiently tolerant of the presence of metals in their environment to be able to act as monitoring organisms. However, adult oysters and mussels may react to the presence of metals or to the estuarine environment, where fluctuations in water salinity may occur regularly and where effluents may be discharged into the freshwater stream. The mollusc which has closed its valves for either of these reasons may avoid the pollutant. This reaction obviously affects the ability of molluscs to monitor such pollutant inputs.

Theoretically, the four study species cannot be used to monitor metal pollution in coastal marine environments quantitatively, as metal accumulation is influenced by too many environmental variables. However, the results from field sampling surveys can be interpreted with greater confidence when the effects of these variables on metal accumulation are known. In practice, a semi-quantitative measure of metal pollution can be achieved.

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SELECTED MOLLUSCS AS MONITORS OF METAL POLLUTION IN COASTAL MARINE AND ESTUARINE ENVIRONMENTS

CHAPTER 1 INTRODUCTION

1.1 PURPOSE OF THIS INVESTIGATION

South Africa has relatively few estuaries and lagoons along its coastline and, in these, there is likely to be an increasing amount of user conflict. Apparent benefits from industrial and harbour developments may, in the long-term, be counter-balanced by the destruction of fish nursery grounds and/or the loss of local fisheries. It is important to have available an effective monitoring system whereby any development in estuarine areas can be assessed for its degree of pollution. Then in some cases, control measures may be introduced, the flora and fauna of the area preserved and the transfer to man of cumulative toxins prevented.

Potential monitors for the South African marine environment have been discussed in general terms on the basis of the reported use of related species (Darracott and Watling 1975). Trace-metal concentrations in a number of species occurring along the coastline are already being determined in several laboratories as part of the National Marine Pollution Monitoring Programme (e.g. Oliff, 1976). However, few data on the accumulator ability of these species or on their tolerance to metals are available. It is the purpose of the present investigation to define more clearly the conditions under which those species can be used to indicate the presence, or to monitor the extent, of metal pollution in South African coastal marine and estuarine environments by

1.1.1 determining the normal trace-metal concentrations, and natural variations in these, in selected species growing in unpolluted and polluted environments;

1.1.2 determining rates of metal accumulation and/or loss in certain species by means of suitable laboratory and field experiments;

1.1.3 determining the toxicity of metals (including sub-lethal effects) in suitable laboratory experiments.

The research was conducted mainly at Knysna in a laboratory made available by the Fisheries Development Corporation (FISCOR) Oyster Cultivation Unit. The project is complementary to two others being undertaken at the National Physical Research Laboratory as part of the National Monitoring Programme; these are the development of analytical methods for the chemical elements in the environment and the monitoring of trace metals in Knysna

Lagoon. It has therefore benefitted not only from the expertise of FISCOR staff concerning all aspects of oyster rearing and handling, but also from recent developments in the analytical field and data on the trace-metal status of the lagoon.

This investigation is a finite one. It is therefore essential to restrict the study to a manageable size by the careful selection of both the species to be studied and the metals to be tested. However, the methods which are developed during the investigation should not be so specific as to preclude their application to other organisms in related areas. The initial selection of species and metals can be assisted by reference to the published data concerning trace metals and molluscs.

1.2 TRACE METALS AND THE MARINE ENVIRONMENT

The importance of metals in the marine environment emerged from studies of radionuclides resulting from fallout in the oceans during the 1950's and 60's. It became apparent that certain nuclides were being accumulated by organisms in large concentrations, particularly in certain organs, e.g. cobalt-60 in the kidney of the giant clam Trindacna gigas (Lowman, 1960). Since in uptake by organisms the non-radioactive species of the metals may behave in much the same way as the radioactive species, it was suspected that the stable metals were accumulating in marine organisms to high concentrations wherever the metals were present in sea water in higher than ambient concentrations.

Heavy metals normally enter the marine environment in rivers or as wind-blown material following the weathering of rocks (Bryan, 1971). However, mining and agricultural activities, industrial and sewage effluents and air pollutants may all contribute additional metals to the coastal marine environment. Estuaries and lagoons are frequently the sites of urban and industrial developments and, because of their apparent proximity to the open sea, have been regarded as suitable places to discharge quantities of industrial and domestic waste.

The increase in the amount of waste discharged to the marine environment is partly based on the assumption that the sea has an almost infinite capacity to receive and either dilute or oxidise waste materials. This is not the case; perfect distribution does not occur either in coastal waters or the open sea and materials may either accumulate or be concentrated by physical or biological processes. The release of man's wastes to the marine environment affects the composition of waters and sediments which may have an effect on the flora and fauna and may prove toxic not only to marine life but also to man.

1.2.1 Water

The general level of trace-metal pollution cannot be adequately described by the analysis of water samples alone unless a detailed monitoring programme is carried out over an extended period. Trace metals in water exist partly in solution and partly in suspension adsorbed to organic or inorganic particulate matter; assignment of metals to either of these fractions is arbitrary, being based on whether the metal passes through, or is retained by, a filter of known pore size (often 0,45 µm). Either the total or soluble and particulate metal contents can be determined but the form of the metal in the water, which may affect its availability or toxicity to biological organisms, remains unknown. In addition, metal concentrations in the two phases fluctuate where the chemical and physical conditions of the water are variable, such as in an estuary or where sewage or industrial effluents are intermittently discharged. As most studies are orientated towards the prediction of ecosystem or human health effects, this inability to predict the metal availability to biota is a disadvantage in a sampling programme which relies on water analysis.

The identification of polluted areas by the analysis of metal concentrations in water has the greater disadvantage that, even in polluted areas, the very low concentrations found in most water samples necessitate the prior extraction and preconcentration of the metals before chemical analysis; this is normally achieved using organic chelation - extraction (e.g. Brooks *et al.*, 1967) or a chelating-resin exchange technique (e.g. Riley and Taylor, 1968). Such techniques are laborious and there is a risk of sample contamination at each stage in the procedure. Results obtained by different analysts for the same sample have been shown to deviate by up to an order of magnitude particularly for metal concentrations <10 µg/l (the level of most elements in natural water) and such variations are frequently due to systematic errors (Röndell, 1973; Gorski *et al.*, 1975a; Brewer and Spencer, 1970; Wales and McGirr, 1973; McGirr and Wales, 1973).

1.2.2 Sediments

It is generally believed that the pattern of accumulation or dispersion of metal pollutants over an extended period may be revealed by measuring the trace-metal concentrations in sediments from the area of interest; the results of many studies concerning the distribution of trace-metals in sediments from polluted and unpolluted areas have been reported. Phillips (1977c) has described three problems which exist in the interpretation of such data, these being that :

1.2.2.1 The concentration of the metal in the sediment is a function of the ratio of metal deposited to sediment deposited over a given period of time; this relationship is further complicated by the chemical reactions which occur between the sediment and water and which affect the processes of adsorption and desorption and the settlement of particles.

1.2.2.2 Metal concentrations in sediments are partly related to the organic content of the sediment.

1.2.2.3 Analysis of sediment samples provides little data on the availability of metals to the biota, with the possible exception of the sediment in fauna.

The results obtained from sediment analysis are generally more reliable than those for water samples because the metal concentrations being determined are higher and no preconcentration step is required. However comparison of reported results is difficult when different particle-size fractions have been analysed by different methods, such as whole sediment analysis, a strong acid leach or the extraction of "available" metals using, for example, ammonium citrate or acetate, acetic acid or ethylendiaminetetra-acetic acid.

1.2.3 Biological organisms

The trace metal composition of marine organisms has received attention by the scientific community since the widely publicised discovery of hazardous levels of mercury in certain fish and shellfish from Minamata Bay, Japan (Ui, 1971). While most of the attention has been focused on determining whether trace metals can accumulate in organisms to levels which are potentially detrimental to human health, increased attention has also been given to determining the cycling mechanisms of trace metals in the marine environment and the possible damage inflicted by metals on the biota in this environment (Bryan, 1971; Corrill and Huff, 1976).

The ability of many species to accumulate pollutants has been used, with varying degrees of success, to indicate the presence of pollution (e.g. Majori and Petronio, 1973; Bryan and Hummerstone, 1977; Reish, 1970). Indicator organisms are primarily used to identify rather than to measure environmental changes whose cause may be unknown or which may be the result of a variable mixture of pollutants. For example, increased numbers of some species may indicate the presence of toxic pollutants or changes in the overall species composition may occur over a period of time as an indication of increased pollution (e.g. Dills and Rogers, 1974; Halcrow et al., 1973). Bryan (1971) in his review on the effects of selected metals on marine and estuarine organisms, stated that "the concentrations of metals in some sessile organisms, such as brown seaweeds and some molluscs, tend to reflect the concentrations in the water and might, after further study, be used as indicators of chronic water pollution".

Some biological accumulators can be used to monitor pollution levels quantitatively. The ideal characteristics for a monitoring organism have been briefly discussed by several authors (Bittel and Lacourly, 1968; Haug et al., 1974; Phillips, 1977c) and have been the subject of two international workshops (Butler et al., 1971; Portmann et al., 1975). They may be summarised as follows:

1.2.3.1 The organism must be able to accumulate the pollutant without being killed by the levels encountered; accumulation should be proportional to the levels in the environment and, ideally, independent of variations in environmental parameters.

1.2.3.2 The organism should be sedentary in order to be representative of the study area.

1.2.3.3 The organism should be abundant and sufficiently long-lived to allow the sampling of more than one year class if desired.

1.2.3.4 The organism should have a broad distribution, both ecologically and geographically; this condition facilitates comparison between geographically separated areas, but such comparisons must be supported by laboratory data on the similarity of behaviour and physiological responses of individuals from different populations.

1.2.3.5 The organism should be hardy and adaptable so that it can be transferred into a new locality. Euryhaline species such as oysters and clams are particularly useful in locating sources of industrial pollutants which typically enter the estuary in low salinity areas near river mouths; alternatively it is often desirable to transfer the organism to an aquarium where it can purge its intestinal contents before being killed for analysis.

1.2.3.6 The organism should be of reasonable size so that adequate tissue is available for analysis.

1.2.3.7 There should be sufficient knowledge of the biology of the species to recognise its most sensitive life stage, its position in the trophic web and its reaction to environmental changes other than those induced by man.

1.2.3.8 It should be possible to investigate the physiological effects of the suspected pollutants in controlled laboratory studies; the rates at which the organism accumulates and eliminates the pollutants should be studied in relation to the levels of contamination in the environment; these results should facilitate the interpretation of field data.

Assuming that these 8 requirements for a monitoring organism can be met, any monitoring programme must still be carefully planned. Data must be intercomparable and, wherever possible, should be obtained for a specific purpose. Mere measurement, especially on a large scale is wasteful of time and resources (Portmann _et al_., 1975). For a full understanding of any one environmental situation it is advisable, if not necessary, to measure the pollutant levels in sediment and water samples as well as those in the biota. It is also desirable to use a range of organisms. Metals can be derived from 3 possible sources, from solution, from the ingestion of metal-containing particulate matter and from the ingestion of food. (Phillips, 1977c). Not all indicator types will reflect all 3 trace metal loads equally.

Much of our knowledge has been achieved accidentally and information which was once thought extraneous is now considered valuable. Full details of the sample, species, age, sex, condition and size of animal and tissue analysed should be recorded as well as a description of the methods used for sample preparation and analysis (Portmann _et al_., 1975).

Two recent surveys have been reported in which field observations are complemented by laboratory studies in order to assess the use of molluscs as monitors of metal pollution in the marine environment. In the first, the rates of lead uptake and loss by _Mytilus edulis_ were studied in relation to lead concentration in sea water and food, size of individuals, accumulation in tissues and the toxicity of lead to this organism was investigated (Schulz-Baldes, 1972; 1974). The observed gradient in lead contents of _M. edulis_ collected from a number of sites in the Weser estuary could be explained by the dilution of the lead-polluted river water with sea water from the German Bight (Schulz-Baldes, 1973). The research described by Phillips (1976a; 1977$_b$) included investigations of the effects of season, position of the animal in the water column, water salinity and temperature, and the simultaneous presence of all four metals on the net uptake of zinc, cadmium, copper and lead by _M. edulis_. The studies were specifically designed to test the ability of this organism to act as an efficient and accurate indicator of marine contamination by these metals. From the results which he obtained Phillips (1976a) concluded that _M. edulis_ could only be used as an indicator of marine and estuarine contamination if extraneous variables affecting the net uptake of metals were eliminated. He proposed a sampling programme which would minimise these effects, applied it to a study of two bays which were subject to industrial pollution, and concluded that M. edulis was capable of acting as an efficient time-integrated monitor of zinc, cadmium and lead over a wide variety of environmental conditions (Phillips, 1976b).

The use of biological species to monitor metal pollution in the marine environment has the advantage that accumulation will reflect the presence of "available" metals over a period of time. Such organisms can be sampled at convenient intervals independent of the intermittent addition of pollutants to a body of water because they provide an integrated measure of the metal load in the water. For example, severe cadmium pollution of industrial origin was traced to its source, not as a result of the sediment and water surveys of the estuary, but because of the extreme accumulation of this metal by oysters placed in the estuary (Thornton et al., 1975; Boyden, 1975).

Tissue-metal concentrations are much higher than those in the water so that no preconcentration step is required during their analysis. Nevertheless, many problems do exist in the analysis of biological tissues, so that the analytical method must be selected with regard to the overall aim of a particular survey.

1.3 SELECTION OF MOLLUSCS FOR THIS INVESTIGATION

The suitability of oysters and many other bivalves as monitoring organisms was described by Butler et al. (1971) in the following terms:

"Pelecypods are sedentary, or at least non-migratory; long-lived, up to ten years or more; locally abundant, and some genera have global distribution. The pelagic habit of the larvae has prevented geographic isolation so that the species are genetically stable and taxonomically recognised. Molluscs adapt readily to laboratory culture and can be transplanted to field stations varying quite widely in hydrographic conditions. Their filter-feeding habit places them on a low trophic level and their unusual ability to abstract and concentrate both dissolved and particulate matter from the surrounding water on an almost continuous basis makes them unusually suitable as biological monitors of the aquatic environment".

1.3.1 Mussels

1.3.1.1 Laboratory studies have shown that *M. edulis*, *Mytilus californianus* and *Mytilus galloprovincialis* can accumulate several metals from their environment. The rate of accumulation is initially proportional to the concentration of the element in the water (e.g. Fowler and Benayoun, 1976a; Pavičić and Järvenpää, 1974), provided that this concentration is not toxic to the mussel (e.g. Friedrich and Filice, 1976; Majori and Petronio, 1973) and depends upon the element (e.g. Pentreath, 1973). Rates of accumulation may vary depending upon the form of the metal in the water, whether it is ionic or organically complexed (Aubert *et al.*, 1974; George and Coombs, 1977; Kopfler, 1974), occurs in different oxidation states (Fowler and Benayoun, 1976b) or isotopes (Kečkeš *et al.*, 1967), or is associated with particulate matter (Morrison *et al.*, 1977) or food (Schulz-Baldes, 1974). Changes in environmental parameters such as salinity or temperature may affect the rate of accumulation of a given element (e.g. Fowler and Benayoun, 1974; Phillips, 1977b; Fraisier, 1974) as also the presence of other elements (Fowler and Benayoun 1976b; Jackim *et al.*, 1977; Phillips, 1976a). The final tissue-metal concentration may also depend on the size of the individual, smaller individuals accumulating metals at a faster rate than larger ones (e.g. Schulz-Baldes, 1974).

Rates of metal loss are generally slower than for accumulation and may depend on the absolute tissue-metal concentration (Schulz-Baldes, 1974) or on the period of exposure to metals (e.g. Kečkeš *et al.*, 1968; Van Weers, 1973).

The studies on accumulation and loss of metals by *Mytilus* have been complemented by several investigations of the biochemical functions of metals, storage mechanisms and metal distributions in their tissues (Coombs, 1977; George and Coombs, 1975; George *et al.*, 1976; Noël-Lambot, 1976).

1.3.1.2 Metals have been shown to have an adverse affect on mussel feeding behaviour (Dorn, 1976) and byssal thread production (Martin *et al.*, 1975), and to cause valve closure (e.g. Ahsanullah, 1976; Davenport, 1977) and a reduction in filtering rates (Abel, 1976). Survival, respiration and heart-rate, and metabolism may also be affected by selected metals (Brown and Newell, 1972; Delhaye and Cornet, 1975; Scott and Major, 1972). Cadmium has been shown to be toxic to *Mytilus* embryos and larvae (Pavičić and Järvenpää, 1974).

1.3.1.3 Goldberg (1975) has suggested that *Mytilus* species are especially attractive for the purpose of measuring exposure levels of several pollutant types including the heavy metals. Trace metal concentrations in *Mytilus* sp. from many localities have been reported on the assumption that these species have the ability to indicate the presence of elevated metal levels in their environment. This is only acceptable where data concerning the accumulation of a particular element by the selected species have already been reported. For example, Chow *et al.*, (1976) suggest that *M. edulis* and *M. californianus* can be used to indicate lead pollution along the Californian coast; this suggestion seems very reasonable in view of the results already reported for lead in *M. edulis* (Schulz-Baldes, 1972; 1973; 1974) and *M. galloprovincialis* (Majori and Petronio, 1973). Phillips (1977a), on the basis of his previous research (Phillips 1976a; 1977b) reports that *M. edulis* can be used to indicate the presence of zinc and cadmium in Scandinavian waters.

However, there are limitations to this monitoring method. Not all elements are accumulated by mussels in such a way as to indicate the presence of metals. Phillips (1976a, b) considers that *M. edulis* should not be used to indicate copper pollution because the net uptake of copper by this species is affected by the presence of other metals and changes in their concentrations. Stenner and Nickless (1974) also failed to find any correlation between the copper concentrations in mussels from clean and polluted areas. Silver accumulation has been demonstrated in the laboratory and the presence of this element also affects oxygen consumption (Thurberg *et al.*, 1974). However, Bryan and Hummerstone (1977) concluded, on the basis of a field sampling survey, that *M. edulis* did not accumulate silver in relation to environmental levels and could not be used to indicate the presence of this element.

1.3.1.4 Two mussel species immediately suggest themselves as possible monitors of metal pollution in South African marine environments.

Choromytilus meridionalis has been found growing along the coast between Walvis Bay and Port Alfred and is abundant in the intertidal and subtidal zones, mainly on the west coast (Day, 1974). Griffiths (1976) has described the reproductive cycle and larval development of *C. meridionalis* growing at localities in False Bay and at Bloubergstrand and du Plessis (1977) discussed aspects of the biology of this species growing in Saldanha Bay. Trace-metal concentrations in *C. meridionalis* have been reported (Fourie, 1976; Oliff, 1976; Van As *et al.*, 1973; 1975). The effects of low concentrations of ammonium nitrate on the fertilisation and early development of *C. meridionalis* and the effects of selected pollutants on the adult heart-rate have also been investigated (Brown et al., 1977; Currie et al., 1974).

Perna perna has been found growing between Walvis Bay and Delagoa Bay; this species is abundant between False Bay and Durban but is rare on the cold Atlantic coast (Day, 1974). The biology of P. perna growing at 3 localities on the Natal coast has been investigated (Berry, 1976) and trace-metal concentrations in this species have been determined (Oliff, 1976). No reports on the use of this species as an experimental animal have been found.

In this study C. meridionalis was collected from Bloubergstrand by staff of the U.C.T. Zoology Department and transferred to Knysna; P. perna was collected from the rocky shore near the Knysna Heads.

1.3.2 Oysters

1.3.2.1 The excessive accumulation of copper by oysters was reported as early as 1898 and was called "green-sick" because of the green pigmentation in the flesh of such oysters (Boyce and Herdman , 1898). More recently the accumulation of a few metals has been demonstrated for Crassostrea virginica, Crassostrea gigas and Crassostrea angulata, and for Ostrea edulis, Ostrea sinuata and Ostrea angasi.

In general terms the available data suggest that accumulation is initially proportional to the metal concentration in the water providing that this concentration does not exert a toxic effect, and is dependent upon the element and the form of that metal in the water (Boyden and Romeril, 1974; Kopfler, 1974; Pringle et al., 1968; Shuster and Pringle, 1969). Accumulation rates also vary with changed environmental conditions (Cunningham and Tripp, 1975; Duke et al., 1969) and may be affected by the presence of other elements (Romeril, 1971). Smaller oysters can accumulate metals at a faster rate than larger ones (Cunningham and Tripp, 1975).

Rates of metal loss are generally slower than rates of metal uptake (Cunningham and Tripp, 1973) and may depend on the final tissue-metal concentration (Cunningham and Tripp, 1975).

The nature of zinc and copper complexes in oysters have been investigated (Coombs, 1972; 1974; Pequegnat et al., 1969; Romeril, 1971; Wolfe, 1970).

1.3.2.2 The effects of metals on oysters have received less attention than those for the mussels. However, metals have been shown to cause a reduction in growth and increased mortality of embryos and larvae (Brereton et al., 1973; Calabrese et al., 1973; 1977) and the numbers of larvae settling in the presence of certain metals are reduced (Boyden et al., 1975; Prytherch, 1934), with the possible exception of copper at very low levels which may stimulate settlement (Prytherch, 1934). Metals are toxic to adult oysters; they may cause valve closure (Okazaki, 1976) or a change in the rate of oxygen consumption (Thurberg et al., 1974)

1.3.2.3 Trace metal levels in oysters from many localities have been reported (e.g. Brooks and Rumsby, 1965; Freeman et al., 1974; Thrower and Eustace, 1973; Windom and Smith, 1972). In a number of cases it has been possible to relate the accumulation of selected metals by oysters to metal pollution from industrial or other sources (e.g. Boyden, 1975; Boyden and Romeril, 1974; Huggett et al., 1973; Ratkowsky et al., 1974).

Oysters are adaptable and can be transferred to areas outside their normal distribution and grown in rack systems (Thornton et al., 1975). Assuming that the other criteria for monitoring organisms can be met, this means that oysters containing a predetermined concentration of a selected metal can be placed at a site subject to pollution by that metal and the rate of uptake measured. Alternatively repeated sampling from natural populations may provide a measure of pollution for a given period (Drifmeyer, 1974).

As was the case for mussels, many of the trace-metal data have been published on the assumption that oysters can act as indicators of metal pollution. This is obviously not sufficient. Further studies on rates of metal uptake and loss under variable and controlled laboratory conditions together with complementary field experiments, must be carried out before such an assumption can be made. However, in certain cases, the analysis of oysters has indicated the presence of severe contamination of an area (e.g. Thrower and Eustace, 1973); it is better to have made this discovery, so that control measures can be implemented at an early date, rather than to wait until sufficient data have been obtained experimentally to define the conditions under which a particular species can be used to indicate or monitor a selected element. By this time irreparable damage may have been caused to the study area. What is important is that the researcher should be aware of the limitations of this method of monitoring.

1.3.2.4 Two oysters, *C. gigas* and *Crassostrea margaritacea* appear to be the most suitable species for this investigation because they are both being cultivated in the Knysna estuary on rack systems. This eliminates the problem of removing individuals from rocks without physically damaging them.

The Pacific oyster *C. gigas*, is a hardy, adaptable, fast-growing oyster which has been introduced into Knysna estuary to be cultivated and grown on a commercial basis; a large volume of data on the biology of this species in South African waters has been collected (Genade, 1973). The biology of this oyster growing in many other countries is also well documented (Hatai, 1929; Galtsoff, 1932; Thomson, 1952; Walne and Spencer, 1971). *C. gigas* has been shown to accumulate metals to very high levels (Thrower and Eustace, 1973) and can be used for both laboratory and field experiments, (e.g. Pringle *et al*., 1968; Thornton *et al*., 1975).

C. margaritacea grows on the southern African coast between False Bay and Inhaca Island (Mozambique); it is found on flat sandy reefs near low tide and penetrates the mouths of estuaries, and is most abundant in suitable localities between Breede River and Knysna (Day, 1974). *C. margaritacea* has been transplanted from Knysna estuary into Langebaan Lagoon, an area outside its normal distribution but where it grows well. The biology of this species has been described by Korringa (1956) and trace metal concentrations in *C. margaritacea* from several sites have been reported (Fourie, 1976; Oliff, 1976).

C. gigas and *C. margaritacea* were obtained from FISCOR at Knysna and had previously been grown in the estuary on large trays in a wooden rack system.

A second South African species, *Crassostrea cucullata*, which grows near the top of the balanoid zone on open shores and on mangrove roots and trunks in estuaries between Inhambane and Port Shepstone (Day, 1974) would probably be useful as a monitoring organism along the Natal coast. It is now being cultivated and grown in Knysna estuary so that some cultchless individuals will become available for experimental purposes by 1979.

Ostrea algoensis is also common and accessible but is small for analytical purposes; *Ostrea atherstonei* is not common (Day, 1974) and would therefore not be as useful as the *Crassostrea* sp. for the purpose of monitoring metal pollution.

1.3.3 Other bivalves

The published data concerning the accumulation of metals by other bivalve species are very sparse and relate to many diverse species. For the purposes of this investigation it was considered advisable to test species for which some comparative data were available. Then the methods which are adopted could be extended and if necessary adapted, to include other species.

Not all the bivalves listed by Darracott and Watling (1975) will be equally suitable. For example Dosinia hepatica and Loripes clausus have been found at a site in the Keurbooms estuary. However, as approximately 10 individuals are required for a single analysis, the collection of sufficient of these small bivalves would be very time consuming. There is also a much greater risk of sample contamination when many small individuals are scraped out of their shells. Solen capensis, which grows to suitable size, is nevertheless hard to locate in sufficient numbers to be useful as a monitor.

The larger sandy-beach clam Donax serra, which can be found growing between Lüderitz and Port Elizabeth (Day, 1974), would probably be a useful monitor of coastal rather than estuarine pollution. The reproductive biology of this species has been described (de Villiers, 1975) and some data on trace-metal concentrations have been reported (Van As et al., 1973; 1975). The suitability of this species as a test organism would need to be assessed in order to determine whether it meets the criteria for monitoring organisms.

1.4 SELECTION OF METALS FOR THIS INVESTIGATION

Most research on trace-metal pollution has been prompted by the discovery of specific environmental problems. However, the present project was initiated in anticipation of future problems which may arise as a result of increased development and industrialisation in South African coastal areas. The metals to be studied may be selected on the basis of environmental problems experienced in other countries, but this selection should be guided by the relevant data which are available for the South African coast and will be influenced by the choice of analytical technique.

Several surveys of South African estuaries have been carried out and trace metal concentrations in water, sediment and biological material reported (Oliff 1976). In a number of cases the sources of metals have been identified. For example, increased concentrations of copper, cadmium, lead and zinc in water samples from the mouth of the Swartkops River are from the power station cooling water discharged into this river (Connell et al., 1976a);

copper, cadmium, nickel and lead enter Richards Bay in an effluent stream (Connell _et al._, 1976b). Corrosion products from nuclear reactors include iron, zinc, cobalt, chromium, antimony and manganese, the radioisotopes of which may be discharged in reactor effluents (Van As _et al._, 1973).

High cadmium concentrations were found in mussels growing near a sewage outfall in Algoa Bay (Turner _et al._, 1976). These results are being further investigated in a detailed trace-metal study of Algoa Bay, with particular reference to the effects of an ore-loading facility (iron and manganese ores) and of municipal outlets for sewage and/or industrial effluents. Raw sewage, which is sometimes discharged directly to the sea, often contains quite high metal concentrations from industrial effluents. Sewage treatment does not remove all metals from municipal wastes and substandard effluents are occasionally discharged when a sewage works is temporarily overloaded, such as during heavy rains.

Boats are also a source of metals in an estuary or otherwise restricted body of water. Zinc chromate and red lead primers are often used and antifouling paints may contain copper, mercury or arsenic. In addition, 2-stroke outboard motors discharge a variety of compounds into water, the most notable being raw fuel (Jackivicz and Kuzminski, 1973) which in South Africa contains organo-lead additives.

Nine elements were chosen for this comparative study; these are zinc, cadmium, copper, lead, iron, manganese, nickel, cobalt and chromium. The accumulation and effects of zinc, cadmium, copper and lead were studied in greater detail as these elements were expected to be more toxic.

Mercury, arsenic and antimony are volatile elements which require specific and complicated methods of sample preparation and analysis. Published methods are, on the whole, unsatisfactory and these elements are currently receiving attention in the analytical methods project being carried out in the National Physical Research Laboratory. Because of the unreliability of present analytical methods for the thermolabile elements, these were not included in the present study.

CHAPTER 2 THE ANALYSIS OF METALS IN BIOLOGICAL TISSUES BY ATOMIC ABSORPTION SPECTROSCOPY

2.1 INTRODUCTION

The majority of trace-metal determinations are carried out by instrumental methods, some of which have been applied to the analysis of marine biological tissues. For example, neutron activation analysis has been used for the analysis of marine algae, molluscs, crustaceans and fish (Fukai and Meinke, 1959; Van As et al., 1973; 1975). This multielement technique is capable of high sensitivity and there is no contamination of the sample by reagents. However, sample preparation, which includes the removal of water, is complex and samples are subjected to vacuum for the analysis. Other techniques are more suitable for the analysis of such elements as calcium, iron, potassium, magnesium, nickel and lead which have low cross-sections for neutrons (Bowen, 1975). Marine algae have also been analysed for copper, iron, zinc and manganese by X-ray fluorescence (Foster, 1975). The metal concentrations in prepared powders were first determined by atomic absorption spectrometry and these powders were then used to calibrate the instrument. However, X-ray fluorescence has relatively poor sensitivity, particularly for low atomic number elements and suffers from severe interelement effects, particularly when the sample is in a complex inorganic matrix. High-resolution spark-source mass spectrometry, an extremely sensitive technique, has been applied to the multielement analysis of marine mussels (Ball et al., 1975). However, the method which is described would require two determinations for every sample in order to compensate for major element concentration differences between samples. These are three of the many techniques which have been applied to the analysis of metals in marine biological samples. They have another feature in common and that is that the instrumentation was available in the laboratory concerned, thus enabling a method to be developed.

The factors which must be considered when an analytical method is selected have been summarised by Wineforder (1976) as "1) the nature and composition of the sample, which affect the sample treatment prior to measurement; 2) the approximate concentration of the analyte present in the measured sample and the limit of detection by the analytical procedure to be used; 3) the precision and accuracy required in the final analysis; 4) the speed required for obtaining a result; 5) the amount of sample available; 6) the number of samples to be measured; 7) the variability of the sample matrix from sample to sample; 8) the cost per analysis and 9) the instrumentation and methodology available".

Atomic absorption spectroscopy was the most suitable available technique for the present study. It is widely used for the analysis of marine biological samples. In fact, about 90% of all trace metal determinations in environmental samples are carried out by the atomic absorption method, which is basically a reflection of the availability of the relatively simple and inexpensive instrumentation required (Willis, 1976). However, this should not lead to the indiscriminate acceptance of the data produced. Like other techniques it is subject to errors which are either inherent in the method or are a consequence of the sample preparation.

2.2 ATOMIC ABSORPTION SPECTROSCOPY

The principles and general technique of atomic absorption spectroscopy have been discussed in a number of texts; "Atomic absorption spectroscopy" by Welz (1976) was found to be particularly useful during the present study.

A Varian-Techtron AA5 with AA6 readout module and BC6 background corrector was used for all measurements. Single-element hollow-cathode lamps supplied the light source and the resonance lines used for the determination of each element are listed in Table 2.1.

TABLE 2.1 Resonance lines and flames used for the determination of 14 elements in biological tissue.

Element	Line (nm)	Flame	Element	Line (nm)	Flame
Zn*	213,9	air-C_2H_2	Co*	240,7	air-C_2H_2
Cd*	228,8	air-C_2H_2	Cr	357,9	N_2O-C_2H_2
Cu	324,8	air-C_2H_2	Sr	460,7	N_2O-C_2H_2
Pb*‡	217,0	air-C_2H_2	Ca	422,7	N_2O-C_2H_2
Fe*	248,3	air-C_2H_2	Mg	285,2	N_2O-C_2H_2
Mn*	279,5	air-C_2H_2	Na	330,3	air-C_2H_2
Ni*	232,0	air-C_2H_2	K	404,4	air-C_2H_2

*background correction applied

‡slotted tube

Two basic methods of producing an atomic vapour of the analyte element are available. Either the sample solution is nebulised directly into a flame or an aliquot of the sample solution is introduced into an electrically heated graphite furnace. The flameless technique is a much slower procedure, but is particularly useful when the sample volume is limited. However, it has one major disadvantage with respect to this investigation which is a consequence of the complex sample matrix.

In biological samples the analyte element usually occurs in trace concentrations in the presence of large amounts of other organic or inorganic materials. With the flameless technique it is necessary to remove as much as possible of this matrix by preheating the sample at a temperature below that at which the analyte metal is vaporised. Otherwise the molecular vapour and breakdown products of the matrix, covolatilised with the analyte element, will absorb most of the hollow cathode radiation during the atomization cycle. For example, zinc, cadmium and lead can normally be atomized from their salts at temperatures below that at which sodium chloride can be vaporised from the sample (about 1200°C). However, in the presence of high chloride ion concentrations, the metals and sodium chloride vaporise at the same time with the formation of metal chlorides rather than atoms (Willis, 1976; Norval, 1976a). On the other hand, copper, which is normally atomized from its salts at temperatures above those required for the removal of sodium chloride, is partially vaporised in the chloride form at the lower temperature (Segar and Gonzalez, 1972; Norval, 1976b). The loss of manganese during ashing in the graphite furnace has also been reported for samples containing calcium or magnesium chlorides (Smeyers-Verbeke et al., 1976) and a gaseous metal complex of the type $M_xM'_yCl_z$ has been identified (Binnewies and Schäfer, 1973) which could easily give rise to losses.

Accordingly, flame atomization was selected for this investigation where sample volume was not a limiting factor, but where the sample solutions consisted of complex, chloride-rich matrices.

2.2.1 Flames

A pre-mixed air-acetylene flame was used for the determination of 10 elements (Table 2.1) for which it offers a suitable environment and a sufficiently high temperature (2125-2400°C) for atomization.

A nitrous oxide-acetylene flame was used for the remaining four elements. This flame has a higher temperature (2650-2800°C), a low burning velocity (compared with other high temperature flames) and offers a favourable chemical, thermal and optical environment for almost all the metals for which the air-acetylene flame is not suitable (Welz, 1976). Chemical interferences may occur when the analyte element combines chemically with another reactive component in the sample. The resulting compound may influence the atomization process in the flame and thus alter the number of free atoms available to absorb light. The use of this higher temperature flame overcomes many of these interferences because there is more energy to break down compounds which would be stable in cooler flames.

Flame conditions strongly affect the sensitivity for many elements so that it is necessary to optimise such parameters as the fuel/support gas ratio and the observation region for each element. This is particularly important for the nitrous oxide-acetylene flame.

2.2.2 Background correction

Although atomic absorption spectroscopy using a sharp-line source such as a hollow-cathode lamp is generally regarded as being specific for the metal being determined, there is a possibility of absorption or scattering of radiation at the same wavelength by molecules of other compounds present in the sample. For example, Fig. 2.1 shows the background absorption for sea water sprayed into a 100 mm path-length air-acetylene flame (from Willis, 1976). Obviously the analysis of elements with resonance lines at wavelengths shorter than about 280 nm in the presence of sodium chloride can lead to misleadingly high absorption readings.

Correction for these effects can be made by measuring the loss of light at the resonance line of the analyte element using a continuum light source such as a hydrogen hollow-cathode lamp. The hydrogen lamp gives rise to a continuous spectrum over a bandwidth much greater than that of the resonance line. While the broad band spectrum reacts to scatter or molecular band absorption, it is not subject to atomic absorption and may be used as a reference signal.

This correction was carried out using the BC6 corrector for all elements with resonance lines at wavelengths shorter than 280 nm (Table 2.1). However, results may be unreliable if the background absorption is large with respect to the atomic absorption signal to which it is being compared.

2.2.3 Slotted tube

A slotted tube has been described (R.J. Watling, 1977) (Fig. 2.2) which can be used in conjunction with the flame to obtain a marked increase in sensitivity for the determination of lead. The analytical precision is also improved at low lead concentrations (Table 2.2) and the analysis time

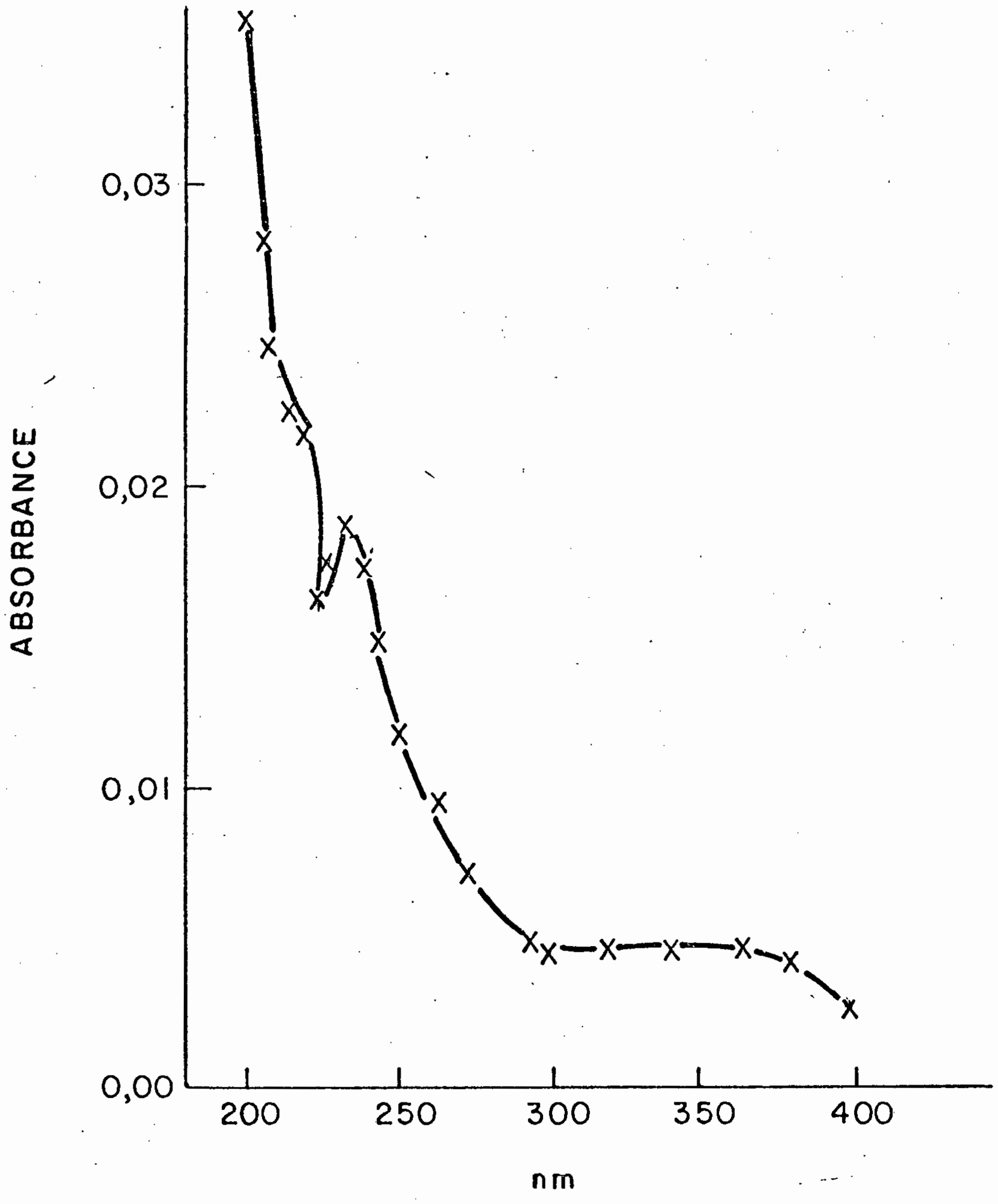


FIG. 2.1 : Background absorption for sea water sprayed into a 100 mm path-length air — acetylene flame (Willis, 1976)

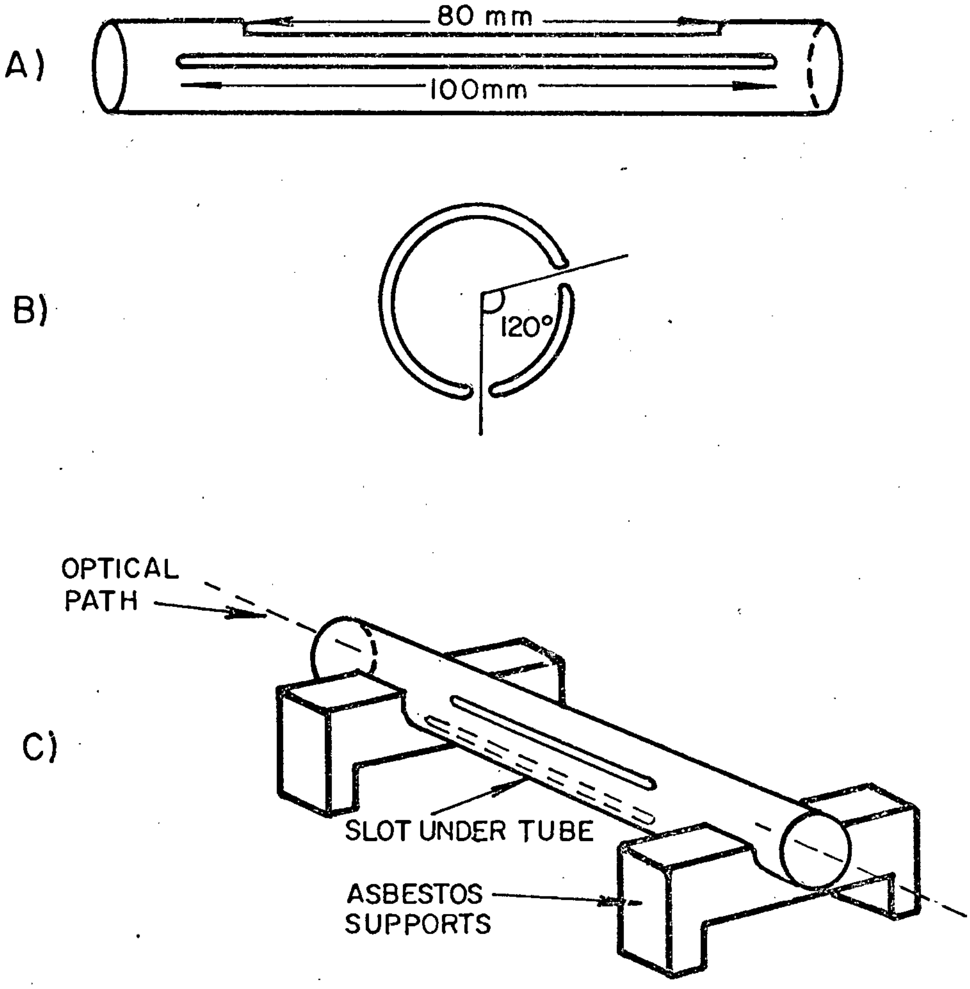


FIG. 2.2 : Diagram of the slotted tube (R.J. Watling 1977)

A) Tube with slot (underside)

B) Cross-section of tube showing relative positions of two slots

C) Tube positioned on asbestos burner positions is only slightly longer than for direct flame nebulisation. Interferences due to major element concentrations in solution were studied and it was found that a mixture containing 1000 µg/ml each of sodium, potassium, calcium and strontium caused only a 5% enhancement of the lead absorbance signal when the slotted tube was used; a 10% enhancement was observed in the absence of the tube. Sodium chloride solutions up to 1000 µg/ml sodium had no effect on the lead absorbance signal.

TABLE 2.2 Comparison of precisions near the analytical limit for lead, for the flame and the slotted tube.

Lead (µg/ml)	Relative standard deviation % (n=20) Flame	Slotted tube
1,0	5,0	1,2
0,5	9,0	2,3
0,1	-	9,0
0,05	-	27,0

2.2.4 Matrix-matched standards

Matrix interferences occur when physical properties such as viscosity or surface tension differ between the sample solution and the standards. These interferences may occur when samples contain a high dissolved salt concentration or when the samples and standards are prepared in different solvents. This interference is usually controlled by matching the dissolved salt concentration and the solvent in the samples and standards or by diluting the sample until the dissolved salt effect is negligible.

Ionization interferences may occur when the flame temperature is high enough to ionize a significant fraction of the element being determined. This reduces the number of atoms which can absorb radiation and reduces the analytical signal. Analytical errors occur when the samples and standards exhibit different degrees of ionization of the analyte element. The simplest way to control this is to add an excess of an element with a low ionization potential, such as potassium, to both samples and standards. The electrons provided by the ionized potassium combine with the ions of the element being determined and increase the number of neutral atoms which can absorb radiation.

Composite standards containing zinc, cadmium, copper, lead, iron, manganese, nickel, cobalt, chromium and strontium in the range 0,1-20 µg/ml in the presence of sodium, potassium, calcium and magnesium in the range 100-5000 µg/ml were prepared in 10% nitric acid. The effect of varying the major element concentrations on the determination of the trace elements was negligible for major element concentrations >500 µg/ml.

Sample solutions, which were also prepared in 10% nitric acid already contained a sufficient excess of these major elements so that no addition was necessary.

2.2.5 Analytical precision

The analytical precision of the instrumental method was determined for the nine trace elements (not including strontium) in the composite standards. Instrumental parameters were optimised for each element. The instrument was operated in the concentration mode and the absorbance signal was expanded to 3 digits so that a 1 µg/ml element solution gave a 100 readout for all elements except iron where 1 µg/ml read 10. The results are summarised in Table 2.3.

TABLE 2.3 Analytical precision for the determination of nine elements in the presence of excess sodium, potassium, calcium and magnesium

Element concentration (µg/ml)	Relative standard deviation % (n=12)								
	Zn*	Cd*	Cu	Pb*‡	Fe*	Mn*	Ni*	Co*	Cr
0,02	12	25	52	54	-	-	-	29	25
0,05	7	12	16	27	-	18	25	-	-
0,10	4,5	6	6	9	18	5,5	10	13	6
0,20	2,4	2,0	3,5	3,8	-	2,4	4,3	5,3	3,1
0,50	0,8	1,0	2,3	2,3	-	1,5	2,1	1,7	3,1
1,0	0,5	0,7	1,1	1,2	2,0	0,7	1,3	1,0	1,2
2,0	0,8	0,8	0,8	1,2	0,9	0,5	0,9	0,6	0,7
5,0	1,1	0,6	0,5	0,8	0,5	0,6	0,3	0,5	0,4
10,0	3,5	1,1	0,5	0,5	0,4	0,5	0,4	0,3	0,4
20,0	-	-	-	-	0,5	0,6	-	-	-

*background correction applied

‡slotted tube

The trace element concentrations in the standards were chosen to bracket those in the sample solutions and the instrumental conditions were those used for the routine analysis of samples. The standard atomic absorption curve is not necessarily a straight line, but at low element concentrations it does approximate one very closely. It is therefore possible to expand the absorbance signal so that the element concentration in solution can be read directly when working in this region. For most of the elements, sample solution concentrations were in the 0,1-2,0 μg/ml range.

Where element concentrations in sample solutions were greater than the suitable analytical range, as dictated by calibration curvature, then a 10- or 100-fold dilution of the solution was used. An error of up to 4% for the 100-fold dilution is introduced which affects the accuracy of the determination, but this is counteracted by the greater analytical precision which can be achieved by working in the optimum analytical range.

2.3 PREPARATION OF BIOLOGICAL SAMPLES FOR ATOMIC ABSORPTION ANALYSIS

2.3.1 Preliminary cleaning

The increasing use of small organisms as indicators of metal concentration variations in the environment involves the assumption that the concentrations of metals detected in the samples represent the amount which is biologically incorporated in the tissues. The effect of sediments on an elemental analysis has previously been recognised. Bertine and Goldberg (1972) related the high cobalt, chromium, iron, antimony and scandium values in *Mytilus edulis* to a large amount of sediment in the gut. Flegal and Martin (1977) found an inorganic residue, presumed to be ingested sediment, in two rocky intertidal gastropods, which, when expressed as a percentage of the sample mass, often correlated significantly with the elemental concentrations measured in the organisms. In a metal polluted area the contamination of individuals by an indeterminate amount of sediment would seriously hinder any attempt to relate tissue-metal concentrations to metal levels in the environment. Therefore, if molluscs are to be used as monitors of metal levels in the environment, their intestinal contents must be purged prior to chemical analysis. This was achieved by suspending the samples collected during this investigation in sea water from three to five days before preparing them for chemical analysis.

2.3.2 Dehydration of wet tissue

The usual procedure prior to oxidation of a biological sample is to dehydrate the tissue, either by heating in an oven at about 100°C or by freeze-drying under near vacuum conditions. It has been reported that certain elements may be volatilised from biological tissues during such dehydration (Fourie and Peisach, 1977) but that losses appear to depend on the type of tissue and the element (Strohal *et al.*, 1969). The following experiment was carried out to test whether the metals to be determined during this investigation were volatilised from a marine biological tissue during oven-drying and, if so, at what temperature this loss must be regarded as serious.

A large quantity of marine mussel (Atrina squamifera) tissue was macerated and homogenised. Approximately 5 g portions were weighed into conical flasks, 10 replicate samples being prepared for each temperature to be tested. Each sample was dried at the selected temperature (50–200°C) in a preheated, thermostatically controlled oven. Constant mass was achieved after 29 h at 50°C and after shorter periods at the higher temperatures; a minimum 24 h period was used for all samples. The dried tissue was digested with a 4:1 mixture of nitric-perchloric acids, the resulting residue dissolved in 10 ml 10% nitric acid and the metal concentrations determined by atomic absorption spectroscopy.

The effects of drying temperature on the measured metal contents of the tissue are illustrated in Fig. 2.3 and summarised in Appendix 1. The results are compared with an analysis of the same homogenised sample digested in the acid mixture without being dried. The mean of 10 measurements and the error bar, representing one standard deviation either side of the mean, are shown for each temperature. The differences between the mean element values for different populations have been examined using the students' t test (Spiegel and Boxer, 1972). No significant differences were observed between any of the data sets up to 120°C. The broken lines in Fig. 2.3 represent the overall standard deviation for the combined measurements 25–120°C.

Element losses are negligible up to a drying temperature of 120°C when a 24 h drying period is used. This result is in agreement with that of Koirtyohann and Hopkins (1976) who reported that iron, zinc, chromium and cadmium were not volatilised from rat tissue during oven-drying at 110°C. Fourie and Peisach (1977) reported that chromium, iron, manganese, cobalt and zinc were not volatilised from oyster tissue during drying at temperatures of up to 120°C. These authors also reported significant losses of both cadmium and lead during drying at temperatures >50°C. Similar losses at these low temperatures were not observed in the present study. However, significant volatilisation of nickel, and to a lesser extent, cadmium, was observed at temperatures >120°C. No references to the loss of nickel during dehydration of biological tissue have been found. Strohal et al., (1969) have observed that elements behave differently in a number of species, which may explain the apparently conflicting results described for cadmium in these three tissues.

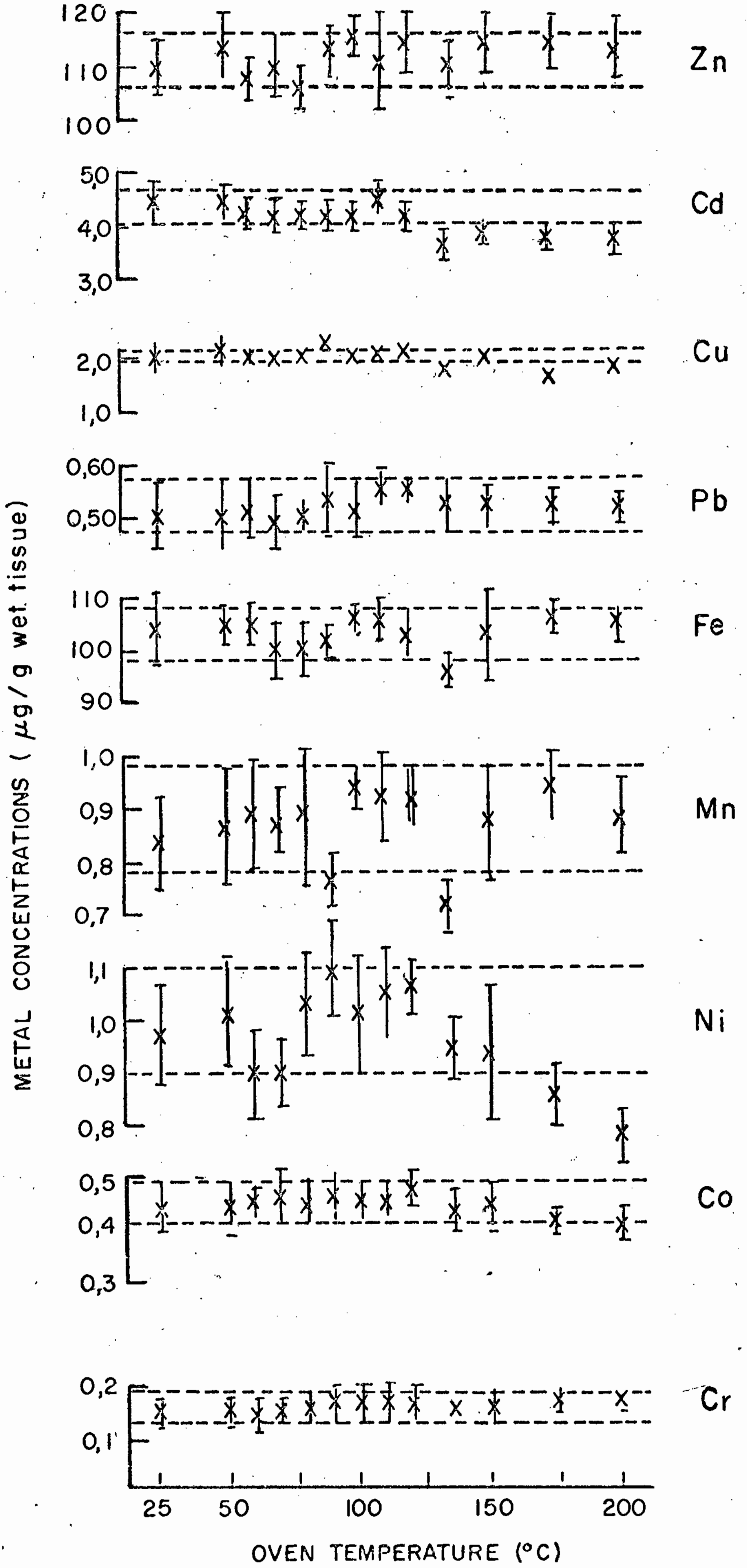


FIG.2.3 : Effect of drying temperature on metal content of biological tissue

A second experiment was carried out in order to determine whether metals are lost during freeze-drying of the marine mussel tissue. Eight portions of the homogenised tissue were frozen in a commercial food freezer (about -20°C) for 12 h. The samples were then dried at an initial temperature of -30°C which rose to +30°C during the 48 h drying period. The final system pressure was 270 Pa. Metal concentrations in the freeze-dried tissue are compared with those in an undried sample and after drying at 100°C. (Table 2.4).

TABLE 2.4 Comparison of results obtained by freeze-drying and oven-drying of marine mussel tissue

Element	µg metal/g wet tissue Freeze-dried	Un-dried	Oven-dried (100°C)
Zn	111 ± 7	110 ± 5	116 ± 2
Cd	4,9 ± 0,2	4,5 ± 0,3	4,2 ± 0,1
Cu	2,0 ± 0,1	2,0 ± 0,1	2,0 ± 0,1
Pb	0,22 ± 0,02	0,50 ± 0,06	0,51 ± 0,05
Fe	94 ± 7	104 ± 7	106 ± 2
Mn	0,77 ± 0,05	0,83 ± 0,09	0,94 ± 0,04
Ni	0,66 ± 0,14	0,97 ± 0,10	1,01 ± 0,11
Co	0,43 ± 0,02	0,44 ± 0,04	0,45 ± 0,03
Cr	0,19 ± 0,04	0,15 ± 0,02	0,17 ± 0,03

Lead, and to a lesser extent nickel, are apparently volatilised during freeze-drying. Fourie and Peisach (1977) have reported that lead and also cadmium are volatilised during freeze-drying but zinc, cobalt, manganese and iron are not (Van Raaphorst et al., 1974; Fourie and Peisach, 1977).

The present experiment can be criticised on the grounds that the sample was not maintained at -30°C during the drying procedure. Obviously, under these conditions of reduced pressure, the vapour pressure of unbound metals or of organometallic compounds in the sample will be greater than their pressure in the sample environment and losses could occur. Such losses will be greater if the temperature is allowed to increase while the sample is still contained in an evacuated chamber.

2.3.3 Oxidation of biological tissue

Most biological materials are readily ashed by either wet or dry oxidation procedures, the purpose being the removal of the organic fraction of the sample without loss of the inorganic constituents. Ashing procedures for many organic matrices have been critically reviewed by Gorsuch (1970). The deciding factor in the choice between a wet or dry ashing procedure for this study was the result of a simple dry ashing experiment using the homogenised marine mussel tissue prepared for the dehydration experiments.

Approximately 2,5 g portions of the dry tissue were weighed into clean porcelain crucibles of known mass. The samples were placed in a cool muffle furnace in which the temperature was raised slowly to the selected ashing temperature in order to avoid sample combustion. Ten replicate samples were prepared for each temperature and each set of samples was ashed to constant mass at the selected temperature. At 350°C the process required 72 h; progressively shorter ashing periods were required as the temperature was increased. However a 24 h period was employed at temperatures >450°C.

The inorganic content of the tissue (ash (g)/dry tissue (g) x 100) was calculated for each temperature (Table 2.5). These results immediately suggest that if ashing is complete at the lower temperatures then some material is certainly being volatilised at the higher temperatures.

TABLE 2.5 Percent inorganic material in marine mussel after ashing at different temperatures

Temperature (°C)	Ash (%)
350	16,8
450	16,7
550	16,5
650	16,0
750	13,6
850	10,2

Analysis of the ashes for six elements confirmed that volatilisation does take place during the dry ashing of this marine tissue. The results are plotted as percentage loss at each temperature (Fig. 2.4) and are summarised in Appendix 1. In view of the excessive losses observed for zinc, cadmium, copper and lead no other elements were determined.

A wet ashing procedure was investigated for use in the present study.

2.3.3.1 Nitric-perchloric acid oxidation

Nitric acid is the most widely used primary oxidant for the destruction

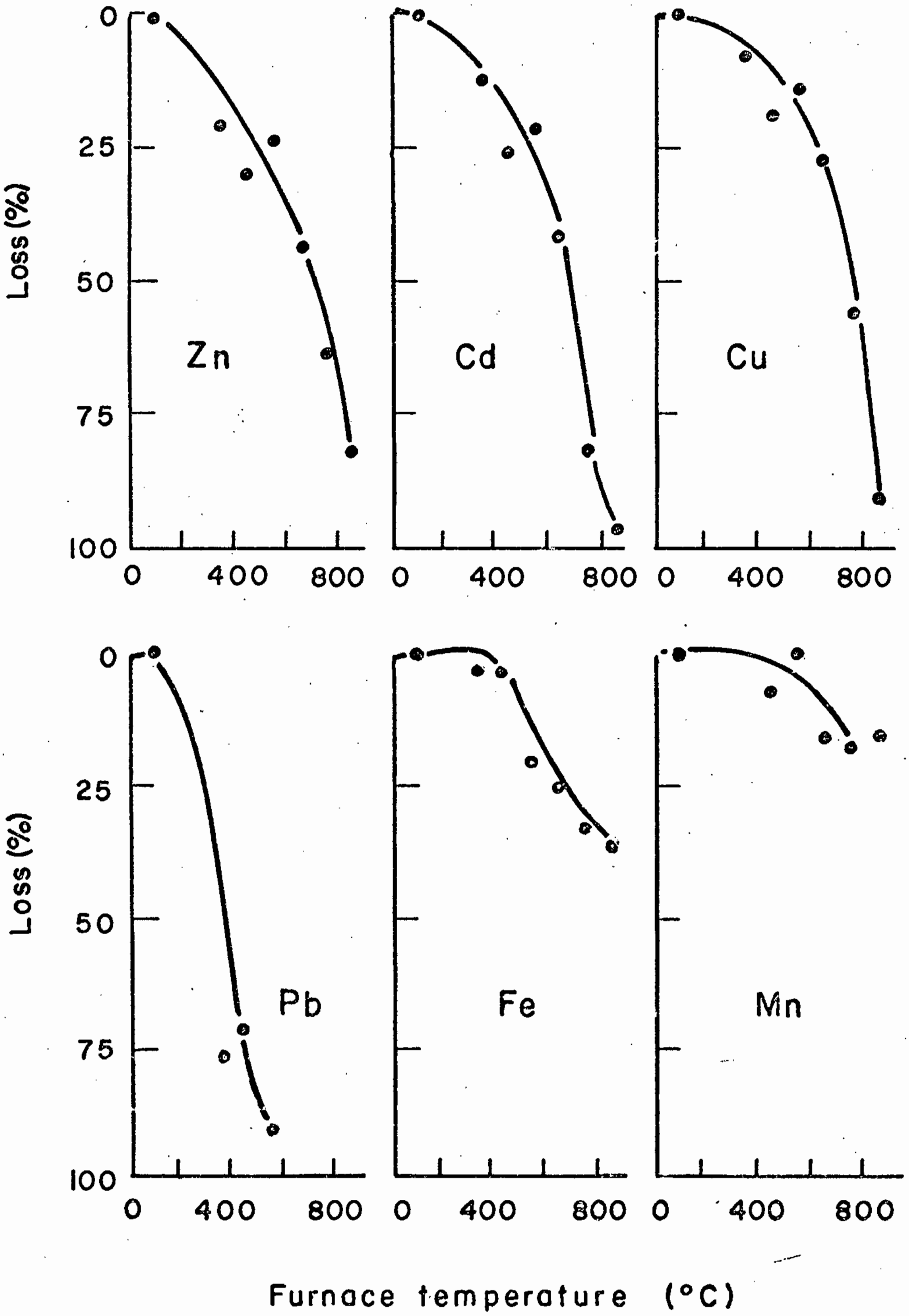


FIG.2.4: Loss of metals during dry ashing of biological tissue

of organic matter. The concentrated acid boils at approximately 120°C, a factor which assists in its removal after oxidation but correspondingly reduces its effectiveness. It can be used with perchloric acid which continues the oxidation after the nitric acid has been evaporated.

Reagent grade perchloric acid is generally supplied as either a 60% or a 72% aqueous solution. If the 60% acid is heated it loses water until it reaches a concentration of approximately 72%, when the azeotropic mixture evaporates without further concentration (Gorsuch, 1970). The concentrated solution is stable when cold and has no oxidising power. When heated, the oxidation potential increases as the temperature rises to 203°C, the boiling point of the acid-water mixture.

The danger with perchloric acid arises when it is heated with hydroxyl compounds which give rise to the formation of unstable perchlorate esters. However, hydroxyl compounds such as alcohols and carbohydrates are very susceptible to oxidation with nitric acid. Accordingly, the use of nitric acid in addition to perchloric acid should prevent explosion during the oxidation of these hydroxyl compounds, provided that sufficient nitric acid is present and the reaction is allowed to proceed for an adequate period to ensure the oxidation of these compounds before the nitric acid has been boiled off (Gorsuch, 1970).

In general, the temperatures involved in wet oxidation methods are very much lower than those used for dry ashing so that the volatilisation of elements is less likely. The nitric acid digestion of marine samples will generally remove chloride ion as nitrosyl chloride at temperatures below the volatilisation temperatures of most other chlorides. One of the problems with wet oxidation is that in every case reagents are added to the sample, frequently in amounts much larger than the sample, and these reagents may contain contaminants. Precautions must therefore be taken to ensure that any such contamination is reduced to negligible amounts with respect to the levels routinely determined.

2.3.3.2 The effect of acid temperature in wet oxidation

In order to investigate whether metals could volatilise under the conditions used for wet ashing, 10 replicate 1 g samples of wet homogenised marine mussel tissue were digested with 25 ml nitric acid at selected temperatures between 50-250°C. The temperature of the hot plate was pre-set. The solutions were boiled to dryness at this temperature but were removed from the hot plate before the sample charred. A second volume of nitric acid was added and the procedure repeated to complete the oxidation. The residue was dissolved in 10 ml 10% nitric acid and the metal concentrations in this solution were determined.

A second set of samples was prepared and digested with 25 ml nitric acid, followed by 25 ml 4:1 nitric-perchloric acid mixture. The samples were fumed to dryness at 150, 200 or 250°C. The results, expressed as µg metal/g wet tissue, are summarised in Appendix 1.

The mean values of 10 measurements, together with their error bars (representing one standard deviation either side of the mean), are plotted for each metal at each temperature (Fig. 2.5). The broken lines have been drawn through the limits observed at the lowest temperature, assuming that at this temperature losses due to volatilisation would be a minimum. The results of the second experiment are also plotted but, for clarity, they are displaced slightly to the right of those obtained for the nitric acid digestions at equivalent temperatures.

The results indicate that no losses occurred with digestion temperatures of up to 150°C although some volatilisation of lead, iron, manganese and nickel may have occurred at 250°C. The loss of nickel during high-temperature acid digestion is interesting, particularly in view of its apparent volatility during oven- and freeze-drying, and the nature of the nickel complexes in biological tissues warrants further study.

The hot plates used routinely for the oxidation of biological tissues reach a maximum temperature of 150°C; the digestion temperature normally employed is between 130–140°C, at which no significant volatilisation is observed.

2.4 METHOD FOR THE ANALYSIS OF BIOLOGICAL TISSUE

2.4.1 Procedure used for the preparation, dissolution and analysis of samples

2.4.1.1 Living specimens were suspended in clean sea water for up to 5 days to allow them to purge their intestinal contents. The wet tissues were then removed from the shells and frozen.

2.4.1.2 Glassware was cleaned by scrubbing in hot soapy water, rinsed, soaked in 25% hydrochloric acid for 24 h and then rinsed three times with borosilicate-glass distilled water; analar-grade nitric and perchloric acids were redistilled before use; and routine reagent-blank determinations confirmed the absence of metal contamination of the apparatus.

2.4.1.3 The frozen specimens were thawed, weighed into clean dry flasks and oven-dried at 90°C for 24 h. The dried samples were weighed and their

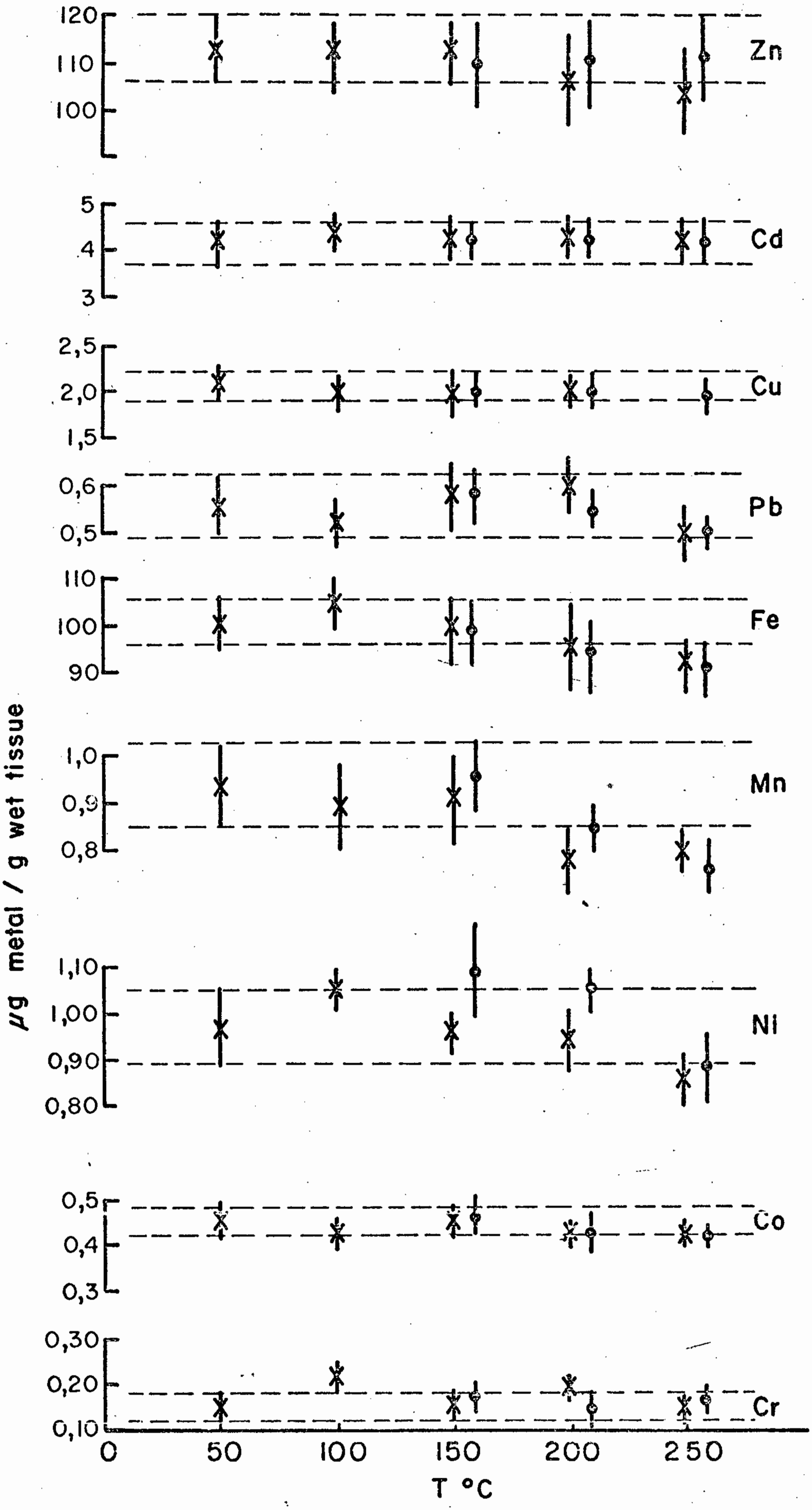


FIG.2.5 : Effect of solution temperature on metal content of biological tissue

water contents calculated as a percentage.

The dried samples were dissolved in 25 ml nitric acid and heated. The initial exothermic reaction (solution temperature <100°C) was accompanied by the vigorous evolution of nitrogen oxides. The yellow solution was boiled and evaporated to near dryness but was removed from the hot plate before the sample charred. The residue was dissolved in 25 ml of a 4:1 nitric-perchloric acid mixture. This solution was fumed to dryness at about 140°C. The white residue was redissolved in 10 ml 10% nitric acid for atomic absorption analysis.

2.4.1.4 Composite standards containing zinc, cadmium, copper, lead, iron, manganese, nickel, cobalt, chromium and strontium in the range 0,1-20 µg/ml, in the presence of sodium, potassium, calcium and magnesium in the range 100-5000 µg/ml, were prepared in 10% nitric acid.

Instrumental and flame parameters were optimised for the determination of each element. Background correction was used for all trace elements with resonance lines of shorter wavelengths than 280 nm. The slotted tube was used to increase the sensitivity of the lead determination.

The instrument was calibrated using the composite standards and the metal concentrations in the sample solutions were determined. The results were calculated and expressed as µg metal/g wet tissue.

2.4.2 Precision and accuracy of the method

The precision of the method, including both the preparatory and analytical procedures, is readily determined by performing replicate analyses on a single homogeneous tissue. Samples of five tissues were homogenised using a Waring blender. Replicate 5 g portions were dissolved and analysed by the method described. The results are summarised in Table 2.6.

The precision of the analytical method (Table 2.3) has already been shown to depend upon the element and its concentration in solution; it is also dependent upon the tissue which is being analysed (Table 2.6). These results may be used as a guide to the analytical precision of the element determinations in samples collected during the present investigation, always remembering that the masses of natural samples vary considerably so that a direct conversion is not possible.

Analytical accuracy is somewhat harder to establish. The International Atomic Energy Agency (IAEA) have distributed marine environmental samples to all laboratories wishing to participate in interlaboratory calibration exercises. Statistical analysis of all the submitted results allows a

TABLE 2.6 Analytical precision for the determination of nine elements in marine biological tissues. (Mean element concentration; relative standard deviation (%) in parentheses)

Element	Mussel (n=12)	Fish (1) (n=12)	µg metal / g wet tissue Algae (n=10)	Oyster (n=8)	Fish (2) (n=10)
Zn	120 (2,7)	3,42 (1,2)	2,92 (1,4)	550 (5,7)	3,44 (8,4)
Cd	5,0 (1,6)	<0,01 (100)	0,23 (4,4)	0,55 (7,0)	0,12 (8,8)
Cu	1,46 (4,1)	0,40 (5,0)	2,54 (1,6)	67 (5,3)	1,06 (13,0)
Pb	0,16(25,0)	<0,02 (100)	0,1 (40)	0,16 (6,4)	0,09 (14,3)
Fe	89 (2,5)	26,4 (6,1)	300 (2,1)	59 (5,8)	107 (10,0)
Mn	0,82 (4,9)	0,38 (10,5)	3,28 (1,8)	13,1 (6,1)	0,94 (8,7)
Ni	0,44 (4,5)	0,18 (33)	0,92 (4,3)		
Co	0,20 (20)	<0,02 (100)	<0,02 (100)		
Cr	0,42(14,3)	0,22 (27,3)	0,84 (7,1)		

"probable concentration" to be determined for each element. However, as these materials are not analysed in all details, and the contents of the elements are not known with sufficient precision or accuracy, these samples cannot be considered as equivalent to Standard Reference Materials. Nevertheless useful data are obtained on both precision and accuracy by analysing such materials at regular intervals during any analytical programme.

Four samples, fish solubles (A-6), oyster homogenate (MA-M-1), sea plant (SP-M-1) and copepod (MA-A-1) have been analysed for nine elements using the nitric-perchloric acid digestion already described, followed by atomic absorption determination of the element concentrations in solutions. The results are shown in Table 2.7 together with the IAEA mean values.

2.4.2.1 Fish solubles A-6

This sample is dried fish serum prepared from commercially available fish solubles without the addition of active or inactive materials. The particular structure of fish solubles causes a certain unavoidable inhomogeneity on a microscale which cannot be overcome by mechanical processes (IAEA Information sheet A-6/1975).

The IAEA overall means of the accepted laboratory means are given for zinc, copper, iron, manganese, cobalt and chromium; these values may be considered as "probable concentrations". In some cases (e.g. cadmium, lead and nickel) the distribution of the results was not normal or the latter were so widely spread that a proper statistical interpretation was not possible. Only the median of all values has been calculated (shown in brackets in Table 2.7); the value of this median should be considered with caution (Gorski _et al_., 1975b).

The results obtained in the present study for those elements assigned "probable concentrations" compare well with the IAEA values.

2.4.2.2 Oyster homogenate MA-M-1

The measurements of the elements manganese, iron, copper, zinc and cadmium fall into a less than 10% standard error category; the average values obtained after rejecting outliers can be regarded as "consensus values" which closely approach the actual concentrations of these elements. Cobalt and nickel fall into an intermediate group with standard errors between 10 and 50% and measurements of chromium exceed 50% standard error; the value for lead should not be regarded in any sense as representative (IAEA, 1976).

The results obtained by atomic absorption spectrometry (study value)

TABLE 2.7 Analysis of International Atomic Energy Agency marine environmental samples

	Element concentration (µg/g) in dry sample								
	Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
A-6 Fish solubles									
Study value	20,1 ± 0,9	0,27 ± 0,04	5,4 ± 0,9	0,2	583 ± 20	5,1 ± 0,4	0,9 ± 0,2	0,26 ± 0,13	1,04 ± 0,30
IAEA	18,9 ± 2,9	(0,49)	5,3 ± 1,2	(1,9)	565 ± 93	4,7 ± 1,0	(1,7)	0,22 ± 0,10	0,71 ± 0,30
MA-M-1 Oyster homogenate									
Study value	2710 ± 27	2,5 ± 0,1	333 ± 7	1,0 ± 0,3	301 ± 7	62 ± 2	1,1 ± 0,3	0,22 ± 0,04	1,3 ± 0,3
IAEA	2820 ± 30	2,3 ± 0,2	317 ± 8	(2,7)	304 ± 7	71 ± 2	3,7 ± 0,6	0,44 ± 0,03*	0,7 ± 0,2*
SP-M-1 Sea plant									
Study value	54 ± 1	0,33 ± 0,04	12,5 ± 0,5	14,7 ± 0,5	1710 ± 60	49 ± 1	16,2 ± 0,3	2,2 ± 0,2	6,5 ± 0,8
IAEA (corrected mean)	59	0,41	12,2	15,7	1770	61	19,8	2,6	4,2
MA-A-1 Copepod									
Study value	146 ± 8	0,79 ± 0,17	8,0 ± 0,5	1,1 ± 0,2	74 ± 6	2,9 ± 0,2	1,9 ± 0,3	0,44 ± 0,26	1,0 ± 0,5
IAEA (corrected mean)	152	0,78	7,9	1,5	62	2,9	1,9	0,12	0,7

have been compared with those obtained by neutron activation analysis (IAEA). Those elements which are assigned "consensus values" show good agreement between the two methods. It is assumed that the average values for cobalt and chromium (indicated by an asterisk, Table 2.7) obtained by neutron activation analysis are closer to the actual concentrations, as atomic absorption analysis tended to produce systematically higher results for these elements in this interlaboratory study (IAEA, 1976).

2.4.2.3 Sea plant SP-M-1 and Copepod MA-A-1

The preliminary overall averages of the results reported for selected trace elements in these two samples have been reported (IAEA, 1977). However, as statistical criteria to reject outlying data were not applied, these values in no way indicate the "probable concentrations" of these elements in the samples. A non-statistical rejection of extreme outliers has resulted in a "corrected mean" (Table 2.7).

The values obtained in the present study, which have been submitted for the interlaboratory calibration exercise, are certainly of the right order of magnitude. However, until the final report on these samples has been published by the IAEA, no further conclusions can be drawn.

The use of interlaboratory calibration studies as a means of determining accuracy is a poor substitute for the analysis of Standard Reference Materials. Nevertheless, in the absence of suitable certified samples it is necessary to turn to samples which have been used previously for intercomparisons. Generally the degree of accuracy with which these contents can be named is inferior to that pertaining to Standard Reference Materials.

Interlaboratory calibration studies are usually run on a voluntary participation basis, i.e. samples are supplied to any laboratory which is willing to analyse them. The results of the overall study are then evaluated using statistical methods so as to present a totally "unbiased" account. However, some of the participants may not have analysed such samples before, in which event it is possible that an unsuitable method has been applied to the problem. Yet all submitted results are equally valid in terms of the statistical programme used.

If the aim of an intercalibration study is to determine the metal concentrations in a sample with sufficient precision and accuracy so that it may be distributed as a Standard Reference Material (which is the stated intention of the IAEA), then the initial analyses should be performed by a few relaible laboratories with previous experience in analysing such samples. These laboratories would submit detailed descriptions of their techniques and, hopefully, the results from different laboratories would be comparable.

The sample could then be distributed to participants and their results compared with those already determined.

If the more usual procedure of submitting the sample to all laboratories is followed, then the methods used by these laboratories should be scrutinised by experts. Preliminary rejection of "outliers" should be based on a careful appraisal of the methods of sample and standards preparation and of the analytical method employed. The results from laboratories using obviously unsound techniques should be discarded regardless of whether these are "nearly correct" or not. Such results can only be regarded as fortuitous. The statistical method can then be used to evaluate those results which are analytically acceptable, assuming that a sufficient number remain. The results from such an exercise would probably compare well because only the results from reliable laboratories would remain.

2.5 SUMMARY

2.5.1 The procedure used for the preparation, dissolution and analysis of marine biological tissues has been described.

2.5.2 The volatility of selected trace elements during sample preparation and dissolution has been investigated and volatilisation of nickel during oven-drying (>120°C), freeze-drying and high-temperature acid digestion was observed. No comparative data on the behaviour of nickel during the preparation of related biological tissues could be found, in spite of the fact that concentrations of this element in such tissues are often reported.

2.5.3 Problems associated with the atomic absorption analysis of marine biological tissues have been discussed and corrective procedures are described. The precision of the analytical method as a whole is shown to depend on the element, its concentration in solution and the type of tissue being analysed. The accuracy of the results obtained using this method has been investigated using some samples distributed by the IAEA. The results obtained generally agree well with those reported as "probable concentrations" or "consensus values".

CHAPTER 3 METAL CONCENTRATIONS IN SOME BIVALVE MOLLUSCS

3.1 INTRODUCTION

It is apparent from the large number of determinations of metal levels in molluscs that differences between species, even closely related species, are such as to invalidate interspecific comparisons. Thus, for the purposes of this investigation, comparative data must be limited to those species which grow along the South African coast. Although the absolute values which are obtained should not be compared directly with those reported for other species, data relating to other species may nevertheless be useful when interpreting any unusual features observed for South African bivalves.

Metal concentrations have been determined for 11 species growing in or near the Knysna estuary and samples of these species have also been collected from a number of other sites on the South African coast. The results are listed in Appendix 2.

3.2 KNYSNA ESTUARY - MAIN STUDY AREA

Knysna is situated on the south coast of South Africa between Cape Town and Port Elizabeth (Fig. 3.1). The Knysna river has a relatively small catchment and is tidal for the last 20 km. Day <u>et al</u>. (1952) described the physical conditions and the benthic fauna of this estuary; they concluded that "the interesting features of Knysna are the depth at the mouth, the evenness of the rainfall, the absence of silt in the river and the resulting clarity of the estuary".

Korringa (1956) reported that three species of indigenous oysters, <u>Crassostrea margaritacea</u>, <u>Ostrea algoensis</u> and <u>Ostrea atherstonei</u> could be found at Knysna, although natural oyster beds did not occur in the estuary. He also reported that the Portuguese oyster <u>Crassostrea angulata</u> grew and fattened satisfactorily at Knysna. However, the European flat oyster <u>Ostrea edulis</u> was sensitive to the fine sediment and sand stirred up by the strong winds which could occur in the estuary. The Pacific oyster <u>Crassostrea gigas</u> is now being cultivated at the FISCOR Laboratory and is grown to commercial size in the estuary.

The metal concentrations in Knysna surface sediments are very low with the exception of a few isolated sites (R.J. Watling and Watling, 1977).

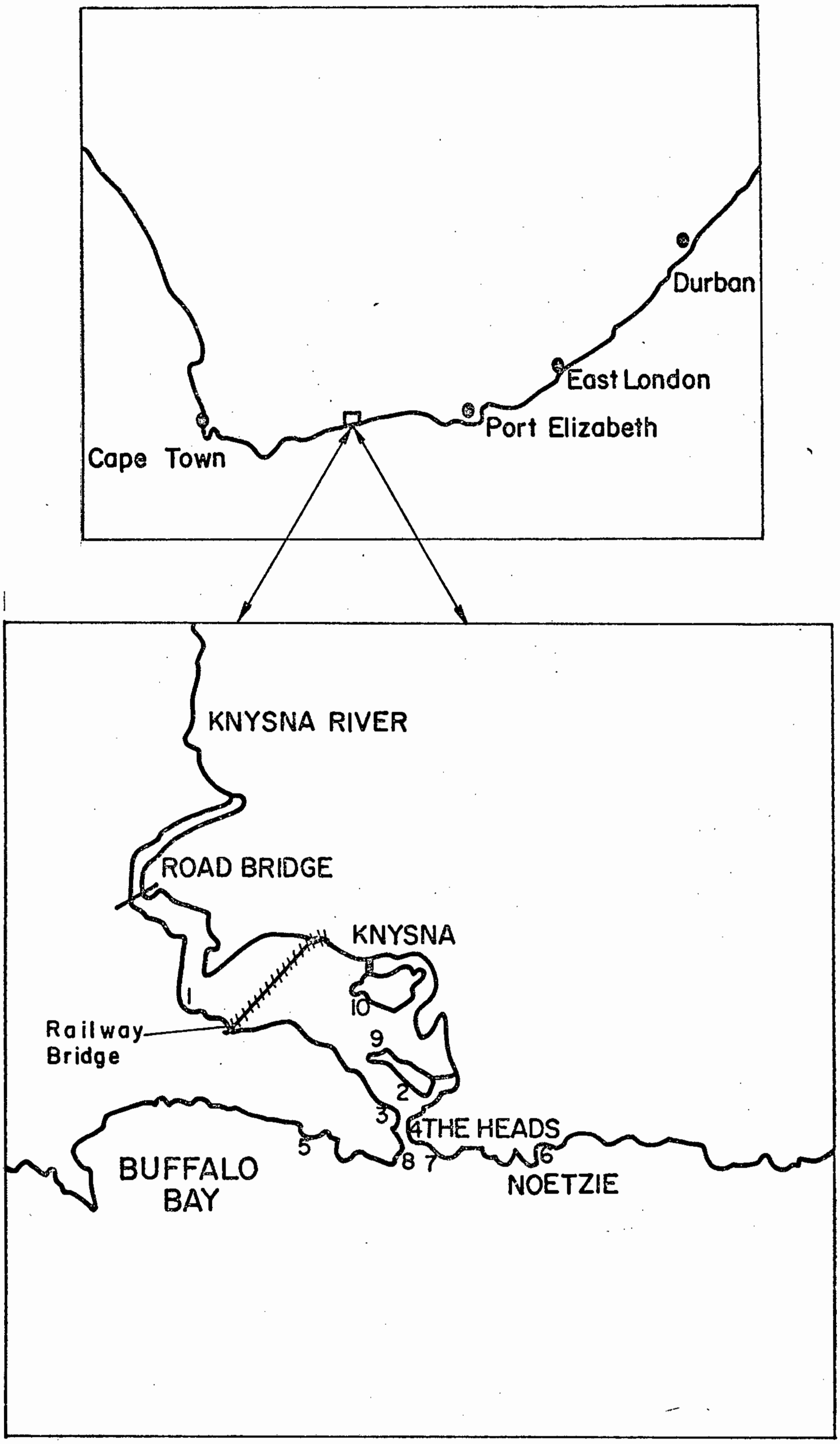


FIG. 3.1 : Knysna Estuary : Sample locations

3.3 TISSUE-METAL CONCENTRATIONS IN CRASSOSTREA GIGAS AND OSTREA EDULIS GROWN IN KNYSNA ESTUARY

C. gigas is grown and studied in many countries and comparative data on tissue-metal concentrations are available, particularly for locations where metal pollution is already a recognised problem. The metal concentrations in C. gigas from Belvedere (Fig. 3.1, Site 1) are compared with data for the same species growing in other areas (Table 3.1). Data have also been reported for O. edulis which are compared with the metal concentrations in this species grown at Belvedere (Table 3.2).

The concentrations which have been determined for C. gigas and O. edulis at Belvedere are much lower than many of the reported values and clearly indicate that Knysna estuary is unpolluted with respect to these metals.

3.4 TISSUE-METAL CONCENTRATIONS IN SOME SOUTH AFRICAN BIVALVES

Metal concentrations in C. gigas and O. edulis grown at Belvedere are low. Therefore it may be assumed that concentrations in C. margaritacea from the same site will also represent background levels. These concentrations (Table 3.3) are compared with those determined for the same species from sites near Knysna (Fig. 3.1) and on the southern (Fig. 3.2) and eastern coasts. The results are the arithmetic means obtained for a large number of samples and the variations in concentration are given as standard deviations.

The zinc concentrations for the different populations are variable but the mean natural level is probably about 100 µg/g. The higher zinc concentrations in the Belvedere oysters may be due to the accumulation of this element from the galvanised wires used initially to support the abalone-shell cultch upon which they had settled. Thus during their earlier, fast growing period these oysters could have been subjected to higher zinc levels in the water due to the corrosion of these wires. When the oysters were larger and becoming crowded they were transferred to the wooden rack system and the wires were discarded. The accumulation of zinc from galvanised materials has been reported for C. gigas (Boyden and Romeril, 1974) and in this respect the results indicate a similar reaction by C. margaritacea.

The oysters collected from Beacon Point (Fig. 3.1, Site 4) also contain more zinc than the expected background level as well as elevated nickel and chromium concentrations. This may be due to urban pollution although no obvious source of these metals was discovered. The East Head

TABLE 3.1 Metal concentrations in <u>Crassostrea gigas</u>

Sample Location		Mean wet tissue mass (g)	µg metal / g wet tissue									Reference
			Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr	
Belvedere (Fig. 3.1 Site 1)	1975	11,85	69±36	0,56±0,13	5,7±3,6	0,21±0,07	20±6	2,1±0,7	0,26±0,12	0,15±0,05	0,11±0,08	Present study
Langebaan Lagoon RSA	1974	-	21	0,87	3,7	0,34	17	1,3	0,25	-	0,54	Fourie, 1976
Saldanha Bay RSA	1977	10,17	100	1,10	9,3	<0,1	32	2,2	<0,1	<0,1	0,34	Watling (unpublished data)
Helford R. UK	1972	5,93	421	0,30	85	1,2	64	5,6	0,3	0,1	0,15	Watling, 1974
Conway R. UK	1971	2,69	480	0,61	25,2	1,4	85	6,2	1,6	0,9	0,40	
Poole H. UK	1972	4,62	379	3,8	56,1	0,6	66	4,2	0,3	0,1	0,2	
Colne R. UK	1971	8,58	180	0,35	26,3	1,1	45	2,0	0,5	0,2	-	
Menai Straits UK	1973*	9,32	413	0,90	5,1	1,1	24	4,2	0,30	0,15	-	Boyden and
Hinkley Power Stn.UK	1972*	1,99	1479	6,00	972	2,4	59	3,0	0,98	0,33	-	Romeril, 1974
Hinkley Power Stn.UK	1973*	3,14	5268	4,05	264	2,6	63	2,4	0,57	0,53	-	
Derwent estuary (Tasmania)	1972	-	6990	17,7	96	-	-	-	-	-	-	Thrower and Eustace, 1973
Tamar estuary (Tasmania)	1972	-	1005	5,9	122	-	-	-	-	-	-	Thrower and Eustace, 1973
Pacific coast USA	1967	-	206	0,80	14,3	<0,20	49	2,2	<0,20	<0,20	<0,20	Pringle <u>et al</u>., 1968
Poole H. UK	1973*	13,50	265	0,69	30,0	0,90	34	2,7	0,45	-	-	Boyden, 1975

*converted from dry tissue data, assuming 85% water content

TABLE 3.2 Metal concentrations in <u>Ostrea edulis</u>

Sample Location		Mean wet tissue mass (g)	μg metal / g wet tissue									Reference
			Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr	
Belvedere (Fig. 3.1 Site 1)	1975	2,79	130±52	0,61±0,13	7,1±3,3	0,29±0,08	34±13	1,04±0,36	0,36±0,19	0,16±0,09	0,30±0,30	Present study
Helford R. UK	1972	4,29	1089	0,59	286	1,2	69	1,9	0,5	0,13	0,17	Watling (unpublished data)
Restronguet Ck. UK	1972	7,07	655	0,40	122	1,5	73	1,7	0,5	0,4	0,4	
Lyner R. UK	1972	8,57	763	0,78	117	1,8	36	2,25	0,3	0,3	<0,3	
Poole H. UK	1973*	8,46	296	0,89	12,9	0,75	59	1,05	0,3	-	-	Boyden, 1975
Menai Straits UK	1973*	2,20	463	0,90	54,5	1,50	58	-	1,95	-	-	

* converted from dry tissue data assuming 85% water content

TABLE 3.3 Metal concentrations in _Crassostrea margaritacea_

Sample Location	Mean wet tissue mass (g)	Zn	Cd	Cu	µg metal / g wet tissue Pb	Fe	Mn	Ni	Co	Cr	Reference
Fig. 3.1											
Belvedere (1)	4,59	197±60	0,49±0,17	3,6±1,6	0,33±0,12	11±4	0,46±0,27	0,38±0,24	0,22±0,13	0,40±0,50	Present study
Featherbed (3)	4,46	95±27	1,73±0,37	1,1±0,2	0,82±0,50	22±10	0,97±0,59	0,44±0,20	0,32±0,13	0,34±0,24	
Beacon Point (4)	2,70	322±228	1,34±0,35	2,5±1,6	0,44±0,22	47±20	0,74±0,37	1,45±1,03	0,06±0,03	2,96±2,42	
Castle Rock (5)	3,04	107±32	2,39±0,48	3,8±1,7	0,85±0,45	15±7	1,35±0,67	0,46±0,19	0,24±0,12	0,42±0,20	
Noetzie (6)	2,29	156±61	2,49±0,60	4,1±1,4	0,69±0,26	23±9	1,20±0,65	0,54±0,33	0,31±0,12	0,40±0,23	
Fig. 3.2											
Fish Bay (11) 1975	2,94	107±46	1,93±0,24	3,5±1,5	0,92±0,44	28±15	1,96±1,09	1,39±1,14	0,36±0,20	1,39±1,89	
Walker Point West 1975 (12)	3,34	249±144	1,30±0,44	2,9±3,2	0,32±0,48	50±26	0,79±0,36	0,62±0,96	0,04±0,03	0,68±0,89	
Walker Point East 1975 (13)	7,44	60±15	1,61±0,32	3,1±0,6	0,73±0,40	11±2	1,50±1,51	0,34±0,18	0,22±0,10	0,38±0,40	
Cathedral Rock(14)1975	2,03	50±15	2,28±0,31	4,7±0,7	0,37±0,24	36±11	1,30±0,67	0,79±0,68	0,03±0,01	1,02±3,60	
Algoa Bay (15) 1977	10,77	574±78	0,21±0,11	7,7±5,0	0,15±0,07	39±57	1,18±1,09	0,06±0,12	0,02±0,03	0,23±0,11	
Langebaan Lagoon 1974	-	120	0,88	1,9	0,42	5	0,55	0,20	-	0,50	Fourie, 1976
Swartkops R. 1975	-	333	0,26	-	-	27	-	-	-	-	Oliff, 1976
Bashee estuary 1975	-	689	0,76	9,6	5,2	38	-	-	-	0,22	Oliff, 1976
Umgababa estuary* 1976	-	600	1,01	81,9	1,35	46	-	-	0,63	0,03	Oliff, 1976

* converted from dry tissue data assuming 85% water content

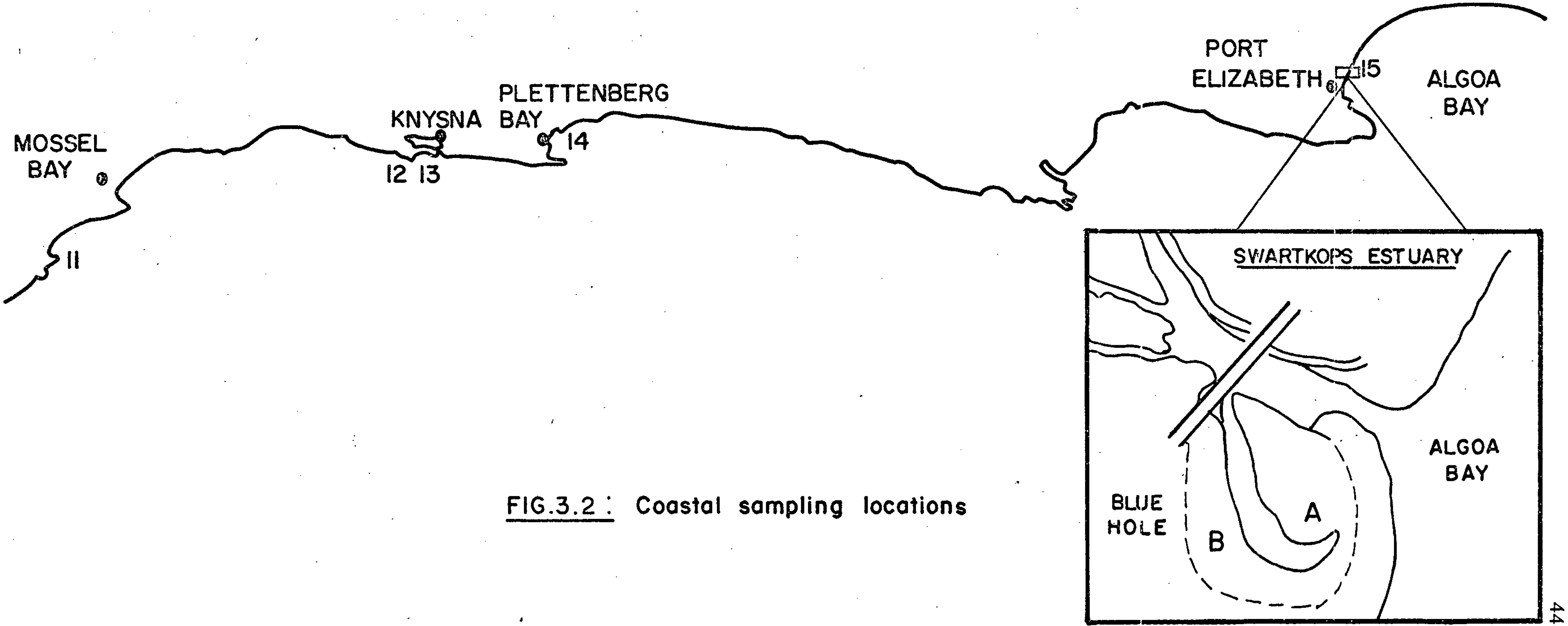


FIG.3.2 : Coastal sampling locations

is a built-up area and a popular fishing site. In addition, debris from the estuary and also from the surrounding coast is deposited and decomposes in this area.

Cadmium levels in the Belvedere population are lower than for the oysters growing on the nearby rocky shore. Elevated cadmium levels, thought to be of geochemical origin, have been found in the surface sediments near the Heads (Fig. 3.3) (R.J. Watling and Watling, 1977). These higher cadmium concentrations are not confined to Knysna but occur in oysters collected between Fish Bay (Fig. 3.2, Site 11) and Cathedral Rock (Fig. 3.2, Site 14).

The concentrations of other elements vary between the Knysna populations, but in view of the range of values found within each population and the difficulty in determining some of these elements at low concentrations (where the relative analytical error increases), these differences are not considered to be significant. The fact that oysters from some areas are reported to contain very high levels of zinc, copper or lead indicates that this species can accumulate metals when they are present in its environment in greater than normal amounts.

Metal concentrations in Perna perna collected from a number of sites in Knysna estuary are compared with those determined for this species growing on the South African coast (Table 3.4). Levels are generally low except for the sample collected from a disused slipway near Leisure Isle (Fig. 3.1, Site 2). Cadmium levels in the Knysna coastal samples are slightly higher than those in some other populations.

Choromytilus meridionalis does not normally grow at Knysna. However, a number of small individuals (10-20 mm shell length) were placed in a mesh tray, secured at Featherbed (Fig. 3.1, Site 3) and grown for 8 months. (Small P. perna were grown in a second tray for comparison.) The metal concentrations in these C. meridionalis are compared with those determined for samples collected along the South African coast (Table 3.5). The Knysna sample contains near background levels for all of the elements determined.

Several other bivalve species were collected from sites in and near Knysna estuary. The metal concentrations in these are very variable and some relatively high values are observed (Table 3.6). Few published data are available for comparison with these values. However, in view of the relatively low levels already determined for the oysters and mussels, it is expected that, with the possible exception of cadmium, the values obtained for species growing in and near the Knysna estuary represent near background levels.

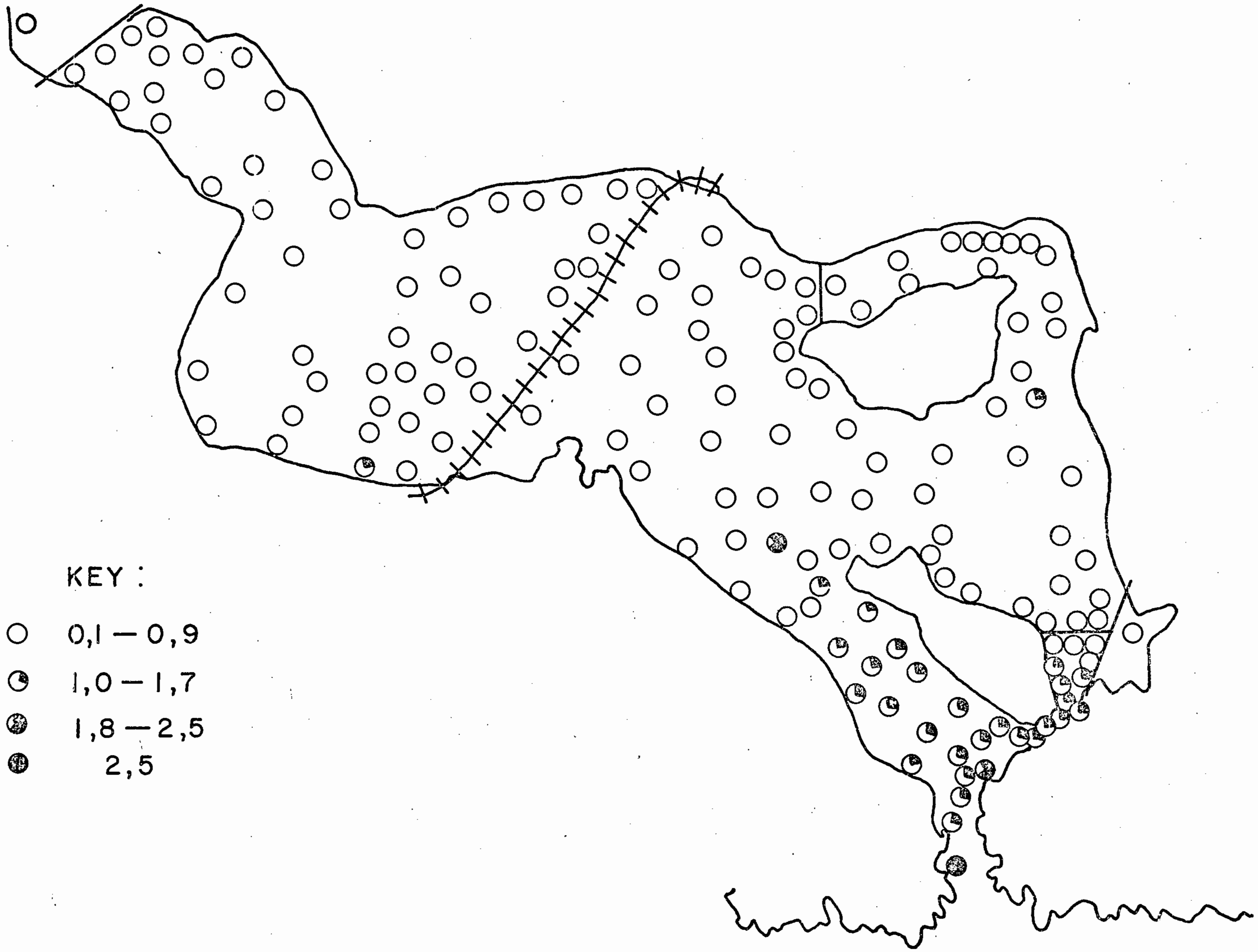


FIG.3.3: *CADMIUM CONTENT OF KNYSNA SEDIMENTS (µg/g)*

TABLE 3.4 Metal concentrations in _Perna perna_

Sample Location	Mean wet tissue mass (g)	µg metal / g wet tissue									Reference
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr	
Fig. 3.1											
Featherbed (3) in rack	4,06	13,1±2,7	0,52±0,18	1,15±0,30	0,13±0,10	99±55	0,78±0,32	0,98±0,87	0,08±0,05	0,69±0,37	Present study
East Head Rocks (7)	1,81	18,4±5,8	0,61±0,20	1,4±0,8	0,08±0,15	105±40	1,01±0,58	1,41±0,89	0,17±0,12	0,35±0,06	
Beacon Point (4)	5,54	6,8±2,5	0,30±0,15	0,43±0,16	0,15±0,12	36±13	0,40±0,19	0,30±0,19	0,02±0,02	0,32±0,32	
Castle Rock (5)	4,69	15,6±3,0	0,86±0,23	1,02±0,33	0,50±0,14	44±10	0,97±0,47	1,98±0,50	0,32±0,08	0,37±0,23	
Noetzie (6)	5,11	12,0±1,7	1,07±0,29	0,84±0,15	0,40±0,10	41±9	0,70±0,16	1,37±0,16	0,24±0,06	0,16±0,07	
Leisure Isle (2) (wood)	1,93	138±135	0,93±0,85	1,57±0,09	0,17±0,09	93±41	0,91±0,19	3,2±1,9	0,19±0,17	1,4±1,7	
Thesen's Jetty (10)	2,52	5,0±1,3	0,12±0,03	0,38±0,10	0,06±0,03	39±8	0,28±0,08	0,40±0,27	0,04±0,06	0,11±0,04	
Fig. 3.2											
Fish Bay (11)	4,82	16,7±3,3	1,02±0,36	1,12±0,28	0,64±0,28	52±14	1,20±0,44	2,08±0,62	0,49±0,14	0,85±0,36	
Cathedral Rock (14)	2,83	7,8±3,7	0,37±0,13	0,70±0,57	0,11±0,14	37±13	0,56±0,38	0,66±0,30	0,04±0,03	0,46±0,31	
Walker Point West (12)	1,55	21,4±9,1	0,54±0,24	1,9±0,7	0,25±0,21	107±28	1,43±0,69	1,45±0,60	0,13±0,22	0,70±0,65	
Umhlanga Rocks Natal	-	14,0	0,27	1,01	0,56	84	1,04	0,95	0,44	0,35	Watling, unpublished data
Port Elizabeth Sg*	-	18,6	0,24	1,83	3,28	72	-	-	-	1,05	Oliff, 1976
N4*	-	9,5	0,29	1,35	5,00	70	-	-	-	0,44	Oliff, 1976
St. Croix*	-	9,0	0,50	1,68	3,95	63	-	-	-	0,62	Oliff, 1976
Kosi Bay*	-	6,6	0,18	0,99	23,6	216	-	-	0,71	1,13	Oliff, 1976
Bashee estuary	-	10,2	0,39	1,4	2,1	54	-	-	-	0,12	Oliff, 1976

* Converted from dry tissue data assuming 85% water content

TABLE 3.5 Metal concentrations in <u>Choromytilus meridionalis</u>

Sample Location	Mean wet tissue mass (g)	µg metal / g wet tissue									Reference
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr	
Featherbed in rack (Fig.3.1;Site 3)	5,74	13,8±2,7	0,43±0,22	1,87±0,43	0,12±0,09	27±13	1,78±0,57	0,33±0,25	0,02±0,01	0,57±0,12	Present study
Port Elizabeth S3*	-	16	0,65	2,6	3,53	20	-	-	-	0,53	Oliff, 1976
S2*	-	15	0,39	2,9	4,55	93	-	-	-	0,68	
Cape of Good Hope		16	-	-	-	18	1,7	-	0,04	0,13	Van As <u>et al</u>.1973
Melkbosch Strand	-	16	-	-	-	20	2,7	-	0,04	0,10	Van As <u>et al</u>.1975
Saldanha Bay (entrance)	-	12	0,36	0,9	0,07	8	2,1	0,26	-	0,80	Fourie, 1976
(within)	-	13	0,16	1,3	0,23	21	1,6	0,26	-	1,3	
Blouberg strand	-	12	0,31	1,09	0,08	13	1,6	0,13	0,07	0,09	Watling (Feb.1977 sample)

* converted from dry tissue data assuming 85% water content

TABLE 3.6 Metal concentrations in some bivalve molluscs

Species	Sample Location	Wet tissue mass (g)	µg metal / g wet tissue									Reference
			Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr	
Atrina squamifera	Leisure Isle sand (Fig. 3.1; site 2)	52,3	70±23	2,6±0,6	0,74±0,27	0,13±0,03	45±13	0,54±0,17	0,59±0,19	0,38±0,13	0,20±0,09	Present study
Venus verrucosa	Leisure Isle sand (Fig. 3.1; site 2)	6,01	7,6±1,5	0,55±0,22	1,15±0,32	0,63±0,27	52±19	0,71±0,36	1,08±0,51	0,56±0,15	0,87±1,00	Present study
Mactra glabrata	Leisure Isle (Fig. 3.1; site 2)	10,37	12,0	1,27	1,07	0,34	111	1,10	-	-	-	Present study
	Saldanha Bay	-	7,9	0,19	0,22	0	41	0,34	-	-	0,54	Fourie, 1976
Solen capensis	Thesen's Island (Fig. 3.1; site 9)	8,65	16,3	0,58	1,09	0,62	105	1,21	-	-	-	Present study
	Keurbooms River	14,74	8,7±1,4	0,27±0,06	0,52±0,15	0,36±0,16	56±18	1,01±0,52	0,26±0,04	0,22±0,04	0,21±0,08	
Ostrea atherstonei	Belvedere (Fig. 3.1; site 1)	7,65	692	0,75	14,2	0,31	81	0,70	-	-	-	Present study
Donax serra	Fish Bay	8,50	13,0±2,3	0,07±0,02	0,82±0,12	0,34±0,05	81±29	1,33±0,64	0,47±0,13	0,19±0,04	0,65±0,29	Present study
	Buffalo Bay	-	19,3	0,12	1,29	0,76	79	1,39	-	-	-	
	Keurboomstrand	13,43	15,6±2,7	0,14±0,12	1,18±0,09	0,03±0,02	84±7	1,15±0,32	0,43±0,07	0,04±0,01	0,16±0,03	
	Maitland, P.E.	6,03	28	0,04	1,6	0,03	72	1,93	-	-	-	
	Cape of Good Hope	-	16	-	-	-	47	0,84	-	0,04	0,19	Van As *et al.*, 1973
	Melkbosch Strand	-	18	-	-	-	59	1,0	-	0,04	0,24	Van As *et al.*, 1975
	Saldanha Bay	19,42	17	0,09	0,64	0,34	42	0,62	0,21	0,30	0,17	

3.5 TISSUE-METAL CONCENTRATION VARIATIONS

Metal concentrations may vary by more than 100% in bivalves collected from a single population (Huggett *et al.*, 1973; Mackay *et al.*, 1975) even within each age group (Ayling, 1974). The smaller individuals of a population frequently have higher metal concentrations than the larger individuals (Boyden, 1974; 1977). Metal concentrations in bivalves collected during the present study are very variable as indicated by the calculated deviations about the means for each population (Tables 3.1-3.6). In order to examine this variation in greater detail samples of 40 or more individuals were collected from a single population of the selected species. The results which are shown are from a single population but are typical of all the populations of the species studied.

The concentrations of 6 elements in *C. margaritacea* are plotted with respect to individual size (Fig. 3.4). The variation in concentrations between individuals of any given size is evident. The majority of high concentrations are found in smaller individuals but the relationship between concentration and wet mass is not linear. Concentrations of zinc, cadmium, copper, lead and iron (Fig. 3.4) and also nickel, cobalt and chromium decrease with increasing wet mass. However, the total amount of metal (μg) increases with wet mass (Fig. 3.5). This implies that the growth rate of this oyster is greater than the rate of metal accumulation from an unpolluted environment. This relationship between metal accumulation and growth also holds for *C. gigas*, *O. edulis* and *O. atherstonei*.

However, when *C. margaritacea* has grown in a polluted area (e.g. the Blue Hole, Algoa Bay), the relationship between size and metal concentration is masked by the higher levels which have been accumulated and the consequent greater variation in tissue concentrations of the polluting element. Two main factors probably interact to cause this variation. Smaller (younger), faster-growing individuals would be expected to accumulate metals at a greater rate than older members of the population. This would enhance the relationship already described in that the smaller individuals would have higher metal concentrations than the larger ones. However, these older individuals have probably been subjected to the metals for a much longer time, accumulating higher amounts than would be expected if the whole population had been exposed for a given length of time.

A similar relationship between metal concentration and size exists for mussels growing in an unpolluted environment. However, in the case of *C. meridionalis* (Fig. 3.6) it is evident that some other factor has been

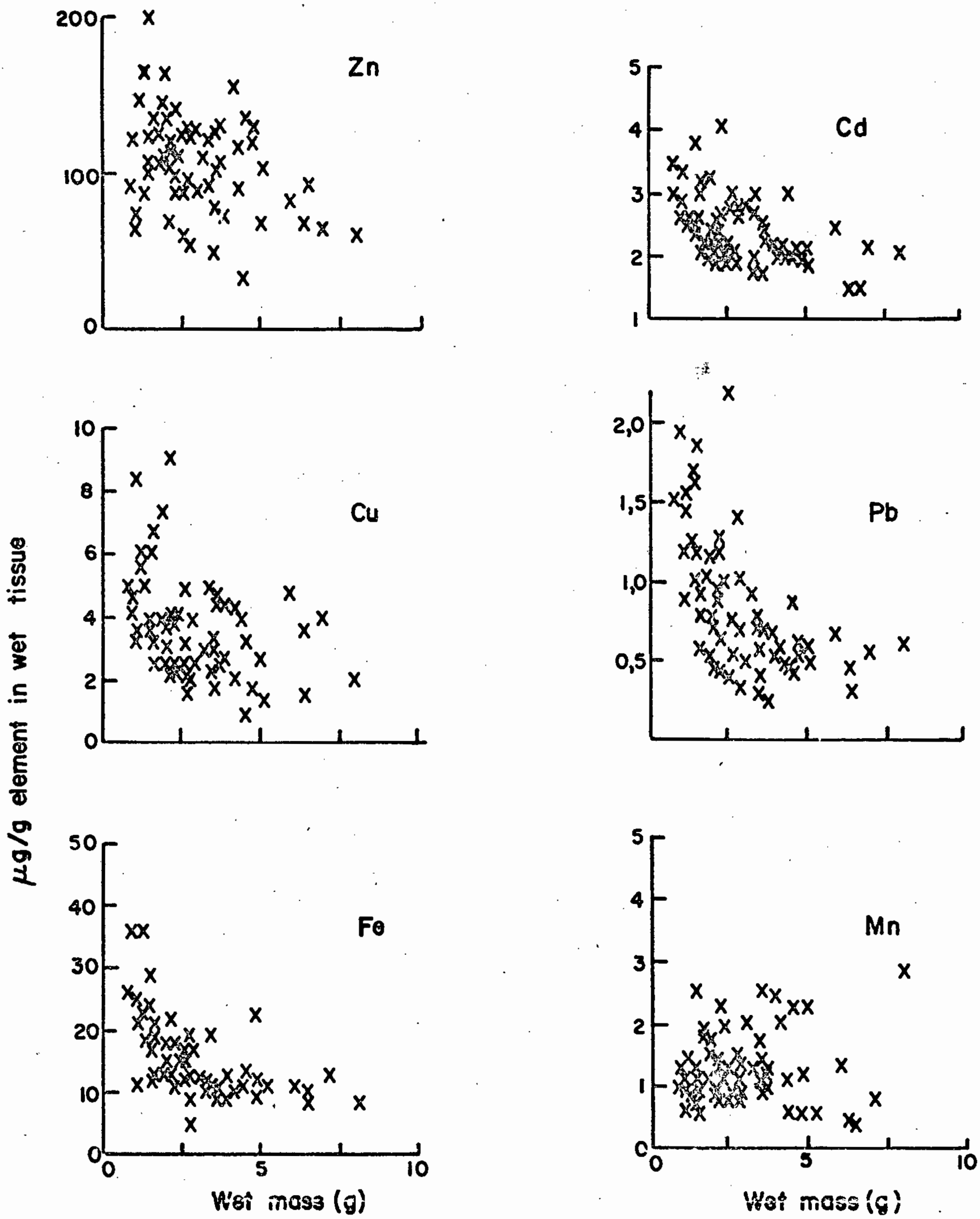


FIG. 3.4: Relationship between element concentration and wet mass in *Crassostrea margaritacea* from an unpolluted environment

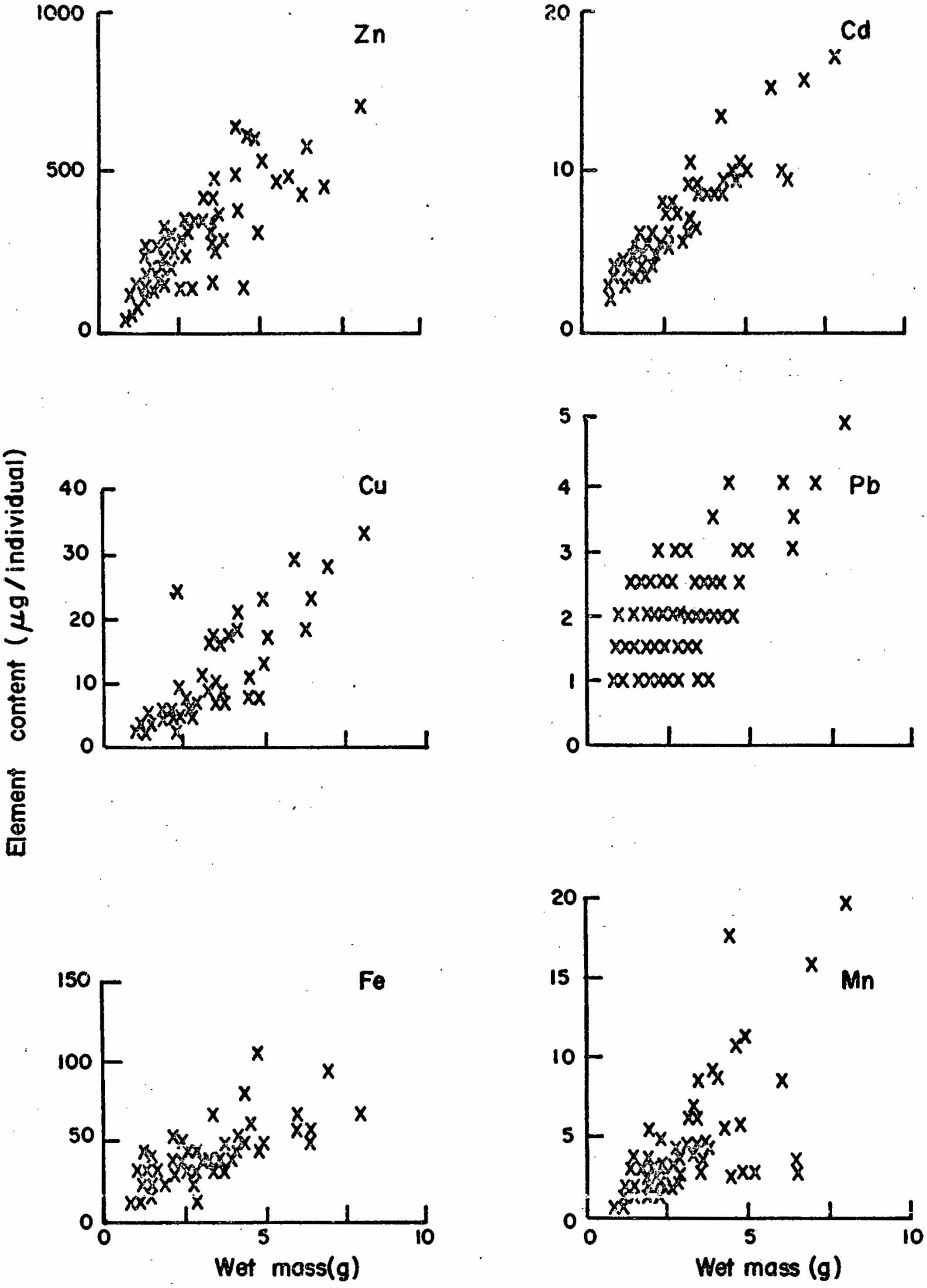


FIG. 3.5: Relationship between element content and wet mass in *Crassostrea margaritacea* from an unpolluted environment

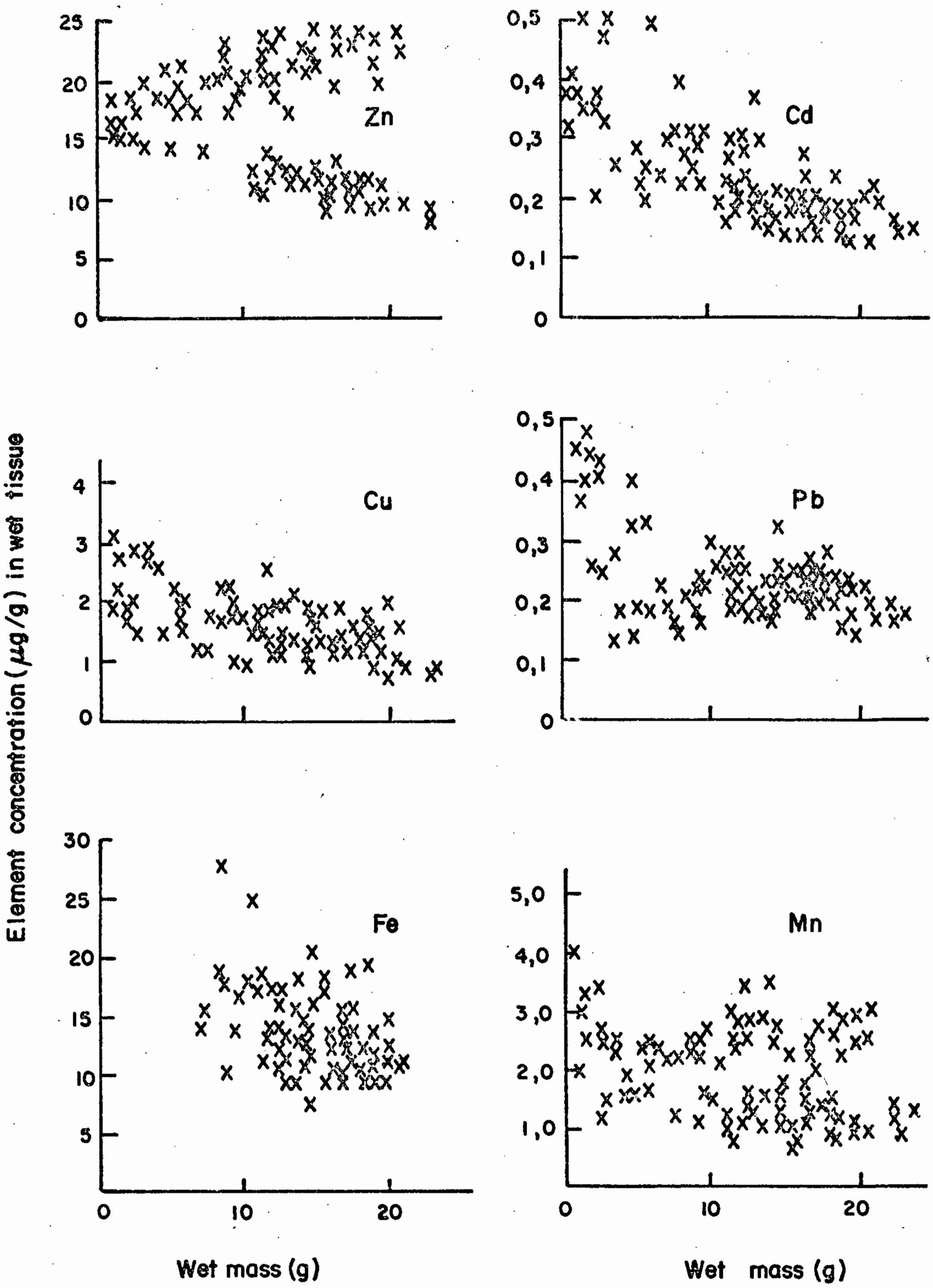


FIG. 3.6: Relationship between element concentration and wet mass in *Choromytilus meridionalis*

introduced. These elemental distributions are more readily explained when the results, plotted as metal content (μg), are grouped according to sex (Fig. 3.7).

The greatest difference is observed for zinc, where the mean concentration in females is almost twice that in males of similar size. Differences between the sexes are also observed for copper and manganese, both of which occur in higher concentrations in the females, and possibly lead which is higher in males. Concentration differences between the sexes were investigated for many species but were only found in the mussels and possibly Atrina squamifera (Table 3.7). Gonad tissues as well as whole animals were analysed.

TABLE 3.7 Differences in metal concentrations between sexes

Species and tissue		metal concentration (μg/g) in wet tissue Zn		Cu		Pb		Mn	
		M	F	M	F	M	F	M	F
C. meridionalis	whole	13	21	0,3	0,5	2,1	1,8	1,0	2,0
	gonad	13	23	1,4	1,8	0,3	0,2	0,5	1,7
P. perna	whole	17	24	1,0	1,6	0,1	0,1	0,8	1,7
	gonad	14	34	0,8	1,5	0,4	0,4	0,4	1,2
A. squamifera	whole	55	81	0,7	0,8	0,1	0,1	0,5	0,6
	gonad	82	118	1,2	1,7	0,9	0,6	0,6	1,8

Gonad tissues from male and female Mytilus californianus also showed differences for some elements. The male/female concentration ratios for copper, lead and zinc were 0,5, 1,7 and 0,6 respectively; no significant differences were observed for silver, chromium or nickel and manganese was not determined (Alexander and Young, 1976). Lead concentrations in the individual organs of Mytilus edulis were reported to change after spawning (Schulz-Baldes, 1974). However, these results conflict with those of Phillips (1977c) who could find no metal concentration differences between the sexes for M. edulis. If the metal concentrations which have been determined for C. meridionalis, P. perna and A. squamifera represent baseline levels then these results may reflect physiological differences between the two sexes and the metal distribution will change as a function of growth and maturation.

Concentration variations with season have been investigated for C. gigas and C. margaritacea and, on a less regular basis, for C. meridionalis and P. perna (Table 3.8). Some variations are observed

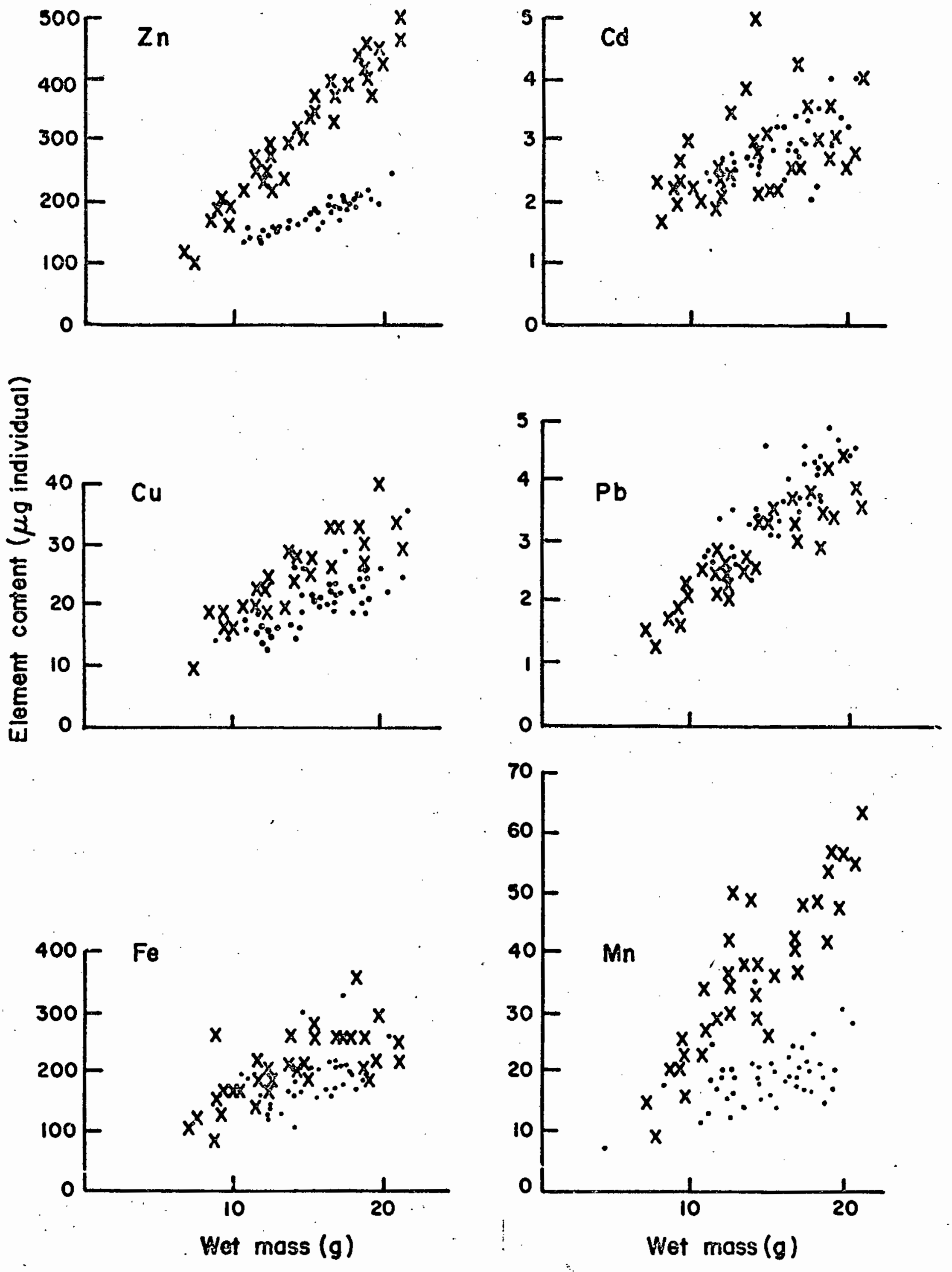


FIG. 3.7: Relationship between metal content and wet mass in *Choromytilus meridionalis*

X Female • Male

TABLE 3.8 Seasonal variations in metal concentrations

Month	Wet mass g	Dry mass %	µg metal / g wet tissue								
			Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
C. gigas											
February 1977	11,91	8,6	104	0,73	11,8	0,08	14	2,0	0,04	0,03	0,23
March	6,36	10,4	112	1,03	10,5	0,07	22	1,6	0,04	0,02	0,29
April	4,58	17,7	122	0,88	11,3	0,05	16	1,4	0,05	0,03	0,17
May	5,49	19,3	99	1,10	9,6	0,04	7	1,0	0,06	0,02	0,20
June	10,29	11,2	125	0,42	11,8	0,12	81	2,2	0,05	0,02	0,35
July	9,59	11,3	113	0,28	7,8	0,06	58	2,8	0,08	0,03	0,24
August	7,67	16,7	150	0,50	13,5	0,16	75	2,9	0,08	0,04	0,39
September	13,32	12,1	122	0,26	8,3	0,04	43	2,0	0,03	0,02	0,14
October	10,14	13,1	121	0,28	11,5	0,07	54	2,1	0,10	<0,01	0,16
November	6,96	14,4	224	0,41	29,4	0,07	71	5,1	0,10	0,04	0,24
December	7,22	11,3	166	0,26	21,9	0,06	51	3,0	0,08	0,02	0,08
January 1978	9,47	10,5	164	0,29	27,5	0,03	42	2,5	0,09	0,02	0,08
February	9,16	12,3	102	0,21	17,0	0,02	34	1,5	0,12	0,01	0,25
C. margaritacea											
February 1977	5,61	11,2	107	1,02	2,1	0,07	7	0,5	0,07	<0,02	0,26
March	4,96	17,5	109	1,15	1,1	0,09	7	0,5	0,05	0,04	0,48
April	7,93	10,3	96	0,84	1,4	0,10	5	0,4	0,02	<0,01	0,51
May	5,42	17,9	94	1,26	1,0	0,06	11	0,8	0,04	0,03	0,27
June	9,12	18,0	106	1,98	2,0	0,06	14	1,1	0,01	0,01	0,37
July	8,90	14,9	82	1,07	1,4	0,04	12	0,7	<0,01	0,02	0,30
August	6,36	18,9	155	1,15	6,0	0,14	19	0,5	0,04	0,02	0,44
September	8,55	14,9	150	1,00	4,0	0,06	17	0,5	0,07	0,02	0,17
October	6,54	14,8	160	0,96	3,4	0,05	17	0,5	0,03	<0,01	0,23
November	7,39	20,0	132	0,94	4,1	0,05	16	0,9	0,04	0,01	0,38
December	5,14	10,9	139	0,60	2,0	0,05	14	0,3	0,04	0,02	0,25
January 1978	8,26	18,8	155	0,72	2,7	0,04	17	0,7	0,07	0,02	0,09
February	9,80	16,4	131	0,76	2,2	0,01	17	0,5	0,11	0,01	0,31
P. perna											
October 1975	2,09	17,4	14	0,64	1,34	0,06	101	0,8	0,13	0,03	0,23
November	2,32	16,1	15	0,64	1,03	0,06	90	0,7	0,10	0,05	0,26
July 1976	1,17	18,1	23	0,73	1,25	0,09	124	1,2	0,17	0,04	0,48
August	2,18	17,3	22	0,51	1,38	0,07	93	1,3	0,16	0,07	0,29
September	0,95	18,5	19	0,53	1,63	0,14	121	1,4	0,18	0,07	0,44
February 1977	3,36	13,4	12	0,61	1,04	0,06	39	0,8	0,21	0,05	0,57
March	3,26	13,5	13	0,87	0,89	0,07	39	0,7	0,32	0,07	0,44
April	4,14	15,6	13	0,61	1,09	0,16	67	0,8	0,20	0,06	0,60
May	4,46	12,3	13	0,63	0,82	0,10	69	0,6	0,22	0,05	0,59
C. meridionalis											
February 1977	8,80	16,4	12	0,31	1,09	0,08	13	1,6	0,13	0,07	0,09
March	6,88	16,7	13	0,26	1,13	0,07	16	1,7	0,13	0,06	0,10
April	6,80	16,1	13	0,27	1,22	0,07	15	2,0	0,11	0,06	0,06
May	8,41	16,4	13	0,25	1,12	0,07	16	1,7	0,13	0,07	0,09

for the oysters where zinc, copper and nickel concentrations tend to increase during the spring and summer but lead and chromium values are slightly higher during the autumn and winter months. No obvious differences are observed for mussels collected during the summer or winter.

Marked seasonal variations in metal levels have been reported, the higher metal levels in several species occurring during the autumn and winter months (Bryan, 1973; Pringle et al., 1968; Romeril, 1974). Metal levels in other species increase during the spring and summer (Romeril, 1974; Hobden, 1967). Bryan (1973) related such changes to food supply, since the highest concentrations occurred when phytoplankton productivity was low. Phillips (1976a) suggested that seasonal fluctuations were at least partly due to the variation of the wet mass (water content) with season. Such seasonal changes in flesh weight may be significant (Dare and Edwards, 1975).

The results obtained in the present study are incomplete. Samples must be collected regularly over a 2-3 year period in order to determine whether these variations are real and predictable. The metal concentration variations should be studied in relation to the physiological condition of the animal and to water quality, temperature and salinity variations including the availability of food. Such an investigation is beyond the scope of the present project.

It has also been reported that metal concentrations vary according to the depth of sampling (Nielsen, 1974; Phillips, 1976a). In order to investigate such variations samples of P. perna were collected from a vertical rock face up to 2 m above low spring water. These samples were analysed for nine elements (Table 3.9).

TABLE 3.9 Tissue-metal concentration variations with depth for Perna perna

Height above low spring water (mm)	Wet mass g	Dry mass %	µg metal/g wet tissue								
			Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
300	3,39	13,0	12,0	0,59	1,13	0,16	67	0,96	0,85	0,05	0,84
600	4,14	11,9	11,3	0,59	1,10	0,11	70	0,82	0,71	0,04	0,82
1000	2,12	14,2	12,0	0,61	1,12	0,20	70	1,04	0,95	0,04	1,15
1300	2,21	14,5	11,8	0,56	0,99	0,16	67	0,83	0,81	0,03	1,11
1600	2,93	16,1	12,4	0,64	0,96	0,07	67	0,89	0,78	0,04	0,66
2000	1,89	13,0	12,9	0,69	1,07	0,13	87	0,94	0,98	0,05	1,05

Nielsen (1974) found that concentrations of zinc, cadmium, lead and iron in Perna canaliculus varied with the depth at which the mussels were sampled at one location on the New Zealand coast; these concentration gradients were absent at a second location. Concentration gradients in M. edulis varied with season (Phillips, 1976a). No clear vertical concentration gradients were observed for P. perna growing in the inter-tidal zone at the Knysna Heads.

3·6 SUMMARY

3.6.1 Metal concentrations in C. gigas and O. edulis from Knysna estuary are much lower than many of the reported values for these species; this indicates that Knysna estuary is unpolluted with respect to these metals.

3.6.2 Metal concentrations in other molluscs growing in or near the Knysna estuary are generally low; it may be assumed that these values represent near natural levels for these species.

3.6.3 Metal concentrations are often higher in the smaller individuals.

3.6.4 Concentrations of zinc, copper and manganese are higher in female mussels than in males; lead may be higher in males.

3.6.5 Concentrations of zinc, copper and nickel in oysters tend to increase during the spring and summer months; no clear seasonal variations were observed for the mussels due to insufficient data.

3.6.6 No clear vertical concentration gradients were observed for P. perna growing in the inter-tidal zone at Knysna Heads.

3.6.7 In spite of these concentration variations which have been found for C. gigas, C. margaritacea, C. meridionalis and P. perna, these species may still be suitable as monitors of metal pollution in the marine environment. However, the fact that considerable variations in metal concentrations may occur would have to be taken into account in any proposal for a sampling scheme.

CHAPTER 4 THE EFFECTS OF METALS ON OYSTER EMBRYOS, LARVAE AND SPAT

4.1 INTRODUCTION

The acute toxicities of a number of metals to the embryos, larvae and adults of selected molluscs have been investigated (e.g. Calabrese et al., 1973; Nelson et al., 1976). The lethal concentrations which are quoted are usually the result of short-term exposures to high metal concentrations which bear little relation to natural events and, as such, the absolute values have little meaning. Different metals are probably toxic in different ways, in which case the relative toxicities of a number of metals determined during short-term exposures to high concentrations may not represent the relative toxicities of the same elements tested at much lower concentrations over a longer period. Thus the effects of chronic (sub-lethal) poisoning, particularly behavioural changes, should also be investigated when assessing the impact of metals upon the environment.

Most toxicity tests are based on the continuous exposure of the bioassay organisms to a series of fixed concentrations of toxin. However, pollutant levels in the environment may fluctuate as a result of the intermittent addition of the polluting substance or of changes in the environment. These fluctuations could permit periods to occur in which the toxin may be absent or greatly reduced in concentration so that affected animals recover (Wright, 1976). Therefore recovery data should also be included in a complete toxicity study.

The acute toxicity approach as applied to the determination of lethal concentrations in adults has been criticised because, in many cases, embryos and larvae are much more sensitive to such pollutants. Therefore, in order to assess the effects of a pollutant, all stages in the life cycle of the species should be tested, but, if this is not possible, the effects on the more sensitive larval stages should be investigated (Brown, 1976).

With the development of techniques for rearing marine bivalve molluscs (Loosanoff and Davis, 1950; 1963) and the ability to condition and spawn adult bivalves throughout the year, the embryos and larvae of many species are available for experimental purposes. These techniques make it possible to subject bivalve embryos and larvae to various pollutants under controlled experimental conditions.

The first indication of toxicity, a marked reduction in the growth of larvae, occurs at concentrations lower than those required to kill the larvae (Calabrese and Davis, 1970). Such a reduction in growth has been observed for Crassostrea gigas larvae which were subjected to zinc at a number of concentrations (Brereton et al., 1973). In addition to a decreased growth rate, these authors reported an increased incidence of structural abnormality, abnormal behaviour and mortality with increased zinc concentration. C. gigas larval settlement was both reduced and delayed in the presence of zinc but those larvae which settled were as viable as controls when on-grown in clean water (Boyden et al., 1975).

The comparative toxicities of some metals to embryos and larvae of Crassostrea virginica and Mercenaria mercenaria have been reported. (Calabrese et al., 1973; Calabrese and Nelson, 1973; Calabrese et al., 1977). It was found that slightly more metal was required to kill 50% of the larvae and that embryos were more sensitive to metal pollutants. The tests described for the embryos were conducted over several months by initiating cultures in artificial sea water, as required; different metals were tested using successive cultures (Calabrese et al., 1973; Calabrese and Nelson, 1973). Although this is not specified, a similar method was probably adopted for the larval toxicity tests (Calabrese et al., 1977) which were carried out in filtered sea water. However, under normal laboratory conditions, the development of oyster embryos and larvae in repetitive tests is variable, some cultures being more hardy and faster growing.

The effects of metals on the embryos, larvae and spat of C. gigas, Crassostrea margaritacea and Crassostrea cucullata have been investigated. Initially the effects of cadmium on C. gigas larvae and spat were studied as this species is hardy and fast growing and is very suitable as a test organism. The experience gained during these experiments enabled the development of suitable working methods for the comparative tests in which several metals were tested on a single population or culture. The metal concentrations were chosen in the range to cause sub-lethal rather than lethal effects. Lethal concentrations (LC_{50}; causing 50% mortality in a specified period) were not determined except where they occurred in the selected concentration range. Experimental observations included growth and behaviour in addition to mortality.

4.2 MATERIALS AND METHODS

Estuarine water of 34-35°/oo salinity was filtered through diatomaceous earth to remove particles greater than 5 µm. The water was preheated to 26°C for the experiments. Trace-metal concentrations were determined in estuarine waters after sodium diethyldithiocarbamate/ chloroform extraction and preconcentration (H.R. Watling, 1974); the mean metal concentrations for water pumped into the hatchery are for zinc, 0,3 µg/l; cadmium, 0,03 µg/l; copper, <0,2 µg/l; lead, 0,6 µg/l; iron, 100 µg/l; manganese, 5,2 µg/l; nickel, <0,1 µg/l and cobalt, 0,2 µg/l.

For larvae up to about 135 µm the experimental solutions were prepared to contain a combination of the flagellates Monochrysis lutherii and Isochrysis galbana and either Chaetoceros calcitrans or Chaetoceros sp. (species unknown) to give a final combined concentration of 80 cells/µl. This food mix was supplemented with Tetraselmis chui to give a final combined concentration of 150 cells/µl for larvae greater than 150 µm and for spat. The algal mix was supplied daily from the hatchery.

The various treatments were prepared by adding aliquots of stock solutions of metal chlorides for zinc, cadmium, copper, lead, iron, manganese, nickel and cobalt, and of sodium dichromate for chromium. The trace metallic species which occur in sea water are not known with any degree of certainty; hydrated oxides, complex chlorides and carbonates have been variously proposed as the predominant species for copper, zinc, iron, lead, manganese and cadmium (Zirino and Healy, 1972; Zirino and Yamamoto, 1972). The use of metal chlorides was preferred for these experiments. Sea water contains such a large excess of chloride ion that the further addition of small amounts of this anion would not affect these experiments; in the case of chromium the dichromate was the most suitable salt and the sodium form was chosen for the same reason, that there is already a large excess of this cation present in sea water. The stabilities of dilute metal-sea water solutions were tested. Lead, iron and manganese all suffered some metal loss in a 24-h period, presumably due to the precipitation of lead chloride and iron and manganese hydrated oxides. Lead loss was considerably reduced in the presence of ethylenediaminetetra-acetic acid (EDTA) which is a constituent of the algal cultures. Metal concentrations were not monitored during the 24-h periods between experimental solution renewal.

Beakers containing the experimental solutions were placed in a water bath and the temperature controlled according to larval age (embryos, 25°C; larvae, 22-23°C; spat 19-20°C). The solutions were aerated and the beakers were subjected to normal laboratory lighting for about 10 h each day. All experimental solutions were renewed daily, at which time the test organisms were washed with fresh sea water.

Samples from each treatment were collected at selected intervals and behaviour and structure examined. Measurements included width across the valve for larvae and length for spat. The ages of larvae and spat referred to in the text always refer to the date of initiation of the culture.

4.2.1 Embryos

Suspensions of eggs and sperm were prepared by stripping the gonads of mature adults. The eggs were fertilised and the solution agitated by aeration for 15 minutes. Aliquots of the mixture were added to 100 ml filtered sea water containing metals.

The experiment was terminated after 48 h because embryonic development under normal conditions is complete by this time. To determine the effect of metals on embryonic development, the embryos that survived and developed into straight-hinge larvae in each culture were collected on a 30 µm nylon screen. These larvae were resuspended in 5 ml sea water in a small petri dish. The samples were examined under a microscope and the numbers of straight-hinge larvae counted.

4.2.2 Larvae

C. gigas and C. cucullata larvae were obtained from hatchery stock cultures. C. margaritacea were spawned and cultivated in a 1000-l tank specifically for these experiments. Hatchery procedure included the sieving of larvae and spat through nylon screens of selected mesh sizes. Thus the range of individual sizes was restricted at the beginning of each experiment.

Larvae were removed from stock containers and approximately 2500 young individuals (3-6 days old) or 1500 older larvae (13-16 days old) were placed in each one-litre pyrex beaker containing one of the experimental solutions. The younger larvae were measured at intervals during their exposure to metals and then transferred to control solutions for a further period. A similar procedure was adopted for the older larvae except where the effect of metals on settlement was being investigated.

Larvae were encouraged to settle on discs of black PVC placed in the bottom of each beaker. These discs were slightly arched so that both upper and lower surfaces were available for settlement. The number of larvae settling in each beaker were counted but not scraped off the black discs. Those which settled in the presence of metals were grown for a further period in clean sea water.

4.2.3 Spat

PVC discs were placed in a hatchery stock container prior to larval settlement. Following good settlement these discs were transferred to beakers containing experimental solutions. The numbers growing in each solution at the end of the experimental period were counted and their lengths measured.

Hatchery procedure involves either the settlement of spat on black PVC sheets overnight, the set spat being scraped off the next morning, or the settlement of spat on clean fine-grained sand, in which case the spat need not be disturbed. These spat are sieved through a series of mesh screens to remove the slow growers and debris. Small cultchless spat were suspended in the experimental beakers on a 400 μm nylon mesh (Fig. 4.1); older spat were suspended on screens of larger mesh size.

Samples were examined daily and measured at intervals during the treatment and during the succeeding period in clean sea water. Gaping individuals were removed. (Spat in the size range tested may have been dead for up to 2 days before the shells gaped; A. Genade, personal communication.)

4.3 THE EFFECTS OF METALS ON EMBRYONIC DEVELOPMENT

The effects of low concentrations of nine elements on the embryonic development of C. gigas, C. cucullata and C. margaritacea were investigated. The number of straight-hinge larvae which developed in 48 h were counted for each treatment (prepared in triplicate). The results from replicate treatments were averaged and are expressed as a percentage of the number developing in the controls. (Table 4.1).

The only element which has any effect in the range tested is copper for which the concentration causing 50% fewer straight-hinge larvae to develop can be estimated (by extrapolation). These concentrations are for C. gigas, 180 μg/l; for C. margaritacea, 160 μg/l; and for C. cucullata, 130 μg/l. These values are similar to the copper LC_{50} of 100 μg/l which was reported for C. virginica embryos (Calabrese et al., 1973).

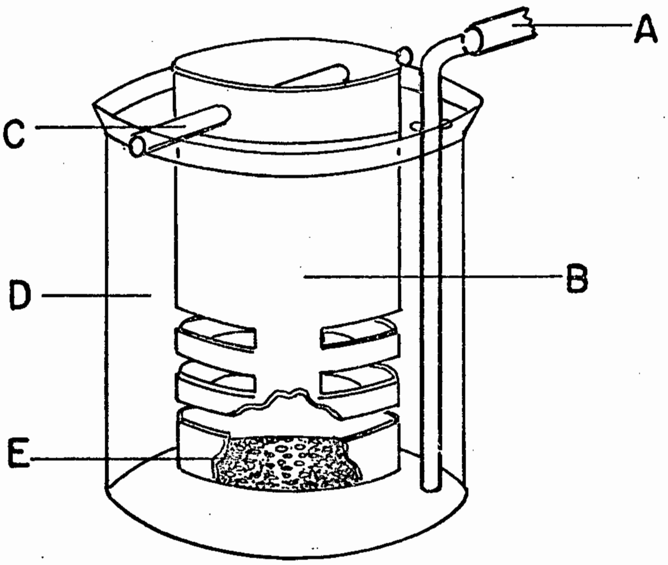


FIG. 4.1: Apparatus used for the suspension of cultchless spat in beakers

A. Bubbler for oxygenation and circulation
B. Length of plastic tubing with slits to allow circulation
C. Glass rod for supporting tube
D. One litre of algae — enriched seawater
E. 400-μm nylon mesh supporting cultchless spat

TABLE 4.1 Development of straight-hinge larvae during 48-h treatment; values expressed as a percentage of the development in control solutions

Treatment (μg/l)	Straight-hinge larvae (%) Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
Crassostrea gigas (520 eggs/100 mls)									
20	94	95	91	99	97	100	94	100	100
50	97	96	84	91	92	97	98	96	93
100	97	101	70	76	101	96	100	97	96
Crassostrea margaritacea (740 eggs/100 mls)									
20	100	98	104	104	100	105	101	105	99
50	98	103	90	99	102	99	104	103	95
100	104	103	75	102	101	99	110	101	102
Crassostrea cucullata (1020 eggs/100 mls)									
20	99	108	99	87	91	106	95	103	105
50	93	93	81	96	102	99	97	96	99
100	103	104	62	93	101	98	91	103	98

4.4 THE EFFECTS OF METALS ON LARVAL GROWTH AND MORTALITY

The effect of cadmium on the size of surviving C. gigas larvae (initially 5 days old) is illustrated in Fig. 4.2. Growth in the control solution was constant up to age 12 days after which a decrease in growth rate occurred. Growth was suppressed in the presence of 20, 40 and 100 μg/l cadmium although the mean larval size was the same in all treatments at the end of the 7-day cadmium exposure. Some growth was observed during the subsequent days in control solutions for the larvae previously exposed to 20 μg/l but virtually no growth occurred in the 40 and 100 μg/l treatments. Larvae in the three cadmium treatments were much less active than those in the control solution.

The mortality percentages observed for larvae exposed to cadmium for a period of 7 days and subsequently grown in control solutions for a further 4 days are given in Table 4.2. The 30% mortality in the control is not excessive and probably reflects the changed environment experienced by those larvae which have been transferred from large stock containers to one-litre beakers. Clearly cadmium is extremely toxic to the larvae, the mortality increasing rapidly with increased cadmium concentration.

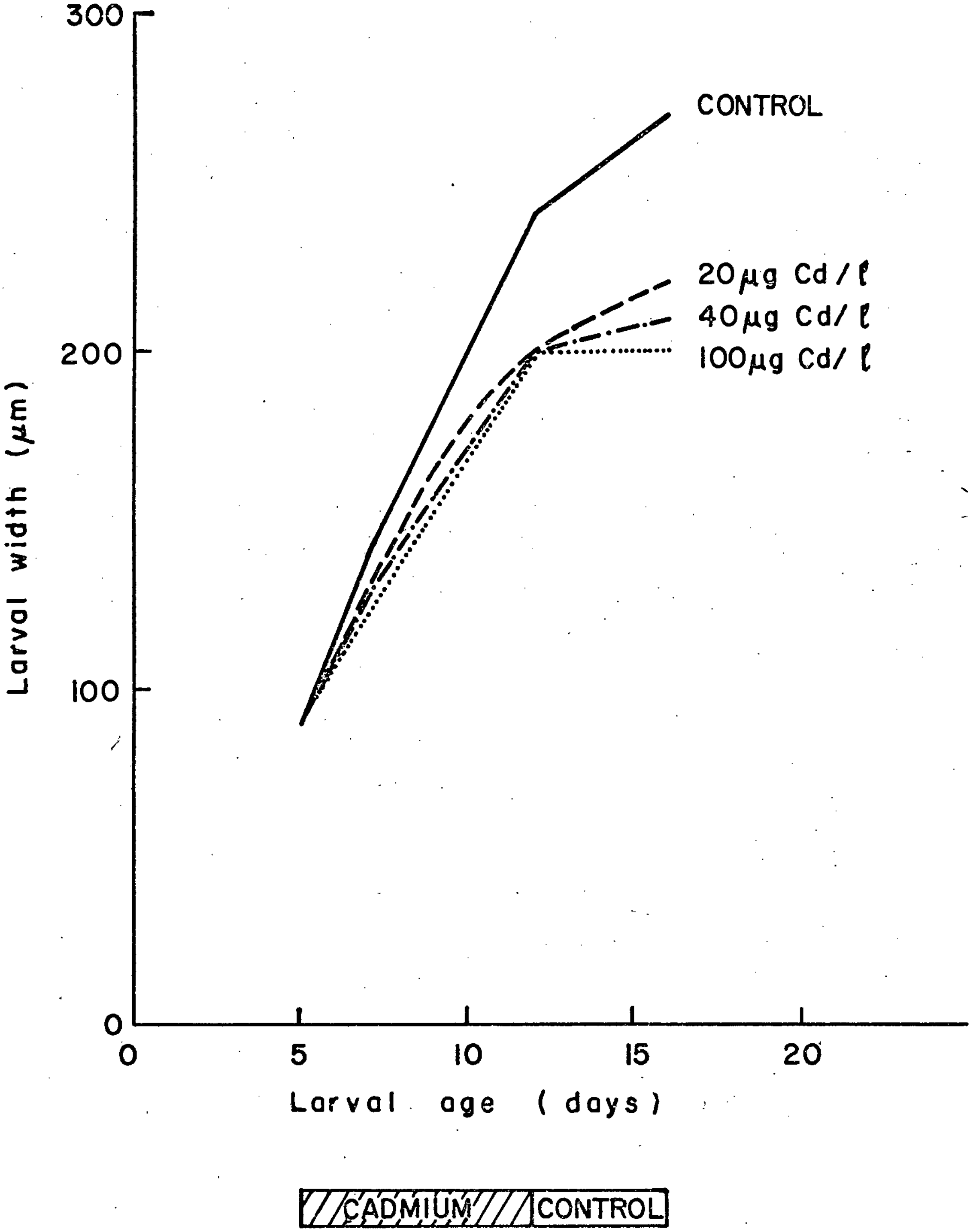


FIG. 4.2: *Crassostrea gigas*. Relationship between mean larval size and cadmium concentration

TABLE 4.2 Mortality of 5-day-old *C. gigas* larvae exposed to cadmium

Cadmium (µg/l)	Mortality (%) after 7 days	Mortality (%) after 11 days
Control	30	35
20	50	65
40	75	90
100	85	95

The short-term effects of zinc, cadmium and copper in the range 0-100 µg/l were tested on 6-day-old *C. gigas* and 3-day-old *C. margaritacea* and *C. cucullata* larvae. Each treatment was prepared in duplicate. Larvae were exposed to the metals for 4 days and were then transferred to control solutions for a further 4 days. A similar experiment was carried out using 16-day-old *C. gigas* and 13-day-old *C. cucullata* and *C. margaritacea*. These *C. gigas* larvae were not measured after their 4 days in clean sea water because growth was suspended while individuals settled. The results of both experiments are summarised in Table 4.3.

The concentration range tested caused a decrease in growth rate for each of the elements and species. In order to compare the effects of the three elements in these species the mean width (µm) after the 4-day exposures was plotted against element concentration (µg/l) and the concentration which had caused a 50% reduction in growth (GC_{50}) was determined. These values are compared with the concentration which caused 50% mortality (LC_{50}) for the same species (Table 4.4).

The calculated concentrations are greater for the older larvae, indicating an increased tolerance to the presence of metals. The levels are very similar for the three species. On the basis of growth, the overall order of element toxicity is copper>zinc>cadmium, although differences between the elements are small. The LC_{50}'s are generally higher than their equivalent GC_{50}'s and the order of lethal toxicity is copper>cadmium>zinc.

It is also possible to calculate an 8-day GC_{50} for *C. margaritacea* and *C. cucullata* which takes into account any recovery during the subsequent clean water conditions (Table 4.5). Using these values the order of element toxicity is cadmium>copper>zinc.

TABLE 4.3 The effects of zinc, cadmium and copper on larval growth

	Crassostrea margaritacea						*Crassostrea cucullata*						*Crassostrea gigas*					
	Age (days)	Treatment					Age (days)	Treatment					Age (days)	Treatment				
		0	10	20	50	100		0	10	20	50	100		0	10	20	50	100
Zinc																		
Initial width (µm)	3	80					3	75					6	135				
After 4 days in metal (µm)	7	158	152	142	114	95	7	142	147	133	111	91	10	199	203	203	190	148
After subsequent 4 days in clean sea water (µm)	11	234	230	218	170	154	11	200	205	201	170	150	14	275	280	275	265	223
Initial width (µm)	13	239					13	254					16	309				
After 4 days in metal (µm)	17	290	-	288	275	260	17	305	-	318	310	265	20	370	-	375	358	340
After subsequent 4 days in clean sea water (µm)	21	318	-	314	298	285	21	340	-	349	345	311						
Cadmium																		
Initial width (µm)	3	80					3	75					6	135				
After 4 days in metal (µm)	7	258	152	145	106	98	7	142	132	124	107	79	10	199	195	187	180	155
After subsequent 4 days in clean sea water (µm)	11	234	220	200	124	105	11	200	185	185	125	112	14	275	283	270	260	169
Initial width (µm)	13	239					13	254					16	309				
After 4 days in metal (µm)	17	290	-	290	278	275	17	305	-	296	285	280	20	370	-	368	356	345
After subsequent 4 days in clean sea water (µm)	21	318	-	300	285	255	21	340	-	333	315	293						
Copper																		
Initial width (µm)	3	80					3	75					6	135				
After 4 days in metal (µm)	7	158	160	149	99	84	7	142	135	130	105	79	10	199	200	185	163	145
After subsequent 4 days in clean sea water (µm)	11	234	218	194	174	125	11	200	191	185	170	128	14	275	270	270	200	290
Initial width (µm)	13	239					13	254					16	309				
After 4 days in metal (µm)	17	290	-	295	285	255	17	305	-	300	290	275	20	370	-	364	356	318
After subsequent 4 days in clean sea water (µm)	21	318	-	320	310	270	21	340	-	335	328	308						

TABLE 4.4 Element concentrations which caused a 50% reduction in growth (GC_{50}) and a 50% mortality (LC_{50}) in 96 h.

Species	Larval age (days)	Element concentration (μg/l)					
		Zn		Cd		Cu	
		GC_{50}	LC_{50}	GC_{50}	LC_{50}	GC_{50}	LC_{50}
C. gigas							
	6	80	>100*	75	85	50	80
	16	95	>100	120	>100	75	>100
C. margaritacea							
	3	45	>100	40	75	35	60
	13	85	>100	100	>100	85	>100
C. cucullata							
	3	50	>100	45	80	40	60
	13	85	>100	120	>100	85	>100

*. > indicates the highest concentration tested

TABLE 4.5 Element concentrations which caused a 50% reduction in growth (GC_{50}) following 4 days treatment and a subsequent 4 days in control solution.

Species	Larval age (days)	8-day GC_{50} (μg/l)		
		Zn	Cd	Cu
C. margaritacea				
	3	75	35	65
	13	120	60	90
C. cucullata				
	3	130	40	90
	13	130	90	120

4.5 THE EFFECTS OF METALS ON LARVAL SETTLEMENT

Exposure of 16-day-old C. gigas larvae to 50, 100 and 200 µg/l cadmium for 5 days resulted in the expected decrease in growth rate and increase in mortality with increased concentration (Table 4.6). Comparison of these mortalities with those for 5-day-old larvae (Table 4.2) indicates that larval tolerance to both changed environmental conditions and to the presence of cadmium has increased with age.

TABLE 4.6 Mean width and mortality of 16-day-old larvae following a 5-day exposure to cadmium

Cadmium (µg/l)	Age (days)	Mean width (µm)	Mortality (%)
Initial sample	16	260	
After 5 days	21		
Control		340	5
50		320	25
100		310	35
200		280	60

Larvae in the control solution were very active after the 5-day experimental period (age 21 days). In the 50 and 100 µg/l treatments larvae were less active but some exhibited foot extension and crawling movements, behaviour which is indicative of searching for a suitable settlement surface. Larvae exposed to 200 µg/l were inactive and no searching movements were observed. Some early settlement on the beaker walls occurred in the three cadmium treatments at age 22 days. Black PVC discs were placed in all beakers at this stage to encourage settlement.

The numbers of larvae settling and the patterns of settlement are shown in Fig. 4.3. In this experiment the cadmium treatments were continued for 16 days (larval age 32 days). In a second experiment the 50 and 100 µg/l treatments were terminated after 7 days (larval age 23 days) and the larvae grown in clean sea water for the remainder of the experiment.

Maximum settlement occurred in the control from age 26-32 days. Foot extension and crawling were less evident after maximum settlement had occurred and larvae which had failed to settle died in large numbers. This is not unexpected. Normal hatchery procedure is to retain those individuals which settle early and to reject the remaining larvae as slow growers which are less likely to survive.

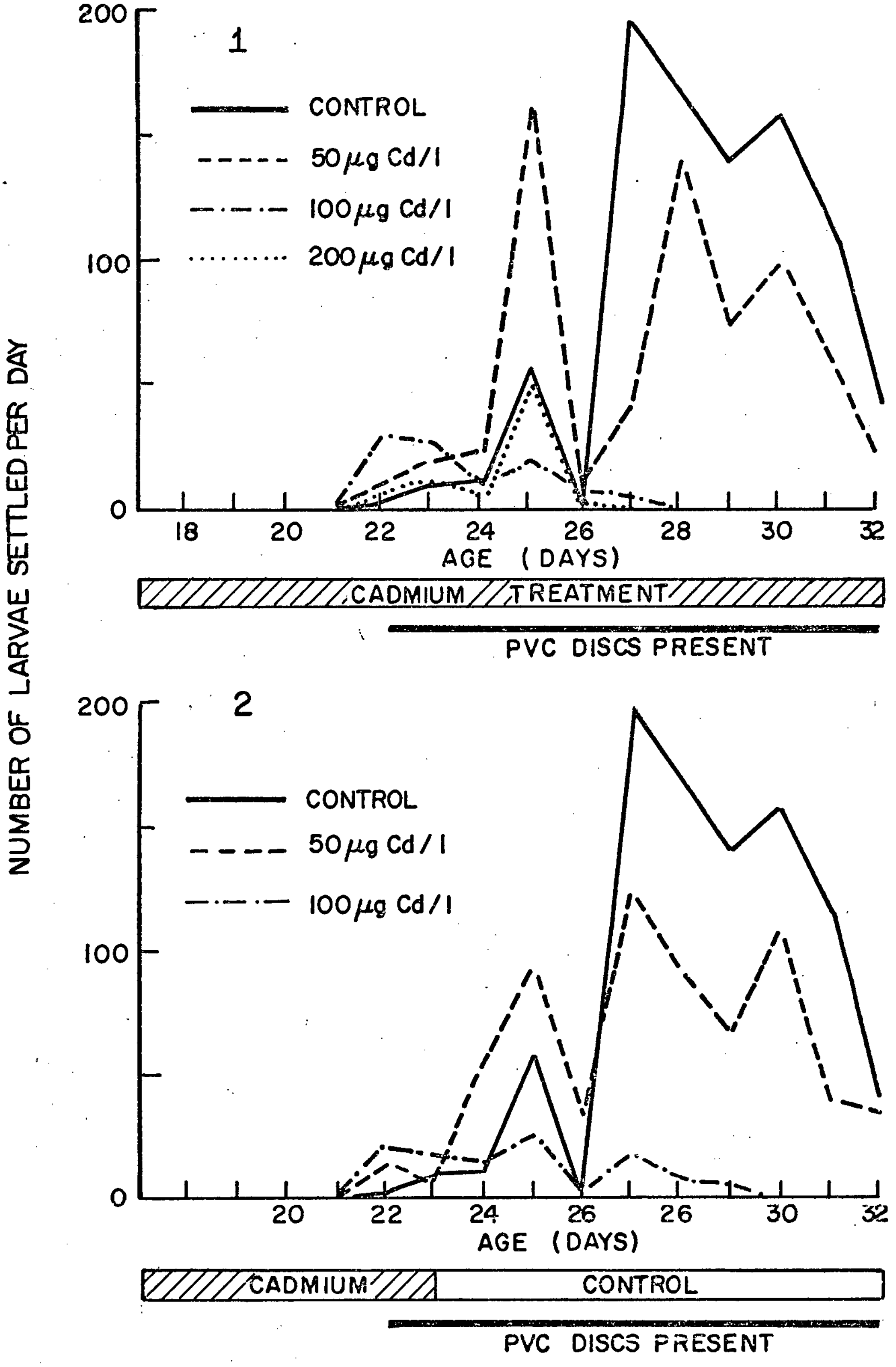


FIG.4.3: *Crassostrea gigas*. Patterns of settlement for larvae exposed to cadmium for 16 (1) and 7 (2) days

Clearly the presence of cadmium at a concentration of 50 µg/l has reduced settlement. However, there is no significant difference in the numbers settling between larvae treated for 7 days and larvae treated for 16 days (Fig. 4.3), in spite of the fact that in the case of the 7-day treatment larvae would actually be settling in control solutions. The success of settlement in both the 100 and 200 µg/l treatments was negligible.

The presence of cadmium appears to induce early settlement. This is shown by the proportion of total settlement which occurred in each of the treatments before an age of 26 days (Table 4.7). This age was chosen arbitrarily because maximum settlement in the control occurred at age 27 days. It has already been noted that larvae in the 50 and 100 µg/l solutions exhibited searching movements at age 21 days whereas in the control maximum searching was not observed until age 23 days, 4 days before maximum settlement.

TABLE 4.7 <u>Percentage settlement during exposure to cadmium</u>

Cadmium (µg/l)	Total settlement (%)		Percentage of total settlement occurring before age 26 days	
	7-day exposure	16-day exposure	7-day exposure	16-day exposure
Control		58		9
50	42	41	29	33
100	6	5	66	92
200		5		100

The viability of the spat which settled on the PVC discs in the presence of 50 µg/l either during the 16-day exposure or after the 7-day exposure, together with those which settled in the control solution, was examined after a further 5 days growth in control solutions. The discs which were used in this experiment held both early and late settling individuals which may account for the low overall survival which was recorded (Table 4.8). Nevertheless, the results indicate that the number surviving is reduced and that the growth rate of the survivors is slower. The effect is less marked in those larvae which were subjected to cadmium for only 7 days.

The effects of eight elements on 19-day-old <u>C. gigas</u> larvae were compared. (Unfortunately it was not possible to test the other species as <u>C. cucullata</u> settled earlier than was anticipated, coinciding with an already saturated experimental system and too few <u>C. margaraticaea</u> larvae remained

TABLE 4.8 Viability of larvae which settled during or after exposure to cadmium

Treatment	Initial number on PVC disc	Number growing (%)	Mean length (n=30) at age 37 days (μm)
Control	390	55	930
50 μg Cd/1			
7-day exposure	410	41	860
16-day exposure	350	29	720

after the two previous experiments). The treatments, 10 and 20 μg/l of each element, were continued throughout the 20-day experiment.

Settlement was plotted on a daily basis (Fig. 4.4); the settlement patterns for zinc, cadmium and copper illustrate the three possible cases, these being :

1. Maximum settlement delayed with respect to that in the control (zinc, also lead).
2. Maximum settlement coinciding with that in the control (cadmium, also manganese, nickel and chromium).
3. Maximum settlement occurring earlier than that in the control (copper, also cobalt).

In terms of the numbers settling in each treatment, the only element which appeared to be beneficial to metamorphosis and settlement was copper, for which 80 and 95% of the larvae settled in the 10 and 20 μg/l treatments respectively, compared with 72% in the controls and 68% in the presence of manganese. All other elements tested caused a significant decrease in the total numbers of larvae settling (between 35-45%). On the basis of settlement, the order of element toxicity is chromium > nickel > lead> cobalt>zinc> cadmium>>manganese> control>copper.

In view of the apparent positive response to the presence of copper, two further experiments were prepared. 29-day-old fast-growing larvae (those retained by a 200 μm screen at age 16 days) and slow-growing larvae (those which passed through a 200 μm screen at age 16 days) were placed in duplicate sets of beakers containing control, 20, 40 and 60 μg/l copper. The treatments were continued for 20 days.

In the case of the fast-growing larvae, copper was added to the solution for 3 days before substantial settlement occurred; low copper concentrations (<60 μg/l) were beneficial to the settlement process (Fig. 4.5.1). The slow growing larvae were exposed to copper for 8 days

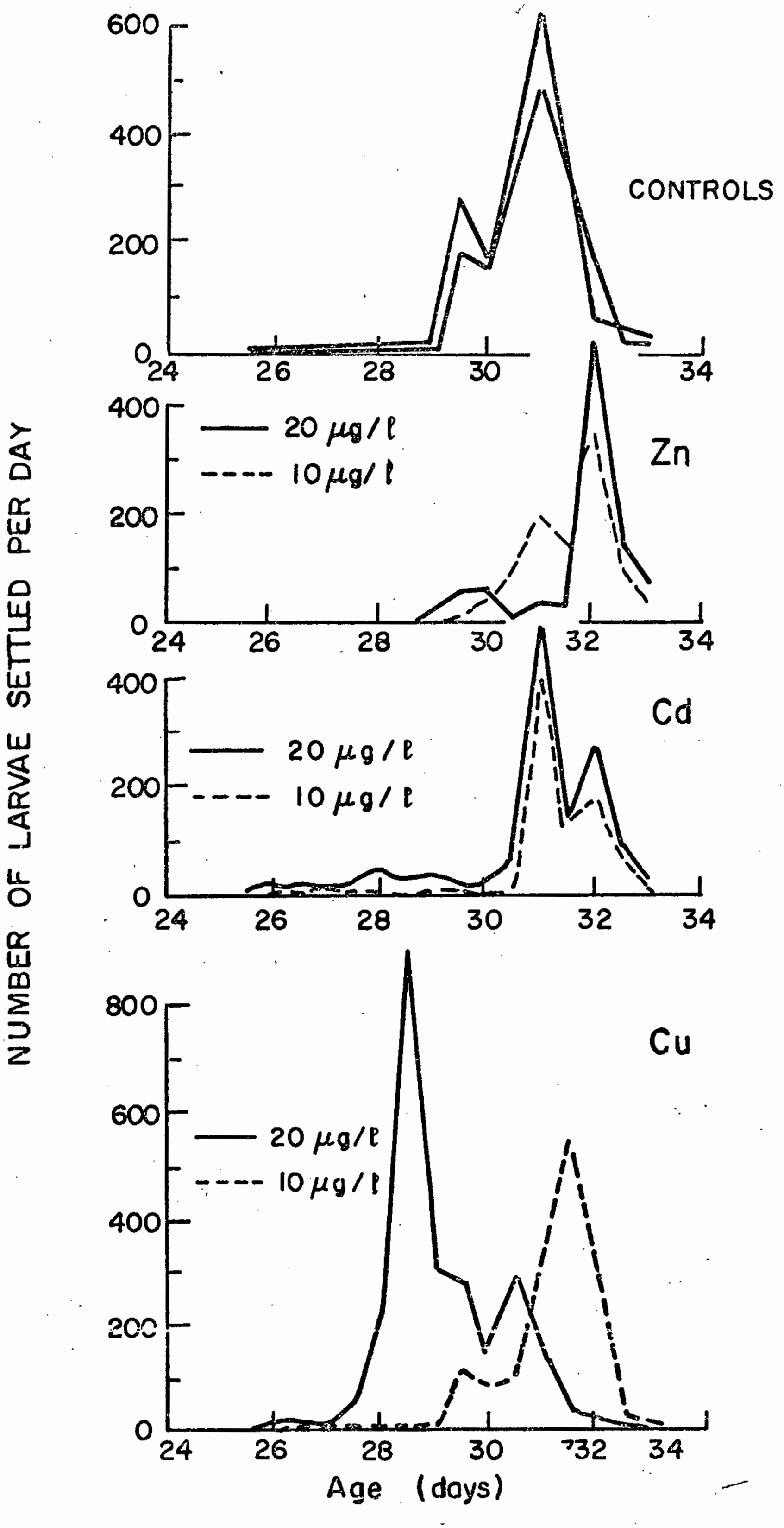


FIG.4.4: *Crassostrea gigas.* Patterns of settlement for larvae exposed to zinc, cadmium and copper.

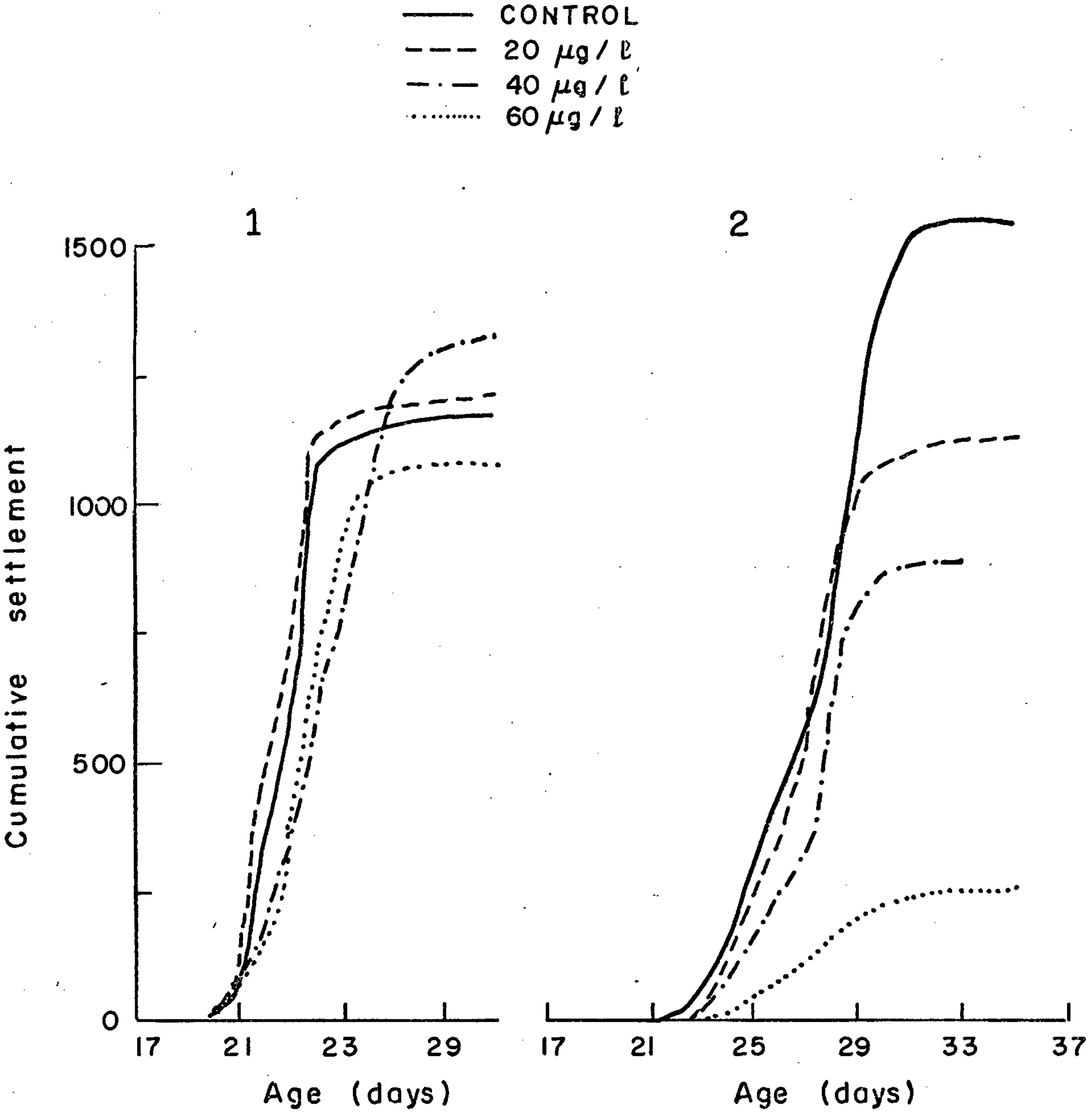


FIG. 4.5: *Crassostrea gigas*. Cumulative settlement during 20-day exposure to copper

before substantial settlement occurred; fewer larvae settled in the presence of copper, the effect increasing with increased copper concentration (Fig.4.5.2)

A third experiment on 16-day-old larvae was carried out. Larvae were exposed to zinc, cadmium and copper in the range 0-100 μg/l for 6 days after which the larvae were resuspended in clean sea water. Substantial settlement occurred 3 days later (age 25 days). Without exception, increased metal concentration resulted in fewer individuals settling. Copper is toxic rather than beneficial under these conditions.

The effects of the three metals can be compared directly, not on the basis of total settlement but rather in terms of the metal concentration which prevents 50% of the larvae from settling, as compared with settlement in the control. Percentage settlement was plotted against concentration for each element and the concentration which caused a 50% reduction was calculated. The results for zinc (30-35 μg/l), cadmium (20-25 μg/l) and copper (35-45 μg/l) indicate that metamorphosis and settlement is a very sensitive stage in the life of the oyster.

4.6 THE EFFECTS OF METALS ON THE GROWTH AND MORTALITY OF SPAT

The effect of cadmium on the growth and mortality of early C. gigas spat which had settled on PVC discs in clean sea water was investigated. The results obtained (Table 4.9) are compared with those for spat which settled during their exposure to cadmium (Table 4.8).

TABLE 4.9 The effect of cadmium on early spat which had settled in clean sea water

Cadmium μg/l	Spat length (μm)			Survival after 10 days (%)
	Initial sample	After 5 days in cadmium	After further 5 days in control	
Control	560	840	1020	78
100		780	980	65
250		730	900	63
500		660	670	21

The survival of the control after 10 days (78%) is somewhat higher than that observed in the previous experiment where both early and late settling spat were present (55%). Once again a decrease in both growth rate and survival is observed with increased cadmium concentration, although the overall tolerance of the spat to cadmium has increased.

The growth of 24 and 64-day and 3-month-old cultchless spat in the presence of 0-1000 μg/l cadmium was also investigated. The effect of 100 μg/l on 24-day-old spat was negligible during the 5-day exposure period but subsequent growth in clean water was reduced (Fig. 4.6). 5-day exposure to 250 μg/l suppressed spat growth but some further growth did occur during the period in clean water. Growth was very much reduced at 500 μg/l and subsequent growth in clean water was negligible. No growth was observed for spat subjected to 1000 μg/l.

Following exposure to cadmium for 4 days with a further 10 days in clean water, the survival of 3-month-old spat was 100% in the control, 90% in 250 μg/l, 50% in 500 μg/l and 10% in 1000 μg/l.

The effects of eight elements on 51-day-old C. gigas spat were compared (Fig. 4.7). All the metals which were tested caused a reduction in growth during the 14-day treatment period. However, recovery was such that individuals in all treatments were approximately the same size as those in the controls after a further 14 days in clean sea water.

The effects of zinc, cadmium and copper in the range 0-50 μg/l were tested on 35-day-old C. gigas and 51-day-old C. cucullata spat (Fig. 4.8). Growth was reduced in the presence of cadmium and copper to a greater extent than in the presence of zinc; a general decrease in growth rate with an increase in metal concentration was observed for both species. On the basis of recovery during the subsequent period in control solutions, zinc is the least toxic element. Mortality after the 11-day treatment was a maximum of 75% in the 50 μg/l copper solution, but this increased during the subsequent period in clean sea water. 23-day LC_{50}'s have been calculated; these are 75 μg/l zinc, 50 μg/l cadmium and 60 μg/l copper for C. gigas and >100 μg/l zinc and cadmium and 80 μg/l copper for C. cucullata.

4.7 DISCUSSION AND CONCLUSIONS

The elements zinc, cadmium, lead, iron, manganese, nickel, cobalt and chromium in the range 0-100 μg/l do not have an affect on the embryonic development of C. gigas, C. margaritacea and C. cucullata. The results reported by Calabrese et al. (1973) and Calabrese and Nelson (1973) indicate that greater concentrations of these metals are required to inhibit embryonic development. The copper concentrations which cause 50% fewer straight-hinge larvae to develop are 180 μg/l for C. gigas, 160 μg/l for C. margaritacea and 130 μg/l for C. cucullata. These values are close to the LC_{50} of 100 μg/l determined for C. virginica embryos (Calabrese et al., 1973).

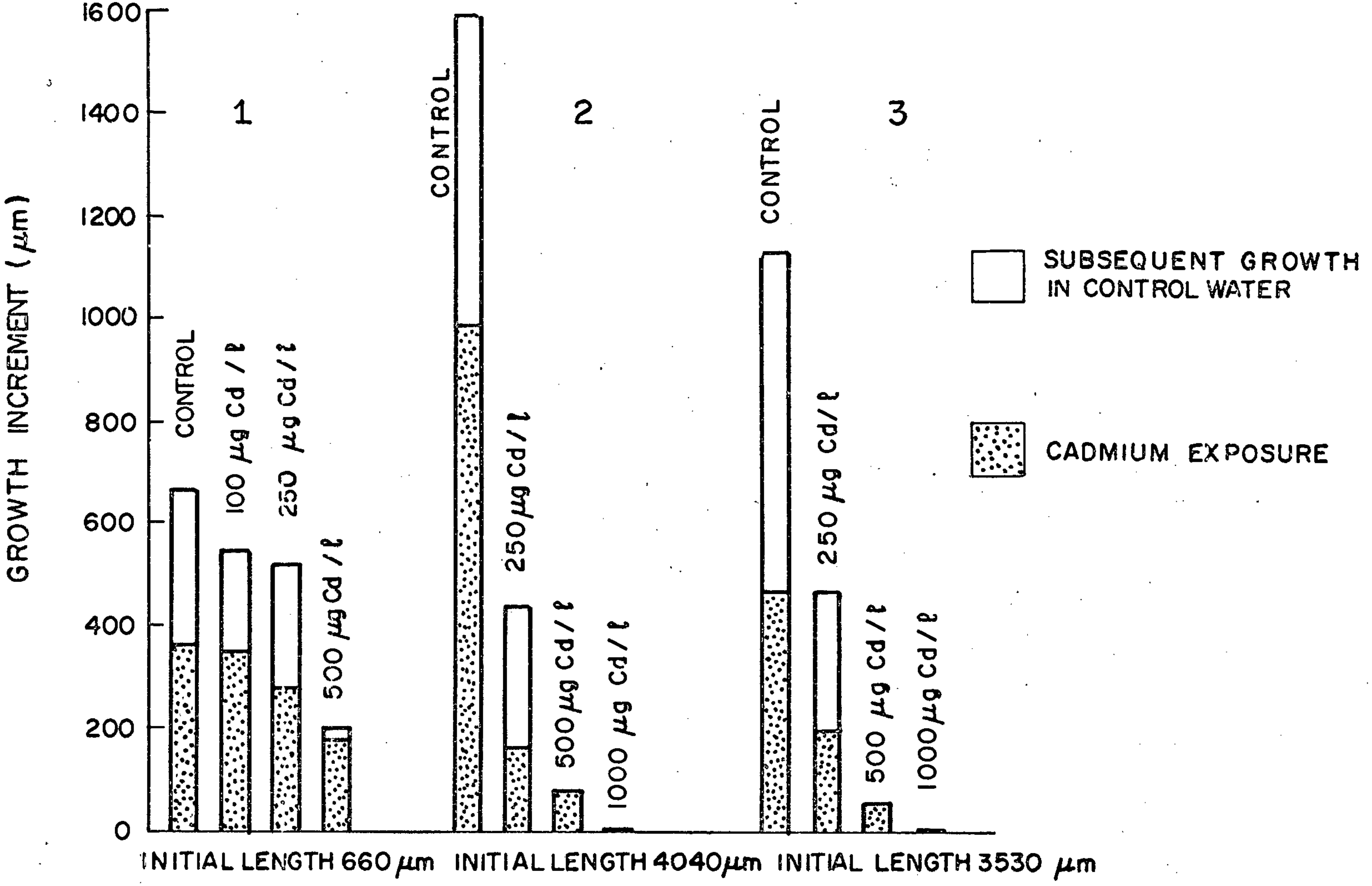


FIG. 4.6: *Crassostrea gigas*. Cultchless spat: 24-day-old spat subjected to 5 days cadmium, 5 days control (1); 64-day-old spat subjected to 3 days cadmium, 5 days control (2); 3-month-old spat subjected to 4 days cadmium, 10 days control (3).

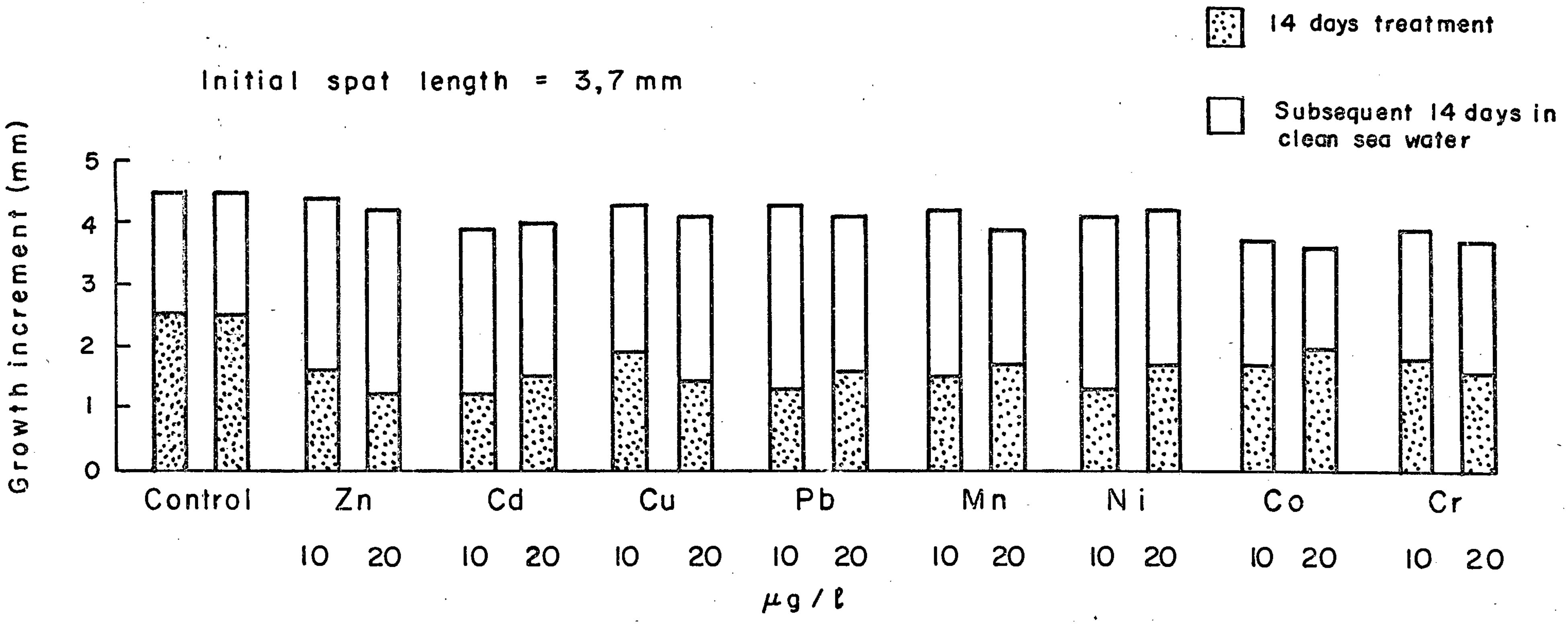


FIG. 4.7: *Crassostrea gigas*. Growth and recovery of 51-day-old cultchless spat exposed to eight elements

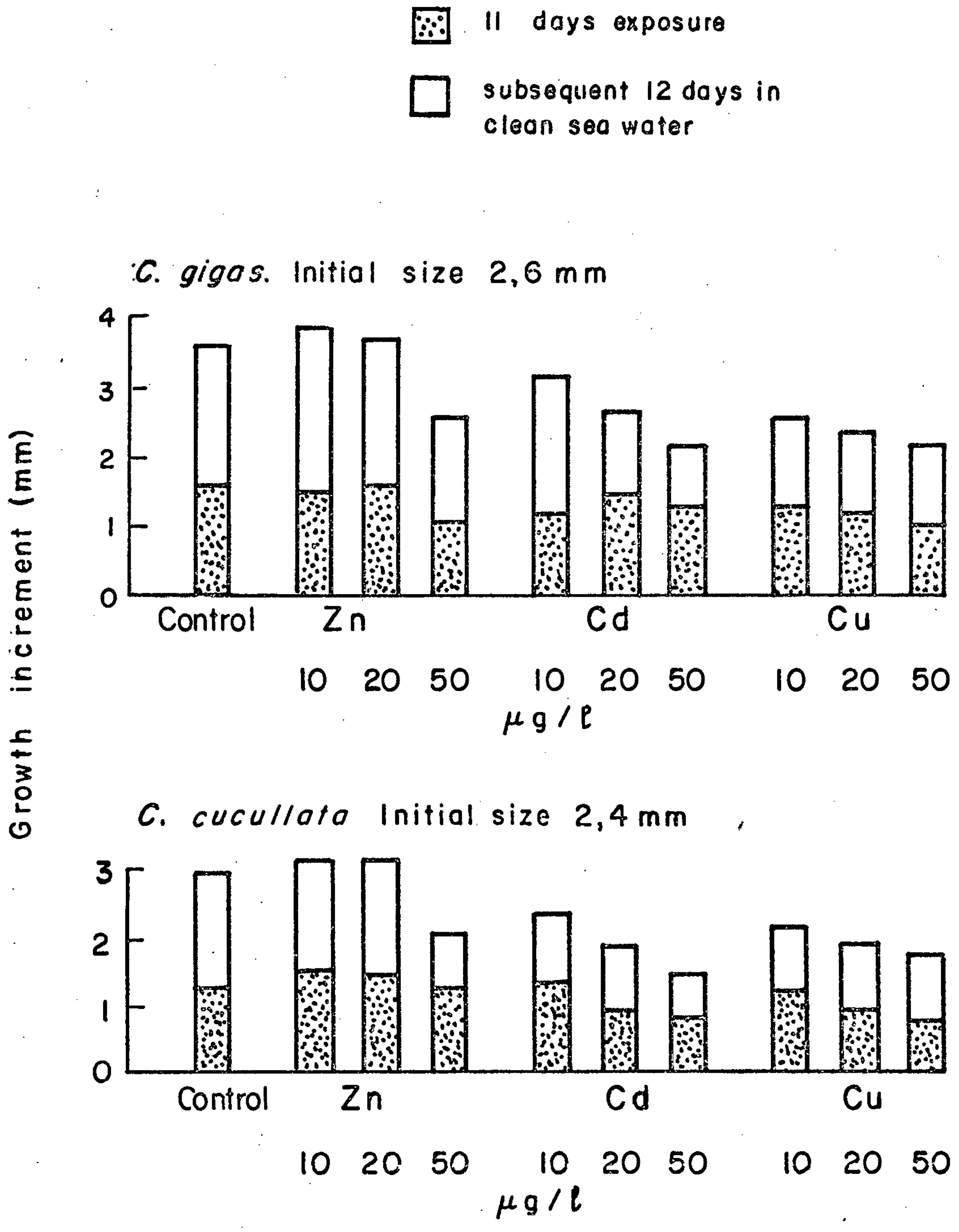


FIG. 4.8: Growth and recovery of 35-day-old *Crassostrea gigas* and 51-day-old *Crassostrea cucullata* cultchless spat exposed to zinc, cadmium and copper

Cadmium is extremely toxic to C. gigas larvae and spat. A concentration of only 20 µg/l caused increased mortality and a 20% reduction in the growth of 5-day-old larvae. The numbers of larvae settling and the viability of those which settle in the presence of 50 µg/l are significantly lower than for larvae grown in clean sea water. In general, an increase in mortality together with a suppression of growth is observed as the cadmium concentration is increased.

The sensitivity of C. gigas larvae and spat decreases with age, with respect to short-term cadmium exposure. 96-h LC_{50} concentrations of 50 µg/l for 5-day-old larvae, 200 µg/l for 16-day-old larvae, 1000 µg/l for 24-day-old spat, 1500 µg/l for 64-day-old spat and 2000 µg/l for 3-month-old spat have been calculated. These concentrations are approximate and intended only to illustrate the increased tolerance of older individuals to cadmium. The results already discussed indicate that cadmium can seriously affect the growth and development of C. gigas larvae and spat at much lower concentrations than those just quoted.

Some of the results from these experiments contrast with those obtained from two studies on the effects of zinc on C. gigas larvae and spat. In the first place cadmium appears to be more toxic than zinc to both larvae and spat. Secondly, the effect of cadmium appears to be permanent. In the case of spat exposed to zinc for a short period, during which growth is suppressed, growth increases radically as soon as the spat are returned to clean water so that, after a further 5 days, individuals from all zinc treatments are approximately the same size as those in the control (Boyden et al., 1975). This recovery and rapid growth is not observed for cadmium-treated spat following their return to clean water (Fig. 4.6). Thirdly, the presence of zinc inhibits behavioural development and delays settlement of larvae but those larvae which settle in the presence of zinc are no less viable than the controls (Boyden et al., 1975). In the present study cadmium induced early settlement; however, the numbers settling and their viability are markedly reduced.

The short-term effects of zinc, cadmium and copper in the concentration range 0-100 µg/l were compared for early and late C. gigas, C. margaritacea and C. cucullata larvae; a decrease in growth rate with increased metal concentration is observed for each element and species. The concentrations which caused a 50% reduction in growth were generally lower than their respective LC_{50}'s for each species. Using either of these measurements as a guide, copper is the most toxic element. However, on the basis of recovery during the subsequent period in clean water, cadmium is the most toxic element.

Of the eight elements tested only copper and manganese were not detrimental to C. gigas settlement success. Element effects on settlement patterns can be divided into three groups: induced early settlement, settlement at the same time as that in the controls and delayed settlement. However, the effects were not consistent for all the experiments. For example, prolonged exposure to low zinc concentrations resulted in delayed settlement whereas short-term exposure to slightly higher zinc concentrations induced early settlement. Copper induced early settlement where the presence of this element was apparently beneficial but delayed settlement where copper was toxic. Apparently induced changes in settlement patterns do not only depend upon the metal present. Further research is required to elucidate the mechanisms by which metals affect the processes of metamorphosis and settlement.

The effect of copper has been accorded particular attention because Prytherch (1934) reported that, of all the elements he tested, this was the only one which stimulated settlement, and that within a concentration range of 50-600 µg/l the number of individuals responding to copper stimulation was directly proportional to the amount present. Higher copper concentrations (>800 µg/l) were extremely toxic to C. virginica larvae. These concentrations are much higher than the ones tested here. However, the larvae were exposed to copper for much shorter periods during which they were continuously examined.

The results of the four copper tests indicate that low copper concentrations (20-40 µg/l), added to the sea water immediately prior to larval settlement and for only 2-3 days, may stimulate larval settlement. However, the same copper concentrations, added too early or for longer periods, had the usual toxic effect of causing fewer larvae to settle. The effects of copper on oyster larvae should be investigated more thoroughly and the research extended to include other bivalve species. It may be possible to improve settlement success by the addition of small amounts of copper at a particular stage in larval development. This could be of significant value to the shellfish cultivation industry.

Zinc, cadmium, copper, lead, manganese, nickel, cobalt and chromium in the 10-20 µg/l range all caused a reduction in spat growth during metal exposure. However, recovery is such that individuals in all the treatments grew to approximately the same size as those in the controls during the subsequent 14 days in clean sea water. The results of a second experiment indicated that zinc is less toxic to C. cucullata and C. gigas than either cadmium or copper.

The most important and critical stage in the life history of the oyster is reported to be that of metamorphosis and settlement. Stafford (1913) states: "Spatting is the all important event. The value of the oyster harvest does not depend upon the number of eggs spawned, nor upon the number of larvae in the water, but upon the number of successful spat". Sufficient data are available to compare the sub-lethal effects of zinc, cadmium and copper on C. gigas embryos, larvae and spat (Table 4.10). The results of these experiments indicate that the process of settlement is the most sensitive period with respect to the effects of metals.

TABLE 4.10 . Summary of zinc, cadmium and copper toxicities to C. gigas embryos, larvae and spat

Effect	Element concentration (μg/l)		
	Zn	Cd	Cu
50% fewer straight-hinge larvae	>>100	>>100	180
50% reduction in growth			
6-day-old larvae	80	75	50
16-day-old larvae	95	120	65
50% reduction in numbers settling	30-35	20-25	35-45
50% reduction in growth of spat	>50	>50	>50

It must be remembered that the results which have been obtained apply only to the experimental conditions which have been used, these being controlled water quality, food quality, temperature and aeration. Low metal concentrations which have had a measurable effect under these conditions would be expected to have a more serious effect under normal conditions where the parameters listed are variable. The most obvious indication of toxicity has been a marked reduction in the growth of larvae. As was stated by Calabrese et al., (1973) "such a retardation of growth would serve to prolong the pelagic life of the larvae and, thus, increase their chance of loss through predation, disease and dispersion, thereby reducing recruitment into the population".

CHAPTER 5 THE EFFECTS OF METALS ON MOLLUSC FILTERING RATES

5.1 INTRODUCTION

There are two basic methods for the quantitative determination of the volume of water pumped by a suspension-feeding animal. The direct method often entails physical separation of the inhalent current from the exhalent current in order to measure the volume of water pumped through the gills. The indirect method is based upon the rate of removal of particles from a known volume of suspension. The rate so calculated is a function of the feeding current and the efficiency of particle retention and may be termed filtering rate to distinguish it from the pumping rate measured by the direct method (Coughlan and Ansell, 1964).

Four assumptions are fundamental to the indirect method:

1. The reduction in the concentration of particles is due to filtration by the animal.

2. The animal's pumping rate is constant over the experimental period.

3. Particle retention is 100% efficient; alternatively, a known constant percentage of particles is retained.

4. The test suspension is homogeneous over the experimental period.

Given these conditions, the filtering rate calculated would be the volume of water pumped by the animal in a given time.

Six equations for estimating filtering rate from the clearance of suspensions have been published. However, by applying a standard notation, Coughlan (1969) has shown that these equations are identical. Filtering rate is given by

$$m = \frac{M}{nt}\log_e \frac{Co}{Ct}$$

where m = filtering rate in ml/minute

M = volume of test solution in ml

n = number of animals in the solution

C_o = suspension concentration in initial sample

C_t = suspension concentration in final sample

t = time between samples in minutes.

The use of Neutral Red as an indicator instead of suspended material (e.g. algal suspensions) simplifies the experimental procedure because the dye concentration in solution can be determined by colorimetry (Cole and

Hepper, 1954). Neutral Red is absorbed and retained by the gills of lamellibranchs and the rate of removal from suspension is directly dependent upon the flow of sea water through the gills.

The filtering rate of bivalves is known to be influenced by environmental parameters such as salinity, temperature, dissolved oxygen and concentration of suspended matter (Cole and Hepper, 1954; Badman, 1975; Foster-Smith, 1975; Mane, 1975 and Widdows, 1973), and the effects of some pollutants including copper, zinc and mercury, on the filtering rate of Mytilus edulis have been measured (Abel, 1976).

The method has been applied to the effects of copper, zinc, cadmium and lead on the filtering rates of Crassostrea gigas, Crassostrea margaritacea, Perna perna and Choromytilus meridionalis. The effective concentrations are compared with the results of conventional but more time consuming lethal toxicity tests.

5.2 DESCRIPTION OF THE METHOD AND PRELIMINARY STUDIES

5.2.1 Experimental solutions were prepared in one-litre pyrex beakers and were aerated in order to maintain a homogeneous suspension throughout each experiment. Most of the tests were made using one animal per beaker. Previous filtering rate experiments have been criticised by Galtsoff (1964) because, in many cases, care was not taken to ensure that all experimental animals were filtering. For the experiments described here neither the metal solution nor the dye was added to the beaker until the individual appeared to be filtering. Experimentally this was achieved by preparing more beakers than were required for a particular test and then discarding those in which the individuals did not filter in a reasonable time. Care was taken not to disturb the animal as each sample of solution was withdrawn for measurement.

5.2.2 The Neutral Red dye solution (1000 μg/ml) was prepared freshly each day in sea water. 1 ml of this stock solution was added to each beaker (dye concentration 1 μg/ml).

The dye concentrations were measured colorimetrically using a Techtron 1200 atomic absorption spectrometer operated with a hydrogen continuum hollow cathode lamp as source and measuring the absorbance of the solution at 425 nm. A cell holder (Fig. 5.1.1) was designed which replaced the normal burner head in the instrument. Two 20 mm spectrometric cells were held in a perspex tray which could be moved so as to bring either of the cells into the light path of the instrument.

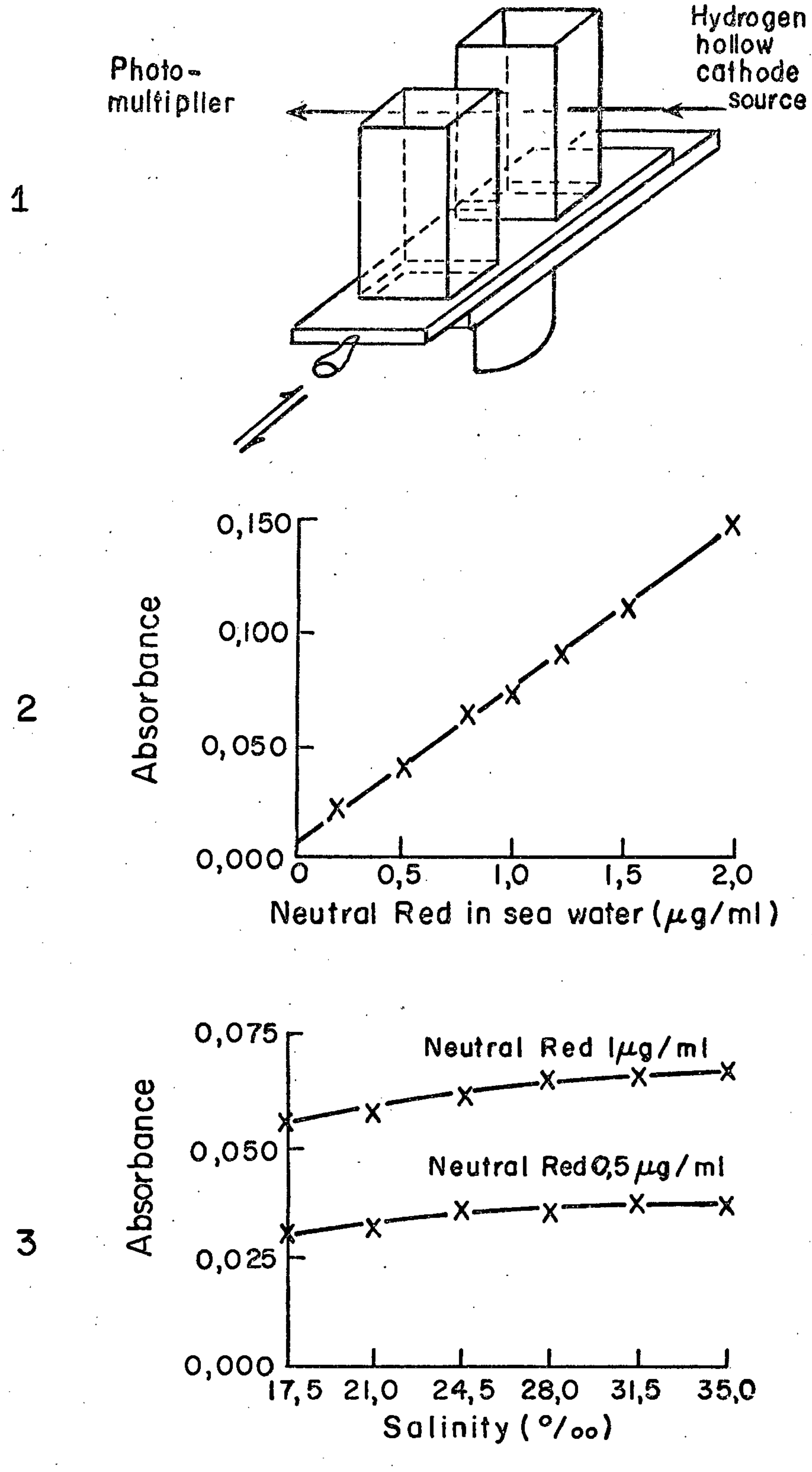


FIG.5.1: The colorimetric method

1. Diagram of cell holder
2. Neutral Red calibration curve
3. The effect of water salinity on the absorbance of a given dye concentration

One cell, containing sea water, was used to zero the instrument. When the second cell, containing the experimental solution, was moved into the light path absorbance of the light occurred. A calibration curve was determined each day by adding aliquots of the freshly prepared dye solution to 1 l sea water in the same way as the experimental solutions were prepared. The absorbance of each solution was measured and a curve plotted (Fig. 5.1.2). The curves varied only slightly from day to day and normally only three solutions (0, 0,5 and 1,0 µg/ml dye) were measured.

5.2.3 The reproducibility of measurement was tested at 10-min intervals for 1 h and the error (relative standard deviation) of the measurement was determined to be 4% at dye concentrations greater than 0,25 µg/ml. The aerated dye suspensions were stable for at least 1 h.

The presence of zinc, cadmium or copper did not cause a significant change in the absorbance of a given dye concentration at all the concentrations used. Lead, which precipitated as lead chloride at higher concentrations, interfered with the determination. As the salinity decreased the absorbance of a given dye concentration also decreased slightly (Fig. 5.1.3) but the signal reduction did not cause significant differences in the filtering rates calculated for these salinities. Neither increased solution temperature, nor the presence of certain organic compounds caused any significant change in the absorbance of a given dye solution.

5.2.4 Filtering rates were calculated according to the formula given. Considerable variation between the filtering rates of individuals was observed. Solutions were therefore prepared in replicate and the results quoted are usually mean filtering rates for from three to ten animals tested individually. When several individuals were contained in a single solution it was more difficult to ensure that all the individuals filtered throughout the experiment. The practice of keeping the experimental animals out of water prior to the experiment, in order to increase the chance of filtering (Cole and Hepper, 1954), was not adopted as it was felt that the observed filtering rate would be influenced by the exposure period and might not be constant during the measurement period. In addition, the introduction of faecal matter into the test solution would interfere with the colorimetric measurement.

5.3 MEASUREMENT OF FILTERING RATES

All individuals were cleaned and acclimatised to experimental conditions, firstly in trays in a flowing water pond and then in 1000-litre tanks. Filtering rates for each of the species were measured in order to establish the standard working method. The range of filtering rates for these species was determined under different experimental conditions.

5.3.1 Variation of filtering rates between individuals

Shell length is closely related to whole mass for both P. perna and C. meridionalis; both parameters are related to tissue mass (Fig. 5.2). Filtering rates can therefore be related directly to shell length.

The situation is more complicated for the oysters, especially C. margaritacea, where shell growth is irregular and the animal's tissue mass is not necessarily related to its shell dimensions. The filtering rates of a number of individuals were determined and plotted against both the whole mass and wet tissue mass (Fig. 5.3). Large variations between individuals of equal whole mass or equal wet tissue mass are observed for both species.

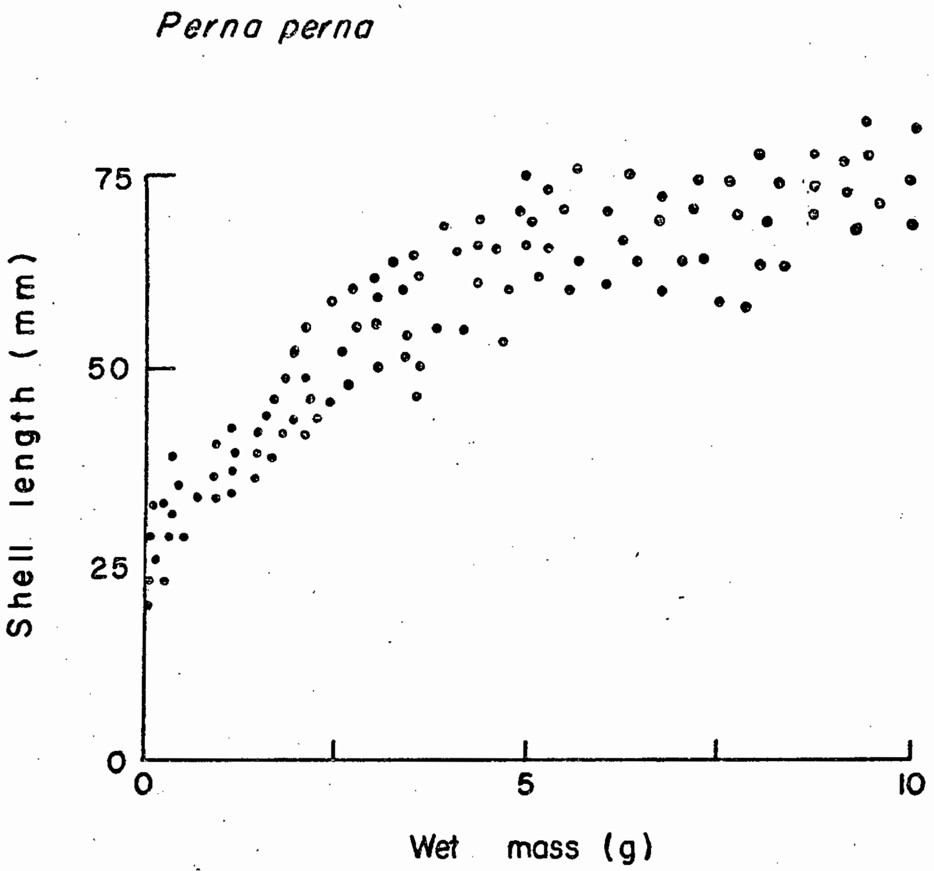
All further filtering rates for C. gigas and C. margaritacea reported in this study are based upon mean values for a number of individuals of approximately equal whole mass, as there appeared to be little advantage in opening the animals to determine their wet-tissue masses.

5.3.2 Variation of filtering rate with time (T=23°C)

The assumption that the filtering rate of an individual remains constant for the experimental period is fundamental to the method. A series of 10 beakers containing individuals of one species was prepared. Samples were withdrawn from the first two beakers after 10 min, from the next two beakers after 20 min, continuing to the final two samples taken after 50 min. The experiment was performed five times for each species. The calculated filtering rates shown in Figs. 5.4.1 (mussels) and 5.5.1 (oysters) are the means of 10 measurements.

Two experiments were performed for C. gigas (Fig. 5.5.1). The oysters were kept out of water for the 24 h prior to the second experiment, as was suggested for mussels (Cole and Hepper, 1954). The initial filtering rate is significantly higher than when the individuals were removed from a holding tank, weighed, and placed directly into the beakers.

Filtering rates for each of the species are relatively constant with time. A standard 10-minute experimental period was adopted for C. gigas, C. meridionalis and P. perna and a 20-minute experimental period for C. margaritacea for all further tests. These periods were sufficient to give a measurable difference between the initial and final dye concentrations.



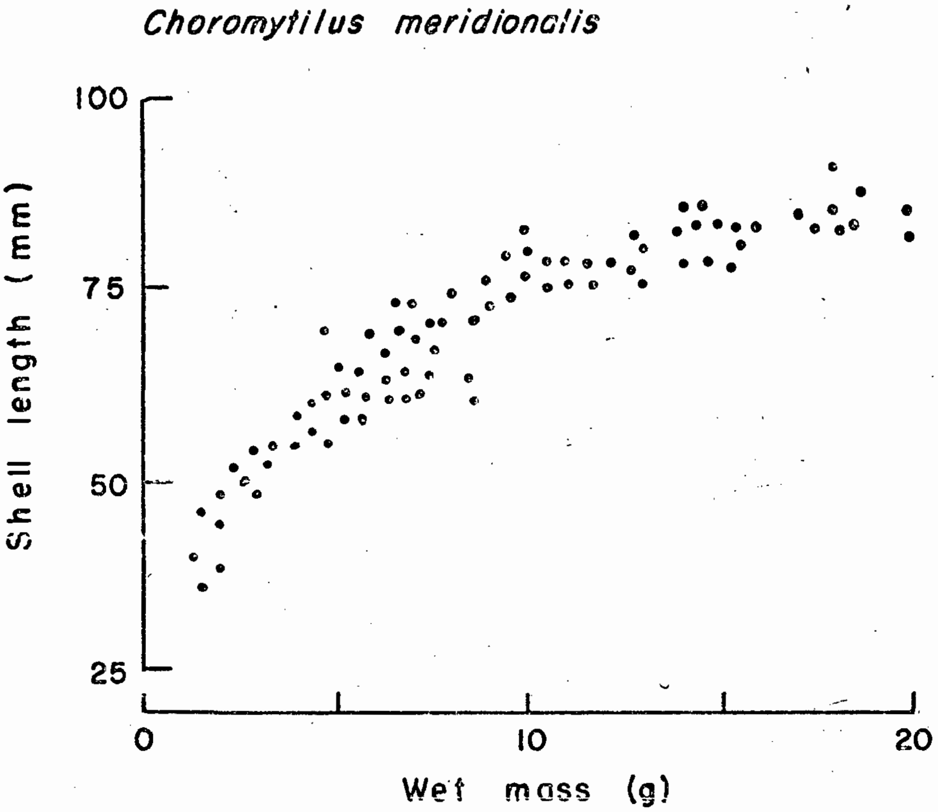
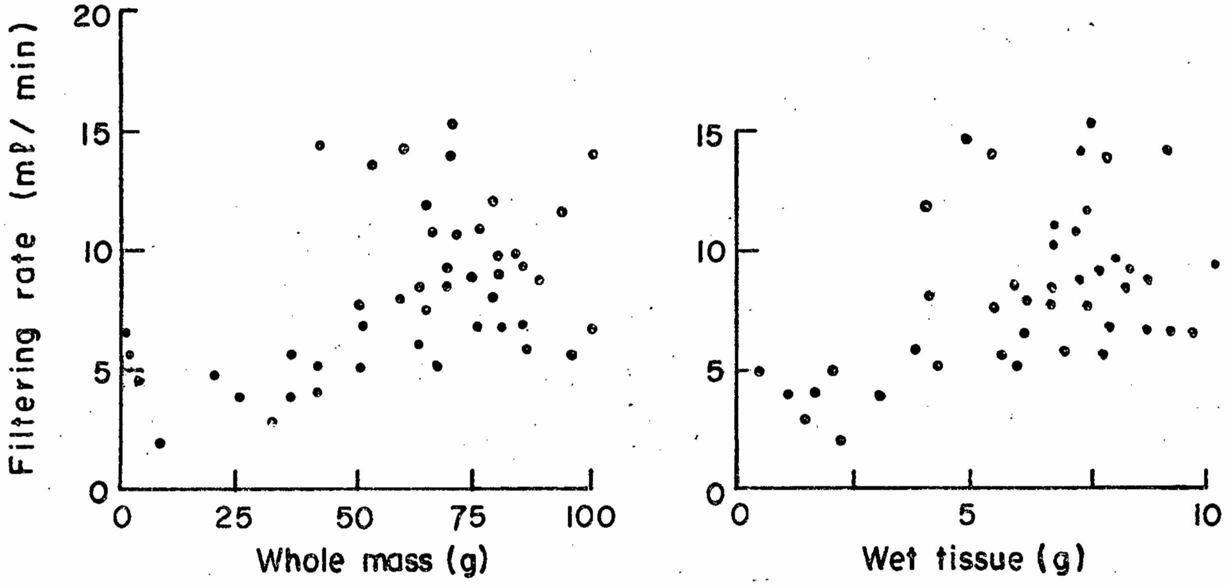


FIG.5.2: Relationship between mass and length for *Perna perna* and *Choromytilus meridionalis*

Crassostrea margaritacea



Crassostrea gigas

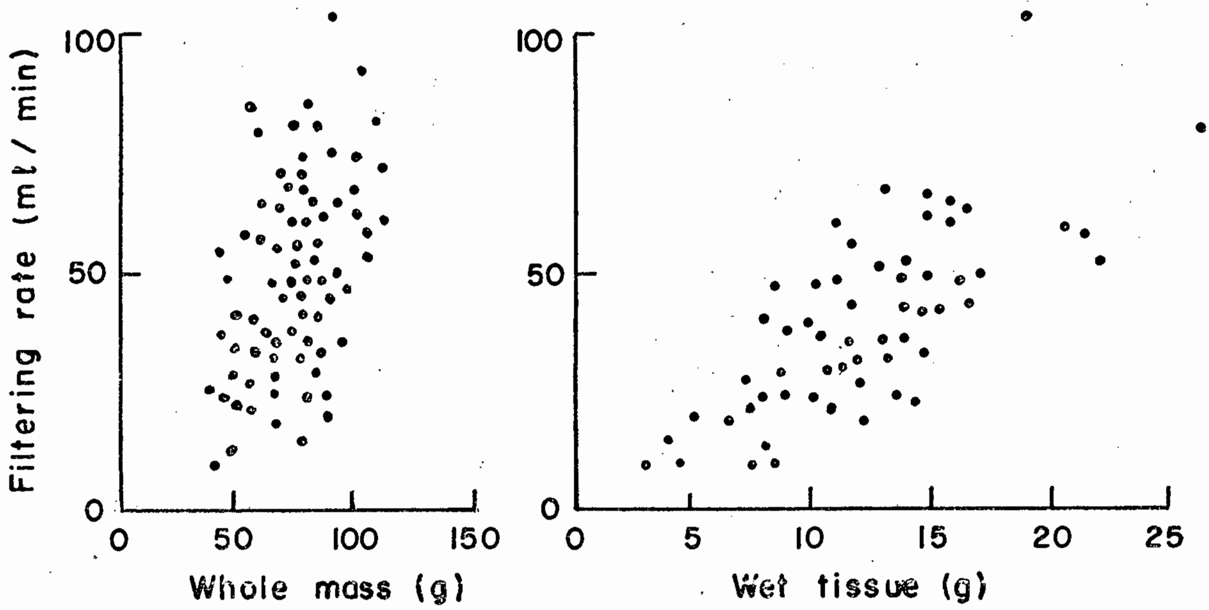


FIG. 5.3 : Variation of filtering rates with size for *Crassostrea margaritacea* and *Crassostrea gigas*

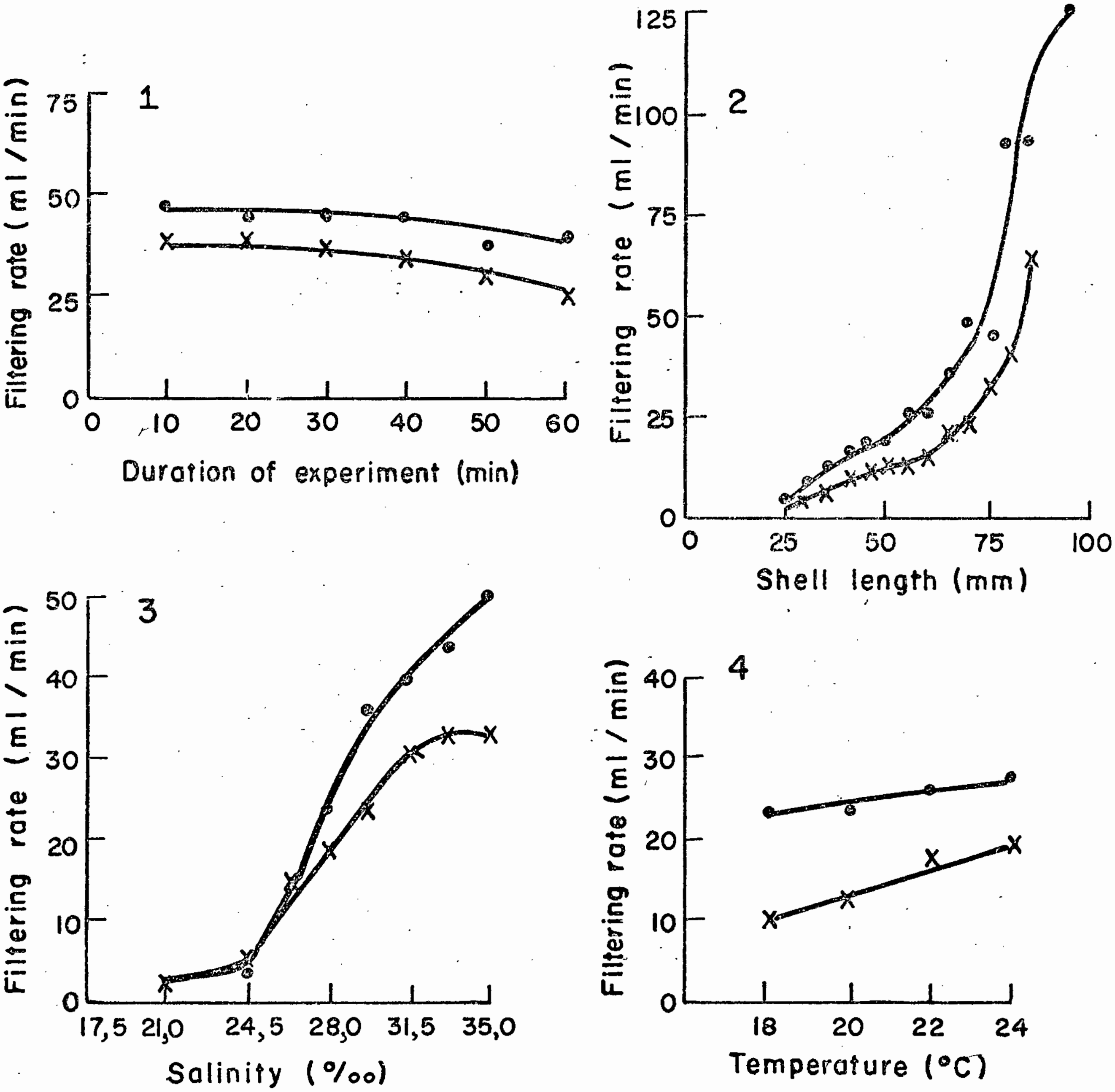


FIG. 5.4 : Filtering rates of *Perna perna* (X) and *Choromytilus meridionalis* (∘) under different experimental conditions.

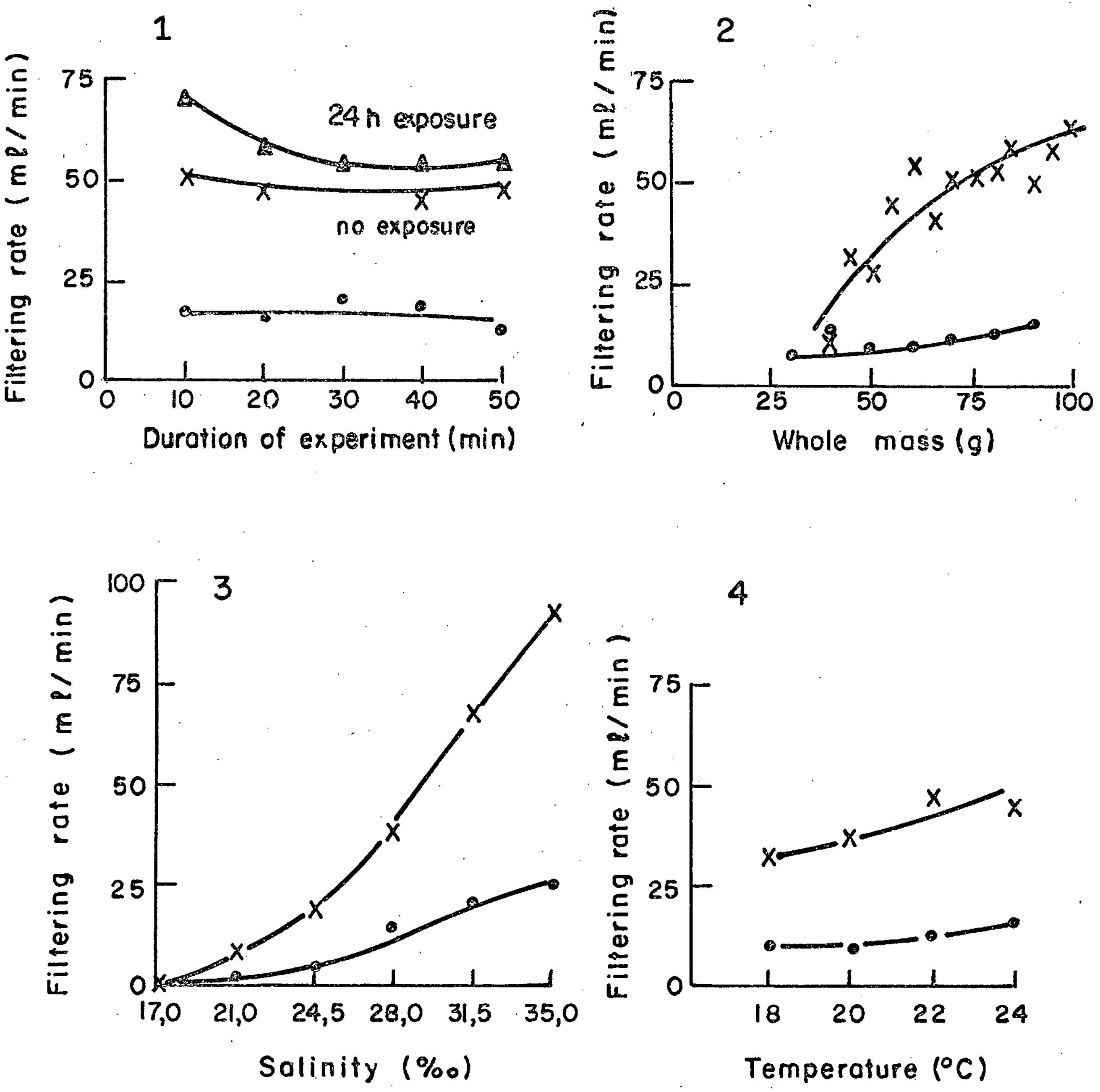


FIG. 5.5: Filtering rates of *Crassostrea gigas* (X ; ▲) and *Crassostrea margaritacea* (⊙) under different experimental conditions

5.3.3 Variation of filtering rate with size (T=22°C)

Individuals were selected, on the basis of length for mussels and whole mass for oysters, to cover a wide size range and filtering rates were measured. The results, which are the means of five measurements, show good correlation between filtering rate and size (Figs. 5.4.2 and 5.5.2).

5.3.4 Effect of salinity (T=22°C)

Individuals were placed in beakers containing measured amounts of sea water. After they had started filtering the volumes were slowly made up to one litre by the addition of demineralised water. The dye suspension was added after a further 15 minutes. The results from a single experiment are plotted in Figs. 5.4.3 and 5.5.3, each point being the mean of three measurements. The experiment was repeated a number of times for each species and the salinities at which the filtration rate was reduced by 50% were determined (Table 5.1). Individual size did not affect the results significantly.

TABLE 5.1 Salinities required to reduce the filtering rate by 50% (FS_{50})

	C. gigas	C. margaritacea	C. meridionalis	P. perna
	29,0	26,8	27,4	22,5
FS_{50}	28,4	27,8	26,5	25,0
(°/oo)	28,8	27,4	26,0	27,0
		26,2	27,0	
			28,3	

5.3.5 Effect of temperature

The animals were placed in beakers which were situated in a temperature controlled water bath. Filtering rates were determined after 4 hours at the selected temperature. The results are plotted in Figs. 5.4.4 and 5.5.4, each point representing the mean of five values

Filtering rates increase slightly with increased temperature over the short range which it was possible to test.

5.4 EFFECTS OF ZINC, CADMIUM, COPPER AND LEAD ON FILTERING RATE

The technique described was used to determine the effects of four metals on the filtering rates of *C. gigas*, *C. margaritacea*, *C. meridionalis* and *P. perna*. For each metal and species measurements were made on individuals of approximately equal size. Metals were presented as metal chlorides.

Some preliminary experimentation was required to determine the range over which each metal affected filtering. Concentrations which are too high are reported either to arrest filtering entirely or to cause animals to close their shells; concentrations lower than the appropriate range are found to produce results which are too erratic to allow a curve to be constructed with confidence (Abel, 1976).

5.4.1 The effects of zinc, cadmium, copper and lead on filtering rate

The effects of zinc, cadmium and copper on the four study species and of lead on the two mussels, have been studied. Some typical curves are shown in Figs. 5.6 (mussels) and 5.7 (oysters), each point representing the mean of three measurements.

Obviously the absolute filtering rates which have been determined cannot be compared because, of necessity, not all tests were performed on individuals of equal size. In order to express the results in a simple numerical form the concentration required to reduce the filtering rate to half its value at zero concentration (FC_{50}) was read off the relevant graph of concentration plotted against filtering rate. These values are given in Table 5.2.

For those elements where several tests were made on different sized animals, there appears to be a tendency for the larger individuals to be less affected by a given element concentration.

5.4.2 Acclimatisation to metals

The tests already described relate to the immediate effect of metal upon the filtering rate of an individual which had previously only experienced clean sea water. Cole and Hepper (1954) reported that mussels acclimatise to conditions of reduced salinity, a parameter which has been demonstrated to have a great effect upon filtering rate. It is of interest to establish whether acclimatisation to metal exposure, with respect to filtering rates, also takes place.

The filtering rates of *P. perna* have been determined following longer exposures to zinc, cadmium, copper and lead. The results are illustrated

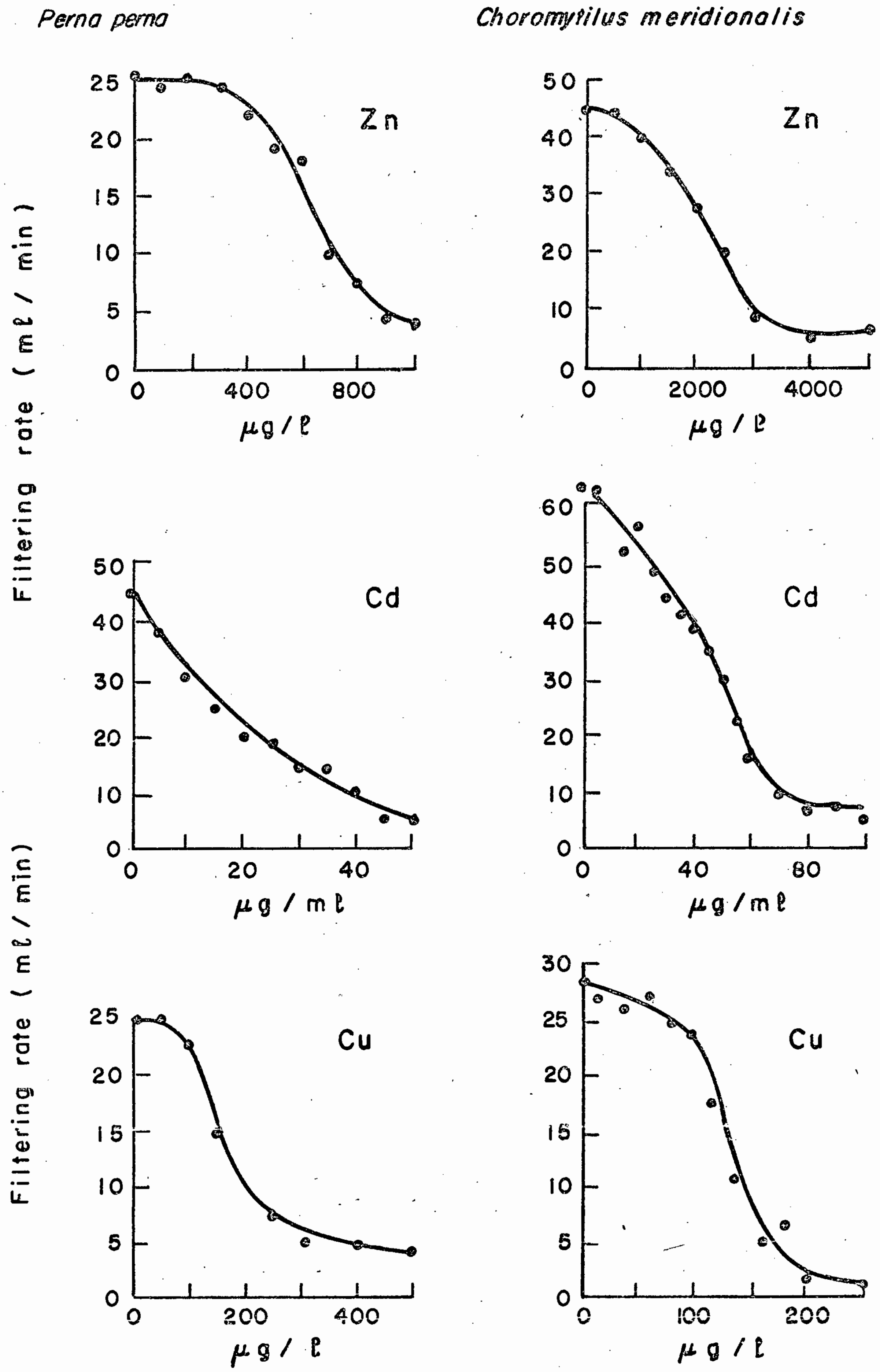


FIG.5.6 : The effects of zinc, cadmium and copper on filtering rates of *Choromytilus meridionalis* and *Perna perna*

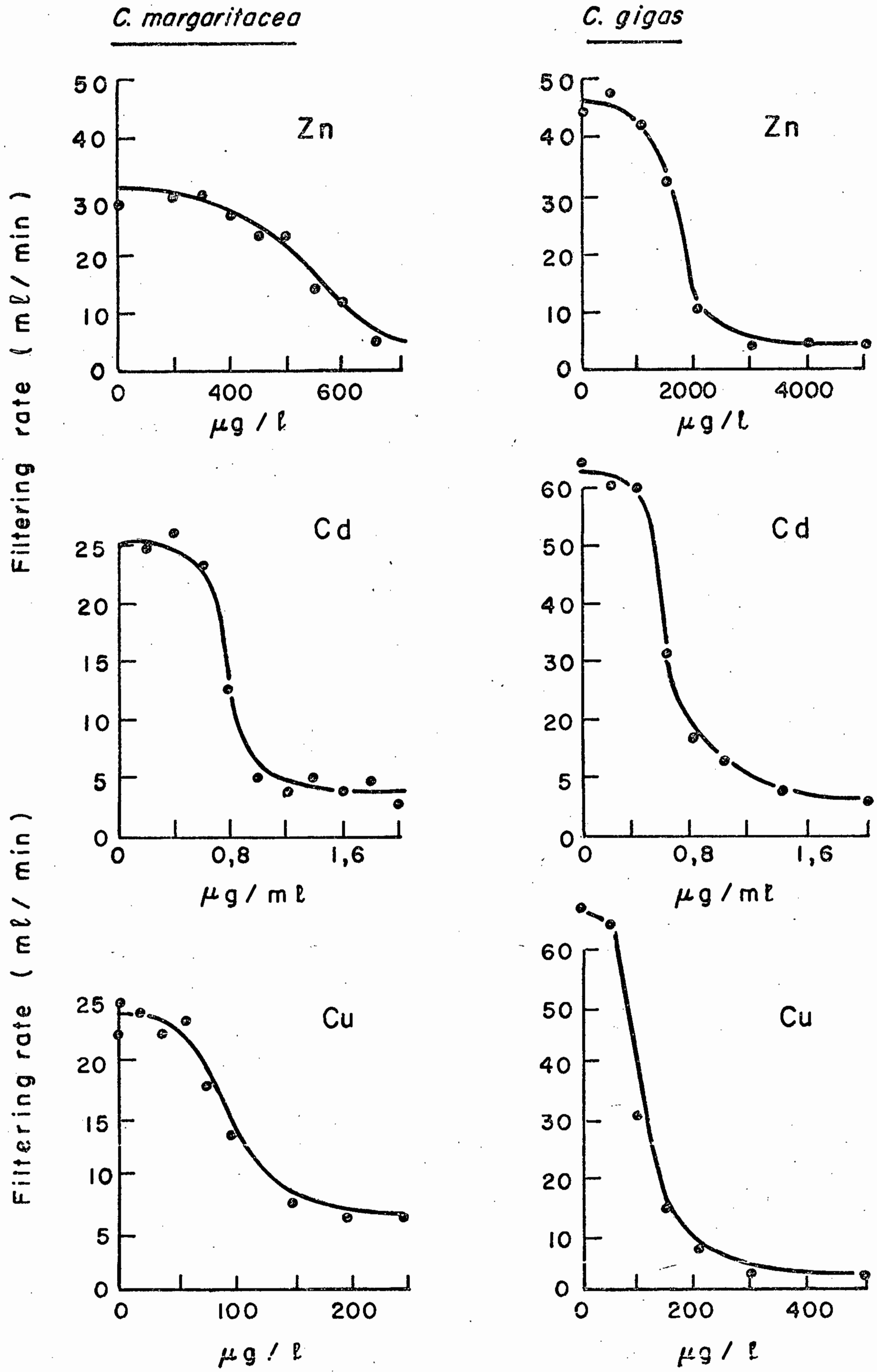


FIG.5.7 : The effects of zinc, cadmium and copper on the filtering rates of *Crassostrea gigas* and *Crassostrea margaritacea*

TABLE 5.2 Metal concentrations required to reduce filtering rate by 50% (μg/l) (FC$_{50}$)

SIZE	Zinc	Cadmium	Copper	Lead
P. perna				
40-50 mm	560 640 700	38000	170 170	
60-70 mm	720 840 900	25000 21000 28000	120 170	3800 4600 4100
80-90 mm	900			
C. meridionalis				
60-70 mm	1900 1700			
70-80 mm	2200 2000	46000 32000	90 120	
80-90 mm	2350 2500 3000	28000	130 120	4500 4300
C. margaritacea				
60-80 g	780 800	800 900	100 70 60 120	
C. gigas				
70-95 g	1300 1750 1450	900 700	90 80 80	
40-50 g	350 560	600 400 540 550	90	

in Fig. 5.8. The most dramatic recovery is observed in the case of zinc where filtering rate has increased to its normal level after 48-h exposure to 600 µg/l. P. perna has also acclimatised to cadmium and lead, although neither of these elements had a great effect on filtering rate at the levels tested. The exception is copper, which caused even lower filtering rates during 8-h exposure.

The filtering rate of C. gigas following 15-h exposure to zinc was also measured and the results are shown in Table 5.3. In addition, an attempt was made to measure the zinc levels before and after the experiment and these values are also given.

The filtering rate recovered during the 15-h exposure, as was shown for P. perna. Zinc may have been absorbed from solution during the process; alternatively it may have been adsorbed onto the shell or the walls of the beaker.

C. gigas filtering rates were measured following 3- and 7-day exposures to nine elements (including copper) at 100 µg/l and no significant differences between any of the treated animals and the controls were observed.

TABLE 5.3 Crassostrea gigas. Acclimatisation to zinc during 15-h exposure, and loss of zinc from solution

Filtering rate (ml/min)		Zinc concentration (not corrected) (µg/l)		
Initial	15h	Initial	15h	Apparent loss
16,0	16,0	10	10	0
13,1	14,5	10	10	0
12,0	13,4	80	20	60
11,8	12,2	90	15	75
10,2	10,7	220	145	75
8,4	9,8	220	155	65
6,4	10,3	310	235	75
8,1	12,3	320	230	90
4,6	11,0	380	275	105
2,7	12,9	370	270	100

5.4.3 The effects of selected organic compounds on filtering rate

The effects of sodium citrate, sodium acetate, ethylene diaminetetra-acetic acid (EDTA) and sodium diethyldithiocarbamate (NaDDC) on the filtering rates of the four study species have been determined. The results are illustrated for C. meridionalis in Fig. 5.9.

Sodium citrate and sodium acetate in the range 0-30 µg/ml have no effect on the filtering rates of C. meridionalis (Fig. 5.9) nor of

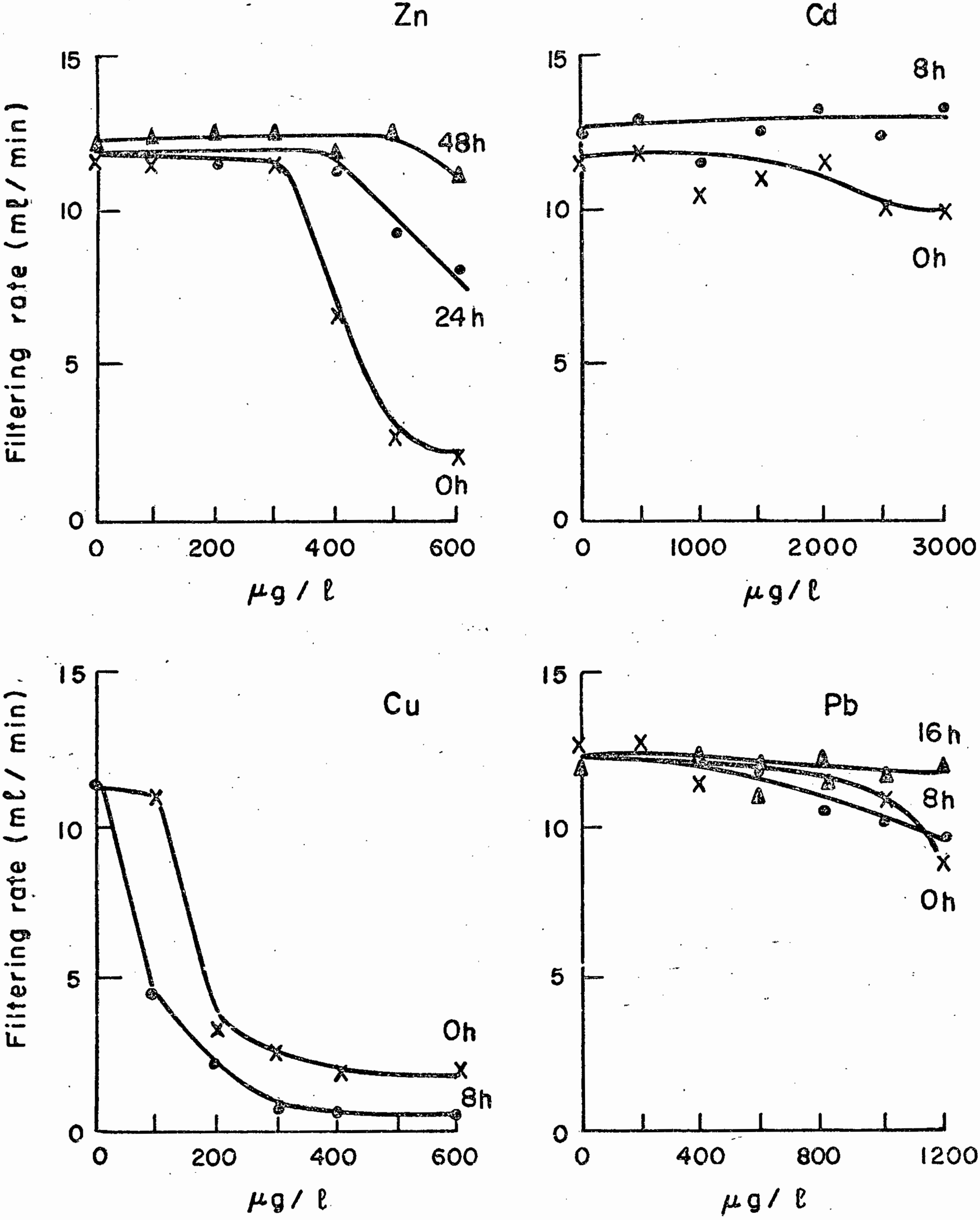


FIG.5.8: *Perna perna.* Acclimatisation to metals as measured by filtering rate.

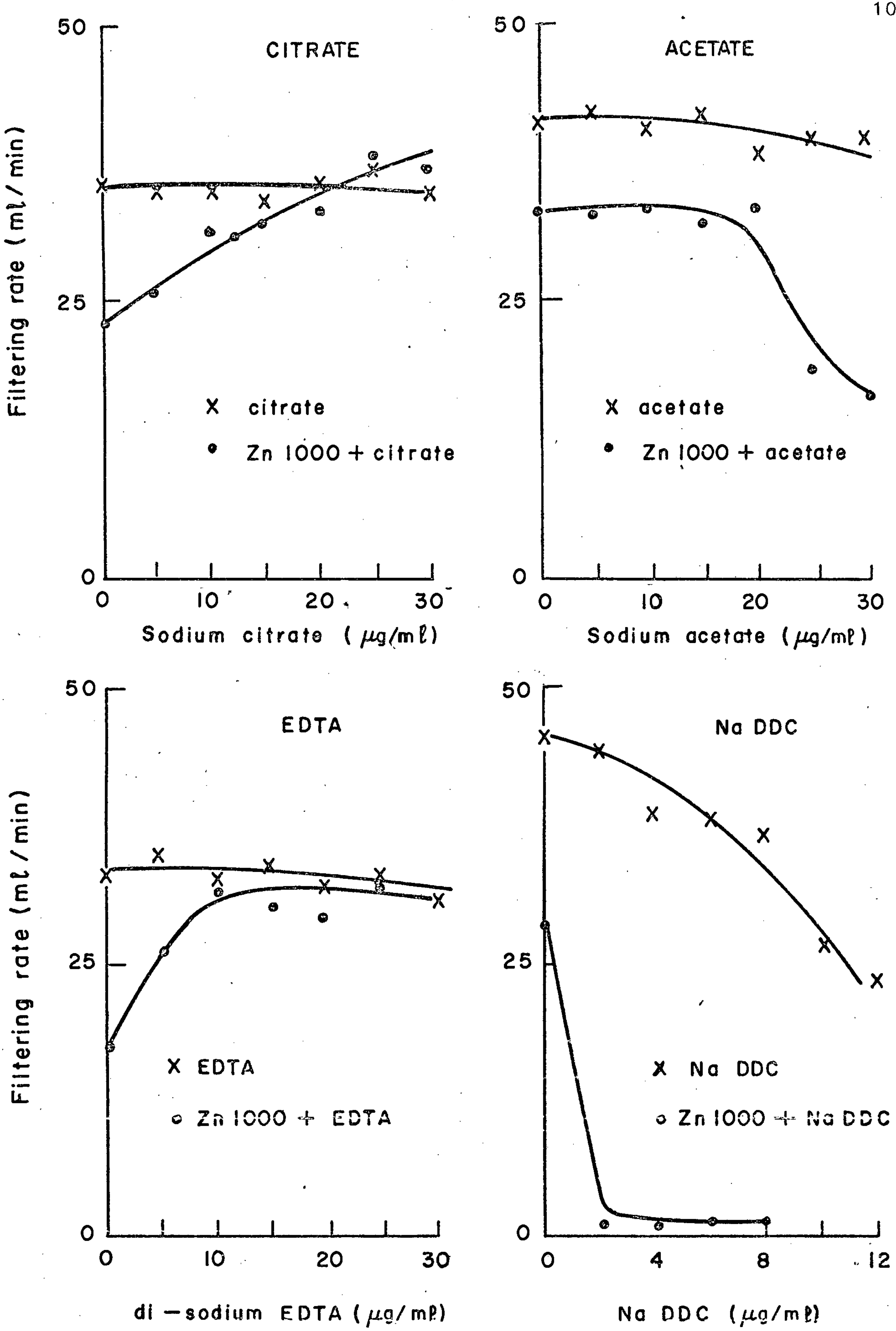


FIG.5.9 : *Choromytilus meridionalis*. The effects of 1000 μg / l zinc in the presence of increasing concentrations of some organic compounds

P. perna, C. margaritacea or C. gigas. EDTA in the range 0–30 µg/ml possibly causes a slight reduction in filtering rate for each species. However, NaDDC in the range 0–12 µg/ml causes a significant reduction in filtering rates and the FC_{50} values have been determined for each species. (Table 5.4).

TABLE 5.4 Concentrations of NaDDC required to reduce the filtering rate by 50% (FC_{50})

Species	NaDDC FC_{50} (µg/ml)
C. gigas	6
C. margaritacea	7
C. meridionalis	12
P. perna	7

5.4.4 The effects of metals in the presence of organic compounds

The effects of 1000 µg/l zinc on the filtering rate of C. meridionalis in the presence of these organic compounds have also been examined (Fig. 5.9). It has already been shown that 1000 µg/l zinc suppresses the normal filtering rate by between 10 and 20%. However, in the presence of increasing concentrations of sodium citrate, this suppression is counteracted. The presence of the lower concentrations of sodium acetate has no effect on the zinc-suppressed filtering rate; indeed at higher acetate concentrations the filtering rate is further suppressed. EDTA, a strong metal-complexing reagent, counteracts the zinc suppression of the filtering rate. However, NaDDC, another strong zinc-complexing reagent, which might be expected to act in the same way as EDTA, increases the zinc suppression of the filtering rate; the complex is more toxic than either of its components added separately.

The effect of copper on the filtering rate of C. meridionalis in the presence of sodium citrate and acetate, EDTA and NaDDC has been examined. For each compound, present at a fixed concentration, the copper FC_{50} has been determined (Table 5.5). A similar experiment to determine the effect of zinc in the presence of these organic compounds on the filtering rate of C. gigas was carried out. The results are summarised in Table 5.6. In both cases the presence of EDTA has reduced the effect of the metal whereas NaDDC significantly increased the toxic effect.

TABLE 5.5 Copper concentration required to reduce the filtering rate of C. meridionalis by 50% (FC_{50}) in the presence of organic compounds

Treatment	Cu FC_{50} (μg/l)
Control	145
20μg/ml citrate	165
20μg/ml acetate	150
20μg/ml EDTA	350
4μg/ml NaDDC	80

TABLE 5.6 Zinc concentration required to reduce the filtering rate of C. gigas by 50% (FC_{50}) in the presence of organic compounds

Treatment	Zn FC_{50} (μg/l)
Control	1300
20μg/ml citrate	1200
20μg/ml acetate	1450
25μg/ml EDTA	3000
4μg/ml NaDDC	450

5.5 LETHAL TOXICITY TESTS

The conventional short-term toxicity test, often applied to adult animals at high pollutant concentrations which bear little relation to natural events, has been soundly criticised by Brown, (1976) and Wright, (1976). One of the failings of the test is that toxicity is dependent upon many factors other than the pollutant being tested. For example, the toxicities of both zinc and copper to Mya arenaria apparently decrease as the temperature decreases (Eisler, 1977). An apparent decrease in the toxicity of copper at low salinities was demonstrated for M. edulis by Davenport (1977) who attributed this to the fact that M. edulis closed its shell during periods of low salinity, thus avoiding the copper.

It is not the purpose of this study to experiment at ever increasing concentrations until 50% mortality is experienced in a given time. However, Abel (1976) has suggested that the metal concentrations which reduce filtering rates by 50% are of the same order as those reported to cause 50% mortality of the same species. A number of toxicity tests were therefore performed in order to obtain similar comparable data for C. gigas, C. margaritacea, C. meridionalis and P. perna.

5.5.1 Procedure

All tests were performed in tanks of a sufficient volume to allow at least one litre of solution per individual. Experimental animals were suspended in the tanks on plastic nets. Test solutions were renewed each day, at which time the experimental animals were examined and dead individuals were discarded.

Mean mortalities from equivalent experiments were used to calculate the metal concentration which was lethal to 50% of the test individuals in a given time.

5.5.2 Results

The toxicities of zinc, cadmium, copper and lead, and of a mixture containing equal concentrations of zinc, cadmium and copper, were investigated for the four study species. The LC_{50}'s for specified time periods were calculated (Table 5.7). Recovery during a further 5-day period in control solutions was also tested following all 96-h lethal toxicity tests, as suggested by Wright, (1976). All individuals which survived the initial treatment also recovered during the control period.

Copper is the most toxic of the four elements tested. The upper copper concentration which can be tolerated by the mussels is well defined. Both P. perna and C. meridionalis survive a 3-week exposure to 0,20 µg/ml copper with apparently no ill effects, yet concentrations of 0,25 and 0,23 µg/ml copper, respectively, are sufficient to kill 50% of the individuals after only four days.

One interesting feature which arose during these lethal toxicity tests is illustrated for the effect of copper on C. meridionalis, compared with equivalent results for P. perna (Fig. 5.10). There are apparently two copper concentrations which cause 50% mortality in C. meridionalis, 0,25 µg/ml and 3,0 µg/ml. It has been reported that M. edulis can detect 0,5 µg/ml copper in its environment and that it responds by closing its valves. Thus, the apparent non-toxicity of 0,6 µg/ml (Fig. 5.10) is probably a measure of the ability of C. meridionalis to remain closed during the 96-h test. The apparent increase in toxicity from 0,6-4 µg/ml may be due to copper, the mussel being briefly exposed to these very high levels during the test and suffering some damage as a result. Copper concentrations in the range

TABLE 5.7 Toxicities of zinc, cadmium, copper and lead as indicated by lethal toxicity tests

Species and element	LC_{50} (µg/ml) 4-day	21-day
Perna perna		
Zn	>12,0*	>0,20
Cd	>10,0	>0,20
Cu	0,25	>0,20
Pb	> 5,0	>0,20
Zn, Cd, Cu-MIX	0,1	
Choromytilus meridionalis		
Zn	>12,0	>0,20
Cd	>10,0	>0,20
Cu	0,23	>0,20
Pb	> 5,0	>0,20
Zn, Cd, Cu-MIX	0,20	
Crassostrea gigas		
Zn	>2,50	>0,50
Cd	0,80	>0,50
Cu	0,55	0,45
Pb	> 5,0	>0,50
Zn, Cd, Cu-MIX	0,5	
Crassostrea margaritacea		
Zn	>2,50	>0,50
Cd	> 5,0	>0,50
Cu	>1,50	>0,50
Pb	> 5,0	>0,50
Zn, Cd, Cu-MIX	5,0	

*> indicates the highest concentration tested

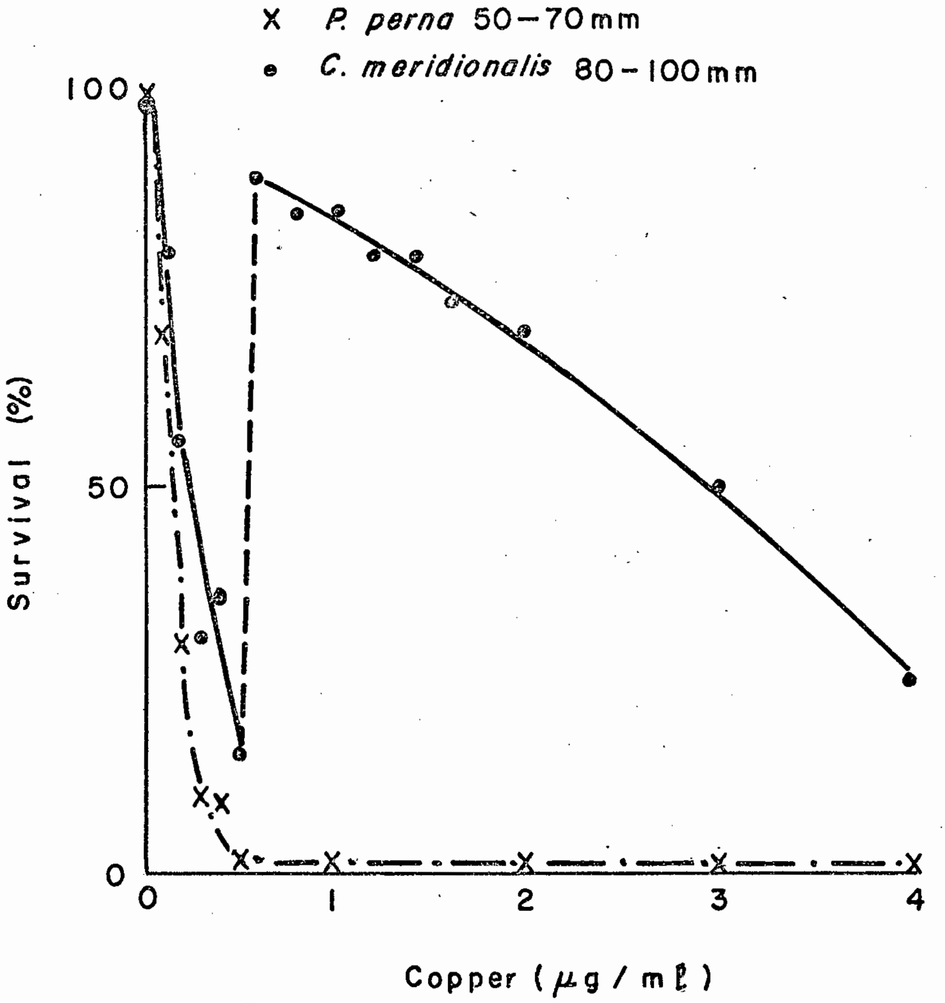


FIG.5.10: Lethal toxicity of copper to *Choromytilus meridionalis* and *Perna perna*

1-4 µg/ml were 100% toxic to P. perna of smaller size than C. meridionalis and this may be attributable to the inability of this mussel to remain closed for the 4-day period.

Equivalent high concentration tests have not been performed on C. gigas or C. margaritacea. However, Okazaki (1976) has reported that although 0,56 µg/ml copper is toxic to 50% of C. gigas in 96 h, there was 100% survival at concentrations between 5-8 µg/ml. He suggests that this may be because copper at high concentrations is chemically dissimilar to that existing at lower concentrations; that the metal may be coagulating and precipitating at a faster rate and the oysters may be able to sense this form and react by closing their valves.

5.6 DISCUSSION AND CONCLUSIONS

The preliminary experiments show that the method can be used to determine the filtering rates of both mussels and oysters. The filtering rates determined for C. meridionalis and P. perna fall within the range of previously published filtering rates for M. edulis which have been summarised by Foster-Smith (1975). Published filtering rates for C. virginica and C. gigas (Foster-Smith, 1975) are similar to those obtained here for C. gigas and also for C. margaritacea when the whole mass/wet tissue ratio (Fig. 5.3) is considered. Filtering rates increase with the size of the individual so that for any comparison of the effects of a pollutant, the size range of individuals to be tested should be restricted. This is particularly true for the mussels.

Conditions of low salinity depress the filtering rates of the four species significantly. However this effect could be lessened if the animals were frequently and regularly exposed to conditions of reduced salinity (Cole and Hepper, 1954). Filtering rates increase slightly with increased temperature over the restricted range which was tested, and this also agrees with previously published data for related species (Cole and Hepper, 1954; Foster-Smith, 1975).

7-day LC_{50} copper concentrations of between 0,2-0,3 µg/ml have been reported for M. edulis (Scott and Major, 1972; Delhaye and Cornet, 1975; Abel, 1976). These results are remarkably close to the LC_{50}'s obtained for P. perna (0,20-0,25 µg/ml) and C. meridionalis (0,20-0,23 µg/ml).

The sub-lethal effects of copper on M. edulis have also been studied. Martin et al. (1975) found that 0,25 µg/ml reduced byssal thread production by 50%. Oxygen consumption was shown to be reduced by 50% on exposure to 0,7 µg/ml copper (Scott and Major, 1972); an equivalent value of 0,2 µg/ml was reported by Delhaye and Cornet (1975). Abel (1976) reported that 0,15 μg/ml copper caused a 50% reduction in filtering rate. The equivalent concentrations determined for P. perna and C. meridionalis are 0,16 and 0,12 μg/ml copper respectively. These results suggest that there is a critical copper concentration at about 0,2 μg/ml and that concentrations above this level are very toxic to mussels.

Martin et al. (1975) reported that 1,8 μg/ml zinc caused a 50% reduction in M. edulis byssal thread production; 1,6 μg/ml zinc caused a 50% decrease in the filtering rate of the same species (Abel, 1976). These values are considerably less than the LC_{50} concentrations of >5,0 and 7,8 μg/ml zinc reported by these authors. Similar results were obtained in the present study. The zinc concentrations required to reduce the filtering rates of P. perna and C. meridionalis are 0,75 and 2,24 μg/ml respectively; the LC_{50} is greater than 12,0 μg/ml zinc for both species.

Concentrations of 28 and 35 μg/ml cadmium have been shown to cause a 50% reduction in the filtering rates of P. perna and C. meridionalis. The equivalent LC_{50} values are >10,0 μg/ml for both species. The increase in salt content, although high, relative to the other metals tested, is not sufficient to cause this decrease in filtering rate. It must be assumed that cadmium has only a slight effect on filtering rate. However, it should not be assumed that, because a metal has no effect on filtering rate, it is not toxic. Martin et al. (1975) reported that 0,5 μg/ml cadmium caused a 50% reduction in M. edulis byssal thread production. Ahsanullah (1976) noted that whereas Mytilus edulis planulatus usually gaped when in control or cadmium solutions below 2,5 μg/ml, their shells remained closed when they were transferred to solutions of higher cadmium content. Cadmium is reported to cause an increase in the respiratory rate of the clam Argopecten irradians (Nelson et al., 1976) but to decrease the heart rate of C. meridionalis (Brown et al., 1977).

Concentrations of 4,4 and 4,2 μg/ml lead cause a 50% reduction of the filtering rates of C. meridionalis and P. perna respectively; however the lead 96-h LC_{50} for both species is greater than 5,0 μg/ml. Few comparative data for the effects of lead on mussels are available. A 96-h LC_{50} of about 50 μg/ml can be calculated from the data presented by Schulz-Baldes (1972) for M. edulis, and Martin et al. (1975) reported the 7-day LC_{50} to be greater than 25 μg/ml. These authors also showed that a lead concentration of 2,5 μg/ml reduced M. edulis byssal thread production by 50%. This concentration is of the same order as those which affect the filtering rates of C. meridionalis and P. perna.

In order of decreasing toxicity, with respect to their effects on mussel filtering rates, the elements are copper>zinc>lead>cadmium.

Fewer lethal toxicity tests were carried out on C. gigas and C. margaritacea, and the levels which were tested allowed only the toxicity of copper and cadmium to C. gigas to be measured. The copper LC_{50} for C. gigas was determined to be 0,45-0,55 µg/ml, which agrees with the value of 0,56 µg/ml reported by Okazaki (1976). The concentration required to reduce filtering rates by 50% is somewhat lower, being 0,09 µg/ml for both C. gigas and C. margaritacea.

Cadmium affects oyster filtering rates at a much lower level than was determined for the mussels. The concentrations required to reduce the filtering rates by 50% were 0,85 µg/ml for C. margaritacea and 0,62 µg/ml for C. gigas. The 96-h LC_{50} of 0,8 µg/ml for C. gigas is of the same order.

Zinc is equally effective, the equivalent concentrations being 0,79 µg/ml for C. margaritacea and 1,08 µg/ml for C. gigas. However the zinc 96-h LC_{50} is >2,5 µg/ml for both species.

The elements in order of their effect on the filtering rate are copper>cadmium>zinc; the effect of lead was not measured.

Comparative data for the effects of metals on filtering rates, or indeed for the effects of metals on other bodily functions, for oysters have not been found. In the case of filtering tests, this could be due to the relative difficulty experienced in persuading the experimental animals to open their shells and filter. Certainly the mussels were much easier to experiment with.

Both oysters and mussels apparently become less sensitive to cadmium and zinc (insufficient measurements were obtained for lead and copper) with increased size (Table 5.2). In addition, they may acclimatise to metal solutions so that the filtering rate returns to normal during longer exposures.

The effects of sodium citrate, sodium acetate, EDTA, and NaDDC are similar for each of the species tested; only NaDDC caused a significant reduction in filtering rates. The combined effects of a fixed organic-compound concentration with a variable metal concentration have been investigated for C. meridionalis (copper) and C. gigas (zinc)(Tables 5.5 and 5.6). The presence of citrate and acetate anions had no effect on the concentrations of those elements required to reduce the filtering rates by 50%.

The presence of EDTA reduced the toxicity of both zinc and copper so that in both cases the metal concentration required to reduce the filtering rate by 50% significantly increased. The metal-NaDDC complex proved more toxic than either constituent added separately and the metal concentration which reduced the filtering rate by 50% was significantly reduced.

Despite the considerable amount of data now available on the accumulation of metals in marine organisms there is little information on the effects of metals on molluscs. The mechanisms by which pollutants affect filtering rate are not known. Brown and Newell (1972) tested the effects of high concentrations (500 µg/ml) of copper and zinc on M. edulis gill tissue. They showed that copper inhibits ciliary activity but does not affect the respiratory enzyme system. Zinc does not affect either process. Delhaye and Cornet (1975) showed that copper preferably accumulates in M. edulis gills and suggest that the inhibition of respiration takes place in this organ.

Scott and Major (1972) showed that living organisms or a heat-killed M. edulis homogenate could neutralise the copper (II) toxic effect and suggested that this was achieved passively by the complexing of the inorganic ions with available organic ligands. They reported that during uptake studies at 0,3 µg/ml copper, the immediate response of the mussels was to secrete copious amounts of mucus. Korringa (1952) found that cations could be absorbed onto the mucus of C. virginica gills. Scott and Major (1972) concluded that, since 0,3 µg/ml copper was lethal to 100% M. edulis, the lethal damage occurred during the first 36 h and was essentially irreversible, the initial metal-organic ligand complex formation being the toxic step.

The interpretation of metal-induced changes in respiration or other physiological functions is complicated by the fact that such changes differ for different metals, for different species, and from one experimental condition to another. Few detailed studies have been conducted on the physiological effects of metals on marine molluscs. Such studies are essential to an assessment of metal pollution.

CHAPTER 6 SOME FACTORS AFFECTING THE ACCUMULATION OF CADMIUM BY MOLLUSCS

6.1 INTRODUCTION

Laboratory studies have shown that some molluscs accumulate metals. The initial accumulation rate is proportional to the concentration of the metal when a minimum pollution threshold is exceeded, providing that the element concentration in the sea water is not toxic to the mollusc (Majori and Petronio, 1973; Pavičić and Järvenpää, 1974). Small individuals may accumulate metals at a faster rate than large ones (Schulz-Baldes, 1974; Cunningham and Tripp, 1975). The effects of varying water temperatures and salinities depend upon the metals and species being tested (Fowler and Benayoun, 1976b; Phillips, 1976a). Similarly the presence of other metals may affect the accumulation of a selected element (Romeril, 1971; Fowler and Benayoun, 1976a). The physico-chemical form of a metal can also affect the rate of metal uptake (Kopfler, 1974; George and Coombs, 1977), and metals may be accumulated directly from the water or from suspended matter such as food or sediment particles (Preston, 1971; Schulz-Baldes, 1974).

The species chosen for this study of some of the factors which affect cadmium accumulation are Crassostrea gigas, Crassostrea margaritacea, Perna perna and Choromytilus meridionalis. Experiments include the effects of changing water temperature and salinity, the presence of other metals or organic compounds, and accumulation of cadmium from food or sediment particles.

6.2 MATERIALS AND METHODS

All individuals were cleaned and acclimatised to experimental conditions, firstly in trays in a flowing water pond and then in 1000-litre tanks.

Comparative accumulation studies were carried out using 10 of each species (40 individuals) in each tank containing 40 l sea water. The experimental animals were suspended in the tanks on plastic nets in order to facilitate their removal and examination. Dead individuals were discarded.

Aliquots of a 10000 µg/ml stock cadmium solution (prepared using cadmium chloride) were added to achieve the required concentrations in each tank. Cadmium levels in the experimental solutions were not monitored during the experiments.

The experimental solutions were renewed daily for some experiments but only on alternate days for the remainder. This change was necessitated in order to fit in with FISCOR requirements for the communal sea water supply. The water was aerated continuously throughout each 3-week experiment.

The wet tissues of individuals which survived to the end of each experiment were removed from their shells and frozen preparatory to chemical analysis. The method used for the determination of the metal concentrations in those tissues has been described in Section 2.4. All the results, expressed as µg metal/g wet tissue, are tabled in Appendix 3. Although each set should comprise 10 results, some accidental losses have occurred during the chemical analysis. Incomplete sets are not necessarily due to mortality in a particular solution.

6.2.1 Uptake from solutions of different concentrations

The four species were exposed to cadmium in the range 0-200 µg/l for 3 weeks. The water temperature was 23-24°C and the solutions were renewed on alternate days.

6.2.2 Uptake with length of exposure

Three tanks containing 50 µg/l cadmium solutions were prepared. The solutions were renewed daily and the water temperature was 13-15°C. Ten individuals of each species were placed in the 3 tanks. After 1 week, three individuals of each species were removed from each tank; this procedure was repeated after 2 weeks and the remaining animals were collected at the end of the third week.

6.2.3 Effect of mollusc size on accumulation rate

Approximately 70 P. perna (wet mass range 0,1-10g) and 40 C. meridionalis (wet mass range 0,5-20g) were exposed to 100 µg/l cadmium for 3 weeks. Comparative data for C. gigas and C. margaritacea were obtained from other experiments.

6.2.4 Effect of temperature on accumulation rate

Duplicate tanks were prepared and maintained at 15, 18, 21 and 24°C using 150 watt thermostatic heaters. The experimental animals were acclimatised to the different temperatures for 5 days. Cadmium was then added to one tank at each temperature to give a final concentration of 50 µg/l. The solutions were renewed daily and were heated to the required temperature with a circulatory pump before the experimental animals were resuspended in the tanks.

6.2.5 Effect of salinity on accumulation rate

Duplicate tanks were prepared at salinities of 35, 30,6, 26,3 and 21,9°/oo and the experimental animals were acclimatised to these solutions for 4 days. Tap water was used to prepare these solutions for the first 3 days but rain or demineralised water was used to prepare all further solutions when it was discovered that the tap water contained significant concentrations of zinc and copper (Table 6.1).

TABLE 6.1 Metal concentrations in tap, demineralised and rain water at Knysna

	(µg/l)			
	Zn	Cd	Cu	Pb
Tap water	250	<0,1	750	<0,5
Rain water	1,8	<0,1	1,3	<0,5
Demineralised water	0,7	<0,1	0,4	<0,5

6.2.6 Effect of zinc, copper or lead on cadmium uptake

The four study species were exposed to 50 µg/l cadmium in the presence of 50 µg/l of one of the other elements. Solutions were renewed every second day.

6.2.7 Effect of some organic compounds on accumulation

Duplicate tanks containing 10 µg/ml of sodium citrate, sodium acetate and EDTA and 1 µg/ml NaDDC were prepared. Cadmium (100 µg/l) was added to one set of tanks and the other set was used as the control.

6.2.8 Uptake from sediment

A suspension of kieslguhr in 50 µg/ml cadmium in sea water was shaken for 3 days in order to facilitate adsorption of the cadmium on to the clay particles. The clay suspension was filtered, washed three times with clean sea water, air-dried and ground. The cadmium concentration in this powder was 1360 µg/g. 1g portions of untreated kieslguhr, a 50% mixture and the treated product were weighed into glass vials prior to the experiment.

Three tanks containing the four species were prepared. The water was renewed daily and the 1g clay sample was mixed into the clean water to form a fine suspension. A film of clay covered the shells at the end of 24 h and this was hosed off both shells and tanks prior to the next addition.

The calculated solution concentrations were 0, 17 and 34 µg/l cadmium.

6.2.9 Uptake from food

Tetraselmis chui cultures were prepared in the range 0–50 µg/l cadmium in sea water and were maintained for 1 week. Growth was the same in all treatments. Two 20-l cultures, a control and 20 µg/l cadmium, were prepared. 1100 ml volumes were removed daily from each culture; a 100 ml sample of each was filtered and retained for analysis; 1 litre was added to a 40-l tank containing 10 individuals of each of four species. The experiment was terminated after 3 weeks.

When the algal samples were analysed it was found that Tetraselmis chui had not accumulated cadmium. The experimental animals were discarded.

A second experiment was attempted using Phaeodactylum tricornutum. Four cultures were initiated in 10-l containers of artificial sea water, prepared according to Courtright et al. (1971) (Table 6.2). Zinc, cadmium and copper were added individually to three of the cultures to give a final concentration of 200 µg/l. All these cultures failed after 4 days. The cause of death is unknown but could be due to either the artificial medium or to lack of light. The presence of metals in three of the cultures probably contributed to their failure.

TABLE 6.2 Artificial sea water formulation used for algal cultures and oyster experiments (S=35°/oo)

Compound	Amount	Chemical quality
NaCl	1262 g	Cerebos coarse sea salt
$NaHCO_3$	7,65 g	AR
KCl	19,12 g	AR
$MgSO_4 \cdot 7H_2O$	294 g	AR
$CaCl_2 \cdot 2H_2O$	50,65 g	AR

The salts are added in order and dissolved in about 30 l water; $CaCl_2$ is dissolved in 5 l water and added to the tank and the volume made up to 40 l.

In a third experiment artificial sea water was prepared and filtered through a membrane filter of 0,45 µm pore size. Two cultures of P. tricornutum were initiated in 40-l tanks. These tanks were covered with a sheet of perspex and illuminated continuously with four daylight fluorescent tubes situated about 150 mm above the water surface. The cultures were aerated vigorously and volumes of a prepared nutrient solution were added daily. The original algal culture and the nutrient solution were supplied by A. Genade, FISCOR Oyster Cultivation Unit.

Cadmium was added to one tank to give a final solution concentration of about 200 µg/l; the concentration was monitored and more cadmium added as required. Samples of algae were collected and analysed to monitor cadmium accumulation.

Four 40-l tanks of artificial sea water were prepared and 25 oysters, either C. margaritacea or C. gigas, suspended in each. Volumes of the algal cultures were filtered through 0,45 µm membrane filters to separate the algae from their culture medium and these free algae were washed into the tanks of oysters with clean sea water. One tank each of C. margaritacea and C. gigas received treated algae; the other two tanks served as controls. The experiment was terminated after 7 days when the cadmium level in the filtered algae dropped to a very low level.

6.3 RESULTS AND DISCUSSION

Cadmium is accumulated from solution by C. gigas, C. margaritacea, P. perna and C. meridionalis. In all cases accumulation is proportional to concentration (Fig. 6.1) and increases with exposure period (Fig. 6.2). Smaller individuals accumulate cadmium at a greater rate than larger individuals of the same species (Figs. 6.3 and 6.4). However, different rates of uptake are observed for each species.

Cadmium uptake by C. gigas is more rapid than by C. margaritacea. This is due, in part, to a difference in behaviour between the two oyster species. C. gigas filters almost continuously while submerged whereas C. margaritacea does not start filtering immediately, nor does it filter continuously once it has started. In order to compare the rates of uptake for individuals of approximately equal whole mass it was necessary to use younger C. gigas because this species is inherently larger and faster growing than C. margaritacea. It has been shown that C. gigas (whole mass 50g) pumps about three times as much water as C. margaritacea of the same size (Fig. 5.5) and that the presence of low cadmium concentrations has a negligible effect on the filtering rates of these oysters (Fig. 5.7). Therefore the exceptional

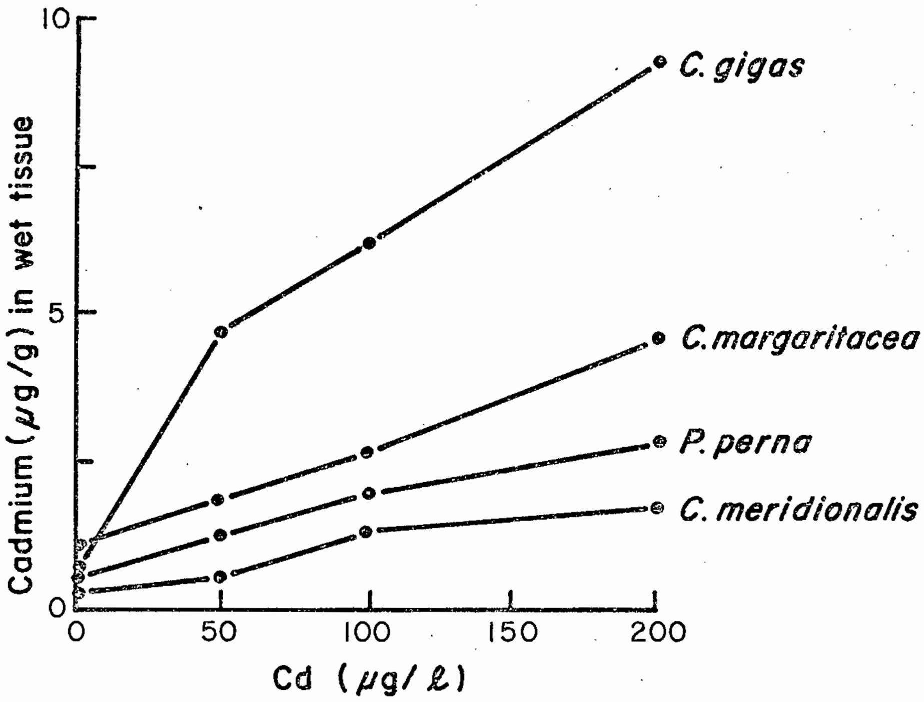


FIG. 6.1 : Cadmium uptake from solutions of different concentrations

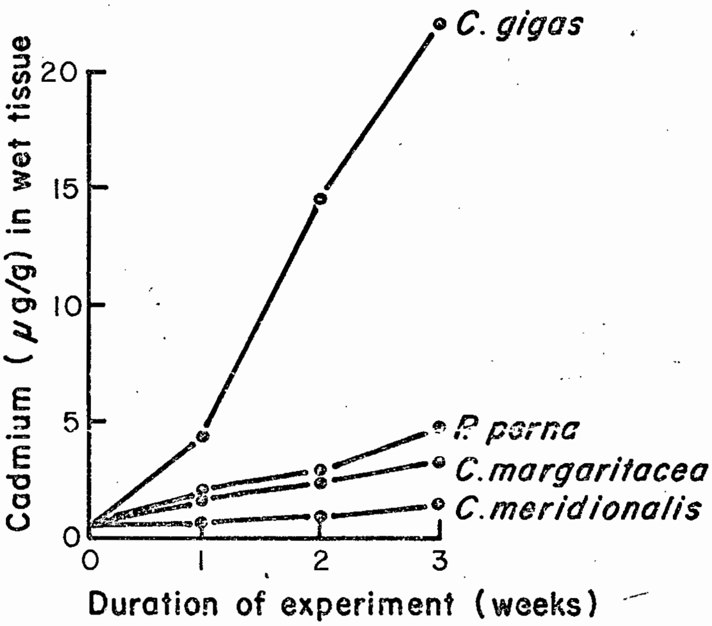
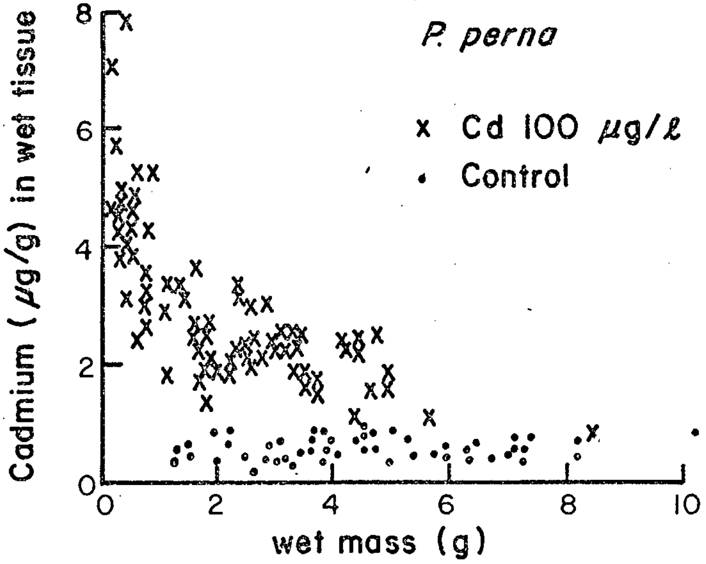


FIG. 6.2 : Cadmium uptake during 3 weeks exposure



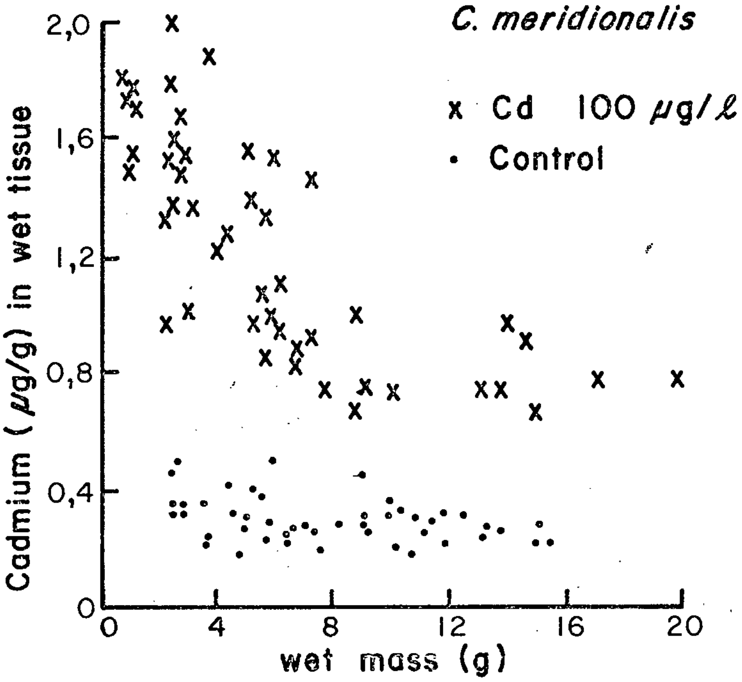
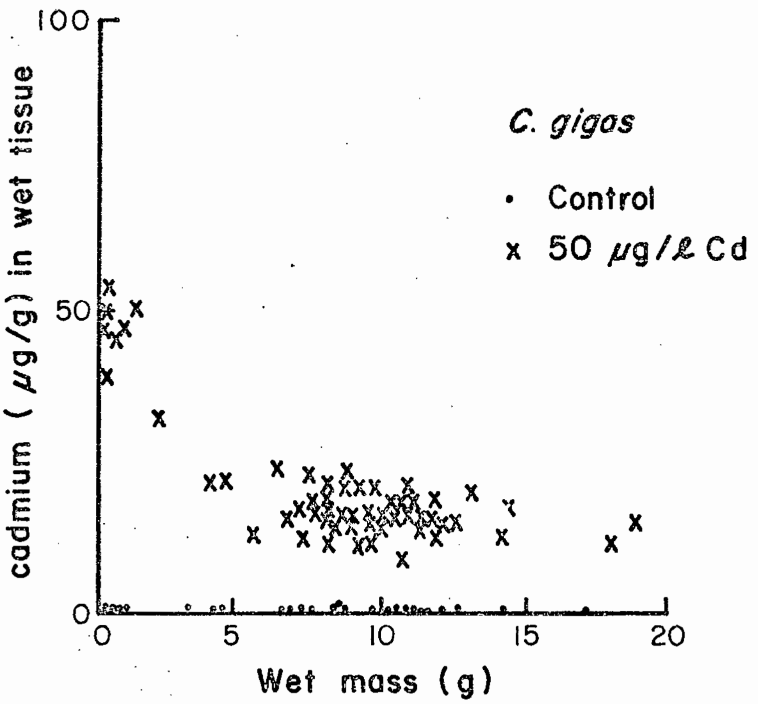


FIG. 6.3: Comparative rates of cadmium accumulation for mussels of different sizes



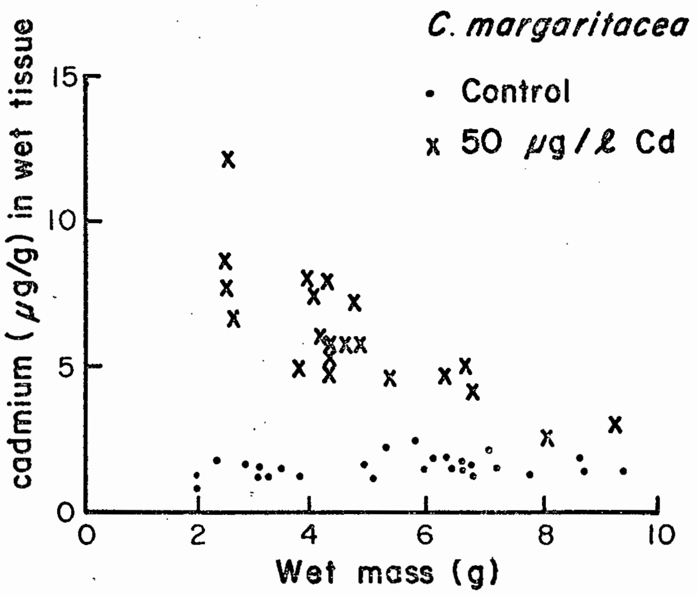


FIG. 6.4: Comparative rates of cadmium accumulation for oysters of different sizes

cadmium accumulation by C. gigas may be due to a higher metabolic rate in these young, fast growing individuals, compared with that of the mature (4-years-old) C. margaritacea.

C. meridionalis (shell length 50 mm) pumps twice as much water as P. perna of the same shell length (Fig. 5.4); low cadmium concentrations have a negligible effect on the filtering rates of these mussels (Fig. 5.6). Smaller mussels accumulate more cadmium than larger ones (Fig. 6.4). However, when individuals of equal whole mass are compared, it is seen that P. perna accumulates more cadmium than C. meridionalis under the same experimental conditions. The results indicate that there is a species difference between these two mussels.

The rate of cadmium uptake increases with increased temperature (Fig. 6.5) but this increase is not necessarily directly proportional to water temperature. The mussels were obviously stressed in the 24°C tanks. None died in the control-24°C solution, but, in the presence of 50 µg/l cadmium, seven C. meridionalis and one P. perna died during the first 12 days. No further deaths occurred to the end of the experiment and no oysters died in any treatment. This mortality is almost certainly due to an insufficient period of acclimatisation before the experiment was started. No deaths occurred at cadmium concentrations four times as high and at the same temperature (Fig. 6.1). Filtering rates in these four species increase slightly as the temperature is raised (Figs. 5.4 and 5.5) so that a larger volume of cadmium-rich sea water would be drawn through the mantle cavity. These results corroborate those observed for Mytilus edulis where accelerated cadmium uptake with increased temperature has been demonstrated (Jackim et al., 1977; Phillips, 1976a).

The effects of reduced salinity on cadmium uptake have also been tested (Fig. 6.6); no significant effects were observed for the salinity range 22-35°/oo. These experimental solutions were only renewed every second day so that the overall tissue concentrations are less than those which were attained in the previous experiment. These results contrast with those observed for M. edulis where cadmium uptake increased at lowered salinities (15-20°/oo) (Jackim et al., 1977; Phillips, 1976a).

Sudden reductions in salinity caused severe decreases in the filtering rates of the 4 study species (Figs. 5.4 and 5.5) which should result in a lower rate of cadmium accumulation. However, it has been reported that molluscs acclimatise to constant low-salinity conditions, so that for this experiment, the effect would be diminished. Nevertheless, in the estuarine situation, the overall effect of natural fluctuations in salinity would be

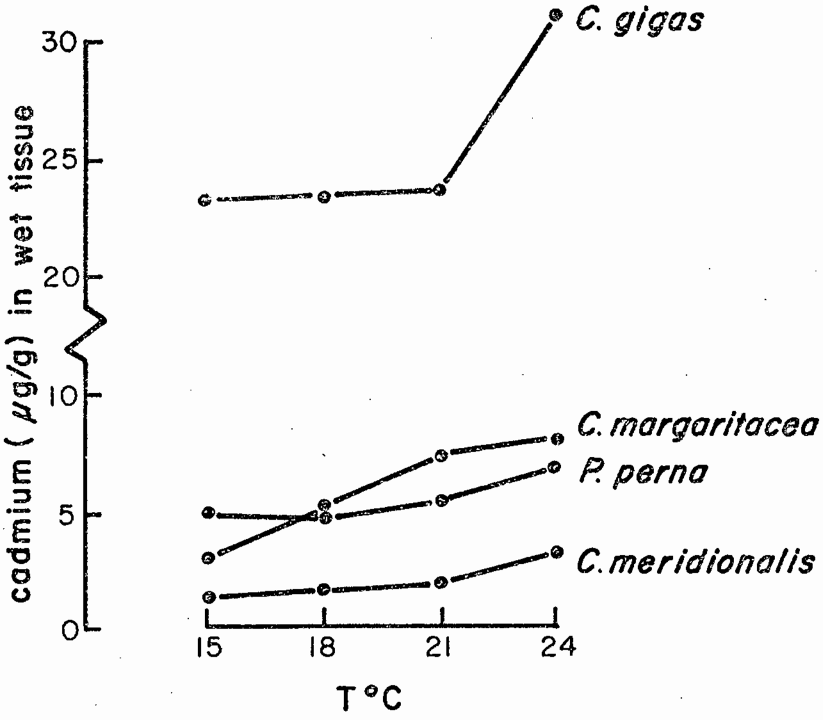


FIG. 6.5: The effect of temperature on cadmium uptake

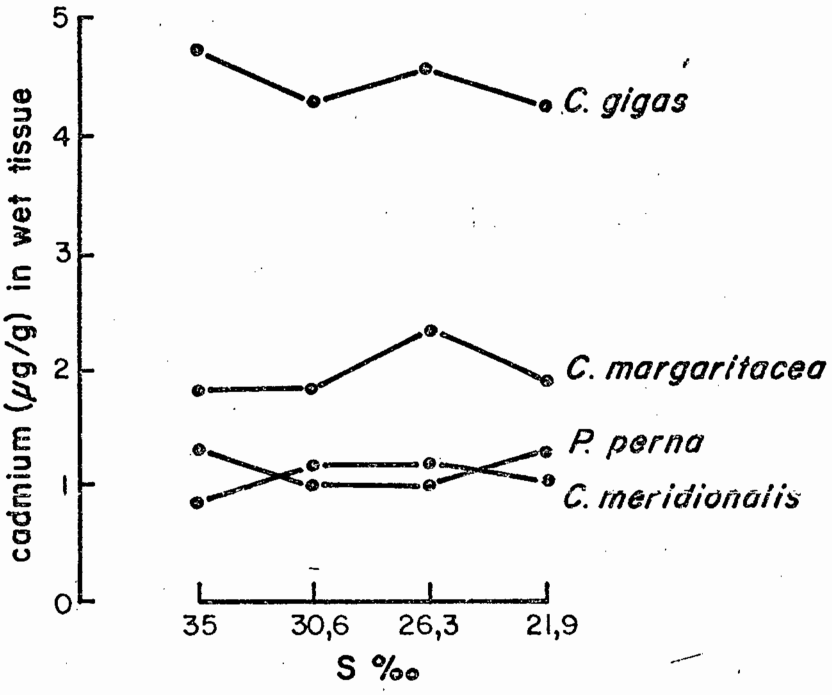


FIG. 6.6: The effect of salinity on cadmium uptake

to reduce the amount of water filtered, and presumably also the amount of metal taken into the body. Metals are often introduced into the marine environment in fresh water outfalls. Thus, if the behavioural reaction of the mollusc is to reduce its filtering rate and even to temporarily close its shell, it is possible that the presence of these metals will not be reflected in the mollusc tissue-metal concentration.

The presence of zinc has no significant effect on cadmium uptake by the four study species (Table 6.3).

TABLE 6.3 Cadmium uptake in the presence of zinc, copper and lead

Treatment µg/l	Results expressed as µg cadmium/g wet tissue C. gigas	C. margaritacea	P. perna	C. meridionalis
Cd 0	0,57	1,13	0,57	0,27
Cd 50	4,75	1,86	1,32	0,58
Cd50 + Zn50	4,11	2,09	1,45	0,67
Cd50 + Cu50	2,92	2,52	1,40	0,64
Cd50 + Pb50	4,82	2,43	1,49	0,83

The presence of copper may have inhibited cadmium uptake by C. gigas, but this effect is not observed for the other species; the presence of lead may have caused slightly increased cadmium accumulation in C. gigas, P. perna and C. meridionalis. The differences are small and no definite trend is observed for four study species. The observed results agree with those reported by Phillips (1976a), that no interactions between the various metals occur at these low levels. The presence of much higher zinc concentrations (500-1000 µg/l) have been reported to decrease cadmium (5 µg/l) uptake by M. edulis (Jackim et al., 1977). Fowler and Benayoun (1974) showed a trend towards decreased cadmium uptake at 100 µg/l zinc by Mytilus galloprovincialis. Evidently, the presence of zinc inhibits cadmium uptake by some species but not others. This competition is probably not significant from an ecological point of view because of the high zinc levels required to reduce cadmium uptake, particularly as cadmium is not an essential element. Nevertheless, the physiological mechanisms of metal interactions remain of interest.

The presence of citrate or acetate anions has no definite effect on the rate of cadmium uptake (Table 6.4), nor on the filtering rates for the four species (Section 5.4.3); 10 µg/ml of these sodium salts were not toxic during the 21-day experiment.

TABLE 6.4 Cadmium uptake in the presence of four organic compounds

Treatment	Results expressed as µg cadmium/g wet tissue			
	C. gigas	*C. margaritacea*	*P. perna*	*C. meridionalis*
Control	0,57	1,13	0,57	0,27
C+citrate	0,33	1,02	0,66	0,36
C+acetate	0,43	0,96	0,56	0,44
C+NaDDC	0,32	1,12	1,17	0,48
C+EDTA	0,34	1,01	0,55	0,52
Cd100 (µg/l)	9,6	3,68	2,19	1,48
Cd100+citrate	9,1	2,77	2,34	0,95
Cd100+acetate	10,1	4,12	2,33	0,92
Cd100+NaDDC	21,2	8,63	15,9	17,8
Cd100+EDTA	2,0	1,96	1,55	0,53
Experiment 2 using EDTA-complexed cadmium				
Control	0,70	1,17		
EDTA	0,98	1,24		
Cd100	79	11,1		
Cd100-EDTA	15,9	3,6		

The presence of the strong chelating agent sodium diethyldithiocarbamate (NaDDC) causes cadmium uptake to double in the case of oysters, and to increase by a larger factor for the mussels (Table 6.4). This chelating agent is extremely toxic to *C. gigas*; four individuals in the 1 ppm NaDDC-control and nine individuals in the NaDDC-100 µg/l cadmium treatment died during the 3-week experiment. NaDDC was shown to cause an immediate and significant reduction in filtering rates (Table 5.4) and the zinc-NaDDC complex was found to be much more toxic to *C. meridionalis* than either the metal or the organic compound alone. The exceptional accumulation of cadmium which occurred during this experiment is surprising in view of the measurable toxicity of the organic compound.

EDTA, another metal-complexing agent, has caused a decrease in cadmium uptake (Table 6.4). The presence of EDTA was reported to double the rate of cadmium accumulation by *Mytilus edulis*, the difference being that the cadmium was complexed prior to its addition to the experimental solutions (George and Coombs, 1977). These authors suggest that ionic cadmium must first be complexed before uptake can occur. However, if this is the case, then the addition of EDTA to cadmium-rich sea water should also cause an increase in the rate of cadmium uptake, although this increase may be less than for an equivalent concentration of precomplexed cadmium.

A second experiment was carried out using C. gigas and C. margaritacea. Stock cadmium (ionic) and cadmium-EDTA solutions were prepared and aliquots of these added to artificial sea water; the accumulation rates of ionic and complexed cadmium are compared (Table 6.4). A similar result to the first experiment has been obtained, ionic cadmium being accumulated at a greater rate than EDTA-complexed cadmium.

Cadmium is accumulated more rapidly when presented in particulate form (Fig. 6.7). This experiment can be criticised on the grounds that the cadmium may desorb from the clay when it is added to the sea water, and thus be present in ionic form. However, in order to minimise such desorption the cadmium adsorption on to the clay was carried out in sea water and the treated clay was washed three times with clean sea water before use. In the event that all the cadmium which was adsorbed on to the clay should desorb when the clay is suspended in sea water, the total amounts of cadmium added to each tank (calculated as µg/l) are accumulated more rapidly than when the equivalent cadmium concentration is prepared by addition of cadmium chloride. For example, C. gigas exposed to 34 µg/l cadmium (added as clay suspension) for 3 weeks achieved a final tissue concentration of 36 µg/g, compared with 24 µg/g when this oyster is exposed to 50 µg/l ionic cadmium. The differences are even greater for the other three species. These results suggest that ingestion plays a role in cadmium uptake. Similar work is reported by Morrison et al. (1977) who used "tracer microspheres" labelled with cadmium-109. The nuclide is incorporated within the particle and is not leached into the experimental solution. Their results showed that the particles accumulated in the digestive tract from whence cadmium could be adsorbed into the body tissues.

Cadmium is also accumulated from algae (Table 6.5). This experiment was terminated after 7 days when the cadmium concentration in the algae dropped to 0,05 µg/g wet tissue, which meant that a much larger amount of algae had to be added to the oysters in order to present sufficient cadmium for accumulation. This amount of algae was not cleared from the water in the 24-h period between additions.

The total amount of cadmium added to two of the experimental tanks was 900 µg. In the case of C. gigas, where the increase in mean tissue-cadmium concentration is about 3 µg/g, 70% of the added cadmium has been taken up; C. margaritacea has accumulated about 20% of the added cadmium.

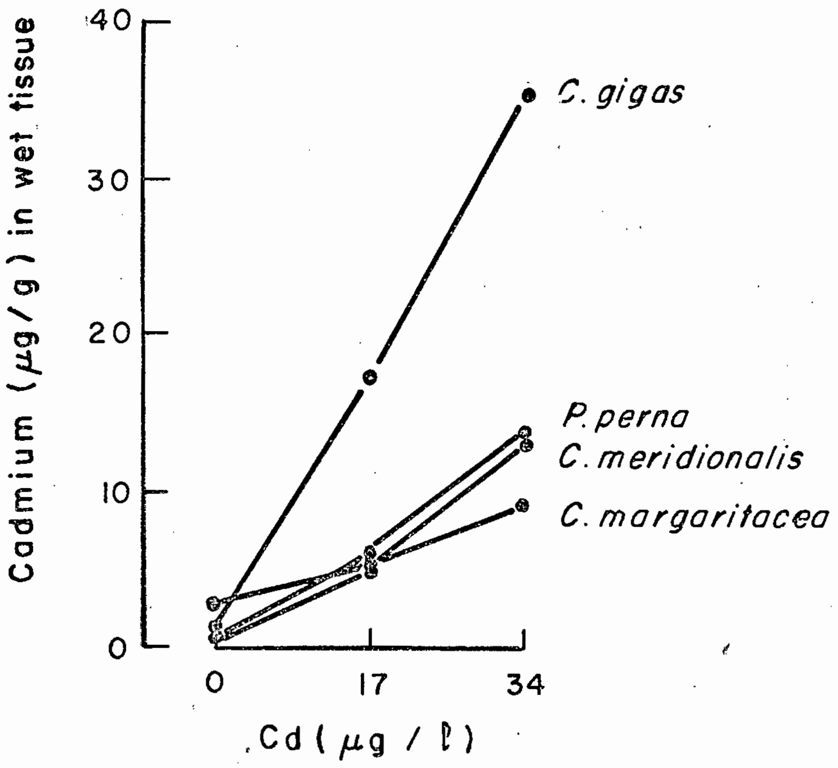


FIG.6.7: Cadmium accumulation from sediment

TABLE 6.5 Accumulation from cadmium-rich *Phaeodactylum tricornutum*

SPECIES	Results are expressed as µg cadmium/g wet tissue	
	Control algae	Cadmium-rich algae
C. gigas	0,44	3,40
C. margaritacea	0,29	1,37

The mean equivalent cadmium concentration in the water is 3,2 µg/l during the 7-day exposure; the cadmium tissue concentrations which are achieved by the end of this period (Table 6.5) are similar to those observed for the same oysters after a 3-week exposure to 30-40 µg/l ionic cadmium (Fig. 6.1). Food could be a very important source of metals for oysters. These results contrast with those reported for *M. edulis* where approximately equal amounts of lead from ionic solutions and from lead-rich algae in control solutions were accumulated (Schulz-Baldes, 1974). Chromium uptake from water was more rapid than uptake from food for *Crassostrea virginica*, although Preston (1971) concluded that under natural conditions more chromium would be available to this oyster from the particulate phase. *M. edulis* is reported to accumulate the metals zinc, manganese, cobalt and iron from food to a greater extent than from water (Pentreath, 1973).

The main difficulty which was experienced with this experiment was to cause the algae to accumulate cadmium. The cadmium concentrations in *P. tricornutum*, monitored on a daily basis, fluctuated between 0,05 and 1,32 µg/g. The greatest concentrations were recorded when the culture was initiated in cadmium-rich sea water and grown to strength over a period of 5 days; cadmium was not accumulated significantly when the metal was added to the mature culture. Only two cultures were prepared for this experiment and subsamples of these were used to feed the oysters. Ideally, 10 or more 2-litre cultures should have been initiated at the rate of two a day, so that cadmium accumulation would take place as each culture matured; these cultures could be filtered individually (the cadmium concentration in the algae having been measured) and used to feed the oysters. New cultures would be initiated at regular intervals to ensure the continuation of the experiment for a preselected period.

6.4 SUMMARY

6.4.1 The rates of accumulation from solutions of low cadmium concentration are proportional to the solution concentrations for C. gigas, C. margaritacea, P. perna and C. meridionalis. Different accumulation rates were observed for each species. The amounts of cadmium accumulated increase with increased exposure period. Smaller individuals accumulate cadmium at a greater rate than larger ones.

6.4.2 Rates of cadmium accumulation increase with increased temperature. Although reduced salinity did not have a significant effect on the rates of cadmium accumulation by these species, nevertheless the effects of changes in this parameter may be greater under slightly different experimental conditions. Such effects are important, particularly in estuarine areas, since most metals enter the marine environment in freshwater outfalls.

6.4.3 The presence of certain organic compounds may affect the rates of cadmium uptake. Low concentrations of other metals were not shown to have any effect.

6.4.4 Accumulation from cadmium-rich food and cadmium-rich sediment occurs at a greater rate than from ionic solution of equivalent concentration.

6.4.5 These experiments relate only to the accumulation of cadmium by the four study species. Further experiments should include studies of the effects of changing environmental conditions on the uptake of other metals by these species and should be extended to other species of interest.

CHAPTER 7 COMPARATIVE STUDIES ON THE ACCUMULATION OF METALS

7.1 INTRODUCTION

Laboratory studies indicate that a number of elements may be accumulated by certain molluscs. However, in most cases, the experiments have been concerned with the accumulation of a single element by a selected species under controlled laboratory conditions. Relatively few studies on comparative rates of metal uptake and on interelement effects when more than one element is presented at the same time, have been reported; even fewer of these studies compare such effects for two or more species.

Comparative studies have been carried out for a number of elements using *Crassostrea gigas*, *Crassostrea margaritacea*, *Perna perna* and *Choromytilus meridionalis*. In addition, some data have been obtained on the accumulation and loss of metals by *C. gigas* and *C. margaritacea* under natural conditions.

7.2 MATERIALS AND METHODS

7.2.1 Laboratory studies

General experimental conditions were similar to those already described for the experiments on cadmium accumulation (Section 6.2). Stock solutions were prepared from metal chlorides for the elements zinc, cadmium, copper, lead, iron, manganese, nickel and cobalt; sodium dichromate was used for the chromium standard. Metal levels in the experimental solutions were not monitored.

The results, expressed as μg metal/g wet tissue, are tabled in Appendix 3.

7.2.1.1 The four study species were exposed to 100 μg/l of one of the elements zinc, cadmium, copper, lead, iron, manganese, nickel, cobalt and chromium for 3 weeks. In a second experiment, the same four species were subjected to 0, 50, 100 or 200 μg/l of either zinc, copper or lead.

7.2.1.2 The effect of cadmium on the accumulation of zinc, copper and lead was investigated and accumulation from a zinc, copper and cadmium mixture (0-50 μg/l) was measured.

7.2.1.3 Three tanks were prepared which contained 10 ppm sodium citrate in sea water; either 100 µg/l iron or manganese were added to two of the tanks and the third served as the control.

Stock solutions of zinc, copper and lead were prepared containing an excess of ethylenediaminetetraacetic acid (EDTA); ionic metal solutions were prepared at equivalent concentrations. The relative accumulation rates for ionic and complexed metals were measured for C. gigas and C. margaritacea. This experiment was carried out in artificial sea water (Table 6.2).

7.2.1.4 Known amounts of stock solutions containing either zinc, cadmium, copper or lead were added to 40 l of artificial sea water to give final concentrations in the range 0-500 µg/l. These experimental solutions were renewed every fourth day during the 21-day experiment.

7.2.2 Field studies

Wooden frames were prepared, covered in plastic mesh and wired together in such a way that the oysters were completely enclosed. The oysters (50 per tray) were scrubbed clean, weighed and measured before being secured in the trays. In Knysna estuary these trays were roped to a pre-constructed wooden rack (Fig. 3.1; site 9). At the Blue Hole (Algoa Bay), these trays were supported on concrete blocks about 300 mm above the sediment.

The trays were retrieved at intervals and samples collected for analysis. The remaining oysters were secured in freshly prepared mesh trays and replaced at their original site.

Sample analysis was carried out using the method described in Section 2.4; all results, expressed as µg metal/g wet tissue, are tabled in Appendix 3.

7.3 RESULTS AND DISCUSSION

Mean tissue-metal concentrations for C. gigas, C. margaritacea, P. perna and C. meridionalis exposed to nine elements are listed in Table 7.1. From these results it is possible to calculate an Accumulation Factor, defined as the ratio of the mean concentration of the study element in the tissue of a treated individual to the mean concentration in the tissues of a number of reference individuals which had not been exposed to that element. The use of the composite mean for the reference sample is valid because the presence of an element did not cause an increase or decrease in the values

TABLE 7.1 Mean tissue-metal concentrations following 3 week exposures to nine elements

Treatment	µg metal/g wet tissue								
	Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
C. gigas									
Control	142	0,57	11,2	<0,05	24,1	2,03	0,05	0,01	0,20
Cd 100	110	6,32	11,0	0,07	12,8	1,36	0,08	0,04	0,28
Zn 100	132	0,33	12,0	0,05	14,0	1,61	0,04	0,01	0,18
Cu 100	99	0,45	23,3	<0,05	14,1	1,31	0,06	0,02	0,22
Pb 100	94	0,35	8,6	1,34	12,8	1,62	0,07	0,02	0,24
Fe 100	124	0,37	10,4	<0,05	13,7	1,74	0,07	0,02	0,22
Mn 100	116	0,35	10,5	<0,05	14,3	1,60	0,02	0,02	0,20
Ni 100	97	0,33	6,9	0,05	18,3	1,54	0,47	0,01	0,25
Co 100	105	0,34	9,2	0,07	15,1	1,61	0,05	0,41	0,15
Cr 100	155	0,46	13,8	0,06	22,2	1,67	0,05	0,02	0,65
C. margaritacea									
Control	115	1,13	1,42	0,08	5,8	0,50	0,03	<0,02	0,21
Cd 100	114	2,70	1,04	0,07	5,8	0,34	0,04	<0,02	0,24
Zn 100	128	0,92	1,36	0,14	5,2	0,33	0,04	<0,02	0,47
Cu 100	125	1,13	7,36	0,06	6,9	0,50	0,05	<0,02	0,25
Pb 100	134	1,16	1,51	1,78	6,5	0,40	0,04	<0,02	0,22
Fe 100	120	1,01	1,32	0,05	7,1	0,40	<0,02	<0,02	0,28
Mn 100	98	1,04	1,00	0,10	6,4	0,40	0,07	<0,02	0,40
Ni 100	101	1,02	1,44	0,12	6,7	0,46	0,28	<0,02	0,28
Co 100	127	1,03	1,52	0,11	6,6	0,41	0,02	0,07	0,36
Cr 100	118	1,10	1,63	0,09	7,4	0,35	0,02	<0,02	0,61
P. perna									
Control	12,0	0,57	0,74	0,22	12,8	0,28	0,38	<0,02	0,28
Cd 100	9,7	2,05	0,70	0,26	15,3	0,34	0,48	0,03	0,43
Zn 100	12,7	0,41	0,51	0,27	12,5	0,28	0,46	<0,02	0,31
Cu 100	13,1	0,52	1,79	0,18	15,3	0,32	0,52	<0,02	0,42
Pb 100	9,1	0,56	0,46	2,93	15,0	0,29	0,45	<0,02	0,25
Fe 100	12,6	0,53	0,55	0,17	15,0	0,29	0,48	<0,02	0,35
Mn 100	10,8	0,53	0,55	0,16	15,6	0,37	0,38	<0,02	0,36
Ni 100	10,9	0,64	0,62	0,20	13,9	0,35	0,82	0,02	0,29
Co 100	10,0	0,68	0,54	0,35	16,9	0,26	0,47	0,46	0,44
Cr 100	10,6	0,51	0,68	0,30	16,7	0,38	0,49	0,05	0,81
C. meridionalis									
Control	14,3	0,27	1,16	0,19	6,1	1,29	0,07	0,03	0,24
Cd 100	15,0	1,40	0,99	0,12	9,0	1,44	0,12	0,02	0,32
Zn 100	15,8	0,32	0,84	0,16	8,4	1,31	0,13	0,02	0,34
Cu 100	12,4	0,31	1,44	0,10	7,7	1,49	0,10	0,02	0,28
Pb 100	13,3	0,32	0,85	3,32	8,5	1,20	0,10	0,02	0,34
Fe 100	15,1	0,32	1,11	0,17	7,4	1,51	0,09	0,02	0,28
Mn 100	13,5	0,31	0,91	0,17	7,8	1,55	0,15	0,03	0,24
Ni 100	14,7	0,36	1,08	0,20	7,4	1,42	0,65	0,02	0,41
Co 100	13,3	0,30	0,81	0,19	6,4	1,51	0,12	0,38	0,29
Cr 100	14,0	0,24	0,80	0,12	7,1	1,37	0,08	0,02	0,47

Accumulation factors

	C. gigas	*C. margaritacea*	*P. perna*	*C. meridionalis*
Zn	1,1	1,1	1,2	1,1
Cd	16,2	2,5	3,7	4,6
Cu	2,2	5,4	3,0	1,5
Pb	33,5	19,8	12,7	20,8
Fe	0,8	1,1	1,0	1,0
Mn	1,1	1,0	1,2	1,1
Ni	9,4	7,0	1,8	5,9
Co	24,1	3,5	23,0	19,0
Cr	3,0	2,0	2,3	1,6

of other elements in any of the samples. These accumulation factors can be used to indicate whether significant metal accumulation did occur relative to the normal tissue-metal concentration.

Zinc, iron and manganese are apparently not accumulated under these experimental conditions (Table 7.1); moderate accumulation of cadmium, copper, nickel and chromium did occur. Very high accumulation factors were determined for lead and cobalt.

It is also possible to calculate the rate of accumulation (µg/g/day) of each element by each species for a given set of experimental conditions (Table 7.2) and these figures can be used to compare the accumulation rates of a metal in each of the study species, or the accumulation rates of a number of metals in the same species.

TABLE 7.2 Accumulation rates during 3-week exposures to 100 µg/l metals

	µg/g/day			
Element	*C. gigas*	*C. margaritacea*	*P. perna*	*C. meridionalis*
Zn	0,57	0,57	0,10	0,07
Cd	0,28	0,08	0,07	0,05
Cu	0,61	0,29	0,06	0,02
Pb	0,06	0,08	0,13	0,15
Fe	<0,01	0,03	<0,01	<0,01
Mn	0,01	<0,01	<0,01	0,01
Ni	0,02	0,01	0,02	0,03
Co	0,02	<0,01	0,02	0,02
Cr	0,02	0,01	0,02	0,01

The four species were exposed to 100 µg/l of each of the elements for 3 weeks. The oysters accumulate zinc and copper at the fastest rate while cadmium and lead are accumulated at a slower rate. The remaining elements are accumulated very slowly, if at all. Lead is accumulated at the fastest rate by the mussels; zinc, cadmium and copper at a slower rate; and, as was seen for the oysters, iron, manganese, nickel, cobalt and chromium are accumulated very slowly indeed. The question remains whether the comparative lack of accumulation of these elements is due to a chemical mechanism in the solution whereby the element is rendered unavailable to the mollusc (e.g. precipitation or complexation) or to some form of discrimination, whether passive or active, on the part of the mollusc.

The accumulation of zinc, copper and lead in the range 0-200 µg/l was also investigated (Fig. 7.1). Zinc, added as the chloride, is not accumulated significantly by any species. Copper and lead are both accumulated and the resulting tissue concentrations are proportional to the

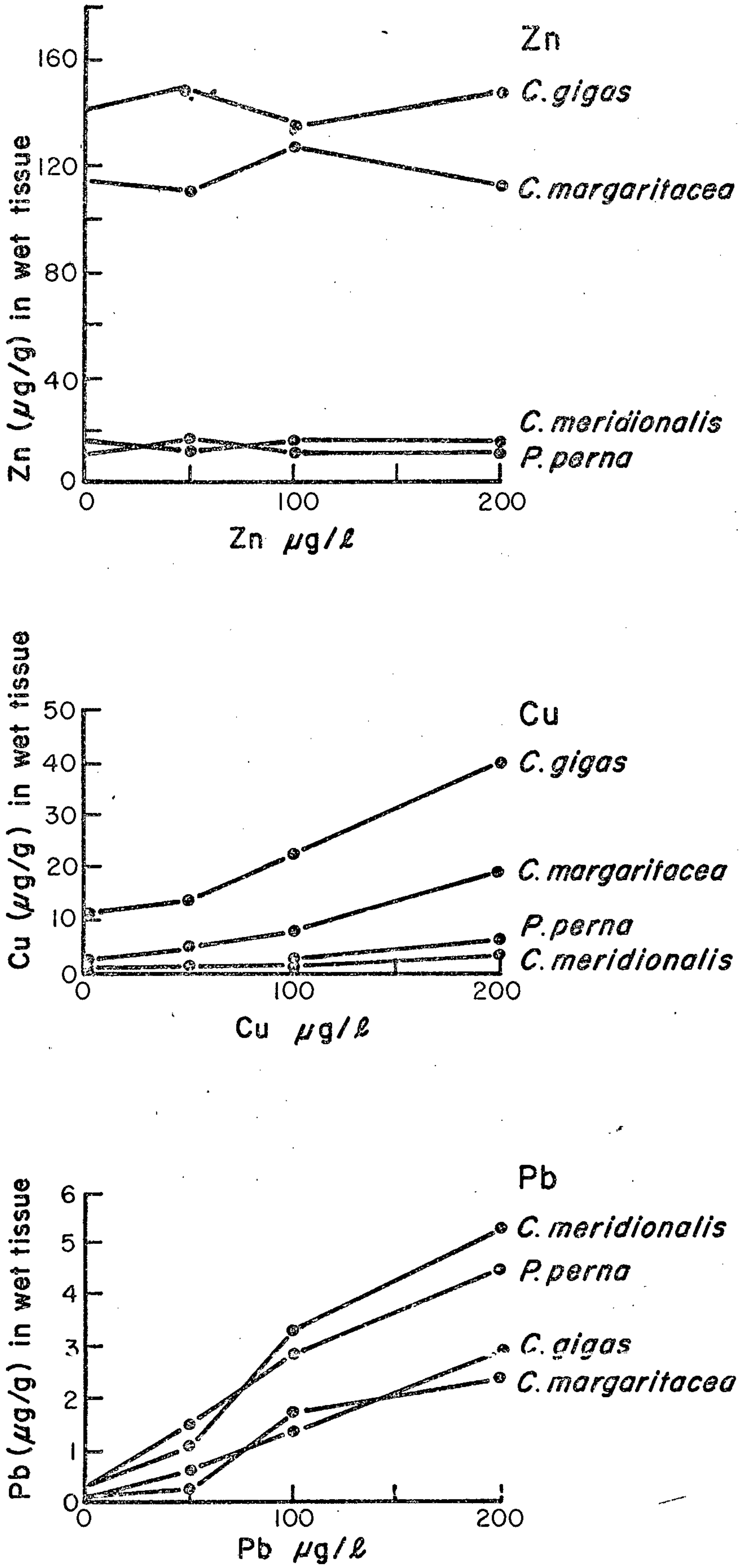


FIG. 7.1 : Accumulation of zinc, copper and lead

solution concentration; lead is accumulated to a greater extent by the mussels.

The presence of cadmium had no effect on the accumulation of zinc, copper or lead (Table 7.3). These results agree with those reported by Phillips (1976a) and are consistent with the theory that no interactions between these metals occur at such low levels.

TABLE 7.3 The effect of cadmium on zinc, copper and lead accumulation

Treatment µg/l	Results as µg metal/g wet tissue C. gigas	C. margaritacea	P. perna	C. meridionalis
Zn 0	142	115	12,0	14,3
Zn 50	154	111	15,9	12,6
Zn 50+Cd 50	140	113	16,2	14,6
Cu 0	11,2	1,42	0,74	1,16
Cu 50	13,9	4,43	1,06	1,21
Cu 50+Cd 50	13,5	4,53	1,29	1,17
Pb 0	0,05	0,08	0,21	0,15
Pb 50	0,62	0,32	1,49	1,02
Pb 50+Cd 50	0,51	0,52	1,16	0,77

The accumulation of zinc, cadmium and copper from solutions containing all three elements in the range 0-50 µg/l was also investigated (Table 7.4). Greater mortality was observed for this experiment than when the metals were added individually or two together; the mussels in the 50 µg/l treatment did not survive the 3-week experiment.

TABLE 7.4 Accumulation of zinc, cadmium and copper from solutions containing a mixture of these elements

Treatment µg/l	Zn	Cd	µg metal/g wet tissue Cu	Zn	Cd	Cu
	C. gigas			C. margaritacea		
0	146	0,5	23	131	0,9	1,5
10	159	6,6	54	140	2,8	8,7
25	178	17,2	138	160	5,5	27,3
50	174	20,3	232	144	6,2	44,9
	P. perna			C. meridionalis		
0	9,7	0,6	0,9	11,3	0,3	1,5
10	14,2	2,3	3,5	11,6	1,0	3,0
25	13,6	4,6	20,1	11,7	2,0	15,3

Copper and cadmium are accumulated extremely rapidly but only slight if any zinc accumulation has occurred, relative to the total concentrations. Solutions in the 100-500 μg/l range were previously tested. Very few individuals survived the 3-week exposures to these higher concentrations and accumulation by those which did survive was slower. The concentrations which have been achieved in the present experiment cannot be compared directly with those of the two previous experiments; these experimental solutions were renewed every day, but only every second day for the other experiments.

The accumulation of zinc, copper and lead, complexed with EDTA was compared with the accumulation of the ionic forms for C. gigas and C. margaritacea (Table 7.5). The results obtained for the uptake of cadmium under similar conditions are included for comparison. This experiment was carried out using artificial sea water.

TABLE 7.5 Accumulation of ionic and EDTA-complexed metals by C. gigas and C. margaritacea

Treatment	Results expressed as μg metal/g wet tissue Zn	Cd	Cu	Pb
C. margaritacea				
Control	105	1,17	8,12	0,56
Control-EDTA	118	1,24	3,92	0,22
M 200 μg/l (ionic)	149	11,1	35,1	3,23
EDTA-M 200 μg/l	101	3,59	6,42	4,22
C. gigas				
Control	221	0,70	30,8	0,67
Control-EDTA	154	0,98	25,7	0,86
M 200 μg/l (ionic)	383	79	242	6,62
EDTA-M 200 μg/l	100	15,9	24,2	3,52

Ionic zinc, cadmium, copper and lead are all accumulated, the first three elements to a greater extent than their equivalent complexed form. The rates of accumulation for C. gigas (7,7, 3,7, 10,1 and 0,14 μg/g/day respectively) and C. margaritacea (2,1, 0,5, 1,3 and 0,13 μg/g/day respectively) are greater than those determined for their exposure to 100 μg/l (Table 7.2); C. gigas accumulates zinc, cadmium and copper at a much greater rate than C. margaritacea. The rates which have been determined are greater than expected on the basis of the previous experiment. Complexed zinc and copper are not accumulated; EDTA-complexed cadmium is accumulated but to a lesser extent than ionic cadmium. Ionic and complexed lead are accumulated by C. margaritacea to about the same extent; the accumulation of ionic lead by C. gigas is twice as fast as that of complexed lead.

This is the first experiment where zinc has been accumulated at a significant rate, relative to normal tissue-metal concentrations. A number of experiments on the accumulation of zinc have been reported. Mytilus edulis accumulated zinc from solutions of 26 µg/l (Pentreath, 1973) and Crassostrea angulata and Ostrea edulis from solutions of 1 µg/l (Romeril, 1971). In both cases the radiotracer zinc-65 was added as the chloride and only the accumulation of the tracer was measured. Phillips (1977b) reported the accumulation of stable zinc from solutions containing 400-1000 µg/l. It is possible that a minimum zinc threshold has only just been exceeded in the present experiments, the highest concentration tested being 200 µg/l, so that although zinc may be taken into the body, either it is being eliminated at about the same rate, or its accumulation from the soluble phase is well regulated.

The zinc levels being tested are already substantially more than those found in so-called polluted areas. However, the zinc concentrations determined for these experimental animals are very much lower than some which have been reported for individuals growing in polluted areas (Tables 3.1-3.3). It must be concluded that these concentrations have been achieved during a very long exposure period or that the chemical or physical form of the zinc plays an important role in the uptake mechanism. Further experiments on the accumulation of this element associated with food or sediment particles or complexed by naturally occurring organic compounds, complemented by biochemical studies such as those described by Coombs (1972; 1974) could clarify the mechanism by which this element is normally accumulated.

Apart from zinc, the other elements which are not significantly accumulated are iron and manganese. These two elements are chemically similar in that they are readily oxidised in solution to form hydrated oxides which may flocculate and precipitate. Therefore, although soluble iron and manganese were added to the experimental solutions, these elements may not have remained in solution for the experiment. The citrate anion stabilises iron in solution preventing the formation of hydrated oxides. The accumulation of both iron and manganese in the presence of sodium citrate has been investigated (Table 7.6).

Iron-59 tracer studies have shown that 'soluble' iron from citrated sea water is accumulated either directly or via adsorption on to the mucus used in feeding (Hobden 1969). However, in the present experiment, the overall iron concentration has not increased either in the presence or absence of sodium citrate, which suggests that if iron is being accumulated

TABLE 7.6 Accumulation of iron and manganese in the presence of sodium citrate

Treatment	µg metal/g wet tissue			
	C. gigas	C. margaritacea	P. perna	C. meridionalis
Iron				
Control	24,1	5,8	12,8	6,1
C+citrate	13,8	7,0	13,4	5,5
Fe 100 µg/l	13,7	7,1	15,0	7,4
Fe 100+citrate	17,8	7,7	16,9	6,5
Manganese				
Control	2,03	0,50	0,28	1,58
C+citrate	1,43	0,49	0,31	1,22
Mn 100 µg/l	1,60	0,40	0,37	1,55
Mn 100+citrate	1,68	0,41	0,38	1,35

it is eliminated at about the same rate. A similar result was observed for manganese.

A mechanism for the elimination of iron from mussels has been identified. Pentreath (1973) used autoradiography to show that iron-59 accumulated in clusters in M. edulis foot. These iron clusters disappeared after 2 weeks in clean sea water and were probably secreted into new byssus threads (Hobden 1969; Pentreath 1973). It has also been shown that 30% of the iron presented to the gut is not absorbed (George *et al.*, 1976).

It is not sufficient that metal accumulation can be demonstrated in laboratory studies where the metals to be tested are necessarily present in much greater than normal concentrations in order to achieve measurable accumulation in a suitably short period. Such studies must be complemented by a demonstration that the same species will accumulate metals under natural conditions.

The ability of molluscs to accumulate metals has been used with varying degrees of success to indicate the presence of, and even to monitor the extent of, metal pollution in the marine environment. However, in most cases these studies have only involved the collection and analysis of samples from a number of sites followed by a discussion relating the results to natural or manmade sources of metals. If molluscs are going to be used to monitor low-level chronic pollution or the intermittent addition of pollutants to water, a more systematic method must be adopted. The method which was investigated in the present study was the introduction of individuals containing near base-line trace metal concentrations into an area suspected to be contaminated with metals.

Connell *et al.* (1976) report that elevated copper, cadmium, lead and zinc in water samples from the mouth of the Swartkops River are derived from power station cooling water. *C. margaritacea* collected from the Blue Hole in Algoa Bay (Fig. 3.2) have been found to contain high zinc and copper concentrations (Table 3.3). *C. gigas* and *C. margaritacea* were transferred from Knysna estuary to the Blue Hole. Six-month-old *C. gigas* were used for this experiment, which was to be terminated within one year, so that this exotic species would not mature and spawn in the bay. At the same time *C. margaritacea* from the Blue Hole were transferred into Knysna estuary in order to measure rates of metal loss from this species.

Samples were collected from the Blue Hole after 4 and 7 months and analysed (Table 7.7). Considerable accumulation of zinc, copper and lead has occurred in both species during the 7 months these oysters were at the Blue Hole. The accumulation of zinc is interesting in view of the absence of significant accumulation during most of the laboratory experiments. Cadmium concentrations, which are suspected to be slightly above background in Knysna oysters, have become lower during the 7-month experiment.

Trace metal concentrations in *C. margaritacea* transferred from the Blue Hole to Knysna estuary (Fig. 3.1; site 9) have been monitored on a monthly basis (Table 7.8); they are compared with the concentrations determined for this species collected from the Knysna coast.

Zinc and copper loss is slow, about 30 and 50% reductions respectively of the initial concentrations occurring during the 10-month period in clean water. The cadmium concentration has not increased. High cadmium concentrations have only been observed for molluscs grown in the region of the Knysna Heads or on the nearby coast; the rack system to which these oysters were transferred is higher up the estuary. Lead concentrations, which were not excessive, have returned to background levels during the period in clean water. Iron and manganese concentrations are also lower but this is probably due to the lower particulate content of the Knysna water, compared with the Blue Hole. It is very hard to clear the gut of all particulate material before analysis. Nickel concentrations may have increased slightly during the period in Knysna but no significant changes are observed for cobalt or chromium. The concentrations of these three elements in *C. margaritacea* from the Blue Hole are not noticeably greater than normal.

Rates of metal loss have been shown to be generally lower than rates of accumulation. It is reported that a large percentage of the cadmium accumulated by *Mytilus galloprovincialis* was lost at an extremely slow rate (Fowler and Benayoun, 1974; Majori and Petronio, 1973). Hobden (1969)

TABLE 7.7 Metal accumulation by oysters transferred from Knysna estuary to the Blue Hole

Species and Sample		Wet mass g	Results expressed as µg metal / g wet tissue									
			Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
C. gigas											
Initial sample	April 1977	4,58	122	0,88	11,3	0,05	16	1,4	0,05	0,03	0,17
Site A	August 1977	5,91	286	0,28	25,4	0,33	87	3,6	0,13	0,05	0,65
Site A	November 1977	10,68	305	0,14	30,3	0,34	72	4,7	0,19	0,01	0,25
Site B	August 1977	6,86	186	0,24	19,4	0,20	68	3,1	0,09	0,02	0,47
Site B	November 1977	11,00	223	0,14	28,8	0,31	63	3,6	0,16	<0,01	0,32
C. margaritacea											
Initial sample	April 1977	7,93	96	0,84	1,4	0,10	5	0,4	0,02	<0,01	0,51
Site A	August 1977	4,46	176	0,61	2,6	0,07	24	0,6	0,05	0,02	0,46
Site A	November 1977	3,96	260	0,28	6,7	0,32	39	1,0	0,19	0,02	0,67
Site B	August 1977	5,56	226	0,58	5,7	0,09	17	0,6	0,09	0,04	0,56
Site B	November 1977	3,82	244	0,34	8,5	0,20	26	0,8	0,09	<0,02	0,25

TABLE 7.8 Trace metal loss from C. margaritacea transferred from the Blue Hole to Knysna Estuary

Sample	Wet mass g	Results expressed as µg metal / g wet tissue								
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
April 1977	10,77	574	0,31	7,8	0,15	31	1,18	0,04	0,02	0,23
June 1977	7,02	550	0,44	9,3	0,13	21	0,65	0,03	0,02	0,36
July 1977	6,18	491	0,35	6,3	0,20	27	0,70	0,06	0,02	0,46
August 1977	9,12	554	0,43	9,3	0,16	20	0,68	0,02	0,01	0,32
Sept. 1977	7,66	428	0,36	7,8	0,11	20	0,73	0,03	0,02	0,22
Oct. 1977	9,17	399	0,67	7,1	0,07	36	0,85	0,07	0,02	0,33
Nov. 1977	11,00	445	0,36	9,7	0,10	22	0,77	0,06	0,02	0,25
Dec. 1977	10,64	380	0,28	3,9	0,09	27	0,99	0,08	0,02	0,21
Jan. 1978	9,45	333	0,28	4,6	0,08	25	0,66	0,06	<0,01	0,19
Feb. 1978	11,21	448	0,29	4,5	0,04	14	0,32	0,08	<0,01	0,12
Knysna coastal oysters April 1977	7,93	96	0,84	1,4	0,10	5	0,4	0,02	<0,01	0,51

found no significant iron loss from M. edulis which, having been subjected to low iron concentrations in a long-term experiment, were then transferred to clean sea water for 10 days. Pentreath (1973) reported significant losses of iron from M. edulis, but not of zinc or manganese, after 42 days in clean water. A very slow rate of loss for zinc-65 in M. galloprovincialis was recorded and Kečkeš et al. (1968) demonstrated that this rate of loss was dependent upon the length of exposure to the activity. Young and Folsom (1967) also recorded a long biological half-life for zinc-65 in Mytilus californianus which they estimated to be 76 ± 4 days.

Major element concentrations in C. margaritacea also changed during the 10 month period in Knysna estuary. These variations are compared with those observed for the same species growing at Belvedere (Fig. 7.2). Calcium, magnesium and sodium levels were initially higher in the polluted oysters; potassium levels were significantly lower. The concentration differences between the two populations became less during the experimental period. Major element concentrations in C. gigas and C. margaritacea transferred to the Blue Hole were also measured (Table 7.9). The potassium levels in both species are considerably lower after 7 months.

TABLE 7.9 Major element concentrations in oysters transferred to a polluted site

SAMPLE		µg metal/g wet tissue Ca	Mg	Na	K
Crassostrea margaritacea					
April 1977	Initial sample	568	1112	6346	2252
August 1977	Site A	446	1198	7294	1163
	Site B	536	1226	7628	1201
November 1977	Site A	660	1058	6405	1496
	Site B	449	792	5154	975
Crassostrea gigas					
April 1977	Initial sample	958	1432	7180	1896
August 1977	Site A	730	1360	8266	1137
	Site B	509	1183	7225	960
November 1977	Site A	826	1051	7065	1225
	Site B	621	1120	7593	1071

An increase in metal content may also correlate with a decrease in body dry mass (Sheppard and Bellamy, 1974). Saward et al. (1975) reported that copper had a significant effect on the condition of Tellina tenius (dry flesh mass at standard length); this was due to a reduction in both

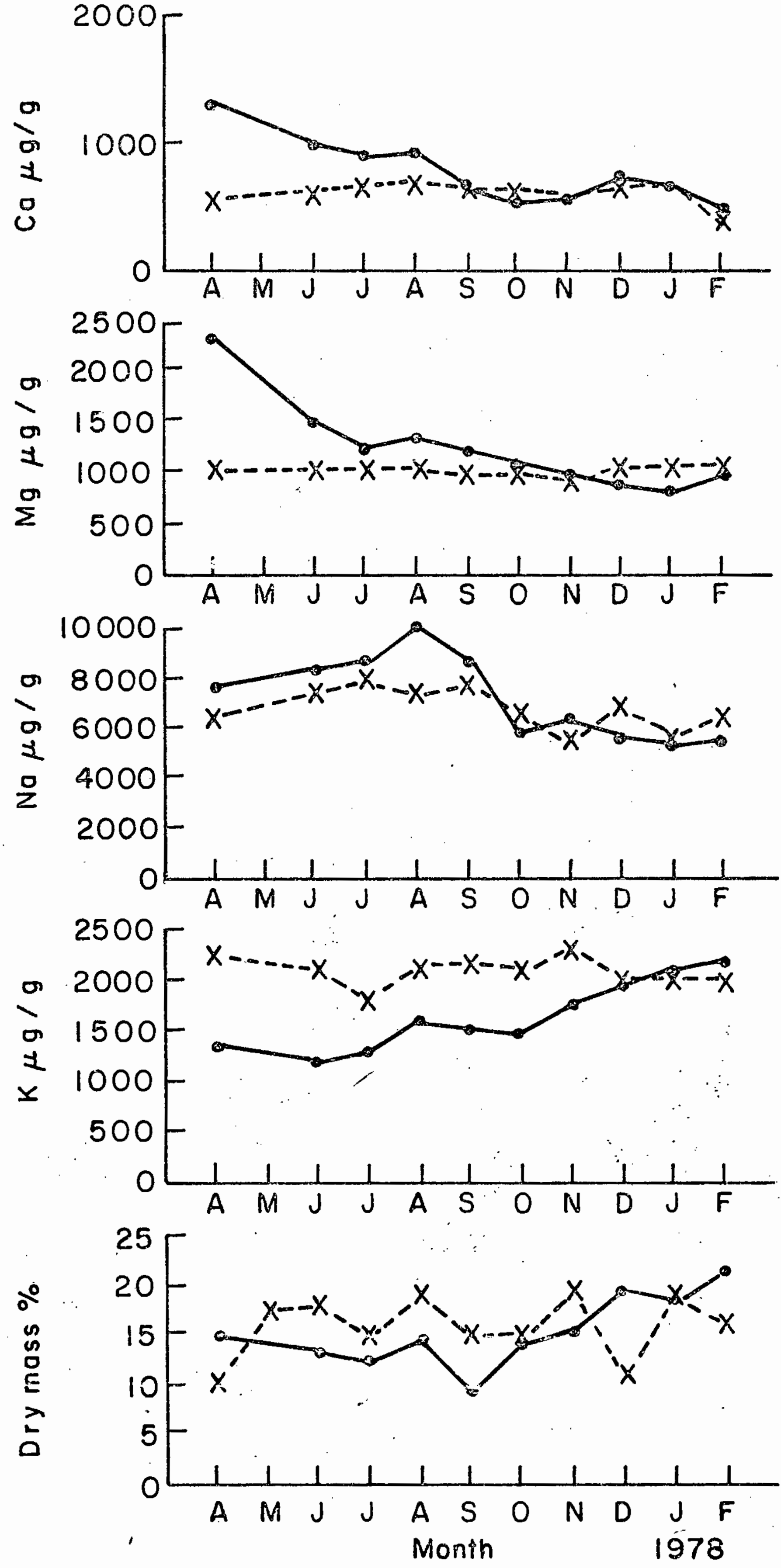


FIG.7.2 : *Crassostrea margaritacea*. Major element concentration variations with season for a normal population (X) and for oysters transferred from a polluted area to a clean one (⊙)

carbohydrate reserves and nitrogen levels. This result is important because reduced reserves would adversely affect the animals' survival potential. Dry tissue (%) is also plotted for C. margaritacea (Fig. 7.2); no significant differences are observed between the two populations.

Variations in major element concentrations were also investigated in two laboratory studies. The effects of 0, 250 and 500 µg/l zinc, cadmium, copper or lead were examined for C. gigas and C. margaritacea (Table 7.10). Following zinc treatment the concentrations of calcium, magnesium and sodium had increased and potassium concentrations decreased for both species. No such consistent results were obtained for the other treatments. A second experiment to determine the uptake rates of ionic and complexed metals was carried out using the same two oysters. Major element concentrations were measured following the 3-week exposures to zinc, cadmium, copper and lead (Table 7.11). Potassium concentrations were lower in all cases following metal treatment. Calcium, magnesium and sodium concentrations were variable and the differences between the treatments and controls were not significant.

One of the problems encountered with regard to major element concentration variations is the dependence of concentration on animal size. The relationships between major element and size are plotted for an unpolluted population (zinc ~ 200 µg/g; copper ~ 1 µg/g) and a polluted population (zinc ~ 500 µg/g; copper ~ 8 µg/g) of C. margaritacea (Fig. 7.3). Calcium concentrations are not significantly different for the 2 populations; magnesium concentrations are greater in the polluted oysters for the size range tested. Sodium concentrations are greater but potassium concentrations are less in the polluted oysters up to 15 g wet mass; there are probably no significant differences for these elements between the two populations for the larger oysters.

Sheppard (1977) has reported that animal tissue concentrations of these four major elements vary greatly but in a way that corresponds to the levels of toxic elements and suggested that this may cause much of the stress experienced by the species studied (two echinoderms and one mollusc) in polluted areas. The results obtained for the gastropod Patella vulgata during this study were very consistent; only potassium showed an inverse relationship with lead, copper, nickel and zinc concentrations. It has been reported that lead and copper can damage cell membranes allowing potassium, which occurs inside cells in higher concentration than in their surroundings, to leak out (Davson and Danelli, 1938). With a disturbance of ionic balance, resulting from a loss of potassium ions, a readjustment by some of the other major cations may be expected in order to maintain concentration and electrochemical gradients.

TABLE 7.10 Major element concentrations in oysters exposed to trace metals

Treatment µg/l	µg metal/g wet tissue				
	Zn	Ca	Mg	Na	K
Crassostrea gigas					
0	158	375	576	8235	999
Zn 250	309	355	648	8994	932
Zn 500	358	420	661	9318	919
Crassostrea margaritacea					
0	125	401	556	8104	1027
Zn 250	160	461	588	8157	1056
Zn 500	208	522	612	8512	925
	Cd	Ca	Mg	Na	K
Crassostrea gigas					
0	0,9	375	576	8235	999
Cd 250	67,3	358	614	8745	901
Cd 500	91,0	327	669	8845	866
Crassostrea margaritacea					
0	1,2	401	556	8104	1027
Cd 250	26,0	438	577	8380	1042
Cd 500	38,9	426	568	8197	1051
	Cu	Ca	Mg	Na	K
Crassostrea gigas					
0	9	375	576	8235	999
Cu 250	253	150	643	8841	964
Cu 500	380	352	662	8538	1057
Crassostrea margaritacea					
0	3,9	401	556	8104	1027
Cu 250	25,4	303	590	8669	1131
Cu 500	32,4	621	563	8288	1068
	Pb	Ca	Mg	Na	K
Crassostrea gigas					
0	0,3	375	576	8235	999
Pb 250	17,4	378	671	9100	921
Pb 500	50,2	346	646	8708	1006
Crassostrea margaritacea					
0	0,2	401	556	8104	1027
Pb 250	11,4	564	560	7990	1028
Pb 500	30,7	564	618	8586	996

TABLE 7.11 Major element concentrations in oysters exposed to ionic and complexed metals

Treatment µg/l	µg metal/g wet tissue				
	Zn	Ca	Mg	Na	K
Crassostrea gigas					
Control	221	250	350	10454	841
EDTA-Control	154	210	360	10826	909
Zn 200	383	200	360	9746	752
EDTA-Zn 200	100	190	360	10488	676
Crassostrea margaritacea					
Control	105	260	300	7424	1718
EDTA-Control	118	240	310	7892	1629
Zn 200	149	184	290	8172	1407
EDTA-Zn 200	101	210	300	8978	1497
	Cd	Ca	Mg	Na	K
Crassostrea gigas					
Control	0,7	250	350	10454	841
EDTA-Control	1,0	210	360	10826	909
Cd 200	79,0	150	360	9774	682
EDTA-Cd 200	15,9	140	380	10080	222
Crassostrea margaritacea					
Control	1,2	260	300	7424	1718
EDTA-Control	1,2	240	310	7892	1629
Cd 200	11,1	200	310	7305	1585
EDTA-Cd 200	3,6	200	290	7776	1521
	Cu	Ca	Mg	Na	K
Crassostrea gigas					
Control	31	250	350	10454	841
EDTA-Control	26	210	360	10826	909
Cu 200	242	210	350	10748	688
EDTA-Cu 200	24	190	330	10193	725
Crassostrea margaritacea					
Control	8	260	300	7424	1718
EDTA-Control	4	240	310	7892	1629
Cu 200	35	300	310	8144	1495
EDTA-Cu 200	6	250	280	9059	1579
	Pb	Ca	Mg	Na	K
Crassostrea gigas					
Control	0,7	250	350	10454	841
EDTA-Control	0,9	210	360	10826	909
Pb 200	6,6	200	360	10589	772
EDTA-Pb 200	3,5	180	330	10276	748
Crassostrea margaritacea					
Control	0,6	260	300	7424	1718
EDTA-Control	0,2	240	310	7892	1629
Pb 200	3,2	220	320	8099	1535
EDTA-Pb 200	4,2	350	310	9748	1385

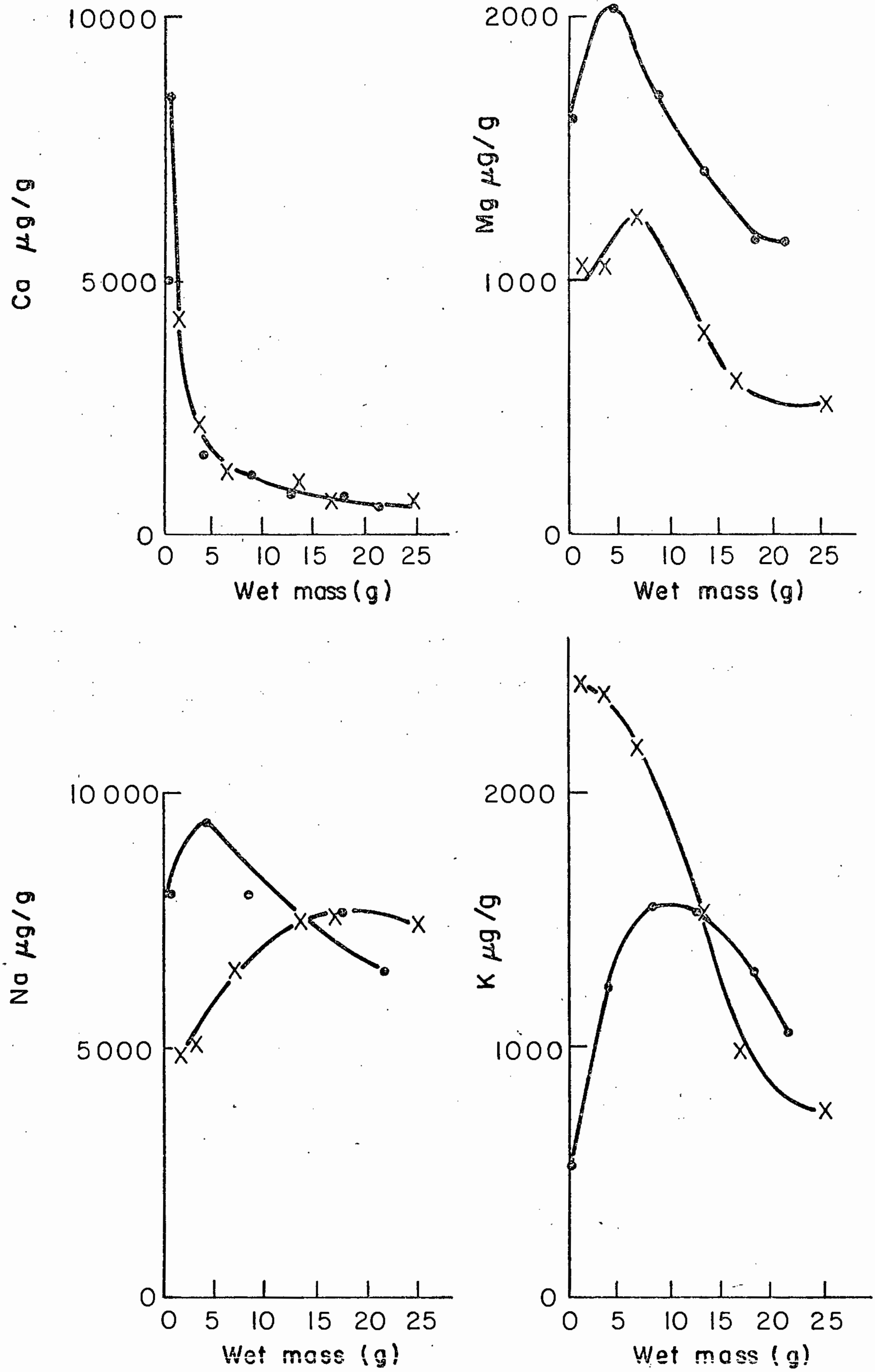


FIG.7.3: *Crassostrea margaritacea.* Relationships between major element concentrations and size

x unpolluted ● polluted

7.4 SUMMARY

7.4.1 The accumulation of nine elements by C. gigas, C. margaritacea, P. perna and C. meridionalis has been studied. Rates of accumulation differ for each of the elements and species. Zinc, cadmium, copper and lead are accumulated at the fastest rates.

7.4.2 Calculated accumulation factors indicate the significance of this accumulation relative to the normal tissue-metal concentration. Zinc, iron and manganese are apparently not accumulated. In view of the excessive zinc concentrations which have been reported, particularly for C. gigas, this lack of significant zinc accumulation suggests that these high concentrations have been achieved during a very long exposure period or that the chemical or physical form of the zinc in solution plays an important role in the uptake mechanism.

7.4.3 Copper and lead accumulation are proportional to solution concentration for all species.

7.4.4 The presence of cadmium has no effect on the accumulation of zinc, copper or lead.

7.4.5 Ionic cadmium, copper and lead are accumulated to a greater extent than their respective EDTA complexes. The presence of sodium citrate does not cause increased iron or manganese accumulation.

7.4.6 C. margaritacea and C. gigas transferred to a polluted environment for 7 months have accumulated zinc, copper and lead. During this period the tissue-potassium concentrations have become considerably lower.

7.4.7 Zinc and copper loss is slow for C. margaritacea transferred from a polluted to a clean environment; however, tissue-potassium concentrations increase during the 10-month period in clean water.

CHAPTER 8 CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

8.1 INTRODUCTION

The purpose of this investigation was to define more clearly the conditions under which selected molluscs could be used to monitor metal pollution in South African coastal environments. The species *Crassostrea gigas*, *Crassostrea margaritacea*, *Perna perna* and *Choromytilus meridionalis* were selected for this study on the basis of the reported use of related *Crassostrea* and *Mytilus* species as indicators of metal pollution in other countries (Section 1.3). The investigation included

1. the determination of metal concentrations in molluscs collected from polluted and unpolluted environments;

2. laboratory and field experiments to determine rates of metal accumulation and loss;

3. the determination of the toxicity of selected metals to the study species (as measured by their effects on filtering rates).

8.2 ASSESSMENT OF THE FOUR STUDY SPECIES AS MONITORING ORGANISMS

8.2.1 Metal concentrations in natural populations

Considerable variations in metal concentrations occur for a single population; for example smaller individuals frequently have higher concentrations than larger individuals of the same species and the concentrations of certain metals vary considerably between male and female mussels. The possibility of seasonal differences in metal concentrations or variations due to the position of the mollusc in the water column cannot be discarded, although significant variations related to these parameters were not observed in the present study.

A monitoring programme should be designed to minimise these differences. Individuals of a selected species should be of similar size (i.e. wet tissue mass) and preferably as large as possible to facilitate analytical accuracy. Twenty individuals from each location is a suggested minimum sample number. The sex of mussels should be recorded so that undue bias in terms of the numbers of each sex in a sample can be taken into account. This is particularly important in the case of zinc. Samples should be collected during the same season unless seasonal effects have been shown to be insignificant with respect to a particular survey. Similarly individuals should be sampled at the same depth unless the absence of vertical concentration gradients have been confirmed.

8.2.2 Metal accumulation and loss

The prime requirement for a monitoring organism is that it should accumulate the pollutant in a predictable way; that is, a simple correlation should exist between the metal content of the organism and the average metal concentration in the surrounding water at each of the locations studied and under all conditions. The experiments described in the present investigation were intended to identify some of the factors which might affect rates of metal uptake. The quantification of effects was expected to be extremely difficult as molluscs in their natural environment are exposed to constantly fluctuating conditions.

The accumulation of cadmium by the four study species has been studied in detail both to determine the effects of selected variables on the rate of accumulation and to demonstrate the suitability of these species as test organisms. The results of these experiments indicate that the rates of ionic cadmium accumulation are proportional to solution concentration and the amounts accumulated are proportional to the exposure period. However, different accumulation rates are observed for each species and the smaller individuals accumulate cadmium at a greater rate than larger ones. Cadmium accumulation increases with increased solution temperature but is not affected by changes in water salinity or the presence of other metals. Accumulation from cadmium-rich food and sediment occurs at a greater rate than from ionic solution and complexation with certain organic ligands also affects the rate of uptake.

Strictly speaking, in view of these results, the four study species cannot be used to monitor cadmium pollution quantitatively because the accumulation of this element is influenced by too many environmental variables. In practice, a qualitative indication can be achieved. The results from field sampling surveys can be interpreted with greater confidence when the effects of these variables are known.

Comparative studies show that different elements presented at the same concentration (100 µg/1), are accumulated at different rates by the four study species. The variables already shown to have an effect on cadmium accumulation will probably also affect the uptake of other elements but the relative importance of these variables may differ. Similar experiments should therefore be carried out to determine the effects of these variables on the accumulation rate of each element considered to be important in a particular survey.

The laboratory experiments have shown that all four species are particularly tolerant of experimental conditions and are excellent test organisms. Field experiments with both oysters and mussels indicate that these species can also be grown in rack systems. This means that individuals from unpolluted areas can be transferred to suspected polluted areas and the rates of metal uptake measured during long-term experiments, thereby providing an integrated measure of the pollutant load in the area.

8.2.3 Metal toxicity

The solution concentrations tested for these accumulation experiments and also those tested for their effects on adult molluscs or their larvae are higher than those which would normally be found under polluted conditions. This implies that these species are sufficiently tolerant of the presence of metals in their environment to act as monitoring organisms.

In order to accumulate metals, bivalves must pump water through the mantle cavity. However, the presence of a metal may affect the filtering rate, which may affect in turn the rate of metal accumulation. Zinc, cadmium, copper and lead do not affect the filtering rates of the four study species to the same extent but the concentrations which reduce the filtering rates by 50% are generally lower than the equivalent LC_{50}'s.

Data from toxicity tests are often used when determining permissible levels for effluent discharges and discussion continues as to the most suitable "standard" toxicity test. However, the results obtained during the present investigation suggest that one "standard test" on one organism is not sufficient for this purpose. For example, the data on the effects of copper on adult mussels show that there is a critical concentration at about 0,2 µg/ml above which this element is extremely toxic. The oysters, however, are more sensitive to copper, 0,09 µg/ml reducing filtering rates by 50% and 0,04 µg/ml causing a 50% reduction in larval settlement. The presence of cadmium does not affect mussel filtering rates significantly; that is not to say that this element is not toxic, but rather that its effect on some other biological function should be measured. For example, 0,5 µg/ml cadmium reduced byssal thread production by 50% (Martin <u>et al</u>., 1975). Cadmium affects oyster filtering rates at a much lower level than was determined for the mussels (50% reduction at ~ 0,8 µg/ml) but the larvae are even more sensitive, 50% fewer settling in the presence of 0,02 µg/ml cadmium.

An important reaction by both adult oysters and mussels is valve closure. For example, it is possible to estimate the 96 h LC_{50} incorrectly because the valves remain closed throughout the experiment. This has a further implication in the context of monitoring because molluscs react to conditions of reduced salinity in the same way. In the estuarine environment, where fluctuations in water salinity occur regularly and where effluents (often freshwater in nature) may be discharged into the freshwater stream, the mollusc which has closed its valves as a reaction to low salinity may, as a consequence, avoid the pollutant; alternatively, the presence of certain pollutants may also cause valve closure. The ability of molluscs to monitor pollutant input under these conditions is diminished.

8.3 SUGGESTIONS FOR FURTHER RESEARCH

8.3.1 Accumulation, toxicity and monitoring organisms

The present research should be continued to include detailed studies on the accumulation and effects of elements other than cadmium on the four study species under variable but controlled conditions. The results of such studies are required for the meaningful interpretation of field data. Other species can also be included in these studies; for example, Crassostrea cucullata may be a useful monitoring organism for the Natal coast. Preliminary experiments with Donax serra show that this species is suitable as a test organism provided that it is allowed to burrow normally in sand. Accumulation and toxicity studies will show whether this species can be used to monitor pollution along sandy beaches. The gastropods Patella and Bullia are also suitable test organisms and may be useful as monitoring organisms as long as they do not move out of polluted areas,

The research described was limited to the effects of metals and their accumulation. However, there is no reason why the experiments cannot be modified in order to study the effects of other pollutants such as oil, pesticides or specific effluents.

8.3.2 Metal speciation

Traditional analytical techniques are unable to determine the form of the metal in environmental samples. The majority of analytical data so far collected has been concerned with total metal concentrations and not with the concentrations of metal species. Little is known with regard to the distribution, residence time and concentration of the various metal species in water and sediment samples. This is primarily because the complex analytical technology required to determine the low concentrations of metal usually present is still being developed. However, the chemical nature of the metal is of critical importance in controlling the toxicity and availability of the element to organisms. Organometallics are often more toxic to organisms than their inorganic forms but in some cases complexation or chelation of ionic metals will reduce their toxicity; for example, compare the influences of sodium diethyldithiocarbamate and ethylenediaminetetraacetic acid on the effects of zinc or copper on mollusc filtering rates (Section 5.4).

Many investigations have been carried out in recent years on certain aspects of the speciation of metals in solution. However, these have been concerned usually with inorganically complexed ions, metal complexes with simple organic compounds and volatile organometallics. Recently gas chromatography coupled with mass spectrometry has been used to isolate, identify and determine some specific organic compounds in environmental samples and the success of this technique has prompted studies using gas chromatography - atomic absorption spectroscopy. These techniques are not yet fully developed but are likely to constitute the major analytical tools with which the environmental chemist can investigate metallic species in environmental samples.

8.3.3 Biochemical studies

Investigations into the potential hazards of heavy metal pollution has focused on molluscs and their ability to concentrate metals. While many studies have been concerned with the total concentrations or tissue distributions, little is known about uptake mechanisms, the subsequent metabolism of trace metals or their detoxification. It has been shown that enzyme activity can be altered by metals (e.g. George and Coombs, 1975); however, there are probably other sub-lethal effects on endocrinology, cell biology, haematology, histopathology and various physiological functions. A knowledge of these effects would contribute greatly to any assessment of metal toxicity, particularly with regard to the setting of permissible levels in the marine environment.

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APPENDICES

1. Analysis of trace elements in biological tissues
2. Natural trace element concentration in selected molluscs
3. Experimental data

APPENDIX 1.1 The effect of drying temperature on metal content of biological tissue

	T °C	Dry mass (%)	µg metal/g wet tissue								
			Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
Mean*	25		110	4,5	2,0	0,50	104	0,83	0,97	0,44	0,15
SD **			5,3	0,3	0,1	0,06	7,2	0,09	0,10	0,04	0,02
RSD%***			4,8	7,7	5,0	12,5	6,9	11,3	10,2	8,3	15,2
Mean	50	18,8	113	4,5	2,1	0,50	105	0,86	1,01	0,44	0,15
SD			3,8	0,2	0,1	0,06	2,4	0,11	0,11	0,05	0,03
RSD%			3,3	4,1	3,3	13,0	2,2	12,5	10,7	12,1	21,7
Mean	60	17,5	108	4,2	2,0	0,51	105	0,89	0,90	0,45	0,14
SD			3,0	0,3	0,1	0,05	3,9	0,10	0,08	0,03	0,03
RSD%			2,8	6,1	5,9	9,1	3,7	11,5	8,5	6,8	22,5
Mean	70	16,8	110	4,2	2,0	0,49	100	0,87	0,90	0,46	0,15
SD			5,0	0,2	0,1	0,06	5,3	0,06	0,06	0,05	0,03
RSD%			4,6	5,8	4,2	12,3	5,3	7,2	6,8	10,7	19,4
Mean	80	16,9	106	4,2	2,0	0,50	100	0,89	1,03	0,44	0,15
SD			4,3	0,2	0,1	0,03	5,3	0,12	0,10	0,03	0,03
RSD%			4,1	5,8	4,5	6,4	5,3	13,0	10,1	6,9	19,7
Mean	90	16,9	113	4,2	2,2	0,53	101	0,76	1,09	0,46	0,17
SD			3,9	0,2	0,1	0,07	3,0	0,05	0,10	0,04	0,03
RSD%			3,4	3,5	3,8	9,7	2,9	6,7	9,1	8,0	16,1
Mean	100	17,3	116	4,2	2,0	0,51	106	0,94	1,01	0,45	0,17
SD			1,6	0,1	0,1	0,05	2,3	0,04	0,11	0,03	0,03
RSD			1,3	1,7	2,7	10,8	2,2	4,1	11,2	7,0	17,0
Mean	110	18,8	111	4,5	2,1	0,55	105	0,92	1,05	0,45	0,17
SD			3,6	0,2	0,1	0,04	4,3	0,08	0,08	0,02	0,03
RSD%			3,2	4,3	5,3	7,7	4,1	9,2	7,8	5,3	14,9
Mean	120	16,9	115	4,2	2,1	0,55	102	0,92	1,06	0,47	0,16
SD			5,0	0,1	0,1	0,02	4,8	0,05	0,05	0,03	0,03
RSD%			4,4	3,5	4,2	4,2	4,7	5,8	4,7	6,3	16,4
Mean	135	16,5	101	3,6	1,8	0,52	96	0,71	0,94	0,43	0,15
SD			3,7	0,3	0,2	0,05	3,3	0,05	0,06	0,04	0,03
RSD%			3,7	9,3	9,8	10,0	3,4	7,0	6,8	8,8	22,9
Mean	150	16,4	114	3,8	2,0	0,52	103	0,87	0,93	0,44	0,15
SD			5,4	0,2	0,1	0,03	8,0	0,11	0,12	0,05	0,03
RSD%			4,7	5,3	3,6	6,0	7,8	12,1	12,4	10,6	18,1
Mean	175	16,4	114	3,7	1,6	0,51	106	0,94	0,85	0,41	0,17
SD			4,5	0,3	0,2	0,03	2,8	0,06	0,06	0,02	0,02
RSD%			4,0	7,2	9,1	6,1	2,6	5,9	6,9	6,0	13,2
Mean	200	16,5	102	3,7	1,8	0,51	104	0,88	0,78	0,40	0,17
SD			6,6	0,3	0,1	0,03	3,9	0,07	0,05	0,04	0,02
RSD%			6,5	7,4	6,1	5,4	3,8	8,4	6,6	10,1	12,9
Freeze-dried											
Mean	-30	19,7	111	4,9	2,0	0,22	94	0,77	0,66	0,43	0,19
SD	to		7,4	0,2	0,1	0,02	7,4	0,05	0,04	0,02	0,04
RSD%	+30		6,7	4,7	6,0	7,7	7,9	5,9	6,0	5,5	21,8

* Mean of ten results

** Standard deviation

*** Relative standard deviation (percent)

APPENDIX 1.2

The effect of furnace temperature on metal content of biological tissue

	Furnace T°C	μg metal/g dry tissue					
		Zn	Cd	Cu	Pb	Fe	Mn
Mean*	WET	401	12,6	4,33	2,11	227	3,61
SD **	ASH	8	0,5	0,2	0,2	26	0,1
RSD%***		2,1	3,8	3,9	9,0	11,5	2,8
Mean	350	319	11,0	4,02	0,53	220	3,67
SD		9	0,4	0,1	0,2	32	0,2
RSD%		2,7	3,3	2,4	36,6	14,8	6,6
Mean	450	280	9,3	3,54	0,61	219	3,37
SD		9	0,8	0,3	0,3	66	0,3
RSD%		3,1	8,5	7,9	41,3	30,2	7,8
Mean	550	307	9,9	3,70	<0,2	179	3,60
SD		8	0,8	0,1	-	12	0,1
RSD%		2,5	8,3	3,5	-	7,0	3,7
Mean	650	225	7,3	3,14	<0,2	169	3,03
SD		24	1,3	0,34	-	18	0,3
RSD%		10,5	18,5	10,7	-	10,8	8,6
Mean	750	144	2,2	1,85	<0,2	151	3,01
SD		14	0,9	0,8	-	14	0,2
RSD%		9,7	40,0	40,7	-	8,9	5,9
Mean	850	73	0,4	0,44	<0,2	147	3,05
SD		14	0,1	0,05	-	20	0,1
RSD%		18,8	24,9	10,7	-	13,6	3,9

* Mean of ten results

** Standard deviation

*** Relative standard deviation (per cent)

APPENDIX 1.3 The effect of solution temperature on metal content of biological tissue

	Acid	T°C	Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
			µg metal/g wet tissue								
Mean*	HNO_3	60	33	0,97	0,39	0,09	54	0,38	0,54	0,37	0,15
SD **		reflux	2,0	0,15	0,03	0,01	3,9	0,03	0,14	0,04	0,03
RSD%***			6,1	15,2	8,8	15,2	7,2	8,3	19,8	9,4	18,1
	HNO_3	50	113	4,17	1,95	0,55	100	0,93	0,97	0,45	0,15
SD			6,6	0,37	0,10	0,07	5,0	0,09	0,08	0,03	0,03
RSD%			5,9	8,9	5,4	11,9	5,0	9,8	8,1	7,7	19,7
	HNO_3	100	111	4,36	1,95	0,51	104	0,89	1,05	0,42	0,21
SD			6,7	0,27	0,10	0,06	5,8	0,09	0,04	0,03	0,02
RSD%			6,0	6,2	5,0	12,6	5,6	10,1	3,8	6,3	8,2
	HNO_3	150	112	4,26	1,94	0,58	99	0,91	0,96	0,45	0,15
SD			5,8	0,24	0,19	0,06	6,4	0,08	0,03	0,03	0,03
RSD%			5,2	5,5	10,0	10,6	6,5	9,3	3,4	7,7	18,7
	HNO_3	200	106	4,21	1,96	0,59	94	0,77	0,94	0,42	0,19
SD			9,7	0,27	0,17	0,06	8,7	0,06	0,06	0,02	0,02
RSD%			9,1	6,3	8,9	10,9	9,3	8,0	5,9	4,3	8,2
	HNO_3	250	104	4,11	1,83	0,49	91	0,78	0,85	0,42	0,14
SD			8,9	0,35	0,16	0,06	5,3	0,06	0,06	0,02	0,03
RSD%			8,6	8,4	8,7	12,8	5,9	8,1	6,9	5,8	21,7
	HNO_3+	150	110	4,23	1,99	0,54	99	0,95	1,09	0,46	0,17
SD	$HCLO_4$		8,1	0,37	0,15	0,03	5,6	0,09	0,10	0,04	0,03
RSD%			7,4	8,8	7,6	5,6	5,7	9,5	9,1	8,0	16,1
	HNO_3+	200	110	4,17	2,01	0,54	9,4	0,84	1,05	0,42	0,14
SD	$HCLO_4$		9,2	0,27	0,14	0,02	7,0	0,03	0,04	0,03	0,03
RSD%			8,4	6,5	7,0	3,2	7,4	3,7	3,9	5,9	23,0
	HNO_3+	250	112	4,18	1,90	0,53	91	0,75	0,88	0,41	0,16
SD	$HCLO_4$		8,5	0,36	0,14	0,04	5,1	0,04	0,07	0,02	0,03
RSD%			7,6	8,6	7,4	7,7	5,6	4,9	8,4	6,0	18,2

* mean of ten results

** standard deviation

*** relative standard deviation (percent)

APPENDIX 2

Crassostrea gigas. Tissue-metal concentrations in Belvedere (Knysna) population.

Wet mass g	Dry mass g	μg metal / g wet tissue								
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
4,01	0,48	75	0,72	8,7	0,20	24	2,79	0,35	0,20	0,15
4,28	0,57	97	0,70	7,7	0,21	22	2,85	0,40	0,12	0,14
1,82	0,28	205	0,66	10,4	0,27	17	2,20	0,82	0,27	0,27
1,89	0,30	73	0,74	8,9	0,26	36	3,02	0,26	0,21	0,21
2,09	0,30	125	0,86	9,5	0,24	29	3,11	0,53	0,14	0,19
1,58	0,23	96	0,76	17,7	0,32	26	3,54	0,38	0,25	0,38
2,92	0,42	109	0,75	10,2	0,24	27	2,02	0,38	0,21	0,14
1,93	0,24	117	0,57	15,5	0,36	27	2,90	0,57	0,26	0,26
2,86	0,34	82	0,56	8,0	0,31	23	1,89	0,31	0,17	0,31
4,42	0,60	78	0,66	6,1	0,23	25	2,38	0,23	0,11	0,20
2,97	0,43	116	0,77	13,4	0,24	30	2,96	0,27	0,27	0,24
4,67	0,59	113	0,77	8,5	0,24	20	1,84	0,49	0,15	0,13
3,32	0,41	180	0,66	12,6	0,33	27	1,96	0,33	0,12	0,09
7,82	0,85	81	0,50	6,7	0,22	25	2,20	0,26	0,13	0,06
7,26	0,98	55	0,61	5,2	0,19	23	2,48	0,30	0,12	0,04
6,49	0,96	69	0,69	6,6	0,18	26	2,34	0,25	0,14	0,11
5,17	0,67	70	0,64	7,9	0,23	19	1,59	0,35	0,14	0,06
6,98	1,03	75	0,63	9,4	0,20	19	1,89	0,21	0,09	0,06
5,81	0,80	84	0,62	7,4	0,21	23	2,48	0,22	0,10	0,10
8,18	0,68	96	0,60	6,2	0,20	19	2,38	0,27	0,11	0,09
5,61	0,65	58	0,61	4,2	0,29	22	0,82	0,25	0,11	0,09
6,54	0,92	68	0,55	4,5	0,17	21	1,41	0,24	0,15	0,11
8,04	0,97	28	0,41	5,8	0,22	17	1,37	0,26	0,07	0,07
8,47	0,98	55	0,46	4,9	0,20	18	1,82	0,24	0,11	0,18
9,25	1,44	88	0,64	6,3	0,16	25	1,44	0,24	0,12	0,13
6,29	0,61	64	0,56	3,5	0,27	25	1,10	0,27	0,13	0,08
8,84	1,29	75	0,52	4,4	0,14	21	2,69	0,28	0,16	0,16
9,90	1,41	46	0,53	3,1	0,15	20	1,75	0,24	0,12	0,08
6,19	0,54	21	0,40	2,9	0,31	18	1,41	0,26	0,06	0,10
11,96	1,51	47	0,45	3,1	0,18	16	1,76	0,18	0,14	0,10
9,54	1,43	79	0,57	5,9	0,20	29	2,71	0,14	0,23	0,13
10,65	1,83	76	0,66	6,1	0,19	24	3,51	0,15	0,17	0,11
15,04	2,19	43	0,43	3,0	0,27	14	2,21	0,13	0,13	0,05
15,84	2,92	59	0,63	6,8	0,10	23	2,41	0,15	0,14	0,06
8,80	1,00	85	0,40	5,0	0,23	21	1,60	0,28	0,15	0,07
7,92	0,73	56	0,59	2,5	0,25	14	1,92	0,23	0,20	0,05
16,79	2,42	52	0,43	4,1	0,19	14	2,33	0,14	0,14	0,13
12,22	1,29	50	0,52	3,1	0,20	9	1,44	0,18	0,15	0,05
11,59	1,82	65	0,62	5,6	0,16	21	2,55	0,16	0,16	0,08
15,81	1,74	27	0,38	1,6	0,23	13	1,21	0,25	0,16	0,09
15,67	2,63	39	0,44	2,8	0,11	13	4,21	0,19	0,20	0,09
27,33	3,20	32	0,38	1,2	0,11	7	1,66	0,22	0,15	0,04
23,73	2,98	32	0,32	1,7	0,11	16	2,42	0,20	0,17	0,04
17,95	2,00	27	0,47	2,6	0,19	21	1,45	0,22	0,17	0,05
18,94	2,68	52	0,39	4,3	0,29	16	2,57	0,23	0,16	0,26
23,93	4,00	51	0,63	3,2	0,15	16	2,84	0,20	0,15	0,10
26,18	2,99	33	0,53	2,7	0,22	11	1,89	0,21	0,15	0,06
24,95	3,14	39	0,37	2,0	0,16	14	1,18	0,19	0,14	0,06
21,41	3,69	98	0,79	5,7	0,26	20	1,91	0,19	0,14	0,08
17,69	2,37	31	0,47	1,6	0,31	19	3,09	0,24	0,11	0,11
22,10	2,87	44	0,49	3,8	0,25	15	2,53	0,22	0,16	0,07
28,49	4,96	34	0,48	2,3	0,10	15	1,83	0,18	0,13	0,05
32,83	3,09	39	0,34	1,9	0,09	7	0,85	0,19	0,07	0,04
19,91	2,65	58	0,59	4,2	0,11	13	1,31	0,20	0,15	0,05
29,49	4,01	51	0,47	4,1	0,09	12	1,82	0,18	0,13	0,03
20,98	2,48	31	0,62	1,5	0,08	14	1,51	0,21	0,16	0,03

Ostrea edulis. Tissue-metal concentrations in Belvedere (Knysna) population

Wet mass g	Dry mass g	μg metal / g wet tissue								
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
1,64	0,39	286	0,67	11,5	0,30	7	0,79	0,28	0,61	0,50
0,80	0,13	87	0,63	6,2	0,50	41	1,25	0,88	0,25	0,88
1,82	0,37	131	0,55	4,9	0,33	39	1,43	0,38	0,22	0,26
2,06	0,41	121	0,53	10,1	0,29	22	1,02	0,39	0,15	0,34
1,83	0,29	174	0,60	7,6	0,27	33	0,55	0,71	0,16	0,49
1,61	0,25	223	0,81	7,4	0,37	47	0,87	0,50	0,25	0,25
2,65	0,53	128	0,53	6,4	0,26	27	1,21	0,42	0,11	0,57
1,83	0,36	185	0,82	11,4	0,16	50	1,15	0,38	0,16	0,33
1,61	0,27	86	0,68	5,5	0,25	37	0,62	0,25	0,12	0,50
1,44	0,24	222	0,76	11,1	0,21	50	1,39	0,35	0,21	0,56
2,89	0,47	235	0,62	12,1	0,17	31	0,48	0,35	0,14	0,62
1,78	0,43	95	0,79	6,1	0,45	45	0,79	0,39	0,11	0,22
3,59	0,66	130	0,56	7,2	0,22	18	0,58	0,33	0,17	0,11
2,57	0,45	97	0,54	4,6	0,27	68	1,28	0,47	0,12	0,19
3,87	0,77	69	0,41	5,1	0,26	13	0,85	0,21	0,16	0,10
0,95	0,11	63	0,84	3,1	0,42	35	0,11	0,21	0,21	0,42
2,24	0,39	196	0,71	8,9	0,31	40	1,12	0,31	0,22	0,22
2,48	0,54	161	0,60	9,2	0,20	41	1,05	0,32	0,12	0,20
3,07	0,58	149	0,68	8,7	0,23	41	1,50	0,26	0,07	0,13
2,32	0,38	168	0,73	6,9	0,30	42	1,03	0,43	0,09	0,22
3,69	0,76	113	0,46	5,1	0,19	48	1,08	0,33	0,11	0,16
2,01	0,35	203	0,70	8,4	0,40	41	1,34	0,45	0,10	0,35
2,37	0,39	92	0,55	5,0	0,34	24	1,01	0,30	0,04	0,17
2,33	0,40	145	0,64	5,5	0,34	32	1,16	0,52	0,17	0,30
2,84	0,49	70	0,46	2,4	0,25	27	0,70	0,21	0,07	0,25
3,48	0,72	114	0,49	7,7	0,23	22	1,44	0,20	0,17	0,20
1,94	0,25	206	0,67	7,7	0,52	34	0,36	0,46	0,26	0,26
2,81	0,51	110	0,50	5,3	0,25	28	0,53	0,21	0,28	0,18
2,50	0,43	144	0,60	7,2	0,28	36	0,96	0,24	0,16	0,36
2,33	0,43	55	0,60	2,1	0,21	15	0,73	0,17	0,04	0,17
4,26	0,83	89	0,45	3,2	0,21	19	0,73	0,19	0,14	0,07
3,54	0,63	152	0,68	9,0	0,28	25	1,07	0,25	0,23	0,17
3,66	0,74	112	0,52	7,6	0,22	24	0,98	0,27	0,19	0,25
3,51	0,57	74	0,60	5,7	0,26	16	0,51	0,26	0,14	0,26
3,59	0,75	103	0,61	4,4	0,22	35	1,03	0,25	0,17	0,42
3,98	0,73	133	0,50	6,7	0,33	30	0,83	0,30	0,20	1,01
2,22	0,38	40	0,63	2,7	0,36	36	1,17	0,32	0,09	0,45
4,98	0,78	114	0,52	8,2	0,28	24	1,73	0,24	0,06	0,14
4,08	0,74	90	0,64	7,8	0,29	13	1,03	0,12	0,20	0,17
3,71	0,68	132	0,67	6,7	0,27	22	1,40	0,19	0,24	0,13
5,87	1,28	136	0,53	8,5	0,20	38	1,23	0,24	0,20	0,14
3,01	0,49	112	0,73	4,9	0,23	20	0,63	0,33	0,23	0,40
4,81	0,88	103	0,58	21,0	0,23	40	0,81	0,33	0,17	0,33
5,47	1,19	113	0,53	12,0	0,37	28	1,55	0,31	0,16	0,26
3,80	0,41	34	0,39	1,5	0,29	24	0,66	0,32	0,05	0,18
5,27	1,02	149	0,61	8,5	0,21	44	1,73	0,32	0,13	0,25
3,08	0,50	168	0,58	4,2	0,26	28	1,27	0,36	0,19	0,32
2,51	0,57	123	0,44	7,1	0,28	31	1,24	0,24	0,16	0,24
1,44	0,32	69	0,35	2,0	0,21	20	1,25	0,35	0,07	0,56
1,73	0,36	92	0,75	4,0	0,35	27	1,62	0,46	0,12	0,46
2,64	0,40	113	0,53	5,6	0,30	42	1,33	0,34	0,11	0,19
2,17	0,40	133	0,74	11,0	0,28	38	1,06	0,51	0,14	0,37
0,64	0,14	109	1,09	6,2	0,47	84	1,56	0,63	0,16	0,63
2,12	0,43	198	0,52	9,4	0,24	39	1,32	0,57	0,24	0,24
1,78	0,38	185	0,79	11,8	0,39	39	1,07	0,45	0,22	0,39

<u>Crassostrea</u> <u>margaritacea</u>. Tissue-metal concentrations in Belvedere (Knysna) population

Wet mass g	Dry mass g	µg metal / g wet tissue								
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
2,52	0,48	230	0,36	5,1	0,32	13	0,44	0,20	0,36	1,94
1,70	0,30	105	0,12	5,8	0,41	17	0,18	0,12	0,35	3,00
2,17	0,38	244	0,60	4,1	0,23	9	0,18	0,32	0,32	0,69
2,44	0,40	217	0,57	3,6	0,53	7	0,16	0,41	0,29	1,02
1,03	0,17	320	0,29	4,8	0,19	21	0,49	0,97	0,29	0,97
2,53	0,50	193	0,47	4,3	0,08	6	0,24	0,28	0,28	0,20
3,31	0,59	190	0,45	3,6	0,21	7	0,12	0,27	0,15	0,09
2,70	0,47	207	0,41	4,0	0,30	10	0,74	0,41	0,19	0,26
3,10	0,53	267	0,45	4,5	0,26	12	0,74	0,39	0,10	0,19
3,53	0,51	254	0,51	4,8	0,31	8	0,76	0,28	0,08	0,20
3,20	0,47	271	0,59	6,5	0,22	10	0,41	0,44	0,19	0,25
4,14	0,58	176	0,56	3,3	0,14	10	0,75	0,31	0,17	0,22
2,71	0,50	206	0,81	4,8	0,15	9	0,85	0,77	0,15	0,48
4,43	0,72	164	0,47	3,3	0,29	5	0,63	0,41	0,16	0,25
3,13	0,54	214	0,51	5,1	0,32	10	0,48	0,86	0,29	0,77
4,53	0,87	216	0,64	6,4	0,24	11	0,26	0,29	0,24	0,40
4,69	0,70	206	0,49	4,6	0,30	8	0,72	0,43	0,15	0,23
5,23	1,03	185	0,42	4,0	0,23	8	0,36	0,36	0,17	0,25
3,61	0,59	182	0,69	3,8	0,28	8	0,58	0,30	0,22	0,25
1,96	0,21	153	0,15	4,0	0,26	12	0,15	0,41	0,20	0,36
4,41	0,53	290	0,29	4,0	0,36	10	0,32	0,23	0,14	0,27
8,89	0,66	120	0,25	1,1	0,16	5	0,30	0,11	0,15	0,11
3,64	0,51	164	0,69	4,6	0,27	8	0,30	0,22	0,11	0,30
3,42	0,75	283	0,64	5,8	0,53	13	0,76	0,58	0,44	0,35
2,82	0,50	301	0,50	4,6	0,39	11	0,96	1,21	0,35	0,57
3,87	0,63	214	0,59	6,2	0,23	13	0,39	0,21	0,28	0,47
4,20	0,64	211	0,60	5,9	0,26	12	0,29	0,21	0,21	0,38
5,31	0,95	259	0,56	4,5	0,45	8	0,85	0,38	0,30	0,15
7,86	1,38	151	0,37	4,8	0,24	9	1,27	0,18	0,22	0,14
2,07	0,35	130	0,63	2,4	0,34	12	0,63	0,29	0,14	0,43
1,96	0,37	275	0,61	3,5	0,41	11	0,61	1,07	0,92	0,36
1,38	0,23	224	0,94	2,1	0,29	18	0,65	0,58	0,36	0,94
2,17	0,31	129	0,51	3,2	0,37	7	0,14	0,28	0,14	0,46
1,25	0,22	184	0,80	4,0	0,32	17	0,80	0,40	0,16	0,64
3,07	0,40	286	0,52	1,3	0,55	13	0,72	0,55	0,20	0,36
3,42	0,68	105	0,53	2,9	0,35	8	0,67	0,38	0,15	0,18
3,32	0,71	213	0,57	4,8	0,48	24	0,39	0,66	0,30	0,24
6,56	1,56	157	0,38	3,2	0,38	5	0,37	0,26	0,12	0,12
5,85	0,68	208	0,32	1,5	0,48	9	0,12	0,19	0,12	0,10
7,22	1,13	123	0,69	1,3	0,30	8	0,19	0,18	0,15	0,08
6,45	0,81	232	0,34	1,0	0,45	7	0,28	0,23	0,19	0,09
7,49	1,28	193	0,28	1,6	0,33	11	0,36	0,49	0,33	0,12
12,90	1,82	148	0,35	2,0	0,23	6	0,21	0,18	0,14	0,08
6,37	1,23	301	0,42	1,5	0,61	14	0,41	0,33	0,19	0,14
6,14	0,97	120	0,42	1,3	0,41	9	0,29	0,28	0,11	0,08
7,47	1,20	109	0,43	1,4	0,40	8	0,27	0,24	0,15	0,04
5,90	0,85	128	0,32	1,5	0,39	7	0,19	0,20	0,07	0,08
11,18	1,39	107	0,31	1,1	0,65	5	0,24	0,19	0,16	0,05
3,66	0,71	172	0,74	3,5	0,41	10	0,77	0,33	0,14	0,30
16,60	2,58	90	0,42	2,5	0,24	8	0,22	0,23	0,14	0,16
24,85	3,26	90	0,66	2,5	0,04	29	1,21	0,03	0,01	0,27
13,19	1,67	163	0,12	2,4	0,10	25	0,28	0,08	0,01	0,37
33,09	3,82	74	0,27	1,0	0,04	16	0,59	0,02	0,01	0,18
24,14	2,93	122	0,45	3,1	0,04	18	1,08	0,09	<0,01	0,28
26,84	3,91	137	0,97	0,8	0,06	11	0,54	0,03	0,01	0,19
14,77	1,29	243	0,83	2,1	0,12	31	0,32	0,19	0,01	0,37
23,73	3,40	147	0,02	1,6	0,06	26	1,37	0,05	0,01	0,28
16,10	3,54	118	0,74	1,7	0,03	11	1,65	0,07	0,01	0,31
13,93	1,92	165	0,94	3,2	0,01	22	0,54	0,04	0,01	0,22
16,31	2,67	116	0,47	1,5	0,09	25	0,92	0,05	0,01	0,26
15,81	2,22	208	0,52	1,9	0,05	22	0,57	0,07	0,01	0,35
12,52	1,50	134	0,36	2,3	0,06	13	0,76	0,05	0,01	0,30
9,17	1,54	161	0,40	1,8	0,12	4	0,49	0,05	0,01	0,19
20,49	3,04	193	0,51	2,6	0,01	6	0,61	0,03	<0,01	0,26
26,88	3,14	124	0,38	0,8	0,04	23	0,48	0,03	0,01	0,22
17,22	2,36	90	0,16	2,9	0,08	9	0,41	0,01	0,01	0,27
16,66	2,66	146	0,04	5,0	0,07	10	0,97	0,04	0,02	0,32
28,55	3,57	171	0,37	1,7	0,04	15	0,88	0,03	0,01	0,19
18,39	3,29	129	0,41	5,3	0,07	20	0,27	0,05	0,01	0,26
18,91	2,76	144	0,90	1,8	0,12	14	0,24	0,11	0,01	0,27
14,02	1,98	34	0,43	0,4	0,10	40	0,74	0,02	0,01	0,36
14,70	2,06	153	0,97	2,2	0,09	10	0,72	0,05	0,01	0,31
16,78	2,11	224	0,85	1,5	0,05	22	0,27	0,19	0,01	0,24
4,69	0,68	132	0,19	1,7	0,02	40	0,35	0,04	0,02	0,30
20,30	2,90	114	0,28	1,6	0,02	6	0,64	0,02	<0,01	0,22

<u>Choromytilus meridionalis</u>. Tissue-metal concentration variations with sex of individuals.

SEX	Wet mass g	Dry mass %	µg metal / g wet tissue Zn	Cd	Cu	Pb	Fe	Mn
F	8,41	20,3	20,7	0,27	2,27	0,20	19	2,46
F	10,58	21,5	21,3	0,19	1,87	0,24	23	2,12
F	11,64	22,2	20,4	0,20	1,93	0,21	14	2,97
M	10,68	21,1	12,4	0,23	1,54	0,25	18	1,11
F	9,63	18,8	17,1	0,23	1,76	0,22	19	1,61
M	11,76	21,9	11,7	0,18	1,56	0,24	11	1,48
M	13,39	21,4	11,6	0,20	1,35	0,20	10	1,06
M	14,28	23,3	9,4	0,18	1,14	0,23	12	1,41
F	12,23	21,5	20,9	0,19	1,88	0,16	16	2,90
M	11,00	20,9	12,4	0,45	1,47	0,25	17	1,19
M	11,92	20,7	13,0	0,22	1,40	0,23	13	0,81
M	11,94	22,1	11,9	0,18	1,16	0,28	14	0,82
F	8,73	21,9	22,5	0,22	1,61	0,18	10	2,35
F	14,11	22,4	21,0	0,19	1,84	0,17	11	2,72
F	11,66	22,7	21,6	0,18	1,67	0,18	18	2,39
M	12,53	21,3	12,6	0,17	1,54	0,22	14	1,64
F	9,11	20,3	23,4	0,29	2,11	0,18	15	2,51
F	7,54	15,6	14,2	0,30	1,27	0,17	16	1,27
M	12,73	21,3	12,4	0,19	1,45	0,21	9	1,53
F	12,17	22,0	23,4	0,19	1,95	0,18	12	2,88
M	20,40	23,7	9,6	0,21	1,07	0,23	13	0,90
M	18,04	22,1	10,8	0,16	1,23	0,20	10	1,49
F	18,33	25,0	24,4	0,16	1,80	0,20	20	2,67
M	14,53	23,1	11,8	0,22	1,27	0,32	21	1,06
F	16,60	24,6	22,8	0,15	1,98	0,23	16	2,23
M	15,25	22,7	12,4	0,18	1,42	0,20	14	1,04
M	19,01	23,0	11,4	0,15	1,27	0,22	10	0,92
M	16,84	21,8	11,2	0,24	1,33	0,20	9	1,14
M	19,59	22,9	9,9	0,19	1,05	0,23	10	1,05
M	14,19	22,1	12,0	0,17	1,52	0,23	13	1,26
M	17,15	22,4	12,2	0,16	1,28	0,25	19	1,42
F	9,50	19,8	20,1	0,31	1,78	0,24	16	2,73
F	15,29	20,0	22,8	0,14	1,81	0,20	18	2,28
F	6,89	21,1	17,6	0,24	1,23	0,18	15	2,22
F	17,65	23,9	22,9	0,20	1,64	0,22	15	2,71
M	12,12	17,6	12,6	0,22	1,04	0,19	10	1,04
F	15,13	25,4	24,9	0,21	1,65	0,23	18	2,33
F	11,54	23,5	23,0	0,22	1,71	0,25	17	2,57
M	17,37	22,0	12,0	0,14	1,29	0,25	10	1,96
M	16,60	21,7	11,2	0,16	1,25	0,22	10	1,18
F	14,07	22,5	22,3	0,15	2,01	0,23	15	1,35
M	17,96	22,5	11,4	0,17	1,26	0,22	10	0,94
M	15,71	19,2	10,5	0,14	1,21	0,23	10	0,92
M	17,97	22,0	11,5	0,16	1,57	0,28	10	1,09
M	11,70	21,0	11,3	0,28	2,72	0,28	18	4,01
F	12,29	22,4	23,7	0,18	1,98	0,21	14	3,45
M	19,95	23,9	6,1	0,17	0,78	0,13	10	0,95
M	18,69	21,4	9,7	0,18	1,24	0,22	11	1,13
M	12,31	23,6	12,9	0,22	1,19	0,21	11	1,31
M	14,05	21,7	11,2	0,17	1,01	0,25	8	1,30
F	21,12	24,5	22,4	0,19	1,41	0,17	12	2,55
M	18,53	22,6	11,4	0,16	1,46	0,19	10	1,18
F	8,96	19,8	21,3	0,25	1,75	0,21	29	2,34
M	16,60	22,9	10,5	0,16	1,39	0,20	10	1,48
F	14,05	23,3	22,6	0,20	1,74	0,19	15	2,41
F	16,86	24,1	19,6	0,15	1,35	0,18	13	2,55
M	15,44	22,3	11,7	0,20	1,34	0,20	14	0,65
F	13,83	23,4	21,5	0,36	2,12	0,20	19	3,54
F	18,59	23,7	23,0	0,16	1,24	0,16	11	3,06
M	15,62	22,5	9,9	0,20	1,28	0,20	12	0,69
M	12,54	19,8	12,0	0,23	1,29	0,28	11	1,32
F	14,90	18,2	22,8	0,14	1,73	0,26	16	1,78

Choromytilus meridionalis. Tissue-metal concentration variations with sex of individuals (continued)

SEX	Wet mass g	Dry mass %	µg metal/g wet tissue Zn	Cd	Cu	Pb	Fe	Mn
F	19,91	24,8	23,0	0,13	2,07	0,22	15	2,41
M	16,30	21,4	12,0	0,16	1,24	0,23	10	1,72
M	16,31	21,6	13,4	0,17	1,43	0,25	13	1,39
F	12,17	18,3	18,6	0,28	1,51	0,24	17	2,46
M	17,14	20,4	10,9	0,16	1,21	0,27	15	1,09
M	18,81	20,9	11,7	0,23	0,94	0,23	9	0,80
F	18,99	23,0	21,4	0,14	1,45	0,22	10	2,84
F	11,42	22,2	24,3	0,16	1,76	0,24	12	4,46
F	18,82	24,0	24,4	0,19	1,63	0,19	14	2,25
F	13,35	17,3	17,7	0,29	1,44	0,19	16	2,89
F	19,33	23,6	19,5	0,16	1,23	0,16	11	2,94
F	20,89	25,4	24,5	0,13	1,64	0,17	11	3,06
M	17,52	21,4	10,7	0,18	1,32	0,20	12	1,18
F	16,62	23,9	24,3	0,27	1,61	0,20	16	2,51
M	13,87	22,1	12,2	0,18	1,21	0,23	13	1,55
M	16,92	22,2	10,2	0,15	1,30	0,22	13	1,06
F	3,59	19,5	14,8	0,47	2,78	0,22	25	2,50
F	5,28	21,1	18,4	0,22	2,27	0,56	27	2,46
M	5,89	24,2	20,4	0,20	1,52	0,16	24	1,69
M	5,90	17,3	17,8	0,22	1,52	0,08	15	2,03
F	6,46	18,1	18,6	0,21	2,01	0,23	26	2,32
F	5,31	18,5	14,5	0,22	1,88	0,18	28	2,25
F	5,98	19,6	20,1	0,30	2,00	0,33	23	2,50
M	9,28	20,4	17,0	0,31	1,07	0,22	20	1,07
M	7,84	21,2	20,4	0,31	1,78	0,23	32	2,16
F	1,95	22,2	16,9	0,51	1,54	0,87	26	2,56
F	1,23	27,1	16,3	0,41	2,44	0,41	33	4,07
F	1,98	19,8	15,2	0,35	1,52	0,26	35	2,53
F	2,44	20,0	15,2	0,37	1,23	0,41	16	2,46
M	5,70	21,4	19,5	0,28	2,10	0,16	18	1,57
M	4,59	22,4	16,4	0,13	1,30	0,33	17	1,52
F	3,58	21,7	16,3	0,11	2,79	0,28	28	2,23
M	4,15	23,6	17,5	0,14	2,65	0,12	31	1,92
M	1,34	18,5	19,3	0,37	2,98	0,37	52	1,49
M	2,45	19,7	16,3	0,32	2,04	0,20	37	1,22
M	2,85	22,4	17,5	0,28	2,80	0,18	32	1,40
F	2,41	21,7	19,1	0,20	2,90	0,41	29	2,48
M	1,06	21,3	17,0	0,37	1,88	0,94	28	1,88
F	1,24	20,3	18,5	0,32	3,22	0,87	40	2,41

Choromytilus meridionalis. Tissue-metal concentrations after 8 months at Featherbed, Knysna

SEX	Wet mass g	Dry mass %	µg metal/g wet tissue Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
M	4,34	13,6	13,8	0,30	2,44	0,02	51	1,98	0,18	0,02	0,90
F	11,11	15,4	14,6	0,56	2,18	0,05	18	2,61	0,23	0,04	0,32
M	5,32	11,3	11,3	0,34	1,97	0,08	32	1,41	0,28	0,02	0,26
M	6,85	16,9	12,0	0,41	2,19	0,01	38	1,90	0,31	0,01	0,42
M	5,92	14,4	14,2	0,79	1,35	0,25	24	1,10	0,32	0,03	1,05
M	4,77	13,0	14,7	1,15	0,84	0,08	34	0,87	0,44	0,02	0,99
F	4,56	14,7	15,4	0,37	2,00	0,20	20	2,08	0,42	0,02	1,29
M	6,11	13,6	12,4	0,33	1,85	0,10	51	1,65	0,23	0,02	0,95
F	5,08	15,4	16,5	0,28	1,75	0,04	18	2,22	0,22	0,02	0,59
F	4,45	15,3	13,0	0,20	1,64	0,09	18	1,97	0,40	0,02	1.06
M	6,27	13,2	9.6	0,37	1,93	0,11	18	1,30	0,32	0,02	0,51
M	5,36	12,5	12,7	0,34	1,79	0,02	22	1,04	0,15	0,02	0,21
F	8,93	19,4	23,3	0,34	2,59	0,12	16	3,08	0,10	0,01	0,37
M	4,65	14,4	15,9	0,39	2,17	0,24	19	1,56	0,13	0,02	0,28
M	2,65	10,9	14,3	0,64	1,55	0,38	53	1,02	1,25	0,04	0,72
M	6,48	14,0	11,7	0,39	1,33	0,06	23	1,50	0,08	0,02	0,46
F	5,34	13,5	12,0	0,73	1,29	0,13	22	1,50	0,24	0,02	0,41
F	6,70	13,3	15,2	0,28	1,76	0,22	15	1,85	0,31	0,01	0,24
F	6,93	14,3	12,7	0,38	2,05	0,14	14	2,31	0,48	0,01	0,20
F	7,22	13,9	11,9	0,26	1,73	0,06	18	1,73	0,07	0,03	0,32
F	4,08	12,7	14,2	0,39	2,16	0,17	17	1,78	0,32	0,02	0,32
F	3,06	13,4	11,8	0,26	2,58	0,07	49	2,61	0,69	0,03	0,65

Perna perna. Tissue-metal concentration variations with sex of individuals

SEX	Wet mass g	Dry mass %	µg metal / g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
F	2,60	18,5	19,2	0,54	1,85	0,10	169	2,21
F	2,40	22,1	25,8	0,54	2,17	0,09	116	1,98
F	2,42	19,8	22,7	0,41	1,78	0,10	116	2,02
F	3,24	20,7	28,4	0,40	1,91	0,08	160	2,53
F	2,24	20,1	26,8	0,49	1,83	0,11	129	1,63
F	2,21	18,1	19,0	0,54	1,40	0,12	131	1,58
F	2,05	22,4	24,4	0,59	1,85	0,22	151	2,44
M	3,19	17,6	9,7	0,47	0,88	0,09	82	0,64
F	2,46	15,4	17,5	0,81	0,89	0,13	81	1,08
F	2,30	19,1	23,5	0,39	1,48	0,23	139	1,46
M	5,25	10,1	11,2	0,29	0,90	0,09	46	0,89
F	1,97	13,2	20,3	0,05	1,52	0,19	86	1,32
F	2,04	19,6	15,7	0,59	1,47	0,13	113	1,72
M	2,16	17,1	13,9	0,05	1,02	0,14	120	0,90
F	3,41	18,8	22,6	0,32	1,61	0,08	99	1,67
M	2,04	23,0	13,7	0,39	1,27	0,09	147	1,13
M	2,40	18,8	13,3	0,38	1,04	0,11	108	0,83
F	1,86	20,4	17,7	0,38	1,99	0,13	161	2,31
M	1,81	19,9	14,9	0,55	1,60	0,28	238	2,87
F	1,33	21,1	27,8	0,53	1,65	0,18	150	1,84
F	2,06	20,4	14,6	0,44	1,21	0,12	58	1,48
F	1,88	19,2	18,6	0,43	1,60	0,14	186	1,68
F	2,40	18,8	19,6	1,29	2,04	0,11	142	1,02
M	2,48	18,6	17,7	0,44	1,76	0,11	141	1,05
F	1,76	17,1	21,6	0,63	1,25	0,17	142	1,76
M	2,42	16,9	14,1	0,41	1,03	0,12	140	1,07
M	2,34	16,7	7,7	0,34	1,07	0,13	111	0,83
M	1,82	16,5	6,6	0,44	1,32	0,17	148	1,24
M	1,47	17,7	19,7	0,41	1,30	0,19	184	1,39
M	2,76	16,3	10,9	0,58	1,05	0,11	83	0,76
M	3,41	16,1	14,9	0,44	1,20	0,09	117	0,87
F	2,47	19,8	25,1	0,73	1,62	0,10	113	1,76
F	2,10	23,8	25,7	1,00	2,14	0,10	171	2,48
M	2,66	21,8	13,2	0,38	0,86	0,09	64	0,56
M	2,29	22,3	27,5	0,70	1,53	0,10	52	0,85
F	2,55	16,9	22,4	0,51	1,57	0,23	149	1,59
M	3,95	18,2	14,2	0,43	1,14	0,07	81	0,76
F	2,63	19,4	16,7	0,46	2,40	0,10	83	2,09
M	2,03	19,7	17,2	0,74	1,48	0,13	133	1,11
M	0,49	15,3	34,7	0,61	1,43	0,14	151	1,12
F	8,17	20,2	16,0	0,72	1,77	0,07	44	2,67
F	9,55	17,9	18,3	0,93	1,84	0,11	26	0,52
M	10,37	15,2	13,9	0,60	0,76	0,06	30	0,57
M	8,10	14,1	12,1	0,96	0,81	0,05	46	0,75
M	8,28	16,9	12,6	0,60	0,72	0,05	43	0,64
F	11,08	18,3	14,4	0,60	1,28	0,05	33	2,07
F	9,31	18,5	18,6	0,69	1,26	0,06	49	2,20
M	6,85	16,9	16,5	0,91	0,85	0,06	26	0,60
F	7,39	15,6	13,9	1,01	1,06	0,05	32	1,14
M	7,25	14,9	15,7	0,90	0,81	0,05	33	0,52
M	7,88	17,1	12,8	0,84	1,03	0,04	32	1,03
M	7,58	17,5	12,7	0,61	0,94	0,04	28	0,91
F	8,60	18,0	12,6	0,95	1,03	0,05	34	1,94
M	6,79	16,0	12,1	0,75	0,69	0,04	38	0,62
M	6,89	15,8	13,1	0,77	0,94	0,04	45	1,07
M	8,72	14,9	11,2	0,69	0,83	0,03	33	0,46
M	8,74	9,6	8,6	0,97	0,65	0,02	30	0,66
M	8,43	11,2	9,9	1,02	0,65	0,04	31	0,76
F	8,30	15,2	16,9	1,00	1,04	0,05	39	1,02
M	6,74	16,1	15,6	0,80	1,04	0,05	48	1,17
M	7,17	15,6	15,3	1,03	0,82	0,08	42	0,88
F	5,96	16,3	15,9	0,82	0,94	0,07	44	1,54
F	6,95	15,7	17,9	0,86	0,99	0,07	62	1,51
F	6,65	16,2	20,3	0,86	1,13	0,05	58	1,73
M	7,29	15,9	13,0	0,75	0,93	0,04	45	0,56
M	7,38	14,3	16,9	1,68	0,88	0,05	38	0,47
F	8,11	16,0	18,5	1,15	0,91	0,05	40	0,69
F	7,48	15,5	16,0	1,23	0,86	0,05	43	0,99
M	7,77	18,0	11,6	0,88	0,66	0,05	36	0,42
M	7,82	16,3	12,8	0,75	0,98	0,09	58	1,04
F	10,26	16,6	14,6	0,95	1,00	0,04	34	1,61
F	8,15	16,1	17,2	0,81	0,85	0,05	50	1,23

Perna perna. Tissue-metal concentration variations with sex of individuals (continued)

SEX	Wet mass g	Dry mass %	µg metal / g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
F	3,82	16,4	17,5	0,65	1,36	0,13	63	1,18
M	4,07	16,5	16,7	0,49	0,98	0,12	54	0,71
F	3,10	19,4	22,3	0,52	1,68	0,16	77	1,66
F	3,49	15,2	21,5	0,46	1,29	0,14	60	1,13
F	4,65	18,9	21,7	0,49	1,63	0,12	73	2,34
M	7,54	43,4	11,0	0,23	0,62	0,07	57	0,48
M	3,61	39,3	9,7	0,72	0,64	0,04	39	0,46
M	3,51	18,2	12,5	0,37	0,60	0,04	85	0,75
F	2,70	14,8	19,6	0,48	1,30	0,09	137	1,13
M	3,61	16,3	19,1	0,47	0,97	0,14	114	0,83
F	2,30	11,7	18,3	0,43	1,13	0,02	122	1,02
F	1,88	17,0	36,2	0,59	1,60	0,09	149	1,20
M	2,68	16,0	14,9	0,45	1,08	0,19	86	0,99
M	2,49	14,9	20,9	0,52	1,04	0,20	96	0,90
F	3,07	27,0	15,6	0,72	1,14	0,16	117	0,83
F	2,54	26,8	17,7	0,71	1,02	0,20	106	0,89
F	2,02	17,4	29,7	0,69	1,83	0,05	129	2,18
M	1,95	14,4	27,7	0,62	0,82	0,06	46	0,54
M	2,50	15,2	16,4	0,32	1,00	0,09	140	0,88
M	2,61	18,0	17,6	0,46	1,19	0,09	137	0,88
F	2,00	21,0	27,5	0,45	1,85	0,05	155	1,83
M	2,43	14,8	20,6	0,49	1,07	0,21	123	0,99
M	2,29	15,3	10,9	0,26	0,92	0,02	113	0,87
M	1,28	24,2	28,1	0,86	1,80	0,09	78	1,13
M	2,38	15,5	17,7	0,46	0,97	0,02	105	0,84
F	1,26	21,4	32,5	0,79	1,83	0,04	222	2,94
F	2,17	15,7	26,3	0,51	1,29	0,02	179	1,80
F	1,84	25,7	18,5	0,33	1,58	0,03	174	1,71
M	2,14	17,3	9,8	0,19	0,61	0,03	89	0,68
F	2,00	19,0	22,0	0,55	2,00	0,03	195	2,45
M	2,06	19,4	17,5	0,63	1,12	0,21	97	0,83
M	2,47	16,6	17,4	0,36	0,97	0,20	117	0,97
F	1,70	17,7	23,5	0,71	1,29	0,05	106	1,44
F	1,31	22,1	29,8	0,99	1,98	0,15	145	1,95
F	1,96	18,4	27,6	0,71	2,45	0,02	133	2,24
M	2,46	18,7	14,6	0,33	1,26	0,20	94	0,79
F	2,30	19,6	20,9	0,43	1,65	0,02	100	1,04
F	2,54	19,7	17,7	0,63	1,61	0,02	87	1,38
M	2,62	18,3	13,0	0,42	1,11	0,02	73	0,67
M	2,30	24,4	16,5	0,39	1,22	0,02	61	0,67
F	2,02	15,8	23,8	0,59	1,63	0,03	114	1,44
M	2,45	16,7	13,5	0,49	1,10	0,04	89	0,71
M	1,85	17,8	11,4	0,65	1,14	0,03	59	0,78
F	1,39	15,1	23,0	0,65	1,73	0,04	143	1,62
M	2,48	17,7	14,1	0,36	1,25	0,02	93	0,73
M	2,50	18,8	17,2	0,48	1,12	0,02	88	0,76
F	2,10	13,8	24,3	0,43	1,48	0,07	100	1,24
F	1,30	20,0	37,7	0,92	1,77	0,04	254	1,77
F	1,58	17,7	27,2	0,70	1,58	0,03	158	1,20
F	2,07	20,8	16,9	0,71	1,55	0,16	121	1,11
F	2,29	24,5	22,3	0,61	2,05	0,09	157	1,85
M	2,60	24,6	11,2	0,54	1,19	0,08	131	0,94
F	2,35	19,6	17,9	0,51	1,74	0,07	196	1,87
F	2,78	26,6	19,4	0,32	1,29	0,14	122	1,38
F	1,92	16,7	21,9	1,09	1,20	0,14	115	0,99
M	3,22	27,0	13,4	0,47	0,96	0,06	106	0,87
M	2,83	34,6	15,9	0,32	1,27	0,05	141	1,04
M	2,39	31,8	23,4	1,17	0,63	0,13	67	1,80
F	1,95	19,0	19,0	0,67	1,54	0,14	128	1,62

Atrina squamifera. Tissue-metal concentration variation with sex of individuals

SEX	Wet mass g	Dry mass g	Zn	µg metal/g wet tissue Cu	Pb	Mn
F	47,81	5,88	95	0,63	0,16	0,59
M	55,40	7,39	95	0,58	0,18	0,43
M	81,35	12,14	62	0,96	0,15	0,59
M	38,82	4,34	52	0,64	0,13	0,49
F	44,80	5,08	77	0,58	0,11	0,45
F	84,45	14,27	91	0,69	0,15	0,78
F	43,00	6,44	68	1,40	0,17	0,70
F	39,32	6,86	60	1,81	0,19	0,97
F	46,54	6,16	53	1,22	0,16	0,60
M	33,23	2,96	39	0,36	0,08	0,30
M	41,25	4,99	36	0,90	0,06	0,32
M	25,67	1,93	34	0,35	0,06	0,16
F	23,41	3,33	59	1,20	0,11	0,73
F	15,04	2,36	70	0,80	0,10	0,86
M	9,94	0,99	35	0,60	0,10	0,70
M	10,81	1,00	27	0,56	0,14	0,28
M	43,07	5,51	35	0,60	0,12	0,42
F	69,85	10,57	120	0,82	0,14	0,62
F	55,12	7,61	78	0,60	0,14	0,40
M	57,86	7,78	73	0,76	0,13	0,48
F	55,69	7,02	100	0,54	0,13	0,41
F	65,73	10,15	77	0,68	0,15	0,43
F	42,35	6,68	85	0,80	0,18	0,71
F	64,77	10,21	74	0,60	0,15	0,45
F	68,09	10,48	92	0,90	0,18	0,44
F	49,48	6,18	60	1,01	0,15	0,57
F	32,19	4,55	102	0,75	0,16	0,53
F	102,30	15,02	62	0,95	0,15	0,54
F	73,89	10,29	106	0,61	0,17	0,31
F	99,92	11,89	102	0,47	0,13	0,41
M	60,42	6,64	54	0,66	0,12	0,36
F	57,77	5,66	74	0,40	0,09	0,28
F	84,32	10,06	92	0,50	0,15	0,40
F	55,07	8,34	119	0,80	0,18	0,60
F	66,07	8,78	98	0,56	0,15	0,45
F	57,16	9,92	122	1,01	0,17	0,65
M	32,39	5,49	80	0,77	0,15	0,56
F	58,39	8,06	96	0,63	0,13	0,57
F	52,79	8,77	54	1,14	0,19	0,93
M	43,78	4,72	35	0,37	0,06	0,41
M	51,16	7,46	61	0,55	0,15	0,47
M	51,62	5,47	93	0,45	0,10	0,48
F	25,32	3,70	75	0,79	0,10	0,83
F	34,69	4,04	76	0,49	0,07	0,43
M	41,37	5,35	33	0,63	0,12	0,41
M	25,61	3,27	31	0,90	0,10	0,78
M	33.38	4,40	74	0,90	0,07	0,42
M	41,59	5,86	58	0,82	0,12	0,63
F	42,67	5,99	90	0,61	0,12	0,61
M	12,20	2,02	49	0,82	0,12	0,66
F	31,95	5,18	71	1,25	0,08	0,66
M	33,99	3,23	35	0,47	0,07	0,29
M	36,01	5,11	45	0,72	0,14	0,72
M	47,95	5,67	64	0,38	0,10	0,42
M	38,31	6,27	63	1,02	0,20	0,84
F	41,34	5,06	73	0,48	0,12	0,56
M	39,62	5,38	84	0,83	0,13	0,43
F	81,85	11,26	72	1,10	0,15	0,61
F	117,08	16,15	65	0,94	0,13	0,59
F	87,82	12,81	82	1,02	0,14	0,83
M	105,68	14,64	60	0,65	0,14	0,47
F	79,24	9,54	80	0,56	0,13	0,63
F	64,36	10,44	67	0,67	0,12	0,81
M	68,18	7,49	54	0,51	0,11	0,50
M	79,19	11,08	50	0,47	0,13	0,49

<u>Crassostrea</u> <u>gigas</u>. Tissue-metal concentration variation with season

Wet mass g	Dry mass g	µg metal / g wet tissue								
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
FEBRUARY 1977										
12,22	1,04	53	0,56	4,2	0,04	11,6	1,68	0,02	0,08	0,38
7,27	0,62	127	0,89	16,8	0,08	16,4	2,23	0,05	0,01	0,26
13,59	1,15	110	0,79	10,1	0,06	12,6	2,27	0,04	0,06	0,10
6,00	0,45	162	0,78	26,0	0,08	15,3	0,83	0,03	0,01	0,13
10,58	0,97	127	0,73	13,1	0,09	18,3	1,91	0,03	0,01	0,20
17,49	1,12	53	0,59	4,8	0,06	8,2	1,25	0,02	0,02	0,16
12,30	1,00	86	0,82	7,2	0,11	9,6	3,64	0,03	0,03	0,12
15,86	1,84	114	0,67	11,9	0,09	17,7	2,21	0,06	0,02	0,47
MARCH 1977										
5,69	0,63	130	1,00	10,2	0,05	22,5	1,32	0,02	0,01	0,27
7,67	0,79	77	0,76	6,5	0,06	17,2	1,87	0,03	0,01	0,29
3,85	0,38	73	1,38	5,2	0,04	41,8	1,30	0,04	0,01	0,39
7,05	0,79	70	0,77	6,0	0,08	15,5	1,55	0,03	0,04	0,16
3,07	0,34	91	1,47	9,8	0,02	17,7	1,83	0,03	0,01	0,27
10,78	1,01	72	0,93	5,9	0,08	21,3	1,76	0,03	0,03	0,12
4,66	0,45	193	0,97	21,5	0,13	23,6	1,97	0,04	0,02	0,22
8,07	0,88	193	0,95	18,8	0,07	14,9	1,52	0,06	0,02	0,56
APRIL 1977										
5,41	0,87	98	1,23	7,5	0,05	20,3	1,15	0,02	0,09	0,15
5,51	1,00	99	1,09	7,8	0,06	12,9	1,49	0,02	0,02	0,21
3,69	0,67	146	0,87	13,9	0,03	12,4	1,00	0,02	0,01	0,18
4,85	0,85	164	1,01	12,7	0,03	15,7	1,19	0,03	0,02	0,22
4,41	0,68	172	0,89	12,8	0,05	20,4	0,59	0,04	0,03	0,21
4,42	0,93	76	0,81	16,0	0,09	27,6	2,21	0,13	0,03	0,21
3,55	0,67	100	0,47	10,4	0,04	12,2	2,15	0,09	0,02	0,12
4,76	0,85	124	0,64	9,6	0,07	9,8	1,49	0,04	0,01	0,05
MAY 1977										
4,51	1,06	140	1,28	7,9	0,02	16,9	1,66	0,05	0,01	0,23
4,64	0,77	82	1,18	15,8	0,05	7,7	1,36	0,02	0,02	0,16
6,03	1,01	48	1,50	8,7	0,04	6,4	0,80	0,03	0,02	0,12
4,80	0,79	79	1,19	10,3	0,04	5,8	0,32	0,04	0,02	0,18
7,08	1,45	117	0,78	9,5	0,03	6,6	1,09	0,06	0,04	0,24
6,41	1,27	140	0,98	8,4	0,02	3,9	0,40	0,06	0,01	0,39
8,14	1,73	80	0,87	9,3	0,03	4,0	1,32	0,15	0,02	0,08
2,32	0,43	109	1,02	6,7	0,07	6,0	1,09	0,09	0,03	0,23
JUNE 1977										
11,63	1,06	58	0,27	10,3	0,03	9	0,25	<0,01	0,02	0,23
11,64	1,29	126	0,40	13,7	0,10	58	0,31	0,30	0,01	0,33
12,26	1,25	111	0,38	11,8	0,07	196	2,69	0,05	<0,01	0,36
13,39	1,60	64	0,28	4,3	0,07	58	3,96	0,02	<0,01	0,19
10,11	1,27	211	0,36	24,1	0,10	88	1,06	<0,01	0,02	0,47
16,96	2,99	128	0,41	11,8	0,10	50	5,90	0,19	0,02	0,23
7,36	0,90	209	0,57	16,8	0,15	83	3,80	0,01	0,01	0,46
7,52	0,83	55	0,44	3,5	0,13	130	3,86	<0,01	0,03	0,42
10,08	1,08	213	0,39	22,3	0,09	54	1,58	<0,01	0,02	0,24
6,72	0,75	238	0,46	1,2	0,12	229	0,33	<0,01	0,02	0,35
17,42	1,57	123	0,22	23,9	0,06	38	1,49	<0,01	0,05	0,15
10,39	1,02	129	0,37	22,7	0,08	40	1,85	0,05	0,03	0,25
9,77	0,94	71	0,40	4,7	0,13	97	1,98	0,07	0,03	0,51
11,28	1,19	50	0,30	3,7	0,10	50	2,57	0,01	0,03	0,28
9,46	1,05	165	0,37	24,3	0,10	60	1,86	<0,01	0,02	0,30
15,37	1,85	109	0,37	9,8	0,10	53	2,67	0,02	0,03	0,25
9,02	0,88	39	0,45	1,9	0,13	61	1,92	0,02	0,02	0,29
4,15	0,59	281	0,82	5,8	0,21	70	2,86	0,10	0,05	0,65
9,55	0,95	37	0,34	2,2	0,10	63	1,50	0,03	0,03	0,35
6,16	0,54	109	0,63	11,5	0,23	86	1,80	0,06	0,03	0,44
8,24	0,76	170	0,42	27,2	0,13	61	2,14	0,05	0,03	0,45
7,96	0,91	43	0,53	3,0	0,14	75	2,60	0,03	0,01	0,40

Crassostrea gigas. Tissue-metal concentration variation with season (continued)

Wet mass g	Dry mass g	µg metal / g wet tissue								
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
JULY 1977										
11,61	1,35	114	0,26	6,4	0,03	57	2,06	0,09	0,03	0,18
8,25	0,98	130	0,32	7,5	0,05	53	3,27	0,07	0,05	0,28
5,33	0,37	45	0,26	1,6	0,06	53	0,62	0,08	0,08	0,26
13,42	1,77	93	0,22	5,1	0,02	39	2,31	0,07	0,02	0,16
13,81	1,71	172	0,22	9,8	0,04	35	2,53	0,08	0,04	0,18
10,45	0,93	98	0,21	8,9	0,03	42	1,32	0,10	0,04	0,19
11,48	1,10	104	0,20	8,5	0,05	57	2,18	0,10	0,04	0,24
9,51	1,11	111	0,22	7,6	0,05	44	2,52	0,06	0,04	0,20
10,01	0,97	115	0,25	8,0	0,04	48	2,50	0,05	0,02	0,18
5,75	0,83	74	0,20	4,9	0,04	82	2,74	0,05	0,02	0,22
9,37	1,03	115	0,28	11,8	0,03	46	3,31	0,02	0,04	0,19
9,06	1,00	164	0,30	12,9	0,04	50	4,08	0,02	0,02	0,19
5,40	0,61	148	0,57	15,6	0,07	96	3,70	0,09	0,06	0,37
10,71	1,44	188	0,35	8,1	0,11	62	2,43	0,07	0,02	0,30
10,38	1,04	69	0,17	3,7	0,04	44	4,05	0,07	0,02	0,23
8,08	1,04	108	0,36	5,7	0,05	46	4,70	0,09	0,02	0,26
9,04	1,34	100	0,33	5,0	0,10	71	3,43	0,07	0,03	0,24
8,19	0,79	123	0,29	8,2	0,10	94	1,84	0,06	0,02	0,35
9,36	0,94	76	0,24	10,3	0,06	61	2,14	0,09	0,02	0,26
12,67	1,34	103	0,41	6,1	0,09	77	4,42	0,19	0,03	0,36
AUGUST 1977										
9,67	1,53	138	0,32	1,2	0,10	40	1,92	0,03	0,02	0,37
9,16	0,98	93	0,35	5,5	0,10	50	1,82	0,04	<0,01	0,49
8,16	1,42	164	0,33	21,8	0,56	69	1,74	0,07	<0,01	0,33
4,17	0,79	106	0,96	9,1	0,22	103	0,67	0,12	<0,01	0,79
12,29	1,95	111	0,40	13,3	0,11	78	3,17	0,23	0,02	0,48
9,12	1,43	140	0,45	13,9	0,15	70	3,95	0,05	0,02	0,34
8,25	1,32	293	0,53	22,5	0,12	79	3,88	0,07	0,06	0,31
4,39	0,49	77	0,41	6,4	0,18	62	2,05	<0,01	0,02	0,52
6,13	0,90	145	0,62	11,1	0,20	147	3,49	0,16	0,07	0,64
11,30	2,08	140	0,30	8,5	0,10	68	3,54	0,09	0,04	0,19
10,64	2,37	254	0,51	16,7	0,11	67	4,23	0,07	0,05	0,21
6,78	1,26	214	0,53	31,8	0,10	59	4,42	0,10	0,09	0,27
10,54	1,86	90	0,43	5,2	0,09	48	0,92	0,09	0,04	0,22
8,79	1,94	187	0,47	22,4	0,14	92	4,89	0,08	0,06	0,39
5,01	0,93	236	0,58	15,2	0,14	90	3,37	0,12	0,10	0,46
6,01	0,72	72	0,58	5,2	0,08	50	1,71	0,12	0,07	0,33
7,85	1,15	173	0,46	23,5	0,08	50	3,02	0,02	0,01	0,24
3,05	0,39	111	0,85	11,1	0,26	141	3,34	<0,01	0,01	0,56
4,61	0,62	190	0,56	16,9	0,13	78	2,60	<0,01	0,04	0,35
7,45	1,53	68	0,44	8,4	0,14	59	3,89	0,05	<0,01	0,29
SEPTEMBER 1977										
12,06	1,32	110	0,23	11,2	0,05	52	1,55	0,04	0,03	0,20
14,00	1,74	120	0,24	6,0	0,04	41	1,38	0,03	<0,01	0,27
11,06	1,36	85	0,21	5,2	0,06	79	1,65	0,09	0,02	0,21
13,67	1,55	77	0,21	3,5	0,04	17	1,43	0,07	0,03	0,10
15,86	1,74	111	0,20	7,3	0,04	22	1,57	0,09	0,02	0,09
8,28	1,57	214	0,52	5,7	0,08	54	2,86	0,04	0,01	0,17
12,88	1,95	162	0,20	11,1	0,05	28	1,96	<0,01	0,05	0,11
14,27	1,44	96	0,15	5,3	0,02	66	1,39	0,02	0,01	0,19
16,30	1,85	112	0,23	7,9	0,02	26	1,39	0,02	0,01	0,09
15,36	2,06	121	0,24	5,6	0,05	31	2,73	0,01	0,01	0,11
16,37	1,76	100	0,20	8,9	0,04	35	1,41	0,02	<0,01	0,10
7,53	1,04	130	0,40	10,1	0,07	64	5,05	0,02	0,04	0,21
11,27	1,09	141	0,20	11,3	0,03	36	1,66	0,01	0,02	0,13
8,67	1,45	145	0,28	16,0	0,02	36	1,88	0,03	0,03	0,14
13,58	1,30	114	0,24	10,0	0,02	27	1,52	0,02	0,02	0,11
19,88	2,35	77	0,13	5,8	0,03	32	1,37	0,02	0,02	0,09
20,11	2,86	153	0,18	7,7	0,03	24	1,79	0,02	0,01	0,09
16,75	1,80	119	0,21	7,1	0,04	41	1,49	0,02	0,02	0,06
7,52	1,30	181	0,51	13,6	0,08	121	4,78	0,03	0,04	0,23
12,23	1,16	97	0,22	7,9	0,04	38	2,21	0,07	0,01	0,12
12,14	1,16	106	0,23	7,7	0,02	26	1,77	0,02	0,01	0,12

Crassostrea gigas. Tissue-metal concentration variation with season.
(continued)

Wet mass g	Dry mass g	Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
		µg metal/g wet tissue								
OCTOBER 1977										
11,23	1,29	105	0,25	7,4	0,07	51	1,9	0,13	0,01	0,11
12,14	1,42	144	0,32	21,0	0,08	54	2,1	0,07	<0,01	0,12
8,04	1,00	119	0,25	7,8	0,09	71	1,6	0,16	<0,01	0,22
11,28	1,47	68	0,24	4,1	0,11	44	2,7	0,14	<0,01	0,12
8,76	0,91	163	0,29	19,0	0,16	92	1,3	0,09	<0,01	0,21
10,07	1,33	170	0,29	16,0	0,06	38	2,9	0,06	<0,01	0,10
14,28	1,77	163	0,22	15,5	0,04	25	2,0	0,09	<0,01	0,09
10,03	1,03	43	0,30	2,5	0,07	35	2,0	0,08	<0,01	0,13
11,58	2,09	175	0,24	13,5	0,09	45	1,5	0,05	<0,01	0,13
10,27	1,19	83	0,22	5,4	0,12	87	2,0	0,10	<0,01	0,23
14,81	3,18	144	0,39	15,2	0,07	38	4,8	0,09	<0,01	0,11
12,25	1,92	109	0,29	15,8	0,06	65	2,1	0,11	<0,01	0,20
10,58	1,06	107	0,23	10,9	<0,01	30	1,1	0,12	<0,01	0,12
7,29	0,95	103	0,33	8,1	0,08	77	2,2	0,11	<0,01	0,33
10,33	1,28	121	0,25	9,6	0,03	46	2,3	0,08	<0,01	0,20
8,50	1,01	204	0,31	24,0	0,08	82	1,5	0,12	0,02	0,20
6,73	0,84	143	0,30	14,5	0,03	42	2,2	0,12	<0,01	0,27
7,71	0,88	95	0,27	16,0	0,08	54	1,6	0,06	<0,01	0,13
6,51	0,67	86	0,28	4,9	0,08	49	1,0	0,09	<0,01	0,12
10,33	1,23	65	0,26	5,8	0,06	45	2,7	0,09	<0,01	0,14
NOVEMBER 1977										
8,21	1,31	341	0,46	33,1	0,07	56	5,7	0,12	0,06	0,23
6,15	0,99	211	0,50	27,2	0,06	67	7,5	0,09	0,09	0,10
4,90	0,69	224	0,48	30,6	0,04	69	6,5	0,08	0,02	0,24
7,98	1,21	213	0,41	18,8	0,08	70	4,9	0,05	0,05	0,32
7,59	1,18	171	0,43	21,6	0,06	78	6,9	0,10	0,06	0,18
7,29	1,36	219	0,35	25,9	0,05	78	6,0	0,09	0,06	0,30
10,49	1,27	181	0,36	19,1	0,03	47	2,9	0,07	<0,01	0,16
5,58	0,80	233	0,35	26,9	0,03	66	4,1	0,10	0,07	0,34
7,76	1,39	232	0,34	37,9	0,03	71	9,3	0,10	0,05	0,25
7,74	1,16	194	0,34	21,4	0,06	75	3,6	0,10	<0,01	0,36
7,24	0,08	221	0,49	27,6	0,11	83	3,6	0,04	0,05	0,17
5,48	0,52	201	0,40	27,0	0,01	67	2,9	0,12	0,09	0,18
6,48	0,88	216	0,38	28,1	0,07	102	3,9	0,09	0,04	0,29
8,43	1,16	213	0,37	29,7	0,05	47	6,2	0,05	0,04	0,22
6,09	0,73	229	0,49	31,4	0,03	65	5,1	0,11	0,04	0,19
6,02	0,73	216	0,43	40,9	0,09	76	4,5	0,06	0,01	0,13
4,38	0,36	274	0,57	43,6	0,04	100	5,3	0,13	0,09	0,23
8,31	1,34	196	0,28	26,3	0,10	49	2,6	0,27	<0,01	0,28
6,30	0,92	173	0,36	36,3	0,20	86	4,9	0,12	<0,01	0,21
6,82	0,96	319	0,35	27,2	0,17	60	5,6	0,07	0,07	0,32
DECEMBER 1977										
8,17	0,79	267	0,25	22,3	0,08	75	1,89	0,11	0,06	0,19
7,17	0,92	171	0,29	13,4	0,09	43	3,84	0,02	0,08	0,09
6,88	0,74	144	0,24	41,5	0,01	57	2,26	0,05	0,05	0,14
5,68	0,58	245	0,29	26,1	0,05	33	1,84	0,05	0,01	0,10
7,06	0,61	184	0,26	20,7	0,08	63	1,54	0,06	0,05	0,12
7,38	0,75	211	0,25	22,9	0,04	26	1,40	0,04	0,05	0,13
5,96	0,68	144	0,20	14,9	0,05	47	3,10	0,15	0,03	0,15
8,12	1,05	176	0,28	17,1	0,06	41	4,90	0,22	0,04	0,13
7,05	0,75	223	0,26	31,3	0,05	61	2,26	<0,01	0,07	0,12
9,15	0,91	174	0,20	14,1	0,07	54	1,15	0,11	0,08	0,19
5,49	0,69	127	0,34	41,1	0,05	74	4,51	0,16	0,07	0,20
9,91	0,82	140	0,23	13,0	<0,01	38	1,70	0,07	0,04	0,10
5,69	0,58	172	0,26	20,0	0,03	64	1,51	0,08	0,08	0,28
7,76	1,02	131	0,28	26,4	0,07	72	3,37	0,07	0,06	0,15
5,53	0,78	141	0,43	16,5	0,12	35	3,77	0,03	0,12	0,19
8,80	1,31	170	0,23	13,9	0,04	32	6,06	0,07	0,06	0,15
6,56	0,85	128	0,30	19,6	0,07	46	3,78	0,09	0,13	0,22
7,84	0,90	130	0,26	15,1	0,07	53	2,95	0,05	0,05	0,17
6,02	0,73	171	0,28	23,8	0,11	53	2,74	0,06	0,01	0,21
8,08	0,91	65	0,24	25,2	0,02	47	4,67	0,01	0,01	0,14

Crassostrea gigas. **Tissue-metal concentration variation with season.**
(continued)

Wet	Dry	µg metal/g wet tissue								
mass g	mass g	Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
JANUARY 1978										
4,98	0,76	166	0,36	27,5	0,04	55	8,3	0,04	<0,02	0,22
7,13	0,86	175	0,30	25,2	0,02	33	2,4	0,13	0,01	0,07
9,43	1,08	157	0,24	28,5	0,01	31	2,7	0,08	<0,01	0,08
12,98	1,36	122	0,20	18,9	0,13	38	2,4	0,20	<0,01	0,12
13,51	1,36	106	0,17	19,3	0,02	29	2,3	0,03	0,01	0,06
14,06	1,50	106	0,24	27,3	0,04	31	3,0	0,08	0,02	0,10
11,24	0,76	276	0,30	29,9	0,01	37	2,4	0,02	0,01	0,10
7,19	0,67	153	0,30	21,4	0,01	51	1,9	0,04	0,05	0,08
9,54	0,95	199	0,33	34,3	0,01	31	1,5	0,10	0,02	0,04
12,41	1,36	193	0,29	17,9	0,01	29	1,0	0,06	0,05	0,04
11,46	0,98	131	0,26	21,0	0,01	43	1,3	0,05	<0,01	0,05
4,15	0,51	241	0,38	40,7	0,02	77	2,8	0,03	0,04	0,09
6,33	0,80	158	0,34	25,2	0,01	49	1,2	0,26	0,03	0,07
7,08	0,83	226	0,29	41,1	0,02	65	1,4	0,15	<0,01	0,05
8,96	0,88	145	0,34	33,3	0,04	41	1,8	0,11	0,02	0,08
8,72	0,96	80	0,36	19,3	0,03	38	4,7	0,06	0,02	0,06
11,69	1,40	154	0,28	35,5	0,02	32	2,9	0,12	0,03	0,08
10,21	0,99	157	0,31	20,7	0,03	31	2,2	0,12	0,04	0,07
12,17	1,05	107	0,22	20,2	<0,01	28	1,3	0,03	<0,01	0,03
6,12	0,75	229	0,34	43,3	0,04	80	2,7	0,09	0,04	0,13
FEBRUARY 1978										
11,55	1,46	67	0,22	11,7	0,09	18	1,45	0,38	<0,01	0,25
9,93	1,34	67	0.19	19,2	0,03	30	0,96	1,03	0,03	0,23
9,69	0,91	97	0,19	14,6	<0,01	17	1,35	<0,01	<0,01	0,23
8,17	1,19	74	0,23	11,7	0,02	19	1,65	0,07	<0,01	0,34
6,36	0,84	209	0,26	23,5	0,03	39	1,49	0,06	<0,01	0,23
8,67	1,01	78	0,25	9,8	0,05	26	1,89	0,04	<0,01	0,40
9,37	1,12	53	0,21	9,7	0,02	24	1,86	0,03	<0,01	0,37
7,34	1,05	75	0,19	10,4	0,05	27	3,10	0,06	<0,01	0,51
6,58	0,74	144	0,19	18,5	0,03	35	0,91	0,10	<0,01	0,15
9,33	0,90	66	0,20	8,7	0,01	19	1,93	0,03	<0,01	0,24
8,24	0,93	60	0,20	6,6	0,01	19	1,97	0,13	<0,01	0,19
7,79	0,85	138	0,19	15,3	<0,01	29	0,12	0,06	0,05	0,14
7,75	0,98	112	0,30	17,5	<0,01	21	1,69	0,06	0,02	0,20
9,83	1,17	98	0,22	13,4	<0,01	26	1,11	0,03	<0,01	0,12
10,93	1,65	132	0,22	37,5	<0,01	22	1,34	0,08	<0,01	0,40
20,56	2,95	112	0,20	38,4	<0,01	21	1,09	0,03	<0,01	0,20
6,61	0,65	124	0,21	15,7	<0,01	38	1,36	0,06	<0,01	0,24
7,92	0,94	96	0,16	19,5	0,02	24	1,26	0,12	0,02	0,27
7,55	0,81	142	0,18	21,5	0,01	34	1,47	0,02	<0,01	0,17

<u>Crassostrea</u> <u>margaritacea</u>. Tissue-metal concentration variation with season

Wet mass g	Dry mass g	µg metal/g wet tissue								
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
FEBRUARY 1977										
2,61	0,37	135	1,34	1,26	0,11	14,2	0,96	<0,02	<0,02	0,50
6,31	0,54	89	0,86	2,85	0,11	4,4	0,30	0,11	<0,02	0,19
6,57	0,71	67	1,00	1,13	0,03	5,0	0,18	0,08	<0,02	0,20
6,42	0,67	89	1,13	2,20	0,03	5,8	0,47	0,08	<0,02	0,28
4,21	0,44	190	0,88	2,85	0,02	6,2	0,64	0,05	<0,02	0,24
7,56	1,02	70	0,93	2,29	0,09	4,1	0,24	0,05	<0,02	0,16
MARCH 1977										
6,21	1,11	152	1,66	1,03	0,12	4,2	0,53	0,02	0,02	0,64
5,12	0,92	138	1,03	0,84	0,06	7,8	0,41	0,03	0,04	0,59
1,91	0,36	152	1,10	1,10	0,05	5,1	0,73	0,08	0,05	0,11
5,38	0,96	61	0,60	0,71	0,09	8,2	0,41	0,03	0,02	0,37
4,76	0,73	97	1,72	0,84	0,17	7,9	0,53	0,07	0,06	0,42
3,95	0,62	116	0,96	1,47	0,03	14,2	0,33	0,04	0,03	0,51
2,80	0,38	96	0,74	1,14	0,07	5,4	0,68	0,04	0,04	0,71
8,28	1,48	74	1,86	0,93	0,05	7,5	0,47	0,04	0,02	0,36
6,30	1,23	99	0,66	1,52	0,13	5,7	0,48	0,06	0,05	0,63
APRIL 1977										
7,97	0,79	100	0,71	2,02	0,08	5,3	1,16	0,02	<0,01	0,53
10,86	1,31	71	0,83	0,71	0,09	4,9	0,22	0,01	<0,01	0,46
8,96	0,82	59	0,74	0,80	0,12	4,1	0,15	0,01	<0,01	0,21
6,46	0,55	147	0,78	0,57	0,06	5,1	0,63	0,03	<0,01	0,71
7,67	0,91	83	0,87	1,83	0,15	5,2	0,19	<0,01	<0,01	0,58
7,76	0,70	110	0,86	2,31	0,10	4,3	0,20	0,06	<0,01	0,72
6,58	0,88	93	1,39	1,59	0,09	6,3	0,53	<0,01	<0,01	0,31
7,15	0,60	105	0,57	0,93	0,08	4,9	0,18	0,04	<0,01	0,53
MAY 1977										
6,15	1,00	96	1,66	1,02	0,03	20,3	1,48	0,04	0,02	0,53
2,83	0,44	124	2,19	0,85	0,04	17,3	0,46	0,04	0,03	0,77
3,91	0,69	82	0,87	0,92	0,03	4,3	0,66	0,04	0,03	0,21
2,40	0,47	91	0,58	1,08	0,12	9,6	0,79	0,05	0,04	0,20
2,53	0,43	71	1,30	0,95	0,12	4,2	1,03	0,06	0,04	0,17
1,76	0,34	130	0,61	1,36	0,06	9,3	0,76	0,04	0,02	0,09
10,61	2,01	113	1,41	1,10	0,03	7,9	1,17	0,02	0,03	0,09
11,62	1,98	74	1,35	0,93	0,07	14,6	0,43	0,03	0,04	0,14
7,05	1,35	67	1,40	0,79	0,07	12,8	0,58	0,05	0,02	0,22
JUNE 1977										
12,29	2,23	116	1,81	1,06	0,06	11,9	3,64	<0,01	0,04	0,33
8,16	1,04	110	2,02	3,43	0,09	14,0	2,87	0,05	0,01	0,39
7,62	1,22	118	2,14	1,31	0,05	10,2	0,28	0,01	0,01	0,20
12,28	1,22	272	0,12	1,47	0,13	7,5	0,25	<0,01	0,03	0,15
11,88	2,61	83	2,06	1,26	0,08	7,7	0,42	<0,01	<0,01	0,31
12,35	2,25	68	2,29	1,29	0,05	8,9	1,85	<0,01	0,03	0,39
10,40	1,57	75	1,21	1,73	0,06	7,9	0,33	0,06	0,02	0,33
13,63	2,42	66	1,20	0,95	0,03	13,6	0,28	0,03	0,02	0,23
6,82	1,34	73	2,35	2,79	0,06	19,6	2,39	0,01	<0,01	0,62
9,05	0,87	128	1,20	1,10	0,07	11,2	0,23	<0,01	<0,01	0,32
13,39	2,47	56	2,06	1,34	0,04	12,8	1,49	<0,01	<0,01	0,27
15,02	2,12	73	1,36	1,19	0,03	13,3	1,13	<0,01	<0,01	0,27
9,00	1,37	73	2,43	0,86	0,10	15,4	0,36	<0,01	<0,01	0,41
14,41	2,63	76	2,05	1,28	0,03	7,0	0,42	<0,01	<0,01	0,26
9,32	1,94	123	2,35	1,68	0,05	17,9	0,43	<0,01	0,02	0,24
6,78	1,03	124	2,36	3,58	0,03	12,8	0,53	0,01	0,03	0,44
5,48	1,43	109	3,80	4,05	0,05	18,6	2,43	0,05	<0,01	0,46
5,04	1,06	187	2,86	2,68	0,10	24,0	0,69	<0,01	0,03	0,58
4,99	0,93	38	2,22	2,00	0,08	15,8	0,81	<0,01	0,04	0,62
4,53	1,12	157	1,69	5,92	0,04	35,9	1,15	<0,01	0,06	0,50

Crassostrea margaritacea. Tissue-metal concentration variation with season (continued)

Wet mass g	Dry mass g	µg metal / g wet tissue								
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
JULY 1977										
9,15	1,23	65	1,15	0,91	0,03	7,1	0,74	<0,01	0,04	0,21
9,06	1,52	105	0,81	1,36	0,04	9,8	0,45	<0,01	0,03	0,21
6,68	1,05	90	1,78	1,05	0,06	10,5	0,39	<0,01	0,03	0,28
10,45	1,50	75	1,13	1,78	0,02	7,4	0,34	<0,01	0,01	0,30
9,57	1,79	77	1,32	1,32	0,02	9,0	1,57	0,06	0,02	0,28
8,93	1,07	68	0,66	1,79	0,03	25,8	0,38	<0,01	0,01	0,27
10,45	1,40	79	1,22	1,11	0,02	6,6	0,79	<0,01	0,04	0,19
8,22	1,18	39	0,64	1,14	0,04	16,3	0,36	<0,01	0,03	0,19
10,37	1,24	63	0,71	3,47	0,04	10,4	0,38	<0,01	0,03	0,22
14,54	1,96	67	1,22	0,86	0,02	12,6	0,34	<0,01	<0,01	0,21
9,41	1,62	84	1,26	1,42	0,06	9,4	1,59	<0,01	0,01	0,31
9,99	1,50	89	0,98	1,16	0,03	6,9	0,31	<0,01	0,02	0,25
3,95	0,49	165	1,32	1,92	0,05	25,6	0,58	<0,01	0,02	0,53
10,79	1,33	70	0,89	0,58	0,03	4,5	0,24	<0,01	0,01	0,19
8,47	1,20	102	0,92	1,70	0,05	8,6	0,34	<0,01	<0,01	0,33
5,80	0,90	72	1,34	0,83	0,07	9,3	0,45	<0,01	<0,01	0,84
7,66	1,53	106	0,85	2,05	0,07	9,5	1,49	<0,01	<0,01	0,29
8,25	1,41	101	0,81	1,19	0,05	24,7	1,72	<0,01	0,04	0,28
6,33	0,98	63	1,04	1,15	0,06	9,8	0,90	<0,01	<0,01	0,33
10,12	1,66	67	1,39	0,90	0,03	9,5	0,33	<0,01	0,01	0,22
AUGUST 1977										
8,07	1,33	145	0,77	3,5	0,55	14	0,40	0,06	0,05	0,25
6,40	1,50	131	1,28	10,8	0,08	23	0,64	0,20	0,02	0,33
6,91	0,89	169	0,74	5,6	0,06	11	0,30	0,07	0,03	0,38
10,95	1,62	153	0,89	3,0	0,05	9	0,35	<0,01	0,03	0,31
7,24	1,29	135	1,02	9,5	0,10	12	0,44	<0,01	0,03	0,32
9,85	1,95	131	1,29	5,0	0,05	13	0,57	0,01	0,04	0,28
5,56	1,13	180	1,04	2,3	0,14	17	0,50	0,01	0,05	0,58
6,22	1,12	130	1,32	4,5	0,06	14	0,40	0,05	0,03	0,35
6,54	1,33	159	1,33	4,4	0,12	15	0,52	0,03	0,05	0,52
4,25	0,82	212	1,25	4,7	0,21	24	0,61	0,05	0,05	0,87
2,62	0,50	130	1,30	4,6	0,19	20	0,80	0,04	0,04	0,84
4,57	1,00	171	1,40	3,5	0,18	57	0,63	0,09	0,02	0,54
5,11	1,22	190	1,62	10,0	0,10	13	0,59	0,02	<0,01	0,45
8,41	1,75	120	0,96	5,7	0,08	11	0,46	0,02	<0,01	0,34
5,58	1,06	195	1,21	17,0	0,09	15	0,54	0,12	<0,01	0,45
4,77	0,79	184	1,15	4,6	0,15	34	0,81	0,04	<0,01	0,50
8,00	1,52	115	1,16	7,1	0,09	20	0,49	0,03	<0,01	0,30
6,09	1,11	125	0,98	5,1	0,11	19	0,48	<0,01	<0,01	0,34
3,77	0,75	151	1,14	5,0	0,21	22	0,58	<0,01	<0,01	0,55
6,30	1,27	165	1,06	4,6	0,10	12	0,46	<0,01	<0,01	0,33
SEPTEMBER 1977										
5,78	0,96	64	1,07	2,4	0,05	57	0,66	0,01	0,03	0,33
6,54	1,09	193	0,87	5.4	0,06	11,9	0,70	0,01	0,04	0,26
6,94	1,13	186	1,29	6,5	0,07	19,2	0,49	0,07	0,04	0,17
7,60	1,33	130	0,86	1,3	0,08	26,2	0,50	0,05	0,04	0,20
13,13	1,56	195	0,72	2,4	0,02	12,7	0,30	0,05	<0,01	0,10
11,57	1,54	190	0,68	1,5	0,04	44,1	0,39	0,04	0,02	0,16
8,81	1,35	212	1,43	1,8	0,05	14,9	0,41	0,07	0,01	0,14
6,44	1,18	138	1,18	3,9	0,06	24,8	0,50	0,06	0,01	0,23
6,11	1,84	133	0,85	4,3	0,07	12,8	0,43	0,10	0,03	0,15
10,02	2,04	97	0,95	7,2	0,04	14,4	1,13	0,04	0,03	0,14
10,96	1,15	109	0,78	2,7	0,04	13,3	0,38	0,07	0,02	0,12
5,77	1,13	191	1,54	6,8	0,05	19,2	1,18	0,05	0,02	0,19
10,02	1,35	142	0,71	2,1	0,03	11,9	0,36	0,03	0,01	0,15
9,96	1,45	110	1,56	2,4	0,04	7,6	1,14	0,04	0,02	0,14
9,77	1,46	198	0,88	4,6	0,03	7,7	0,36	0,03	0,04	0,15
11,17	1,19	70	1,05	4,9	0,04	5,9	0,42	0,35	0,03	0,16
8,05	1,37	150	1,12	7,3	0,07	13,3	0,47	0,04	0,02	0,15
8,73	1,30	302	0,78	2,1	0,05	15,7	0,39	0,05	0,03	0,22
6,58	0,84	88	0,95	5,6	0,08	8,4	0,36	0,09	0,04	0,20
14,48	1,42	146	0,86	1,5	0,03	3,8	0,17	0,06	0,02	0,09
1,18	0,04	97	0,85	7,9	0,17	20,3	0,68	0,17	<0,01	0,16

Crassostrea margaritacea. Tissue-metal concentration variation with season (continued)

Wet mass g	Dry mass g	µg metal / g wet tissue								
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
OCTOBER 1977										
4,84	0,88	349	0,90	7,23	0,04	32	1,07	0,12	<0,02	0,20
8,49	1,33	153	0,83	1,33	0,03	14	0,23	0,05	0,01	0,16
7,67	1,06	118	0,73	2,97	<0,01	8	0,86	0,03	<0,01	0,11
6,95	0,97	118	0,93	1,76	<0,01	11	0,41	0,11	<0,01	0,20
6,00	0,83	95	0,61	5,63	<0,01	22	0,33	0,06	<0,01	0,25
1,44	0,38	118	1,04	6,59	<0,02	22	0,83	<0,06	<0,02	0,27
6,35	1,11	143	0,67	8,86	0,03	15	0,33	<0,01	<0,01	0,11
7,41	1,06	148	0,71	1,55	0,02	24	0,26	<0,01	<0,01	0,18
6,61	0,67	203	0,93	0,92	0,04	17	0,24	<0,01	<0,01	0,19
9,36	1,01	131	0,61	1,97	<0,01	5	0,21	<0,01	<0,01	0,17
6,37	0,72	129	0,95	1,22	0,03	15	0,25	0,03	<0,01	0,26
7,52	1,10	84	0,50	5,02	<0,01	6	0,25	0,03	<0,01	0,21
5,86	0,97	338	1,58	5,42	0,05	18	0,29	0,03	<0,01	0,13
7,69	1,34	108	1,31	1,18	0,05	7	0,32	0,02	<0,01	0,13
5,88	1,15	155	1,19	5,08	0,28	12	0,39	<0,01	<0,01	1,02
5,84	1,07	217	1,38	0,90	0,06	26	0,44	<0,01	<0,01	0,17
7,75	1,53	191	1,09	2,72	0,02	9	2,21	<0,02	<0,01	0,33
8,44	1,11	105	1,45	1,06	0,07	22	0,52	<0,01	0,01	0,18
4,97	0,45	153	0,88	1,77	0,08	16	0,34	0,06	<0,02	0,28
6,51	0,81	123	0,79	1,61	0,04	14	0,23	0,06	<0,01	0,15
5,40	0,87	174	0,98	5,90	0,09	32	0,46	<0,01	<0,01	0,14
NOVEMBER 1977										
7,02	1,47	105	0,45	2,22	0,07	13	0,96	0,02	<0,01	0,52
11,78	2,20	83	1,08	2,52	0,09	17	0,64	0,14	<0,01	0,37
6,43	1,24	127	1,24	1,66	0,09	16	1,15	0,01	<0,01	0,52
4,49	0,90	185	0,58	2,38	0,04	20	0,62	0,11	<0,02	0,40
7,50	1,44	92	1,28	2,18	0,02	12	1,57	0,06	<0,01	0,46
12,58	2,41	102	0,94	2,43	0,04	15	0,42	<0,01	<0,01	0,37
5,18	1,07	195	1,11	2,25	0,11	13	0,55	<0,01	<0,01	0,32
9,03	2,16	208	0,61	12,95	0,05	12	0,44	0,02	0,02	0,42
6,10	1,42	139	0,50	2,09	0,11	19	0,60	0,01	<0,01	0,45
3,03	0,57	142	1,28	6,46	0,13	22	0,62	0,06	<0,03	0,49
8,74	1,50	111	1,15	3,52	0,05	19	0,46	0,06	<0,02	0,26
6,14	1,08	137	1,33	7,44	0,09	24	0,50	0,03	0,04	0,21
7,70	1,86	99	1,09	5,92	0,06	12	0,83	<0,01	<0,01	0,33
7,16	1,35	117	0,52	2,63	0,02	11	0,99	0,01	0,02	0,16
7,99	1,34	96	0,98	7,80	0,03	7	0,33	0,02	0,01	0,30
5,70	1,27	154	1,68	2,78	0,03	13	2,75	0,08	0,03	0,71
6,22	1,13	111	0,98	1,99	0,01	10	0,46	0,01	<0,01	0,28
6,34	1,19	136	0,59	3,20	0,03	12	0,88	0,04	0,03	0,59
10,00	1,59	120	0,82	1,55	0,04	28	1,46	0,06	0,03	0,41
9,24	2,19	119	0,90	3,57	0,03	11	0,38	0,05	0,02	0,20
6,81	1,73	191	0,58	8,07	0,01	23	2,40	0,08	0,02	0,30
DECEMBER 1977										
6,53	0,73	135	0,32	6,82	0,04	9	0,34	0,06	<0,01	0,21
4,09	0,42	100	0,53	1,02	0,07	22	0,32	0,04	<0,02	0,39
6,00	0,58	127	0,41	0,75	<0,01	11	0,36	0,03	<0,01	0,28
5,24	0,51	145	0,26	2,34	0,15	17	0,22	<0,01	<0,01	0,24
6,07	0,64	135	0,47	3,74	0,06	12	0,51	<0,01	<0,01	0,19
5,96	0,65	141	0,45	0,53	<0,01	8	0,18	0,08	<0,01	0,23
4,11	0,38	114	0,58	4,02	0,04	12	0,19	0,06	0,03	0,31
3,98	0,50	135	0,60	0,50	0,02	13	0,30	0,02	<0,02	0,25
6,48	0,78	109	0,24	0,83	<0,01	10	0,27	<0,01	<0,01	0,29
2,87	0,53	212	0,83	4,11	0,17	33	0,41	0,06	0,03	0,45
5,05	0,46	148	0,55	0,59	<0,01	13	0,19	<0,01	<0,01	0,27
4,73	0,65	97	0,82	0,71	0,06	9	0,35	0,01	<0,02	0,29
7,96	0,69	149	0,28	4,45	0,05	7	0,13	<0,01	<0,01	0,11
4,25	0,65	341	0,37	0,55	0,11	24	0,89	0,04	0,07	0,23
1,35	0,25	130	2,07	3,96	0,22	25	0,37	<0,01	0,07	0,22
6,42	0,71	128	0,66	0,93	0,03	8	0,20	0,03	0,01	0,17
6,04	0,65	83	0,77	2,38	0,01	5	0,16	0,09	0,01	0,19
7,08	0,67	120	0,53	2,11	0,02	11	0,21	0,02	0,02	0,18
4,89	0,44	153	0,42	0,61	0,02	18	0,26	0,06	0,06	0,20
5,39	0,49	104	0,53	1,46	0,03	15	0,29	0,07	0,03	0,25
3,56	0,41	109	0,84	0,39	0,02	10	0,28	0,08	0,08	0,25

Crassostrea margaritacea. Tissue-metal concentration variation with season (continued)

Wet mass g	Dry mass g	Zn	Cd	µg metal / g wet tissue Cu	Pb	Fe	Mn	Ni	Co	Cr
JANUARY 1978										
4,84	1,10	130	0,41	4,13	0,08	13	0,42	0,08	0,04	0,06
11,00	2,50	254	0,40	3,45	0,04	14	0,57	0,07	<0,01	0,06
8,63	1,12	58	1,27	1,15	0,04	19	0,52	0,03	0,01	0,03
7,33	1,38	273	1,30	3,27	0,01	23	0,29	0,05	0,02	0,04
8,95	1,12	85	0,32	2,62	0,03	27	0,29	0,03	0,02	0,05
9,61	1,40	104	1,27	1,29	0,05	20	0,30	0,06	0,03	0,04
5,68	1,30	281	0,40	4,29	0,05	5	0,53	0,07	0,03	0,08
7,94	1,33	75	0,25	1,36	0,03	14	1,44	0,08	0,01	0,07
16,99	3,60	112	1,23	2,07	0,01	13	0,88	0,06	0,01	0,10
8,86	1,92	105	0,36	3,82	0,03	12	1,27	0,06	0,03	0,13
10,47	1,47	106	1,29	3,91	0,01	22	1,30	0,03	0,01	0,04
4,83	0,89	290	0,47	2,42	0,04	30	0,41	0,08	0,06	0,08
8,34	1,82	84	1,27	2,23	0,07	9	0,83	0,04	0,02	0,26
10,02	2,41	259	0,26	2,89	0,03	13	0,38	0,23	0,01	0,09
7,80	1,16	174	0,35	1,02	0,02	12	0,24	0,03	0,02	0,06
9,29	2,09	97	0,26	2,50	0,02	26	0,44	0,04	0,02	0,05
9,31	2,08	215	0,31	3,00	0,08	13	1,22	0,09	0,04	0,10
8,63	1,46	69	1,20	1,47	0,03	24	1,91	0,05	0,01	0,10
4,70	0,72	191	0,42	2,85	0,08	9	1,06	0,21	0,04	0,25
10,16	1,59	133	1,27	4,13	0,02	24	0,24	0,02	0,01	0,09
FEBRUARY, 1978										
9,66	1,31	95	1,18	1,08	0,03	15	0,28	<0,01	<0,01	0,25
7,90	1,00	219	0,48	1,41	<0,01	12	0,20	0,01	<0,01	0,29
9,85	1,79	230	0,25	3,45	<0,01	14	0,26	<0,01	0,01	0,27
6,42	0,75	101	1,29	1,68	<0,01	14	0,38	0,43	<0,01	0,21
10,51	2,32	51	0,65	0,93	0,01	16	0,24	0,03	<0,01	0,30
18,66	4,16	187	1,13	2,14	0,01	11	0,23	0,02	<0,01	0,17
7,10	0,88	72	0,26	2,15	0,02	17	0,35	0,02	<0,01	0,19
4,43	0,70	56	0,24	0,58	0,06	34	0,40	0,18	<0,01	0,47
11,94	1,40	69	0,75	2,51	0,03	15	0,30	<0,01	<0,01	0,20
6,61	0,86	181	0,24	1,22	<0,01	15	0,25	<0,01	0,01	0,46
12,21	2,35	42	1,22	1,09	0,01	12	2,21	<0,01	<0,01	0,27
9,42	1,09	167	1,18	1,56	0,02	20	0,45	0,03	<0,01	0,28
10,10	1,93	97	0,75	1,77	0,02	5	0,22	<0,01	<0,01	0,24
11,86	1,97	99	0,86	1,08	0,02	12	0,26	0,59	0,02	0,23
11,55	2,23	89	0,48	1,54	0,01	19	0,19	0,04	<0,01	0,23
7,83	0,73	101	0,29	2,06	<0,01	11	0,26	0,03	0,01	0,21
11,88	1,52	227	1,08	3,11	<0,01	12	0,19	0,07	<0,01	0,31
12,29	2,14	150	0,49	1,95	<0,01	12	0,22	0,96	<0,01	0,34
12,71	2,60	86	1,15	1,45	<0,01	11	0,24	0,03	<0,01	0,35
15,46	2,78	213	1,20	1,61	0,01	17	0,20	0,01	<0,01	0,29
2,39	0,30	122	0,20	11,29	<0,04	42	2,55	0,83	0,01	0,92
5,00	0,64	234	1,28	3,74	<0,02	46	1,26	0,10	0,02	0,38

Perna perna. Tissue-metal concentration variation with season.

SEX	Wet mass g	Dry mass %	µg metal / .g wet tissue								
			Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
OCTOBER 1975											
F	1,36	18,4	22,4	0,83	1,33	0,07	162	0,81	0,27	0,02	0,37
M	1,20	26,7	12,9	0,62	2,99	0,08	117	0,71	0,10	0,03	0,25
F	1,77	17,5	11,9	0,74	1,21	0,11	124	1,84	0,20	0,03	0,26
M	1,49	14,1	14,6	0,53	1,12	0,07	134	0,77	0,12	0,02	0,20
M	3,38	17,2	14,1	0,88	1,22	0,03	80	0,61	0,09	0,09	0,15
M	1,48	18,9	10,5	0,55	1,20	0,07	122	0,71	0,05	0,02	0,20
M	2,00	18,0	11,2	0,60	1,37	0,05	75	0,53	0,06	0,02	0,15
M	3,00	19,3	18,4	0,42	1,09	0,03	63	0,75	0,18	0,01	0,27
M	2,65	18,1	12,1	0,52	1,08	0,04	87	0,64	0,15	0,01	0,30
F	3,05	6,7	15,1	0,69	1,13	0,03	79	0,79	0,16	0,01	0,16
M	1,59	17,0	10,8	0,69	1,03	0,06	69	0,60	0,08	0,02	0,19
NOVEMBER, 1975											
M	2,00	17,0	9,6	0,55	0,95	0,05	65	0,53	0,14	0,02	0,15
F	1,25	14,0	18,1	0,72	1,44	0,08	56	0,56	0,19	0,02	0,24
F	2,26	17,6	25,2	0,66	1,33	0,04	102	0,73	0,06	0,01	0,35
M	2,85	16,4	16,7	0,56	1,05	0,04	84	0,60	0,09	0,01	0,11
M	3,83	14,3	11,0	0,84	0,76	0,03	65	0,44	0,03	0,08	0,08
M	2,60	15,7	14,7	0,69	0,96	0,03	42	0,38	0,04	0,01	0,19
M	2,90	16,5	8,7	0,66	0,90	0,04	69	0,55	0,07	0,10	0,17
M	2,68	14,8	11,0	0,49	0,86	0,02	88	0,67	0,07	0,11	0,30
F	4,34	14,6	17,7	0,71	0,85	0,12	101	0,60	0,09	0,07	0,23
F	0,81	13,1	17,2	0,62	1,11	0,06	86	0,86	0,12	0,04	0,37
M	1,56	18,5	11,3	0,51	1,09	0,14	90	0,64	0,08	0,04	0,19
F	0,73	21,2	19,5	0,68	1,10	0,03	233	1,30	0,27	0,04	0,68
JULY 1976											
M	0,79	21,5	16,0	0,51	1,65	0,13	165	0,89	0,18	0,04	0,38
M	0,81	25,9	25,6	0,99	1,48	0,12	185	0,93	0,20	0,04	0,62
F	1,24	17,7	16,1	0,48	0,97	0,08	112	1,25	0,18	0,02	0,40
F	0,52	21,2	33,9	1,35	0,58	0,09	115	0,96	0,15	0,06	0,96
F	0,89	20,2	21,4	0,90	1,12	0,11	157	0,96	0,20	0,03	0,90
M	1,29	16,3	18,5	0,54	0,93	0,08	77	1,01	0,11	0,02	0,23
F	1,45	22,1	31,8	0,55	1,66	0,07	117	2,07	0,25	0,02	0,34
M	1,62	18,9	15,0	0,49	1,36	0,06	80	0,86	0,16	0,06	0,19
F	1,89	21,1	27,7	0,79	1,53	0,05	111	1,43	0,14	0,05	0,26
AUGUST 1976											
F	1,75	18,5	13,5	0,40	1,03	0,06	114	1,51	0,07	0,06	0,17
F	1,40	15,9	21,8	0,71	1,86	0,07	57	1,46	0,05	0,07	0,21
M	1,61	15,4	20,0	0,25	0,99	0,06	106	1,18	0,11	0,06	0,31
M	3,00	22,9	19,0	0,73	0,80	0,03	37	0,47	0,13	0,03	0,27
F	3,44	19,3	34,9	0,32	1,48	0,03	75	1,69	0,10	0,03	0,29
F	2,68	12,3	20,7	0,71	1,04	0,04	63	1,08	0,19	0,03	0,19
F	3,79	15,7	26,9	0,40	1,24	0,03	92	1,64	0,20	0,04	0,21
F	2,89	14,9	22,2	0,73	1,56	0,04	76	1,42	0,20	0,08	0,28
M	0,60	19,3	17,8	0,50	2,50	0,17	150	1,08	0,19	0,10	0,50
M	0,63	18,3	21,9	0,32	1,27	0,16	158	0,95	0,37	0,17	0,48
SEPTEMBER 1976											
F	1,39	18,3	22,3	0,58	1,29	0,07	127	0,76	0,35	0,16	0,22
M	1,10	19,0	28,0	0,36	2,27	0,27	120	1,91	0,08	0,07	0,91
M	1,33	17,3	16,6	0,53	1,13	0,08	101	0,79	0,08	0,09	0,23
M	0,99	18,2	15,5	0,40	1,41	0,10	120	0,76	0,11	0,08	0,30
M	0,75	15,8	15,6	0,40	1,33	0,13	196	1,07	0,16	0,10	0,40
F	0,61	18,2	17,0	0,82	23	0,16	108	3,93	0,38	0,04	0,63
F	0,74	20,0	21,1	0,41	2,03	0,14	132	0,88	0,12	0,02	0,41
F	0,68	21,3	15,4	0,74	1,32	0,15	64	1,10	0,16	0,02	0,44

Perna perna. Tissue-metal concentration variation with season.
(continued)

SEX	Wet mass g	Dry mass %	µg metal / g wet tissue								
			Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
FEBRUARY 1977											
F	5,56	12,4	10,1	0,50	1,15	0,03	25	0,53	0,19	0,05	0,90
F	5,79	11,1	10,5	0,65	0,81	0,03	22	0,62	0,14	0,04	0,59
F	4,43	12,2	10,4	0,60	0,85	0,04	26	0,65	0,32	0,04	0,77
F	2,66	12,0	13,2	0,52	1,01	0,03	41	0,86	0,16	0,06	0,59
F	3,39	12,4	9,7	0,64	0,85	0,08	32	0,70	0,20	0,07	0,79
F	2,81	14,2	16,0	0,67	1,38	0,07	41	1,17	0,11	0,07	0,53
F	2,74	13,9	14,6	1,07	1,49	0,07	36	1,20	0,28	0,03	0,41
F	2,82	13,8	8,9	0,63	1,34	0,03	33	0,70	0,27	0,04	0,34
F	3,05	11,2	9,2	0,72	0,85	0,03	34	0,72	0,20	0,04	0,43
M	1,32	12,9	14,4	0,90	0,90	<0,07	55	1,13	0,29	0,03	0,53
M	1,92	16,7	11,5	0,72	1,25	<0,05	68	1,09	0,27	0,04	0,32
M	2,45	15,9	12,2	0,61	1,02	0,08	43	0,69	0,14	0,03	0,38
M	2,13	15,5	13,1	0,51	1,12	0,04	52	0,89	0,16	0,04	0,39
M	1,89	14,8	17,5	0,58	0,84	0,10	60	0,79	0,20	0,04	0,67
M	5,08	12,8	14,8	0,74	1,04	0,05	37	0,51	0,19	0,04	0,55
M	5,69	12,1	6,5	0,35	0,80	0,03	24	0,45	0,22	0,08	0,90
MARCH 1977											
F	2,07	15,0	15,5	0,62	1,11	<0,04	61	1,01	0,32	0,04	0,65
F	3,73	16,1	17,7	0,64	1,42	<0,02	39	1,12	0,53	0,05	0,76
F	5,74	13,2	11,8	0,66	1,01	0,06	25	0,64	0,92	0,07	0,33
F	3,17	16,4	10,1	0,69	1,01	0,13	49	1,20	0,31	0,05	0,11
F	5,05	11,7	11,7	1,33	0,75	0,08	32	0,46	0,24	0,04	0,12
F	2,25	13,8	11,1	0,58	0,67	0,09	46	0,62	0,16	0,05	0,09
F	2,53	13,0	14,2	0,79	0,75	<0,04	28	0,63	0,26	0,08	0,10
F	1,91	13,1	14,7	0,79	0,94	0,05	42	0,68	0,30	0,07	0,58
M	4,66	12,5	9,2	1,20	1,03	0,06	31	0,36	0,26	0,04	0,43
M	2,00	14,0	11,5	0,75	0,80	0,10	49	0,40	0,20	0,05	1,06
M	3,03	11,9	10,2	0,63	0,76	0,10	36	0,43	0,20	0,07	0,63
M	4,27	11,2	11,5	1,57	0,56	0,12	33	0,42	0,26	0,06	0,36
M	2,07	13,0	14,5	1,01	0,77	0,05	42	0,43	0,20	0,04	0,45
APRIL 1977											
F	0,70	12,9	21,4	0,86	1,03	0,14	57	1,29	0,20	0,07	0,51
F	5,55	12,1	13,3	0,65	0,54	0,18	33	0,40	0,19	0,04	0,39
F	2,24	18,8	15,6	0,49	1,79	0,22	28	1,56	0,14	0,04	0,44
F	6,47	12,4	10,5	0,87	1,67	0,20	72	0,63	0,14	0,08	0,33
F	4,92	17,3	16,1	0,41	1,18	0,04	72	0,96	0,22	0,06	0,58
F	5,76	14,1	8,5	0,50	0,83	0,12	78	0,66	0,10	0,06	0,55
M	3,69	16,8	10,0	0,51	0,95	0,16	60	0,60	0,28	0,07	0,96
M	4,52	16,4	11,5	0,46	1,04	0,13	87	0,64	0,23	0,06	0,76
M	3,00	16,3	12,3	0,57	0,80	0,23	95	0,77	0,28	0,06	0,54
M	4,51	18,4	10,2	0,82	1,06	0,13	88	0,73	0,19	0,05	0,93
MAY 1977											
F	6,00	13,2	14,0	0,55	0,97	0,16	65	0,96	0,17	0,06	0,55
F	4,47	13,0	10,5	0,72	0,78	0,04	76	0,56	0,18	0,04	0,67
F	6,63	6,6	13,2	0,68	0,33	0,11	29	0,22	0,24	0,05	0,24
F	5,27	13,6	18,2	0,63	0,91	0,02	66	0,56	0,24	0,04	0,87
F	6,55	13,4	9,2	0,66	0,67	0,13	54	0,53	0,25	0,04	0,64
F	2,92	9,9	15,1	0,72	0,65	0,04	64	0,46	0,26	0,06	0,33
M	3,34	9,5	10,8	0,69	1,05	0,07	71	0,65	0,30	0,02	1,07
M	2,61	14,9	11,9	0,50	1,00	0,09	103	0,71	0,34	0,07	0,41
M	3,27	12,8	11,3	0,37	0,83	0,10	107	0,72	0,19	0,05	0,85
M	3,53	15,6	11,9	0,82	0,99	0,21	57	0,46	0,06	0,05	0,22

Chorom̲ytilus meridionalis. Tissue-metal concentration variation with season

SEX	Wet mass g	Dry mass %	Zn	Cd	Cu	µg metal / g wet tissue Pb	Fe	Mn	Ni	Co	Cr
FEBRUARY 1977											
F	7,66	18,5	14,8	0,27	1,23	0,14	20	2,28	0,11	0,08	0,08
F	4,72	16,3	13,8	0,30	1,14	0,06	15	1,82	0,11	0,06	0,10
F	9,22	15,7	12,4	0,33	1,08	0,09	8	1,65	0,10	0,06	0,07
F	10,69	16,8	13,7	0,50	1,04	0,19	10	2,16	0,14	0,07	0,11
M	6,91	17,8	11,7	0,25	1,23	0,04	12	1,79	0,20	0,08	0,11
M	7,66	15,4	11,6	0,27	1,06	0,07	20	1,25	0,16	0,09	0,08
M	4,55	14,7	12,1	0,37	1,16	0,02	7	1,38	0,13	0,07	0,08
M	11,32	15,3	11,1	0,25	1,05	0,06	9	1,03	0,10	0,07	0,07
M	14,04	16,2	10,3	0,24	1,10	0,07	8	1,38	0,10	0,08	0,10
M	11,19	17,3	10,7	0,30	0,82	0,08	21	1,18	0,12	0,06	0,09
	8,80	16,4	12,2	0,31	1,09	0,08	13	1,59	0,13	0,07	0,09
MARCH 1977											
F	2,82	15,2	16,7	0,39	1,24	0,04	18	1,84	0,19	0,05	0,13
F	12,27	18,5	12,1	0,26	0,26	0,09	21	1,69	0,14	0,06	0,07
F	5,62	17,1	14,2	0,23	1,29	0,12	16	2,61	0,13	0,07	0,11
F	3,19	18,2	14,1	0,21	1,34	0,06	22	1,63	0,10	0,05	0,08
F	4,13	18,6	15,3	0,24	1,54	0,12	10	1,84	0,10	0,05	0,12
M	10,24	15,6	12,6	0,35	1,12	0,06	23	1,62	0,13	0,07	0,07
M	7,48	18,4	13,0	0,24	1,16	0,10	20	1,17	0,09	0,07	0,12
M	5,24	16,6	11,8	0,28	1,16	0,03	11	1,52	0,19	0,06	0,18
M	6,30	16,0	11,4	0,19	1,19	0,04	8	1,76	0,14	0,05	0,09
M	11,22	16,3	10,0	0,27	1,03	0,05	17	1,42	0,09	0,05	0,09
M	7,15	13,7	11,7	0,20	1,07	0,02	8	1,24	0,09	0,06	0,05
APRIL 1977											
F	8,56	17,4	15,0	0,25	1,26	0,09	23	1,61	0,09	0,07	0,04
F	10,87	16,3	13,5	0,27	1,11	0,08	13	2,18	0,13	0,06	0,06
F	9,32	16,6	13,5	0,45	1,09	0,11	14	1,62	0,09	0,08	0,06
F	4,38	15,3	12,3	0,25	1,14	0,02	16	2,57	0,11	0,06	0,07
F	6,88	15,2	17,2	0,33	1,75	0,07	17	2,57	0,16	0,06	0,07
M	6,84	16,1	11,0	0,26	1,06	0,04	7	1,16	0,12	0,06	0,04
M	1,31	14,5	13,0	0,15	1,37	0,07	23	1,90	0,10	0,07	0,07
M	5,02	16,3	12,4	0,17	1,11	0,07	12	1,63	0,12	0,06	0,05
M	8,06	17,6	11,7	0,28	1,07	0,06	9	1,17	0,10	0,06	0,07
MAY 1977											
F	4,68	19,0	14,3	0,29	1,32	0,08	15	2,41	0,12	0,06	0,07
F	8,82	16,2	14,5	0,24	1,11	0,06	13	2,67	0,12	0,08	0,05
F	8,59	16,8	12,9	0,22	1,26	0,04	16	1,67	0,17	0,09	0,05
F	13,29	15,5	11,0	0,24	1,11	0,06	11	1,96	0,09	0,07	0,05
F	10,71	15,8	19,8	0,19	0,65	0,04	6	2,36	0,12	0,08	0,01
F	8,95	16,2	13,4	0,23	1,35	0,05	11	1,84	0,14	0,08	0,02
M	6,30	17,9	13,0	0,17	1,63	0,06	14	1,66	0,12	0,07	0,09
M	9,57	17,7	11,0	0,31	1,11	0,09	7	0,90	0,11	0,07	0,10
M	9,47	16,5	12,1	0,17	0,11	0,10	9	1,90	0,10	0,08	0,13
M	13,30	16,2	10,8	0,22	1,03	0,06	10	1,24	0,07	0,06	0,09
M	8,12	16,7	11,9	0,28	1,08	0,09	15	1,46	0,11	0,06	0,08
M	11,00	18,0	11,9	0,29	1,27	0,09	14	1,35	0,07	0,06	0,14
M	0,69	11,6	13,0	0,28	1,30	0,14	44	1,73	0,11	0,06	0,09
M	8,00	14,9	11,9	0,27	0,91	0,06	16	1,30	0,07	0,06	0,09
M	8,53	18,4	10,6	0,37	1,11	0,05	14	1,59	0,09	0,07	0,10
M	14,12	14,7	11,3	0,31	1,22	0,07	16	0,92	0,20	0,10	0,17
M	1,00	14,0	12,0	0,20	1,60	0,10	30	2,20	0,20	0,08	0,15
M	5,35	16,4	12,3	0,24	1,04	0,07	11	1,23	0,19	0,08	0,10
M	9,39	19,1	11,4	0,25	1,11	0,03	24	1,46	0,18	0,07	0,15

Perna perna. Tissue-metal concentrations in samples collected over the tidal range.

Wet mass g	Dry mass %	µg metal / g wet tissue								
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
300 mm above spring low water (N=25)										
4,52	10,4	10,4	0,44	1,12	0,30	64	0,95	0,66	0,06	0,68
4,12	11,4	11,7	0,60	0,75	0,19	61	0,89	1,11	0,04	0,58
5,27	10,2	8,7	0,72	1,10	0,17	44	0,58	0,20	0,01	0,53
4,48	12,7	12,1	0,60	0,93	0,17	54	0,98	1,51	0,11	0,71
5,20	11,2	10,6	0,55	0,76	0,13	42	0,59	0,57	0,05	0,59
5,56	12,8	10,4	0,50	1,40	0,12	63	0,62	1,56	0,08	0,55
4,18	10,5	7,4	0,86	1,12	0,11	65	0,59	0,23	<0,02	0,64
3,15	11,1	10,5	0,50	0,82	0,12	102	0,85	0,50	0,03	1,46
3,27	13,1	16,2	0,64	1,13	0,09	92	1,40	1,92	0,12	0,85
2,87	15,7	15,7	0,55	1,49	0,20	108	1,91	0,76	0,03	0,69
2,88	11,5	8,7	0,62	1,07	0,06	56	0,79	0,65	0,06	0,79
2,06	16,5	20,9	0,87	1,60	0,24	34	0,72	2,08	<0,04	0,97
2,19	15,5	14,6	0,50	1,32	0,18	105	1,46	0,22	<0,04	0,95
2,52	14,3	12,3	0,47	1,07	0,07	36	0,99	0,55	<0,03	0,87
2,55	15,3	15,3	0,58	1,33	0,07	75	1,41	1,05	<0,03	0,90
1,88	14,9	9,0	0,58	1,06	0,31	32	0,58	0,21	<0,05	1,06
0,82	14,2	10,6	0,42	1,06	0,14	97	1,03	0,72	0,04	1,52
600 mm above spring low water (N=34)										
4,88	11,5	10,9	0,63	1,08	0,10	62	0,92	0,32	0,06	0,63
4,05	10,6	9,6	0,71	0,93	0,09	30	0,69	0,61	0,04	0,81
3,39	11,8	10,3	0,64	0,79	0,05	29	0,32	0,44	<0,02	0,88
3,58	12,3	12,8	0,64	1,08	0,13	73	0,72	0,50	0,05	0,86
3,38	11,5	7,7	0,88	0,79	0,05	21	0,32	0,76	0,11	0,79
1,71	11,1	5,3	0,81	1,16	0,17	35	0,40	0,70	<0,05	1,57
2,07	13,5	13,0	0,77	0,96	0,09	39	0,86	0,77	<0,04	1,01
2,40	14,2	15,0	0,50	1,12	0,16	88	1,62	1,04	<0,04	1,29
0,65	14,4	9,3	0,41	1,02	0,15	102	0,88	0,88	0,03	0,51
0,27	14,9	11,2	0,41	1,23	0,16	149	1,40	1,15	<0,04	0,99
8,39	14,2	8,5	0,43	0,94	0,11	61	0,54	0,49	0,03	0,57
7,04	10,1	9,9	0,51	0,99	0,11	30	0,36	0,96	0,07	0,51
7,31	11,1	13,2	0,45	1,03	0,13	81	0,72	0,73	0,02	0,65
5,33	10,1	9,4	0,54	0,76	0,01	41	0,50	0,31	0,03	0,58
6,21	11,6	15,0	0,80	2,22	0,16	179	1,20	0,41	0,02	0,60
5,37	12,8	10,6	0,37	1,30	0,11	78	0,74	0,42	<0,01	0,72
4,35	17,0	21,1	0,48	1,42	0,11	87	1,77	1,93	0,04	0,73

Perna perna. Tissue-metal concentrations in samples collected over the tidal range (continued)

Wet mass g	Dry mass %	μg metal / g wet tissue								
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
1000 mm above spring low water (N=46)										
3,33	13,5	12,6	0,54	0,63	0,09	27	0,36	1,35	<0,03	0,51
2,95	14,9	10,9	0,47	1,08	0,20	95	0,77	0,98	0,10	0,77
2,58	15,5	14,3	0,69	1,20	0,07	78	0,81	1,43	0,03	1,00
2,37	13,9	16,9	0,54	1,30	0,16	84	1,39	0,71	0,08	0,75
3,61	12,2	9,4	0,47	0,72	0,16	86	0,66	1,16	0,05	0,72
2,06	11,2	11,2	0,43	0,87	0,14	78	0,82	0,77	<0,04	1,31
2,08	12,5	11,5	0,62	1,05	0,24	77	0,81	0,62	<0,04	0,86
3,42	13,2	11,4	0,55	0,81	0,08	17	0,38	0,76	<0,02	0,84
1,70	11,2	14,7	0,47	1,11	0,41	77	0,95	1,35	<0,05	1,84
2,20	15,5	14,5	0,45	1,13	0,31	50	1,11	1,27	<0,04	1,22
1,53	14,4	15,0	0,65	1,30	0,39	72	1,11	0,84	<0,06	1,30
1,89	13,2	11,6	0,58	1,11	0,47	122	1,37	0,58	0,10	1,95
1,68	13,1	11,9	0,65	1,13	0,17	119	1,19	1,19	<0,05	2,26
1,68	14,3	8,3	0,59	1,13	0,11	83	1,01	0,83	<0,05	1,78
1,91	12,0	11,0	0,52	0,09	0,10	73	0,94	0,73	<0,05	1,51
2,32	9,1	7,8	0,64	1,12	0,04	69	0,99	1,16	<0,04	0,56
2,40	12,1	13,3	0,66	1,50	0,08	108	1,50	1,12	<0,04	0,79
1,61	11,2	10,6	0,49	0,62	0,06	93	1,24	0,86	<0,06	0,99
1,59	17,0	13,2	0,56	1,32	0,37	113	1,50	1,32	<0,06	1,06
1,42	14,1	9,2	1,05	1,05	0,21	92	0,84	0,63	<0,07	1,69
1,23	13,8	8,9	0,56	1,13	0,16	81	0,13	0,97	<0,08	1,30
1,13	19,5	14,2	0,88	1,15	0,17	35	0,70	0,61	<0,08	1,94
1,22	17,2	12,3	0,73	1,47	0,32	114	1,31	1,88	<0,08	1,31
1,03	12,6	11,7	0,77	1,35	0,38	146	1,55	1,16	<0,09	1,16
1,28	14,1	10,9	0,70	1,01	0,46	86	1,01	1,17	<0,07	1,01
1,80	17,2	12,8	0,61	1,50	0,27	106	1,38	0,55	<0,05	0,83
1,42	12,0	11,9	0,70	1,19	0,21	92	1,12	0,91	<0,07	0,63
1,11	15,3	9,9	0,81	1,35	0,27	108	0,99	0,54	<0,09	2,34
1,12	17,0	14,3	0,80	1,33	0,17	116	1,78	0,80	<0,08	2,32
0,55	15,0	10,8	0,48	1,09	0,09	98	0,99	0,71	<0,01	0,53
4,08	17,4	10,0	0,58	1,02	0,07	17	0,36	1,37	0,07	0,53
2,85	18,2	18,6	0,52	1,68	0,17	21	2,03	0,94	<0,03	0,52
3,49	11,2	8,9	0,34	0,63	0,08	46	0,45	0,40	<0,02	0,74
3,96	14,9	15,7	0,65	0,83	0,15	23	0,65	1,18	<0,02	0,63
3,49	18,1	9,5	0,51	1,20	0,25	120	1,06	0,48	<0,02	0,68
1300 mm above spring low water (N=42)										
0,74	14,9	9,0	0,43	0,95	0,10	103	0,95	0,46	<0,02	0,86
0,42	14,5	6,5	0,35	0,59	0,08	56	0,47	0,41	<0,02	0,38
3,57	13,2	6,7	0,70	1,03	0,14	78	0,67	0,28	<0,02	0,64
3,73	16,6	13,7	0,56	1,12	0,21	59	0,64	0,93	<0,02	0,58
4,93	13,2	14,4	0,36	0,85	0,08	51	0,60	0,66	<0,02	0,58
3,74	15,5	19,3	0,56	0,96	0,13	51	0,48	1,20	<0,02	0,66
2,90	10,0	11,7	0,13	0,17	0,10	30	0,10	0,58	<0,03	0,44
3,20	15,3	11,9	0,50	0,96	0,15	53	0,90	0,75	<0,03	0,29
2,08	15,4	13,9	0,48	1,00	0,24	84	1,00	0,72	<0,04	1,05
3,65	15,9	12,3	0,19	0,90	0,10	49	0,63	0,52	<0,02	1,01
2,80	15,0	9,6	0,42	1,00	0,10	139	1,00	0,96	<0,03	1,78
2,87	13,2	17,8	0,66	1,18	0,17	28	0,90	1,95	<0,03	0,83
2,53	11,9	11,9	0,59	0,71	0,19	63	0,55	0,43	<0,03	0,79
2,92	16,8	16,1	0,75	1,06	0,17	45	0,95	1,33	<0,06	0,51
3,09	15,5	10,4	0,61	0,74	0,16	74	0,55	1,58	<0,03	0,61
1,69	16,6	13,6	0,59	1,12	0,23	71	1,30	0,88	<0,05	1,53
2,00	13,0	12,5	0,60	1,00	0,05	35	0,95	0,60	<0,05	1,20
1,74	12,6	12,6	0,63	0,97	0,11	75	1,03	0,45	<0,05	1,49
1,30	15,4	13,8	1,00	0,84	0,30	54	0,84	0,84	<0,07	1,84
0,94	16,0	9,6	0,63	1,06	0,21	85	1,06	1,17	<0,10	2,34
1,29	17,0	12,4	0,62	1,39	0,07	39	0,85	0,46	<0,07	1,08
1,45	15,2	14,5	1,68	1,37	0,20	14	0,75	0,55	<0,06	1,31
1,04	15,4	10,6	0,67	1,44	0,19	115	1,05	0,67	<0,09	2,30
1,00	13,0	11,0	0,60	1,10	0,40	130	1,40	1,20	0,30	2,00
1,00	11,0	12,0	0,60	1,10	0,20	60	0,90	0,60	<0,10	2,00
0,74	14,9	10,3	0,46	1,08	0,10	114	1,00	0,86	<0,02	0,84

Perna perna. Tissue-metal concentrations in samples collected over the tidal range. (continued)

Wet mass g	Dry mass %	µg metal / g wet tissue								
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
1600 mm above spring low water (N=40)										
2,08	17,8	12,5	0,67	0,91	0,04	77	1,00	0,57	<0,04	0,81
2,00	17,5	13,0	0,70	0,95	0,05	80	1,05	0,60	<0,05	0,85
1,02	17,5	12,1	0,38	0,77	0,04	44	0,63	1,11	<0,04	0,63
1,58	18,6	13,7	0,68	1,17	0,09	127	1,56	0,58	<0,09	1,47
1,04	17,7	13,9	0,56	1,20	0,06	95	1,45	0,69	<0,06	0,75
1,16	18,3	15,4	0,67	0,96	0,09	77	1,05	0,08	<0,09	0,76
2,06	19,8	17,2	0,68	1,29	0,08	60	1,55	1,63	<0,08	1,12
0,29	16,1	12,4	0,52	1,19	0,11	99	1,14	0,59	0,06	0,71
6,51	11,5	14,1	0,89	0,96	0,04	51	0,49	2,05	0,15	0,32
4,96	14,7	8,7	0,82	0,68	0,08	85	0,62	0,78	<0,02	0,54
5,45	13,6	9,2	0,62	0,77	0,07	61	0,55	0,64	<0,01	0,64
2,56	14,5	12,9	0,93	1,32	0,03	70	0,85	0,70	<0,03	0,54
4,58	14,6	11,8	0,61	1,02	0,06	61	0,74	1,02	0,13	0,41
3,15	13,7	15,9	0,44	0,85	0,06	63	0,63	0,69	<0,03	0,53
3,91	15,1	9,0	0,35	0,97	0,05	21	0,35	0,63	0,07	0,46
3,45	17,1	13,6	0,43	0,89	0,08	63	0,78	1,39	<0,02	0,55
3,40	14,4	8,2	0,44	0,91	0,08	68	0,67	0,35	<0,02	0,50
3,85	15,6	12,5	0,85	1,53	0,02	57	0,72	1,11	<0,02	0,64
3,25	14,8	8,6	0,43	0,83	0,09	92	0,86	0,46	<0,02	0,70
3,79	17,9	17,2	0,68	1,24	0,07	79	1,39	1,29	<0,03	0,68
2,82	15,2	14,9	0,85	1,06	0,10	46	1,06	0,99	0,05	0,70
3,52	12,8	9,7	0,96	0,76	0,11	59	0,85	0,53	0,10	0,68
3,54	15,7	9,8	0,74	0,15	0,15	48	0,55	0,31	0,05	0,62
2,96	17,9	10,1	0,54	0,87	0,16	57	0,67	0,20	<0,03	0,60
2,15	18,1	12,6	0,60	0,83	0,04	9	0,46	0,79	<0,03	0,74
2,08	17,3	13,0	0,52	1,00	0,04	101	0,96	0,62	<0,04	0,76
2000 mm above spring low water (N=65)										
2,67	13,9	15,4	0,71	1,04	0,03	45	0,82	0,97	0,03	0,86
2,58	12,8	9,3	0,89	0,93	0,07	58	0,50	1,35	<0,03	0,54
1,77	14,7	10,7	0,73	0,90	0,11	62	0,67	0,96	<0,05	0,84
2,09	14,4	13,9	0,76	1,00	0,28	91	0,86	1,57	<0,04	0,52
2,13	15,0	16,9	0,84	1,22	0,14	89	1,07	1,07	<0,04	0,98
2,64	14,4	14,0	0,64	1,09	0,07	61	0,87	0,56	<0,03	0,08
2,00	13,5	15,5	0,60	1,15	0,05	100	1,00	1,20	<0,05	0,95
2,09	12,4	17,2	0,66	0,86	0,19	86	0,71	2,05	<0,04	0,90
2,37	15,2	10,5	0,50	0,84	0,08	101	0,80	0,84	<0,04	1,05
1,91	16,8	13,1	0,73	0,78	0,31	21	0,52	0,41	<0,05	0,78
1,75	12,0	6,9	0,62	0,62	0,05	40	0,51	0,40	<0,05	1,31
1,79	11,2	12,8	0,61	0,83	0,05	89	0,67	0,94	<0,05	1,22
1,43	11,9	19,6	0,97	1,25	0,20	84	0,97	1,67	<0,13	0,97
2,23	12,6	12,1	0,80	0,98	0,04	108	0,89	0,58	0,17	0,94
1,66	13,3	9,6	0,66	1,02	0,06	127	0,96	0,66	<0,06	0,90
1,74	16,1	12,6	0,63	1,03	0,11	115	1,14	0,63	<0,05	1,20
2,10	13,3	10,5	0,52	0,85	0,09	95	0,95	0,52	<0,04	1,00
1,21	12,4	12,3	0,90	1,81	0,31	124	1,40	1,15	<0,08	1,32
1,59	13,8	11,9	0,69	1,06	0,12	101	1,06	0,44	<0,06	0,75
1,23	17,9	13,9	0,81	1,30	0,18	57	1,21	0,32	<0,08	1,46
1,23	12,2	13,0	0,73	1,30	0,08	130	1,30	0,89	<0,08	1,78
1,12	15,2	14,3	0,89	1,07	0,08	54	0,80	1,42	<0,08	1,25
1,37	12,4	11,7	0,58	1,38	0,21	95	0,94	0,87	<0,07	1,60
1,06	9,4	8,5	0,47	1,03	0,09	57	0,75	0,56	<0,09	1,22
1,41	16,3	16,3	0,42	1,27	0,07	85	1,27	0,85	<0,07	0,56
1,18	11,9	13,6	0,42	0,93	0,08	34	0,93	1,01	<0,08	1,18
0,57	15,8	7,0	0,70	1,22	0,35	35	1,05	0,52	<0,17	1,40
1,00	12,0	8,0	1,00	1,00	0,10	60	0,80	0,80	<0,10	1,40
1,00	9,0	9,0	1,00	0,98	0,50	40	0,70	1,00	<0,10	1,40
1,62	13,6	10,5	0,49	1,13	0,18	95	0,98	1,04	<0,06	1,17
1,06	13,2	10,4	0,56	1,26	0,18	123	1,22	0,94	<0,09	2,07
1,11	13,5	13,5	0,54	1,09	0,27	126	1,53	1,08	<0,09	0,99
0,91	14,3	13,2	0,65	1,15	0,10	99	1,20	0,87	<0,10	2,63
0,69	7,2	7,2	0,43	1,00	0,14	130	1,44	0,28	<0,14	1,59
0,74	13,9	12,2	0,55	1,00	0,11	89	1,00	1,11	<0,05	0,83
0,13	11,5	12,2	0,53	1,14	0,07	153	1,45	1,22	<0,07	1,22
3,94	13,7	16,2	0,81	0,91	0,10	86	0,68	2,05	0,17	1,19
3,73	15,5	19,0	1,15	1,12	0,05	94	0,80	1,52	0,10	0,77
4,71	13,6	11,5	0,48	1,33	0,14	76	0,67	1,08	0,04	0,48
3,61	14,1	10,5	0,80	0,85	0,22	105	0,74	0,88	<0,02	0,74
3,49	14,0	9,2	0,57	0,91	0,20	106	0,91	0,48	0,08	0,80
2,77	11,6	9,7	0,83	0,97	0,10	65	0,68	0,90	0,07	0,61
3,00	14,7	16,7	0,73	1,16	0,06	110	1,10	2,16	<0,03	0,06
3,19	13,5	10,3	0,87	1,12	0,06	85	0,90	1,37	0,06	0,94
2,58	6,6	14,0	0,69	1,00	0,03	93	0,77	0,65	0,11	1,12
2,21	14,0	19,5	0,72	1,17	0,04	104	1,13	2,03	0,13	1,26

APPENDIX 3

Perna perna. Tissue-metal concentrations after 3 weeks exposure to 100 µg/l cadmium (T=24°C)

Wet mass g	Dry mass g	Dry mass %	Cd µg/g (wet)	Wet mass g	Dry mass g	Dry mass %	Cd µg/g (wet)
2,64	0,32	12,1	2,0	2,29	0,28	12,2	1,9
5,67	0,60	10,6	1,1	3,03	0,38	12,5	2,4
3,39	0,49	14,5	2,3	0,81	0,12	14,8	3,0
2,76	0,44	15,9	2,1	0,78	0,12	15,4	3,1
4,69	0,57	12,2	1,6	1,27	0,29	17,1	3,3
2,53	0,37	14,6	2,2	1,46	0,23	15,8	3,1
4,80	0,75	15,6	2,5	0,81	0,08	9,9	3,5
2,49	0,38	15,3	2,3	0,58	0,08	13,8	4,6
1,77	0,31	17,5	2,5	0,52	0,08	15,4	3,8
8,54	0,84	9,8	0,8	0,88	0,14	15,9	5,2
4,23	0,54	12,8	2,4	0,88	0,13	14,8	4,3
1,75	0,30	17,1	1,7	0,68	0,09	13,2	5,2
1,89	0,28	14,8	1,4	0,45	0,05	11,1	3,8
1,69	0,23	13,6	2,2	0,57	0,05	8,8	4,8
3,35	0,52	15,5	2,5	0,48	0,07	14,6	4,3
1,93	0,31	16,1	2,0	0,35	0,06	17,1	4,7
4,23	0,58	13,7	2,3	0,52	0,07	13,5	3,1
3,53	0,49	13,9	2,5	0,45	0,09	20,0	4,6
2,91	0,41	14,1	3,0	0,42	0,05	11,9	4,3
1,12	0,18	16,1	2,9	0,33	0,04	12,1	5,7
2,39	0,31	13,0	2,3	0,23	0,03	13,0	4,6
0,71	0,13	18,3	2,4	0,15	0,02	13,3	7,1
1,67	0,23	13,8	2,6	0,47	0,05	10,6	3,8
0,76	0,13	17,1	2,6	0,38	0,05	13,2	4,9
1,23	0,19	15,4	3,1	4,99	0,57	11,4	1,8
0,48	0,06	12,5	7,9	3,54	0,42	11,9	1,9
1,20	0,22	18,3	1,8	3,27	0,42	12,8	2,3
1,99	0,32	16,1	1,9	3,22	0,38	11,8	2,5
1,68	0,25	14,9	3,6	2,63	0,31	11,8	2,4
1,86	0,25	13,4	2,5	2,64	0,32	12,1	3,0
4,44	0,58	13,1	1,1	2,29	0,28	12,2	1,9
1,85	0,28	15,1	1,8	2,38	0,31	13,0	3,3
1,77	0,28	15,8	2,5	4,41	0,57	12,7	2,3
3,79	0,49	12,9	1,7	3,67	0,46	12,5	1,6
2,38	0,31	13,0	3,2	4,99	0,57	11,4	1,8
4,41	0,57	12,9	2,2	3,54	0,42	11,9	1,9
3,67	0,46	12,5	1,6	3,27	0,42	12,8	2,3

Choromytilus meridionalis. Tissue-metal concentrations after 3 weeks exposure to 100 µg/l cadmium (T=24°C)

6,82	1,04	15,2	0,89	20,43	2,44	11,9	0,79
14,60	2,52	17,3	0,93	15,23	2,38	15,6	0,68
6,81	1,13	16,6	0,85	10,13	1,42	14,0	0,73
5,47	1,00	18,3	0,97	6,33	1,10	17,4	1,12
5,96	1,18	19,8	1,53	5,58	0,84	15,0	1,08
4,02	0,66	16,4	1,22	5,13	0,90	17,5	1,58
2,53	0,50	19,8	1,62	2,59	0,43	16,6	1,35
7,76	0,83	10,7	0,74	3,18	0,56	17,6	1,01
2,86	0,52	18,2	1,55	2,27	0,39	17,2	0,93
2,60	0,41	15,8	2,00	13,92	2,39	17,2	0,75
2,36	0,40	16,9	1,78	13,43	1,98	14,7	0,77
2,80	0,46	16,4	1,46	17,30	2,51	14,5	0,79
2,17	0,40	18,4	1,52	14,27	2,31	16,2	0,97
2,16	0,34	15,7	1,34	9,16	1,34	14,6	0,75
1,17	0,20	17,1	1,54	7,16	1,32	18,4	0,91
1,04	0,13	12,5	1,73	5,91	0,95	16,1	0,95
0,72	0,08	11,1	1,81	8,91	1,38	15,5	1,00
1,08	0,15	13,9	1,53	2,68	0,67	25,0	1,68
1,22	0,18	14,3	1,71	5,63	0,96	17,1	1,33
1,18	0,16	13,5	1,77	5,07	0,94	18,5	1,40
4,30	1,24	16,8	1,26	3,65	0,63	17,3	1,89
6,12	1,03	16,8	0,95	8,86	1,58	17,8	0,68
5,82	0,65	11,2	0,86	7,29	1,38	18,9	1,44

Crassostrea gigas. Tissue-metal concentrations following exposure to 50 µg/l cadmium (T=15°C)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
Initial Sample								
5,28	0,72	13,6	127	0,38	12,5	0,07	19	2,12
0,89	0,19	21,3	124	0,62	10,0	0,12	31	2,42
3,28	0,45	13,6	160	0,35	10,0	0,07	18	2,61
4,10	0,62	15,1	147	0,51	6,5	0,05	21	3,47
4,19	0,71	16,9	101	0,42	10,3	0,04	19	1,57
3,01	0,55	18,2	171	0,46	7,8	0,07	18	2,57
3,40	0,62	18,2	127	0,33	8,0	0,10	23	1,71
3,72	0,66	17,8	193	0,48	10,3	0,08	21	2,00
3,36	0,55	16,3	134	0,49	9,8	0,06	22	2,33
7,56	0,93	12,3	143	0,55	13,8	0,04	20	1,73
After 1 week								
2,51	0,32	12,7	111	4,18	18,3	0,08	22	1,95
4,57	0,63	13,7	146	4,01	17,5	0,04	16	2,08
5,57	0,79	14,2	147	4,52	9,8	0,04	18	2,44
2,43	0,38	15,4	181	5,88	13,4	0,07	21	2,39
5,07	0,76	14,9	222	3,46	10,4	0,06	16	1,72
4,01	0,56	13,8	143	5,37	8,7	0,04	16	2,15
4,00	0,58	14,3	164	4,82	7,2	0,04	16	2,12
5,88	0,89	15,1	94	2,96	9,0	0,04	18	2,21
4,01	0,59	14,7	189	4,21	9,5	0,04	23	1,81
After 2 weeks								
2,90	0,39	12,1	148	14,2	9,7	0,03	24	2,59
0,63	0,07	11,1	181	11,9	8,7	0,06	25	2,17
4,47	0,69	15,4	197	11,6	9,8	0,05	28	2,18
3,99	0,62	15,5	191	16,2	10,3	0,06	24	2,76
5,89	0,88	14,9	151	22,1	14,9	0,04	18	1,53
2,27	0,28	12,3	124	18,7	9,6	0,07	18	2,20
4,97	0,61	12,3	155	12,5	11,8	0,06	12	2,45
7,81	0,86	11,0	131	12,4	9,2	0,03	19	1,97
7,50	0,92	12,3	161	14,7	8,2	0,05	20	1,40
After 3 weeks								
10,51	1,24	11,8	194	22,4	11,6	0,04	13	2,18
9,02	1,53	17,0	197	19,7	10,5	0,04	11	1,86
2,53	0,30	12,8	161	31,8	9,6	0,08	26	2,70
3,33	0,39	11,7	156	24,8	20,3	0,04	18	1,96
5,19	0,53	10,2	154	17,5	9,4	0,06	12	1,39
5,17	0,67	13,0	166	21,1	11,6	0,05	18	1,89
4,46	0,44	9,9	170	18,1	13,8	0,07	20	1,22
3,00	0,31	10,2	157	26,2	7,8	0,05	19	0,83
3,93	0,41	10,5	184	25,1	7,6	0,07	23	1,03
5,82	0,72	12,4	155	17,6	10,3	0,04	21	1,56
5,01	0,69	13,8	160	24,3	13,0	0,05	18	2,18
5,26	0,81	15,4	152	19,0	12,0	0,03	17	1,31

Crassostrea margaritacea. Tissue-metal concentrations following exposure to 50 µg/l cadmium (T=15°C)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue Zn	Cd	Cu	Pb	Fe	Mn
Initial sample								
3,01	0,65	21,4	132	0,42	1,6	0,07	5,5	0,60
5,11	1,02	20,0	196	0,47	1,2	0,06	6,0	0,45
3,29	0,63	19,3	183	0,41	1,3	0,07	5,2	0,41
4,86	1,02	21,0	181	0,41	2,2	0,06	6,5	0,48
5,35	1,17	21,9	161	0,41	2,2	0,05	8,9	0,87
4,25	0,62	14,6	213	0,62	1,1	0,06	10,8	0,32
3,99	0,81	20,2	152	0,84	2,0	0,07	9,9	1,49
3,51	0,81	23,1	191	0,57	2,1	0,12	6,4	1,51
5,72	0,96	16,9	207	0,97	1,6	0,04	4,0	1,48
3,71	0,53	14,3	130	0,50	1,5	0,05	6,2	0,67
After 1 week								
4,81	1,04	21,6	148	1,61	1,9	0,03	6,7	1,60
4,69	0,97	20,8	142	1,93	2,4	0,03	10,6	0,37
7,32	1,48	20,2	226	0,81	1,7	0,05	6,9	1,28
5,25	1,10	21,0	182	2,04	1,8	0,13	10,2	0,24
6,05	1,27	20,9	155	2,33	1,9	0,06	9,7	0,31
3,74	0,75	20,0	135	2,04	1,3	0,16	10,4	1,53
2,64	0,53	20,1	165	1,85	1,4	0,07	14,7	0,38
3,73	0,70	18,8	167	1,27	0,7	0,05	11,0	0,21
0,94	0,24	25,5	194	0,96	1,2	0,06	16,3	0,21
After 2 weeks								
2,04	0,37	18,1	225	2,85	1,6	0,08	13,2	0,92
4,05	0,82	20,4	204	1,86	1,5	0,04	5,7	0,43
4,54	0,88	19,3	163	2,28	1,6	0,04	9,6	0,46
4,88	0,85	17,3	202	2,46	1,4	0,06	9,7	0,99
2,84	0,55	19,3	188	2,01	1,5	0,14	16,3	1,68
3,86	0,68	17,6	224	2,82	1,9	0,05	9,4	1,34
1,99	0,48	24,1	176	2,66	0,9	0,28	17,0	0,50
2,77	0,63	22,7	162	3,24	1,9	0,15	6,9	0,40
2,72	0,41	15,1	157	2,28	1,3	0,06	15,0	1,95
After 3 weeks								
2,10	0,36	17,1	229	2,85	1,7	0,05	19,5	0,38
1,86	0,40	21,5	161	4,20	1,6	0,10	16,5	0,67
2,85	0,47	16,5	215	2,89	1,6	0,07	10,0	1,77
4,13	0,84	20,2	216	3,31	1,0	0,22	9,7	2,01
3,20	0,60	18,8	159	2,96	1,9	0,06	15,2	1,21
4,87	0,90	18,5	121	2,85	2,2	0,14	13,7	0,98
4,48	0,82	18,3	198	1,99	1,2	0,05	15,4	1,34
2,37	0,40	16,9	165	5,15	1,5	0,06	15,6	1,22
3,11	0,58	18,6	172	4,66	1,5	0,04	14,9	1,04
5,16	0,89	17,2	176	3,07	1,9	0,11	11,2	1,76
8,80	1,12	12,7	122	2,62	1,1	0,04	9,1	0,92
5,13	0,74	14,5	149	2,51	2,0	0,06	12,4	1,31

Perna perna. Tissue-metal concentrations following exposure to 50 µg/l cadmium ($T=15^{\circ}C$)

Sex	Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
				Zn	Cd	Cu	Pb	Fe	Mn
	Initial sample								
M	6,62	1,29	19,5	17,3	0,64	1,1	0,26	21	0,54
M	5,61	0,98	17,5	19,3	0,44	1,2	0,25	27	0,61
M	3,06	0,50	16,3	20,8	0,56	1,2	0,31	20	0,57
M	3,83	0,71	18,5	18,5	0,53	1,4	0,36	25	0,72
M	4,14	0,60	14,5	19,7	0,38	1,1	0,23	20	0,56
F	3,58	0,66	18,5	24,0	0,43	2,1	0,58	32	0,97
F	2,42	0,38	15,9	22,8	0,39	1,2	0,60	29	1,61
F	2,54	0,51	19,9	28,9	0,41	2,9	0,73	32	1,23
F	1,50	0,28	18,7	23,3	0,47	1,9	0,38	29	1,10
M	2,13	0,41	19,1	20,0	0,62	1,6	0,41	22	0,69
	After 1 week								
M	1,86	0,31	16,7	19,9	2,27	1,3	0,48	28	0,63
M	3,27	0,49	14,9	20,8	1,86	1,1	0,48	24	0,74
M	2,64	0,42	15,9	18,3	2,45	1,2	0,32	27	0,58
M	2,04	0,34	16,7	19,5	1,96	1,0	0,43	36	0,66
M	1,71	0,31	18,2	22,7	1,75	1,5	0,41	19	0,72
M	0,81	0,13	16,2	17,6	1,65	1,3	0,48	22	0,81
F	3,29	0,59	17,9	23,4	2,05	1,9	0,43	25	1,27
F	3,85	0,58	15,1	26,1	1,93	1,2	0,57	28	1,18
F	2,59	0,49	18,9	21,8	2,16	1,0	0,50	30	1,21
	After 2 weeks								
F	2,63	0,51	19,4	22,9	3,86	1,7	0,31	18	1,88
F	2,88	0,51	17,7	22,6	2,78	1,3	0,34	22	1,60
F	0,92	0,21	22,8	23,8	2,66	0,8	0,43	18	1,22
F	2,45	0,49	20,0	25,2	2,87	1,1	0,43	26	1,00
M	1,66	0,36	21,7	17,7	2,82	1,0	0,26	18	0,81
M	3,65	0,67	18,4	20,0	2,95	0,7	0,31	26	0,68
M	4,17	0,87	20,9	19,6	2,47	0,8	0,43	25	0,73
F	4,39	0,77	17,5	23,8	3,65	1,4	0,32	16	0,46
F	4,63	0,83	17,9	22,7	2,48	1,0	0,26	31	1,22
	After 3 weeks								
F	2,48	0,47	19,1	25,1	5,3	1,0	0,36	21	1,75
F	2,07	0,60	14,5	20,0	3,8	1,0	0,46	18	0,65
F	0,97	0,23	23,3	25,9	4,3	1,5	0,39	27	1,14
M	2,21	0,46	20,8	14,4	3,9	0,9	0,34	32	0,72
M	0,99	0,23	23,2	27,3	4,1	1,2	0,20	29	0,51
F	5,32	0,99	18,6	14,2	4,7	0,7	0,28	17	1,09
F	3,85	0,73	19,0	18,6	6,2	0,7	0,33	15	1,19
M	2,66	0,40	15,0	17,8	7,9	0,8	0,39	16	0,53
M	1,56	0,24	15,4	25,6	6,4	1,4	0,80	22	0,51
M	1,82	0,34	18,7	23,1	4,4	0,9	0,41	11	0,44
F	2,15	0,39	18,1	23,3	3,9	1,3	0,46	23	0,47
M	1,85	0,29	15,7	19,2	3,2	1,2	0,41	23	0,70

Choromytilus meridionalis. Tissue-metal concentrations after exposure to 50 µg/l cadmium (T=15°C)

Sex	Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue Zn	Cd	Cu	Pb	Fe	Mn
	Initial sample								
M	7,75	1,27	16,3	17,6	0,38	1,8	0,23	13,4	1,04
M	7,06	1,32	18,7	16,0	0,29	2,0	0,23	12,4	1,46
M	5,24	1,01	19,3	15,7	0,21	2,2	0,22	13,9	1,67
M	7,18	1,44	20,0	18,5	0,26	2,1	0,32	17,9	1,56
M	9,23	1,85	20,0	18,0	0,37	1,8	0,23	12,3	1,25
M	7,85	1,41	18,0	19,3	0,46	2,1	0,31	14,5	1,62
F	6,36	1,35	21,1	25,2	0,36	0,8	0,27	10,9	2,08
F	9,09	1,73	19,0	25,6	0,35	1,4	0,23	13,8	3,73
F	6,10	1,16	19,0	21,1	0,38	1,0	0,22	13,9	2,42
F	5,26	0,89	17,0	22,8	0,35	1,2	0,28	14,0	2,17
	After 1 week								
F	8,96	1,42	15,8	24,6	0,68	1,8	0,23	15,6	2,37
M	10,17	1,85	18,2	20,4	0,62	2,5	0,22	11,1	0,99
M	8,17	1,46	17,9	18,0	0,69	0,9	0,25	11,4	1,69
M	11,91	1,99	16,7	18,3	0,76	1,1	0,21	12,2	0,97
F	7,50	1,43	19,1	24,0	0,67	1,1	0,27	11,6	3,01
M	12,33	2,15	17,4	15,9	0,69	0,9	0,24	10,6	1,05
M	8,53	1,20	14,1	18,1	0,48	1,4	0,24	14,4	0,60
M	12,90	1,95	15,1	17,3	0,58	1,5	0,18	9,2	1,13
F	7,23	1,22	16,9	22,3	0,26	1,7	0,22	12,7	3,04
	After 2 weeks								
M	7,61	1,08	14,2	18,9	0,91	1,5	0,25	21,4	1,16
M	10,85	1,37	12,6	15,5	0,56	1,7	0,18	14,1	0,91
F	10,04	1,64	16,3	21,4	0,67	1,2	0,18	9,7	3,12
F	10,85	1,68	15,5	24,0	0,84	1,7	0,25	13,3	2,52
M	12,89	1,91	14,8	15,9	0,97	1,2	0,16	14,1	1,02
F	14,11	1,82	12,9	22,1	0,95	1,6	0,20	12,2	2,05
M	8,99	1,70	18,9	19,0	1,27	1,2	0,22	10,0	0,87
F	8,11	1,23	15,2	22,6	1,03	1,2	0,21	11,5	0,75
M	11,51	1,60	13,9	15,7	0,44	1,6	0,25	11,2	1,09
	After 3 weeks								
F	6,12	1,16	19,0	26,6	1,44	1,5	0,20	14,9	2,83
F	8,71	1,41	16,2	21,4	1,26	1,5	0,22	11,8	1,77
F	9,11	1,43	15,7	21,3	1,54	1,4	0,27	11,2	2,93
M	5,75	0,93	16,2	18,4	1,03	1,7	0,23	9,0	1,56
F	7,80	1,46	18,7	26,9	1,17	1,4	0,38	8,6	1,95
F	2,97	0,46	15,5	22,6	1,68	1,7	0,24	11,5	2,73
M	7,34	1,37	18,7	22,6	1,12	1,9	0,20	9,5	1,19
F	8,39	1,07	12,8	25,4	1,63	1,9	0,41	12,0	2,10
M	1,95	0,35	17,9	29,7	0,99	3,4	0,24	13,3	1,72
M	9,13	1,64	18,0	19,9	1,47	1,3	0,22	15,7	1,23
M	11,87	1,94	16,3	18,8	1,35	1,7	0,23	12,3	1,47
F	7,82	1,54	19,7	26,7	1,56	1,5	0,18	12,3	2,74

Crassostrea gigas. Tissue-metal concentrations following exposure to 0, 50 and 100 µg/l cadmium at water temperatures of 15, 18, 21 and 24 °C.

Tissue: 1. Mantle
2. Gill
3. Muscle
4. Remainder

10 individuals per treatment

Cd (µg/l)	T °C	Tissue	No	Wet mass (g)	Dry mass (g)	Dry mass (%)	µg metal/g wet tissue					
							Zn	Cd	Cu	Pb	Fe	Mn
0	18	1	10	11,41	0,92	8,1	116	1,28	15,6	0,31	17,4	1,07
		2	10	11,80	0,91	7,7	139	2,35	22,8	0,26	13,2	1,20
		3	10	6,49	0,95	14,6	54	0,74	6,9	0,34	13,6	1,13
		4	5	9,03	0,63	7,0	64	1,04	10,3	0,28	15,1	0,85
		4	5	8,78	0,77	8,8	75	1,31	14,0	0,35	14,2	1,00
0	21	1	9	8,23	0,59	7,2	102	1,19	17,9	0,27	23,1	1,23
		2	9	9,43	0,69	7,3	146	1,76	23,5	0,26	13,4	1,25
		3	9	5,33	0,73	13,7	71	0,83	10,5	0,42	14,5	1,09
		4	4	10,11	0,62	6,1	58	1,09	10,9	0,27	9,5	0,83
		4	5	7,46	0,51	6,8	71	1,29	12,3	0,32	12,9	0,85
0	24	1	10	9,00	0,77	8,6	122	1,44	14,0	0,34	18,9	1,21
		2	10	8,91	0,67	7,5	196	2,29	23,1	0,28	14,0	1,35
		3	10	6,47	0,81	12,5	54	0,90	9,0	0,26	12,1	0,93
		4	5	5,70	0,38	6,7	89	1,86	19,0	0,32	15,4	1,07
		4	5	7,48	0,53	7,1	80	1,63	14,7	0,28	14,4	0,71
50	15	1	10	8,11	0,69	8,5	132	22,19	15,5	0,20	21,0	1,02
		2	10	5,52	0,49	8,9	174	35,15	28,3	0,21	19,9	1,20
		3	10	6,84	0,97	14,2	82	11,70	8,2	0,20	13,2	0,82
		4	5	6,09	0,47	7,7	115	26,27	15,8	0,19	18,1	0,90
		4	5	4,71	0,47	10,0	127	23,35	17,4	0,24	18,1	1,10
50	18	1	11	9,39	0,71	7,6	117	20,55	16,3	0,33	19,2	1,11
		2	11	8,38	0,66	7,9	165	31,27	27,9	0,28	16,6	1,29
		3	11	5,31	0,67	12,6	53	12,81	8,7	0,33	10,2	1,04
		4	5	4,39	0,30	6,8	75	22,55	13,7	0,40	17,3	1,12
		4	6	4,56	0,37	8,1	90	26,75	16,2	0,35	18,9	1,21
50	21	1	9	7,14	0 61	8,5	108	22,41	15,5	0,26	22,4	0,94
		2	9	5,02	0,41	8,2	185	32,87	24,9	0,27	19,9	1,24
		3	9	4,03	0,54	13,4	52	12,41	6,5	0,26	14,9	0,92
		4	5	6,41	0,53	8,3	81	25,27	11,9	0,22	17,2	0,64
		4	4	3,97	0,27	6,8	83	23,17	9,8	0,18	17,6	0,91
50	24	1	10	6,74	0,54	8,0	153	25,22	21,2	0,25	22,3	0,83
		2	10	6,33	0,53	8,4	167	48,97	32,2	0,23	17,4	1,17
		3	10	3,74	0,54	14,4	75	14,71	10,4	0,22	13,4	0,67
		4	5	6,43	0,58	9,0	126	30,64	15,1	0,24	14,0	0,59
		4	5	7,86	0,50	6,4	116	30,53	17,9	0,20	11,5	0,71
100	15	1	9	6,87	0,52	7,6	124	42,21	14,9	0,18	20,4	0,93
		2	9	4,86	0,38	7,8	195	61,73	20,6	0,25	16,5	1,05
		3	9	3,40	0,41	12,1	74	21,77	7,9	0,25	14,7	0,71
		4	5	4,58	0,38	8,3	129	44,11	12,9	0,24	19,7	0,63
		4	4	2,43	0,18	7,4	111	40,74	14,8	0,27	24,7	0,58

Crassostrea margaritacea. Tissue-metal concentrations following exposure to 0, 50 and 100 µg/l cadmium at water temperatures of 15, 18, 21 and 24°C.

Tissue: 1. Mantle
2. Gill
3. Muscle
4. Remainder

10 individuals per treatment

Cd (ug/l)	°C	Tis-sue	No	Wet mass (g)	Dry mass (g)	Dry mass (%)	µg metal/g wet tissue					
							Zn	Cd	Cu	Pb	Fe	Mn
0	18	1	10	9,65	1,31	13,6	229	0,82	1,25	0,30	17,6	0,45
		2	10	5,96	0,61	10,2	295	0,82	1,17	0,26	18,5	0,49
		3	10	11,46	2,18	19,0	163	0,56	0,93	0,22	10,9	0,64
		4	5	12,22	1,92	15,7	291	0,90	1,63	0,23	17,2	0,75
		4	5	10,10	1,37	13,6	283	0,63	1,52	0,23	14,9	0,71
0	21	1	9	6,44	0,81	12,6	312	0,65	1,43	0,30	18,6	0,48
		2	9	5,35	0,58	11,0	318	0,75	1,61	0,25	20,6	0,36
		3	9	10,19	1,75	17,2	159	0,44	0,84	0,26	17,7	0,45
		4	4	6,30	0,78	12,4	329	0,49	2,10	0,30	20,6	0,67
		4	5	10,35	1,64	16,0	318	0,43	1,70	0,26	19,3	0,51
0	24	1	10	9,51	1,37	14,4	231	0,87	1,12	0,28	20,0	0,57
		2	10	5,52	0,63	11,4	302	1,03	1,56	0,26	18,1	0,65
		3	10	10,48	2,00	19,1	147	0,48	0,95	0,21	8,6	0,37
		4	5	11,18	1,84	16,5	295	0,91	2,20	0,24	14,3	0,87
		4	5	7,20	0,90	12,5	251	0,88	1,38	0,26	19,4	0,63
50	15	1	10	6,16	1,09	17,7	308	4,87	1,48	0,33	22,7	0,73
		2	10	7,14	0,81	11,3	238	4,48	1,40	0,35	26,6	0,84
		3	10	14,33	2,64	18,4	149	1,47	0,72	0,16	10,5	0,38
		4	5	9,86	1,46	14,8	304	2,74	1,79	0,19	16,2	0,48
		4	5	10,93	1,30	11,7	290	3,48	2,28	0,19	15,6	0,83
50	18	1	10	6,29	0,89	14,1	270	6,04	1,54	0,35	23,9	0,51
		2	10	4,52	0,55	12,2	341	9,29	1,50	0,30	24,3	0,51
		3	10	9,28	1,64	17,7	156	2,37	0,69	0,22	12,3	0,29
		4	6	7,96	1,17	14,7	358	5,78	1,92	0,32	26,4	0,57
		4	4	6,84	0,94	14,2	363	4,53	1,75	0,30	26,3	0,48
50	21	1	10	7,85	1,18	15,0	289	8,54	1,20	0,28	19,1	0,54
		2	10	3,76	0,46	12,2	351	13,03	1,78	0,24	23,9	0,45
		3	10	9,82	1,89	19,2	159	3,77	1,01	0,23	13,2	0,36
		4	5	8,24	1,02	12,4	397	8,86	2,50	0,23	15,8	0,29
		4	5	8,23	1,38	16,8	349	6,20	2,55	0,28	19,4	0,77
50	24	1	10	12,06	1,58	13,1	233	7,96	1,38	0,26	15,8	0,47
		2	10	6,25	0,68	10,9	272	12,16	1,06	0,23	22,4	0,51
		3	10	11,40	2,27	19,9	146	4,47	0,83	0,20	10,5	0,45
		4	5	6,72	1,13	16,8	360	9,08	2,10	0,34	25,3	1,00
		4	5	11,39	1,56	13,7	326	8,52	1,65	0,23	16,7	0,78
100	15	1	10	8,00	1,12	14,0	313	10,13	1,29	0,27	25,0	0,58
		2	10	7,31	0,78	10,7	293	12,04	1,15	0,22	21,9	0,38
		3	10	12,04	2,29	19,0	167	2,99	1,03	0,20	15,0	0,39
		4	5	10,41	1,75	17,0	331	7,59	2,13	0,25	15,4	0,88
		4	5	8,70	1,14	13,1	439	7,93	2,02	0,26	21,8	0,37

Perna perna. Tissue-metal concentrations following exposure to 0, 50 and 100 µg/l cadmium at water temperatures of 15, 18, 21 and 24 °C.

Tissue:		
1.	Female - Mantle	7. Male - Mantle
2.	- Gill	8. - Gill
3.	- Gonad	9. - Gonad
4.	- Foot	10. - Foot
5.	- Muscle	11. - Muscle
6.	- Remainder	12. - Remainder

10 individuals per treatment

Cd (µg/l)	T °C	Tissue	No	Wet mass (g)	Dry mass (g)	Dry mass %	Zn	µg metal/g wet tissue Cd	Cu	Pb	Fe	Mn
0	18	1	2	1,42	0,16	11,3	8,8	0,85	0,54	0,26	13,6	0,33
		2		0,33	0,06	18,2	30,3	1,82	0,66	0,30	32,7	0,73
		3		1,43	0,22	15,4	38,5	0,77	1,89	0,33	18,3	1,68
		4		0,05	0,01	20,0	16,0	1,80	1,60	0,60	26,0	0,80
		5		1,92	0,28	14,6	28,1	0,80	0,99	0,42	13,2	0,86
		6		0,79	0,11	13,9	28,0	2,53	1,20	0,46	27,3	0,65
0	18	7	8	8,87	0,99	11,2	6,2	0,61	0,56	0,28	8,4	0,27
		8		2,99	0,40	13,4	19,4	0,87	0,60	0,40	15,4	0,30
		9		4,94	0,68	13,8	15,2	0,71	0,63	0,44	14,2	0,30
		10		1,75	0,31	17,7	9,7	1,34	0,80	0,55	17,9	0,91
		11		8,61	1,50	17,4	21,6	0,78	0,52	0,36	10,6	0,31
		12		3,69	0,58	15,7	21,1	1,27	0,95	0,53	25,9	0,52
0	21	1	6	7,53	0,65	8,6	7,1	0,73	0,60	0,26	9,2	0,31
		2		2,53	0,28	11,1	29,0	1,11	0,79	0,53	22,6	0,55
		3		4,56	0,71	15,6	29,4	0,72	1,38	0,38	13,7	1,14
		4		0,58	0,11	19,0	13,8	2,07	1,38	1,20	33,6	1,21
		5		5,61	0,83	14,8	25,5	0,78	0,70	0,33	9,8	0,48
		6		2,83	0,42	14,8	31,1	2,20	1,13	0,53	27,8	0,85
0	21	7	4	2,62	0,30	11,5	6,5	0,61	0,53	0,42	8,8	0,34
		8		0,92	0,10	10,9	16,3	0,76	0,98	0,50	20,0	0,54
		9		0,87	0,09	10,3	12,6	0,81	0,92	0,46	17,8	0,46
		10		0,41	0,08	19,5	7,3	1,71	1,22	0,72	26,8	1,22
		11		2,71	0,45	16,6	19,9	0,63	0,74	0,44	13,6	0,30
		12		1,19	0,17	14,3	21,9	1,01	0,76	0,53	28,5	0,59
0	24	1	3	2,31	0,20	8,7	10,0	1,04	0,56	0,28	11,5	0,39
		2		0,69	0,10	14,5	33,3	0,58	1,16	0,58	20,7	0,87
		3		1,97	0,25	12,7	32,8	0,91	1,27	0,46	16,7	0,86
		4		0,40	0,10	25,0	12,5	1,25	1,75	0,88	32,3	1,50
		5		2,56	0,35	13,7	29,1	0,90	0,78	0,39	12,1	0,40
		6		1,23	0,17	13,8	27,6	3,09	1,38	0,44	31,9	0,98
0	24	7	7	3,74	0,51	13,6	8,3	0,78	0,88	0,36	13,3	0,43
		8		1,18	0,13	11,0	18,6	1,02	1,27	0,53	21,0	0,59
		9		3,00	0,34	11,3	14,7	1,00	0,93	0,39	15,1	0,40
		10		0,69	0,14	20,3	11,6	1,45	1,05	0,75	22,9	0,87
		11		3,68	0,52	14,1	23,4	1,06	0,79	0,36	11,9	0,41
		12		1,71	0,23	13,5	20,5	1,46	1,23	0,35	31,7	0,64
50	15	1	3	0,93	0,18	19,4	9,7	2,19	0,65	0,24	17,4	0,41
		2		0,51	0,10	19,6	23,5	6,29	0,59	0,38	23,9	0,87
		3		1,02	0,18	17,6	35,5	4,24	1,18	0,38	17,3	1,47
		4		0,23	0,05	21,7	18,7	9,39	1,30	0,52	24,4	3,48
		5		1,68	0,31	18,5	30,2	5,75	0,62	0,56	14,1	0,77
		6		0,82	0,13	15,9	25,6	7,24	0,98	0,63	32,7	0,71
50	15	7	7	1,55	0,29	18,7	7,0	2,13	0,61	0,39	8,3	0,37
		8		1,44	0,23	16,0	18,1	5,83	0,49	0,52	14,2	0,63
		9		2,06	0,29	14,1	12,1	4,18	0,63	0,34	12,9	0,53
		10		0,41	0,08	19,5	14,4	9,27	0,73	0,36	27,8	1,68
		11		3,89	0,70	18,0	22,4	4,60	0,64	0,36	14,1	0,41
		12		1,71	0,29	17,0	18,7	6,96	0,99	0,54	27,9	0,76
50	18	1	1	0,21	0,04	19,0	8,4	2,48	0,48	0,17	14,3	0,36
		2		0,19	0,03	15,8	36,8	6,32	0,53	0,34	29,5	0,63
		3		0,19	0,03	15,8	36,8	4,32	1,05	0,34	15,8	1,63
		4		0,08	0,02	25,0	12,5	10,50	2,50	0,25	32,5	2,25
		5		0,71	0,14	19,7	22,5	6,20	0,99	0,43	15,7	0,43
		6		0,26	0,04	15,4	28,5	8,08	1,08	0,39	37,7	1,31

Perna perna. Tissue-metal concentrations following exposure to 0, 50 and 100 µg/l cadmium at water temperatures of 15, 18, 21 and 24°C. (continued)

Cd (µg/l)	T °C	Tissue	No	Wet mass (g)	Dry mass (g)	Dry mass %	µg metal/g wet tissue					
							Zn	Cd	Cu	Pb	Fe	Mn
50	18	7	9	3,82	0,57	14,9	7,3	2,44	0,55	0,30	8,3	0,39
		8		2,66	0,34	12,8	18,9	5,89	0,49	0,43	16,5	0,45
		9		2,04	0,35	17,2	14,2	4,31	0,74	0,46	17,5	0,49
		10		0,49	0,13	26,5	12,5	9,57	1,23	0,41	22,9	1,25
		11		5,14	0,91	17,7	20,8	4,63	0,68	0,34	13,7	0,37
		12		2,12	0,34	16,0	22,2	7,46	1,03	0,47	28,9	0,61
50	21	1	6	3,97	0,48	12,1	10,1	3,80	0,69	0,24	10,1	0,35
		2		1,75	0,21	12,0	29,4	6,80	0,69	0,37	23,3	0,57
		3		0,91	0,15	16,5	40,7	5,24	1,65	0,39	13,0	1,43
		4		0,64	0,15	23,4	12,5	11,34	1,09	0,16	22,0	1,41
		5		4,37	0,77	17,6	24,9	6,29	0,76	0,31	11,0	0,39
		6		2,55	0,41	16,1	29,8	10,16	1,02	0,34	32,8	0,63
50	21	7	4	3,43	0,36	10,5	7,6	3,38	0,50	0,51	10,6	0,32
		8		1,08	0,14	13,0	18,9	5,28	0,65	0,53	16,4	0,56
		9		2,44	0,27	11,1	11,5	5,26	0,49	0,33	14,8	0,37
		10		0,42	0,09	21,4	11,9	10,71	0,91	0,72	22,4	1,91
		11		2,99	0,51	17,1	20,7	5,59	0,60	0,44	12,9	0,37
		12		1,83	0,25	13,7	21,3	8,63	0,87	0,39	26,9	0,49
50	24	1	3	2,30	0,26	11,3	9,6	4,87	0,74	0,35	11,5	0,35
		2		0,80	0,10	12,5	31,3	8,00	0,88	0,38	29,9	0,63
		3		1,05	0,17	16,2	33,3	8,05	1,52	0,38	17,1	1,14
		4		0,27	0,05	18,5	19,6	11,85	2,63	0,48	26,7	2,44
		5		1,85	0,25	13,5	24,3	6,46	0,87	0,51	12,8	0,60
		6		1,56	0,22	14,1	27,6	11,83	1,03	0,32	27,6	0,96
50	24	7	6	4,27	0,47	11,0	7,0	4,57	0,52	0,27	8,6	0,21
		8		1,61	0,19	11,8	18,0	8,59	0,56	0,50	14,4	0,37
		9		1,43	0,16	11,2	12,6	7,41	0,70	0,53	21,2	0,35
		10		0,71	0,12	16,9	9,9	12,82	0,85	0,71	21,1	0,85
		11		4,15	0,60	14,5	21,2	6,35	0,68	0,40	10,8	0,33
		12		1,25	0,16	12,8	23,2	9,88	1,20	0,51	26,0	0,56
100	15	1	2	1,41	0,21	14,9	8,5	4,82	0,64	0,22	14,2	0,64
		2		0,41	0,07	17,1	34,2	7,32	0,98	0,98	27,6	0,98
		3		1,32	0,23	17,4	32,0	5,53	1,36	0,30	18,8	0,99
		4		0,22	0,05	22,7	19,1	12,64	1,36	0,30	29,6	2,27
		5		2,16	0,40	18,5	28,7	5,93	0,79	0,43	11,1	0,60
		6		1,01	0,18	17,8	25,7	7,23	1,18	0,44	26,2	0,89
100	15	7	8	6,60	0,93	14,1	7,1	4,39	0,55	0,19	9,9	0,35
		8		2,59	0,35	13,5	17,0	8,11	0,46	0,27	13,5	0,43
		9		2,96	0,41	13,9	14,9	7,30	0,54	0,21	16,2	0,41
		10		0,83	0,20	24,1	15,7	14,21	0,84	0,48	21,8	1,57
		11		7,51	1,32	17,6	20,0	6,26	0,54	0,28	16,9	0,29
		12		3,13	0,45	14,4	20,8	10,61	1,02	0,35	28,0	0,58

Choromytilus meridionalis. Tissue-metal concentrations following exposure to 0, 50 and 100 µg/l cadmium at water temperatures of 15, 18, 21 and 24°C.

Tissue: 1. Female - Mantle 7. Male - Mantle
2. - Gill 8. - Gill
3. - Gonad 9. - Gonad
4. - Foot 10. - Foot
5. - Muscle 11. - Muscle
6. - Remainder 12. - Remainder

10 individuals per treatment

Cd (µg/l)	T °C	Tissue	No	Wet mass (g)	Dry mass (g)	Dry mass (%)	µg metal/g wet tissue					
							Zn	Cd	Cu	Pb	Fe	Mn
0	18	1	3	6,56	0,84	12,8	14,9	0,43	0,95	0,17	6,7	2,07
		2		1,13	0,10	8,8	20,4	0,71	2,74	0,35	23,0	1,33
		3		7,42	0,95	12,8	16,0	0,43	1,01	0,17	6,1	1,36
		4		2,10	0,21	10,0	10,0	0,38	0,71	0,19	6,2	1,28
		5		5,94	0,85	14,3	13,3	0,46	0,66	0,13	6,4	0,79
		6		7,90	1,05	13,3	16,8	0,76	1,13	0,14	11,3	1,32
0	18	7	7	14,21	2,12	14,9	15,5	0,39	0,87	0,15	6,6	2,32
		8		3,36	0,48	14,3	13,7	0,45	1,85	0,61	13,1	0,74
		9		16,45	2,61	15,9	7,4	0,31	0,77	0,18	6,4	0,38
		10		4,64	0,59	12,7	9,5	0,37	0,80	0,22	4,7	1,44
		11		15,10	2,47	16,4	10,5	0,41	0,48	0,15	4,6	3,97
		12		11,70	1,68	14,4	11,8	0,80	0,94	0,23	14,4	0,56
0	21	1	7	14,40	1,87	13,0	15,5	0,41	0,74	0,13	5,6	1,60
		2		2,13	0,20	9,4	21,6	1,03	1,97	0,45	20,7	1,97
		3		15,07	2,02	13,4	16,7	0,31	1,05	0,15	7,0	1,67
		4		3,99	0,46	11,5	7,8	0,25	0,75	0,15	6,8	1,20
		5		12,46	2,05	16,5	14,9	0,45	0,63	0,14	6,2	0,76
		6		13,41	1,85	13,8	17,5	0,82	1,10	0,20	13,0	1,33
0	21	7	3	5,70	0,74	13,0	14,2	0,39	0,86	0,23	7,4	2,04
		8		1,11	0,12	10,8	14,4	0,27	1,08	0,54	15,3	0,90
		9		7,99	1,03	12,9	7,1	0,31	0,74	0,18	5,0	0,36
		10		2,02	0,23	11,4	10,9	0,40	0,50	0,28	6,9	1,58
		11		5,57	0,88	15,8	13,1	0,45	0,61	0,20	6,6	0,40
		12		5,62	0,75	13,3	11,4	0,77	0,85	0,23	11,2	0,46
0	24	1	6	12,15	1,67	13,7	14,2	0,46	0,90	0,13	5,8	1,32
		2		3,26	0,40	12,3	20,9	0,77	1,87	0,42	19,0	1,44
		3		14,91	1,95	13,1	15,2	0,38	0,86	0,12	5,4	1,41
		4		3,40	0,40	11,8	7,4	0,32	0,50	0,25	6,2	0,76
		5		12,08	2,01	16,6	15,4	0,51	0,56	0,18	6,0	0,68
		6		13,45	1,76	13,1	15,7	0,97	0,93	0,23	11,2	1,17
0	24	7	4	8,08	1,13	14,0	14,6	0,42	0,80	0,16	7,8	1,51
		8		2,05	0,28	13,7	13,2	0,34	0,73	0,27	11,2	0,49
		9		9,54	1,35	14,2	8,9	0,43	0,67	0,16	8,1	0,31
		10		2,97	0,39	13,1	10,4	0,40	0,57	0,30	5,7	0,91
		11		8,17	1,35	16,5	14,0	0,61	0,55	0,20	6,7	0,29
		12		8,90	1,10	12,4	10,7	1,12	0,71	0,24	13,8	0,38
50	15	1	6	12,85	1,72	13,4	14,4	1,21	1,05	0,17	7,2	1,99
		2		3,45	0,42	12,2	14,2	1,86	1,97	0,39	12,2	1,25
		3		14,59	1,89	13,0	14,3	1,12	1,05	0,20	6,9	1,41
		4		3,88	0,54	13,9	10,1	1,29	0,93	0,26	7,7	1,65
		5		12,36	2,00	16,2	14,5	1,05	0,73	0,15	6,2	0,93
		6		10,19	1,43	14,0	17,9	2,50	1,43	0,22	13,6	1,55
50	15	7	4	6,63	1,05	15,8	14,5	1,34	1,01	0,22	7,7	1,81
		8		1,65	0,20	12,1	13,3	2,00	1,82	0,73	13,9	0,55
		9		10,21	1,58	15,5	7,6	1,18	0,87	0,26	8,5	0,36
		10		2,66	0,35	13,2	9,8	1,32	0,98	0,34	7,5	1,09
		11		7,95	1,27	16,0	13,1	1,06	0,64	0,23	7,4	0,39
		12		6,54	0,99	15,1	13,5	2,46	1,21	0,33	16,4	0,47

Choromytilus meridionalis. Tissue-metal concentrations following exposure to 0, 50 and 100 µg/l cadmium at water temperatures of 15, 18, 21 and 24 °C. (continued)

Cd (µg/l)	T °C	Tissue	No	Wet mass (g)	Dry mass (g)	Dry mass (%)	µg metal/g wet tissue					
							Zn	Cd	Cu	Pb	Fe	Mn
50	18	1	7	13,87	1,93	13,9	13,7	1,47	1,05	0,16	7,6	1,76
		2		3,28	0,45	13,7	13,7	2,20	1,74	0,35	13,4	1,04
		3		14,02	1,80	12,8	16,0	1,23	1,03	0,17	6,3	1,26
		4		4,83	0,57	11,8	11,0	1,39	0,97	0,28	8,5	1,28
		5		14,05	2,13	15,2	13,8	1,19	0,63	0,16	8,0	0,52
		6		17,86	2,37	13,3	13,4	2,52	0,93	0,24	13,7	0,42
50	18	7	3	4,95	1,01	20,4	18,4	1,49	0,95	0,28	8,5	1,66
		8		1,31	0,19	14,5	16,8	2,14	2,21	0,58	16,0	0,46
		9		7,85	1,02	13,0	10,1	1,35	0,84	0,21	8,2	0,39
		10		2,44	0,31	12,7	13,1	1,60	0,90	0,35	10,7	0,90
		11		6,60	1,01	15,3	13,2	1,14	0,50	0,20	6,1	0,36
		12		5,68	0,78	13,7	20,1	2,96	1,33	0,26	13,9	1,76
50	21	1	2	3,26	0,43	13,2	15,3	2,55	1,23	0,22	10,1	1,63
		2		0,79	0,09	11,4	12,7	2,41	1,52	0,45	12,7	1,01
		3		3,07	0,40	13,0	20,2	1,50	1,37	0,31	7,1	1,56
		4		1,31	0,14	10,7	14,5	1,76	1,22	0,42	19,1	1,91
		5		2,92	0,48	16,4	16,8	1,27	0,92	0,19	7,5	1,03
		6		3,24	0,38	11,7	20,1	2,96	1,33	0,26	13,9	1,76
50	21	7	8	19,16	2,62	13,7	14,3	2,35	0,98	0,20	6,3	1,94
		8		4,89	0,59	12,1	12,5	2,25	1,55	0,22	11,0	0,67
		9		31,33	4,18	13,3	8,6	1,58	0,69	0,12	6,5	0,33
		10		6,45	0,71	11,0	16,0	1,92	0,78	0,37	10,2	1,18
		11		16,35	2,59	15,8	12,3	1,21	0,50	0,14	4,6	0,34
		12		16,76	2,42	14,4	9,7	2,64	0,78	0,16	13,7	0,44
50	24	1	2	3,22	0,38	11,8	14,9	3,66	1,21	0,25	11,5	1,15
		2		1,20	0,10	8,3	15,8	3,75	1,00	0,37	15,0	0,83
		3		3,97	0,47	11,8	15,9	2,62	1,56	0,50	10,6	1,21
		4		0,86	0,10	11,6	18,6	2,79	3,37	0,53	18,6	2,21
		5		4,14	0,62	15,0	14,5	2,13	1,26	0,30	10,9	0,56
		6		2,79	0,37	13,3	16,5	4,84	1,68	0,38	27,4	1,08
50	24	7	1	1,52	0,15	9,9	17,1	3,68	1,84	0,29	5,3	1,45
		8		0,59	0,06	10,2	16,9	3,56	1,69	0,34	13,6	0,67
		9		2,33	0,19	8,2	12,0	2,88	1,24	0,32	7,6	0,43
		10		0,56	0,05	8,9	21,4	2,86	0,71	0,63	23,2	1,07
		11		2,05	0,31	15,1	13,7	2,39	0,83	0,25	13,2	0,59
		12		1,75	0,16	9,3	14,9	4,86	1,31	0,29	25,1	0,74
100	15	1	4	8,96	1,34	15,0	16,2	1,95	1,13	0,17	3,6	2,06
		2		2,37	0,30	12,7	14,8	2,74	1,98	0,40	9,3	0,97
		3		5,86	0,91	15,5	20,3	1,45	1,42	0,16	8,5	1,95
		4		3,00	0,39	13,0	10,3	1,90	0,70	0,15	4,7	1,57
		5		7,25	1,18	16,3	14,9	1,92	0,68	0,12	5,5	0,76
		6		9,65	1,32	13,7	16,4	4,33	1,11	0,15	11,9	1,35
100	15	7	6	12,56	1,97	15,7	17,3	1,86	1,00	0,11	6,1	2,29
		8		3,40	0,46	13,5	14,7	2,59	2,26	0,40	9,4	0,74
		9		9,83	1,47	15,0	9,0	1,51	0,98	0,15	7,9	0,46
		10		4,50	0,52	11,6	8,4	1,98	0,78	0,19	5,8	1,60
		11		12,04	1,96	16,3	13,5	1,79	0,58	0,11	5,1	0,40
		12		15,24	2,03	13,3	11,0	3,82	0,96	0,17	10,3	0,49

Crassostrea gigas. Tissue-metal concentrations after 3 weeks exposure to 0, 50, 100 and 200 µg/l cadmium at different salinities (T=24°C)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue Zn	Cd	Cu	Pb	Fe	Mn
Cadmium, 0 µg/l; salinity 35°/oo								
8,43	0,71	8,4	178	0,39	9,7	<0,05	17,6	2,97
4,82	0,50	10,4	191	0,52	5,7	<0,05	24,9	2,08
3,00	0,24	8,0	100	0,77	8,7	<0,05	28,7	2,00
6,66	0,64	9,6	112	0,42	15,5	<0,05	21,0	2,01
4,47	0,43	9,6	114	0,63	11,0	0,13	34,5	1,90
3,83	0,31	8,1	119	0,68	12,0	0,13	23,2	2,22
6,09	0,62	10,2	153	0,54	13,5	<0,05	19,5	1,81
4,00	0,33	8,3	170	0,63	14,0	<0,05	30,3	1,75
7,31	0,63	8,6	115	0,48	7,3	<0,05	16,6	1,64
3,83	0,31	8,1	166	0,63	14,6	<0,05	24,5	1,96
Cadmium, 0 µg/l; salinity 30,6°/oo								
4,28	0,57	13,3	134	0,42	8,1	<0,05	23,3	1,76
1,82	0,28	15,4	148	0,34	10,4	0,14	18,5	2,51
1,89	0,20	10,6	159	0,50	6,8	<0,05	16,4	1,92
2,09	0,23	11,0	148	0,47	11,7	0,08	29,2	2,12
15,67	2,00	12,8	62	0,51	15,1	0,06	20,0	1,97
9,67	1,03	10,7	88	0,37	9,7	0,10	21,0	2,03
12,87	1,26	9,8	118	0,38	9,5	0,07	18,6	1,87
8,92	1,18	13,2	164	0,62	11,3	0,05	23,5	2,08
8,95	0,95	10,6	76	0,57	12,1	0,05	13,2	3,20
9,98	0,94	9,4	201	0,55	15,6	0,11	19,0	1,88
Cadmium, 0 µg/l; salinity 26,3°/oo								
6,89	0,49	7,1	179	0,46	29,3	0,36	21,0	1,24
7,24	0,66	9,1	188	0,40	20,2	0,22	20,2	2,42
6,70	0,57	8,5	206	0,45	32,2	0,34	20,0	2,32
6,56	0,59	9,0	190	0,47	13,2	0,29	23,2	1,45
6,00	0,54	9,0	132	0,47	25,3	0,30	17,8	2,17
6,77	0,57	8,4	86	0,40	24,1	0,21	18,8	2,00
6,62	0,49	7,4	116	0,42	19,4	0,35	20,4	1,66
5,40	0,35	6,6	144	0,50	22,2	0,32	21,3	1,85
6,57	0,57	8,7	204	0,55	19,7	0,32	16,9	2,51
8,90	0,76	8,7	195	0,44	16,6	0,28	16,0	1,03
Cadmium, 0 µg/l; salinity 21,9°/oo								
6,93	0,61	8,8	221	0,59	14,6	0,32	20,6	1,45
7,88	0,55	7,0	138	0,44	29,3	0,30	17,0	2,03
11,80	1,19	10,1	117	0,41	23,0	0,21	15,0	2,21
8,44	0,62	7,3	179	0,56	31,0	0,30	18,7	2,23
8,96	0,60	6,7	102	0,40	20,9	0,30	13,7	1,68
8,72	1,01	11,6	139	0,40	21,0	0,24	16,3	1,03
6,54	1,00	15,2	203	0,40	24,9	0,29	19,9	1,84
8,71	0,62	7,1	118	0,41	29,3	0,32	16,3	1,89
10,14	0,66	6,5	134	0,35	14,5	0,27	13,2	1,68
5,27	0,41	7,8	121	0,63	33,4	0,21	22,8	2,94
Cadmium, 50 µg/l; salinity 35°/oo								
5,91	0,71	12,0	218	3,55	5,4	0,03	19,3	1,06
7,99	0,80	10,0	86	4,63	10,1	0,05	16,3	1,82
3,88	0,41	10,6	153	5,15	17,4	0,03	23,2	1,55
3,86	0,45	11,7	193	8,29	15,0	0,05	26,7	1,95
4,79	0,61	12,7	94	3,97	7,5	0,09	26,3	1,67
5,33	0,60	11,3	189	4,69	13,3	0,04	20,8	2,03
4,07	0,43	10,6	143	3,44	16,0	0,10	23,8	2,09
5,98	0,69	11,5	146	4,52	15,8	0,08	21,4	1,84
6,94	0,80	11,5	143	3,60	11,2	0,10	19,0	2,03
4,92	0,63	12,8	138	5,69	10,1	0,06	22,8	2,44

<u>Crassostrea gigas</u>. Tissue-metal concentrations after 3 weeks exposure to 0, 50, 100 and 200 µg/l cadmium at different salinities (T=24°C) (continued)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
Cadmium, 50 µg/l;			salinity 30,6°/oo					
10,79	0,92	8,5	93	4,08	14,6	<0,05	15,5	1,19
14,00	0,73	5,2	62	2,14	8,2	<0,05	11,1	1,89
9,49	0,71	7,5	106	2,63	19,4	<0,05	13,6	0,89
15,32	1,13	7,3	124	3,66	19,8	<0,05	11,0	1,89
15,66	0,90	5,7	84	1,85	13,5	<0,05	10,1	1,79
17,07	1,26	7,4	89	4,70	12,8	<0,05	9,3	1,64
11,03	0,44	4,0	92	2,81	11,7	<0,05	11,2	2,59
10,85	0,74	6,8	63	2,21	9,5	0,07	10,8	1,11
9,92	0,69	6,9	86	4,92	11,9	0,05	12,9	1,41
8,29	0,64	7,7	88	3,86	12,5	0,06	13,0	1,03
Cadmium, 50 µg/l;			salinity 26,3°/oo					
8,33	0,64	7,7	170	5,6	39,5	0,17	15,2	1,50
13,15	0,76	5,8	114	3,4	24,0	0,14	9,5	0,99
12,48	0,87	7,0	100	6,1	25,8	0,21	13,1	1,32
9,87	0,57	5,8	104	3,4	23,7	0,14	10,7	1,92
12,07	0,85	7,0	171	2,8	26,0	0,12	13,8	1,16
10,54	0,60	5,7	119	4,3	30,0	0,11	11,3	0,95
7,83	0,57	7,3	125	6,9	39,1	0,27	16,5	1,22
8,48	0,52	6,1	111	4,8	20,6	0,15	14,0	1,00
10,86	0,63	5,8	130	1,8	24,0	0,10	12,4	1,66
7,56	0,56	7,4	213	6,6	47,4	0,34	19,6	2,12
Cadmium, 50 µg/l;			salinity 21,9°/oo					
15,42	1,19	7,7	102	6,16	19,7	0,30	11,0	1,85
14,96	1,03	6,9	134	2,87	20,6	0,19	13,2	1,77
11,13	0,69	4,6	183	3,50	24,7	0,17	11,1	1,53
13,95	0,89	6,4	129	3,44	12,4	0,16	9,0	1,76
15,97	0,95	5,9	75	4,38	17,6	0,18	9,0	0,85
12,39	0,64	5,2	115	3,55	19,9	0,14	10,4	1,46
14,96	0,86	5,7	118	3,94	21,1	0,13	10,6	1,27
9,23	0,74	8,0	172	4,98	29,0	0,28	16,7	1,41
9,16	0,36	3,9	127	2,51	19,8	0,13	13,8	0,77
14,36	1,08	7,5	65	7,10	9,9	0,40	13,6	1,26
Cadmium, 100 µg/l;			salinity 35°/oo					
13,58	1,01	7,4	127	4,50	14,1	0,08	11,8	1,73
6,90	0,52	7,5	86	6,52	7,2	0,09	10,6	1,80
11,72	0,97	8,3	91	6,66	7,3	0,10	11,5	1,28
11,80	1,07	9,1	120	3,56	9,8	0,08	14,2	1,93
11,15	0,98	8,8	154	7,26	10,9	0,12	12,0	1,47
8,82	0,69	7,8	141	3,74	12,7	0,10	11,8	0,85
10,44	0,83	8,0	134	4,89	13,9	0,05	13,0	1,37
4,00	0,32	8,0	48	11,25	16,3	0,15	37,3	0,75
8,15	0,66	8,1	65	6,87	6,8	0,13	12,5	1,74
6,56	0,59	9,0	131	7,93	11,1	0,09	13,4	0,63
Cadmium, 200 µg/l;			salinity 35°/oo					
1,58	0,23	14,6	224	9,7	6,5	<0,05	12,1	2,03
2,92	0,32	11,0	138	10,4	11,2	0,09	22,4	1,50
1,93	0,20	10,4	153	8,2	12,1	0,13	14,8	0,97
2,86	0,31	10,8	97	6,1	4,6	0,06	16,6	1,66
4,42	0,50	11,3	94	15,6	9,5	0,07	24,5	1,89
2,97	0,33	11,1	156	7,1	8,3	0,05	8,2	0,98
4,67	0,49	10,5	89	14,4	5,5	0,11	23,0	2,52
11,42	1,25	10,9	102	11,3	9,2	0,12	19,4	2,11
10,16	1,04	10,2	137	7,9	10,0	0,08	30,1	1,87
9,54	0,96	10,1	151	13,7	7,6	0,08	21,2	1,77

Crassostrea margaritacea. Tissue-metal concentrations after 3 weeks exposure to 0, 50, 100 and 200 µg/l cadmium at different salinities (T=24°C)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
Cadmium, 0 µg/l; salinity, 35°/oo								
4,55	0,60	13,2	110	0,88	1,36	0,11	6,2	0,97
4,16	0,44	10,6	123	1,11	1,13	0,10	4,6	0,31
6,01	0,70	11,7	107	1,08	1,21	0,03	4,2	0,17
4,83	0,49	10,1	155	0,91	1,12	0,04	3,7	0,33
3,41	0,37	10,9	111	1,41	1,11	0,09	7,9	0,32
4,71	0,65	13,8	110	0,87	1,38	0,08	6,8	1,15
2,92	0,32	11,0	116	1,54	1,99	0,14	7,5	0,31
6,47	0,78	12,1	90	1,23	2,04	0,06	5,1	0,40
Cadmium, 0 µg/l; salinity, 30,6°/oo								
9,37	1,23	13,1	83	1,26	1,87	0,11	3,8	0,44
7,79	0,92	11,8	81	1,06	1,09	0,07	7,2	0,26
2,29	0,21	9,2	92	0,99	1,39	0,06	5,9	0,19
5,41	0,58	10,7	134	1,05	0,75	0,08	4,7	0,23
9,63	1,35	14,0	98	0,94	1,69	0,02	4,6	0,23
5,40	0,71	13,2	144	0,88	1,94	0,02	3,9	0,18
11,75	1,40	11,9	103	1,31	2,57	0,13	5,1	0,31
0,64	0,07	10,9	148	1,08	1,13	0,10	6,8	0,40
6,18	0,70	11,3	127	0,99	0,85	0,09	6,4	1,17
4,09	0,63	15,4	173	0,46	1,08	0,16	8,6	0,82
Cadmium, 0 µg/l; salinity, 26,3°/oo								
3,04	0,42	13,8	122	1,48	2,40	0,30	11,2	0,23
6,82	0,78	11,4	126	1,45	2,13	0,15	5,7	0,16
3,11	0,38	12,2	127	1,00	1,06	0,29	8,0	0,16
4,71	0,57	12,1	132	1,23	0,98	0,13	6,8	0,15
10,84	1,18	10,9	68	0,78	0,92	0,07	3,4	0,69
5,77	0,48	8,3	97	1,04	3,40	0,17	4,3	0,24
2,80	0,36	12,9	164	0,50	2,10	0,21	7,9	0,50
5,08	0,49	9,7	116	0,91	2,07	0,22	4,9	0,22
5,42	0,73	13,5	125	1,20	1,63	0,09	6,6	0,24
4,79	0,56	11,7	113	0,81	2,55	0,06	6,7	0,25
Cadmium, 0 µg/l; salinity, 21,9°/oo								
2,05	0,17	8,3	159	1,51	2,59	0,20	11,2	0,34
3,00	0,50	16,7	203	1,23	2,23	0,03	12,7	0,43
3,73	0,34	9,1	80	0,99	1,02	0,03	8,0	0,35
5,19	0,52	10,0	102	0,83	1,91	0,15	7,9	0,21
6,13	0,57	9,3	95	0,78	1,63	0,08	5,5	0,21
5,40	0,60	11,1	146	1,15	0,78	0,07	5,4	0,22
7,68	0,97	12,6	83	0,98	3,40	0,31	5,3	0,73
3,71	0,49	13,2	154	1,37	6,40	0,13	8,4	0,57
5,24	0,43	8,2	116	1,45	0,71	0,10	5,3	0,21
4,55	0,28	6,2	67	0,74	2,24	0,02	6,6	0,24
Cadmium, 50 µg/l; salinity, 35°/oo								
6,03	0,79	13,1	161	1,38	0,83	0,07	5,0	0,76
5,20	0,65	12,5	129	1,27	2,77	0,04	5,4	0,25
4,36	0,46	10,6	101	2,91	2,68	0,07	4,6	0,34
5,73	0,60	10,5	110	1,08	1,82	0,03	4,0	0,33
2,84	0,35	12,3	211	2,39	1,88	0,14	8,1	0,32
4,26	0,53	12,4	68	1,38	0,85	0,07	4,2	0,35
4,37	0,53	12,1	158	1,37	2,91	0,07	5,7	0,39
4,18	0,53	12,7	124	3,54	2,32	0,10	5,7	0,91
7,83	1,01	12,9	134	1,44	1,86	0,08	5,1	1,28

Crassostrea margaritacea. Tissue-metal concentrations after 3 weeks exposure to 0, 50, 100 and 200 µg/l cadmium at different salinities (T=24°C) (continued)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
Cadmium, 50 µg/l; salinity, 30,6°/oo								
6,35	0,47	7,4	106	3,12	1,69	0,17	3,9	0,16
6,43	0,85	13,2	129	1,06	1,10	0,20	6,4	0,28
6,70	0,60	9,0	70	2,36	1,04	0,15	5,2	0,21
6,61	0,57	8,6	145	1,21	2,63	0,27	4,7	0,23
2,00	0,21	10,5	75	2.30	3,00	0,30	9,0	0,45
4,00	0,37	9,3	132	1,25	1,58	0,18	6,8	0,53
4,47	0,37	8,2	112	1,19	1,79	0,12	3,8	0,31
4,85	0,36	9,5	64	2,80	2,18	0,16	5,8	0,43
5,69	0,51	9,0	137	1,93	1,62	0,07	5,4	0,39
7,27	0,61	8,4	81	1,16	1,29	0,11	4,4	0,26
Cadmium, 50 µg/l; salinity, 26,3°/oo								
5,53	0,52	9,4	156	1,07	3,24	0,07	3,6	0,18
4,45	0,51	11,5	85	2,54	5,08	0,18	6,1	0,40
4,44	0,49	11,0	142	1,51	3,42	0,11	6,3	0,36
2,85	0,42	12,7	179	2,04	4,84	0,21	11,2	0,35
4,43	0,55	12,4	86	5,20	4,35	0,34	8,1	0,86
4,90	0,54	11,0	133	2,00	1,90	0,10	5,3	0,18
3,81	0,40	10,5	118	2,89	1,80	0,18	7,6	0,39
4,48	0,40	8,9	136	1,27	3,30	0,09	4,5	0,18
4,84	0,58	12,0	107	2,19	2,90	0,06	7,0	0,19
5,52	0,75	13,6	85	2,84	2,34	0,13	6,9	1,14
Cadmium, 50 µg/l; salinity, 21,9°/oo								
3,00	0,34	11,3	160	1,80	2,27	0,07	10,0	0,47
6,07	0,56	9,2	74	1,43	1,12	0,13	6,9	0,18
2,84	0,32	11,3	213	1,94	2,01	0,14	10,9	0,60
5,36	0,46	8,6	123	2,43	2,50	0,19	5,8	0,19
7,09	0,89	12,6	89	1,24	1,75	0,11	5,8	0,20
4,80	0,53	11,0	92	3,60	1,67	0,13	6,5	0,66
5,58	0,72	12,9	120	1,40	1,39	0,02	7,5	0,30
3,71	0,45	12,1	78	2,24	1,75	0,05	4,6	0,24
3,83	0,35	9,1	136	1,83	1,67	0,13	7,3	0,39
6,78	0,62	9,1	156	1,08	2,32	0,04	7,5	0,24
Cadmium, 100 µg/l; salinity, 35°/oo								
4,94	0,50	10,1	130	4,03	0,91	<0,02	4,5	0,24
4,36	0,49	11,2	161	1,81	0,76	0,21	7,8	0,37
7,18	0,59	8,2	118	4,00	0,57	0,10	3,3	0,19
4,77	0,48	10,1	78	1,55	1,85	0,04	4,8	0,57
4,88	0,41	8,4	92	3,16	0,70	<0,02	7,2	0,20
4,84	0,45	9,3	171	2,22	0,45	0,02	4,3	0,21
4,45	0,40	9,0	99	2,16	0,98	0,09	5,6	0,29
5,45	0,61	11,2	86	2,36	0,95	0,03	5,1	0,66
3,40	0,32	9,4	112	2,21	1,94	0,08	6,8	0,35
4,05	0,40	9,9	96	3,47	1,33	0,15	8,4	0,32
Cadmium, 200 µg/l; salinity, 35°/oo								
2,28	0,29	12,7	136	4,56	2,59	0,03	11,2	0,34
9,31	1,45	15,6	131	7,19	1,02	0,03	5,4	0,21
4,23	0,61	14,4	151	8,35	0,78	0,15	6,6	0,73
13,19	1,67	12,7	96	2,97	0,71	0,17	5,4	0,18
4,69	0,68	14,5	116	3,73	1,82	0,08	4,0	0,40
3,31	0,40	12,1	225	3,46	0,85	0,11	5,7	0,32
3,41	0,35	10,3	85	6,50	1,80	0,02	8,1	0,76
2,08	0,22	10,8	124	2,82	1,43	0,09	4,5	0,39
1,12	0,12	10,7	116	3,79	0,97	0,06	6,1	1,14
1,30	0,16	12,3	83	4,11	1,28	0,04	6,9	0,22

Perna perna. Tissue-metal concentrations following 3 weeks exposure to cadmium at 0, 50, 100 and 200 µg/l at different salinities (T=24°C)

Sex	Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
				Zn	Cd	Cu	Pb	Fe	Mn
Cadmium, 0 µg/l; salinity 35°/oo									
F	5,02	0,41	8,2	17,8	0,85	0,77	0,25	19,1	0,21
F	3,74	0,44	11,8	14,2	0,90	0,85	0,20	17,6	0,34
F	3,70	0,28	7,6	13,0	0,56	0,59	0,18	11,9	0,24
F	6,28	0,67	10,7	12,4	0,38	1,01	0,23	9,6	0,27
F	5,98	0,54	9,0	12,2	0,42	0,83	0,30	13,5	0,18
M	5,40	0,57	10,6	10,9	0,40	0,66	0,22	9,8	0,27
M	3,02	0,34	11,3	13,9	0,66	0,73	0,13	12,3	0,20
M	3,51	0,39	11,1	6,8	0,54	0,55	0,25	13,1	0,45
M	4,96	0,43	8,7	8,5	0,40	0,62	0,24	10,1	0,32
M	4,58	0,48	10.5	10,3	0,56	0,78	0,19	10,9	0,30
Cadmium, 0 µg/l; salinity 30,6°/oo									
M	4,32	0,44	10.2	8,7	0,50	0,93	0,17	16,4	0,19
M	3,92	0,41	10,5	10,6	0,62	0,82	0,17	16,0	0,19
M	5,07	0,49	9,7	10,4	0,70	1,07	0,29	14,4	0,38
M	4,28	0,43	10,0	12,1	0,43	0,64	0,13	15,4	0,58
M	5,00	0,48	9,6	7,4	0,54	0,59	0,11	14,2	0,59
F	5,36	0,55	10,3	16,2	0,61	0,32	0,19	16,3	0,25
F	3,98	0,41	10,3	14,6	0,50	0,66	0,16	16,5	0,32
F	2,95	0,31	10,5	12,3	0,53	0,73	0,17	10,2	0,29
F	3,07	0,31	10,1	9,0	0,58	0,75	0,21	10,8	0,18
F	2,67	0,29	10,9	8,8	0,39	0,75	0,17	15,6	0,58
Cadmium, 0 µg/l; salinity 26,3°/oo									
M?	7,32	0,81	11,1	11,3	0,32	0,54	0,34	9,3	0,19
M	8,19	0,82	10,0	10,2	0,66	0,86	0,22	8,9	0,24
M	7,04	0,72	10,2	12,7	0,51	0,64	0,23	9,8	0,28
F	7,11	0,71	10,0	16,5	0,57	0,87	0,41	16,2	0,30
F	5,13	0,53	10,3	15,5	0,56	0,50	0,25	14,0	0,41
F	6,01	0,61	10,1	14,3	0,50	0,58	0,33	19,1	0,72
F	5,17	0,53	10,3	15,3	0,76	1,05	0,51	14,6	0,60
Cadmium, 0 µg/l; salinity 21,9°/oo									
M	6,21	0,68	11,0	7,2	0,43	0,58	0,38	9,9	0,24
M	2,40	0,34	14,2	7,1	0,58	0,36	0,53	22,0	0,58
M	3,39	0,40	11,8	15,2	0,58	0,45	0,63	18,1	0,63
F	2,85	0,40	14,0	16,6	0,58	0,65	0,18	14,6	0,74
F	3,49	0,46	13,2	15,9	0,63	0,40	0,24	10,0	0,52
Cadmium, 50 µg/l; salinity 35°/oo									
M	5,56	0,44	7,9	7,9	1,13	0,46	0,19	11,7	0,23
F	4,22	0,49	11,6	17,5	0,99	0,66	0,18	13,0	0,45
F	3,39	0,32	9,4	11,2	1,74	0,88	0,17	15,6	0,26
F	2,81	0,29	10,3	14,6	1,42	0,81	0,21	10,0	0,39
M	3,82	0,35	9,2	12,9	1,07	0,39	0,15	16,5	0,20
M	3,02	0,30	9,9	11,9	1,78	0,86	0,33	14,6	0,36
M	4,91	0,51	10,4	12,4	0,99	0,63	0,20	9,4	0,22
M	6,12	0,60	9,8	11,3	1,17	0,42	0,22	11,9	0,21
M	3,40	0,37	10,9	7,4	1,61	0,70	0,28	15,6	0,38

Perna perna. Tissue-metal concentrations following 3 weeks exposure to cadmium at 0, 50, 100 and 200 µg/l at different salinities (T=24°C) (continued)

Sex	Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue Zn	Cd	Cu	Pb	Fe	Mn
	Cadmium, 50 µg/l;			salinity 30,6°/oo					
M	8,80	0,88	10,0	6,3	0,89	0,77	0,26	10,7	0,25
M	5,83	0,65	11,2	9,6	0,84	0,72	0,25	13,0	0,18
M	4,19	0,34	8,1	7,6	0,93	0,52	0,19	12,4	0,24
M	2,22	0,22	9,9	10,4	1,35	0,51	0,40	15,3	0,31
M	3,61	0,34	9,4	8,6	0,77	0,61	0,22	14,1	0,29
F	5,29	0,48	9,1	16,8	1,20	0,80	0,26	19,5	0,22
	Cadmium, 50 µg/l;			salinity 26,3°/oo					
M?	2,43	0,28	11,5	17,3	1,46	0,94	0,74	17,3	0,41
M	3,13	0,31	9,9	14,5	0,88	0,84	0.51	16,8	0,45
M	2,38	0,26	10,9	11,2	1,00	0,51	0,48	12,8	0,44
M	2,17	0,22	10,1	8.4	0,64	0,66	0,38	18,0	0,40
F	2,41	0,26	10,8	11,6	1,09	0,66	0,47	14,2	0,33
F	1,86	0,19	10,2	13,3	0,92	0,65	0,38	11,1	0,26
F	3,22	0,35	10,9	13,2	1,16	1,07	0,32	11,2	0,45
	Cadmium, 50 µg/l;			salinity 21,9°/oo					
F	2,32	0,21	9,1	16,1	1,36	1,24	0,51	18,1	0,38
F	6,24	0,54	8,7	8,2	1,00	1,85	0,36	14,4	0,24
F	3,69	0,33	8,9	12,3	1,00	1,38	0,43	21,4	0,65
F	3,14	0,23	7,3	14,6	1,05	0,66	0,38	10,8	0,35
M	3,84	0,32	8,3	7,6	1,61	0,80	0,36	10,8	0,28
M	3,72	0,41	11,0	11,8	1,42	1,26	0,56	14,2	0,43
M	4,51	0,42	9,3	13,3	1,21	1,33	0,44	12,9	0,31
M	1,89	0,25	13,2	9,9	1,16	1,38	0,42	14,1	0,37
	Cadmium, 100 µg/l;			salinity 35°/oo					
F	2,38	0,31	13,0	15,5	3,19	0,63	0,21	16,8	0,38
F	4,41	0,57	12,9	16,6	2,15	0,73	0,14	15,6	0,59
F	3,67	0,46	12,5	11,7	1,63	0,60	0,11	16,6	0,41
F	4,99	0,57	11,4	12,0	1,82	0,66	0,12	14,4	0,40
F	3,54	0,42	11,9	14,4	1,86	0,68	0,11	15,3	0,49
F	3,27	0,42	12,8	11,0	2,32	0,89	0,12	18,3	0,67
F	3,22	0,38	11,8	9,3	2,48	0,70	0,12	20,8	0,34
M	2,63	0,31	11,8	11,0	2,36	0,76	0,15	17,1	0,42
M	2,64	0,32	12,1	10,6	2,97	0,76	0,11	15,2	0,38
M	2,29	0,28	12,2	12,7	1,92	0,61	0,14	16,2	0,31
	Cadmium, 200 µg/l;			salinity 35°/oo					
M	1,36	0,12	7,4	13,7	3,05	0,96	0,15	16,7	0,63
M	1,77	0,17	9,6	15,5	2,61	1,11	0,13	15,3	0,52
M	1,49	0,16	10,7	10,9	4,19	0,73	0,17	28,7	0,41
M	3,38	0,34	10,1	11,3	2,87	0,81	0,13	17,7	0,56
M	1,48	0,15	10,1	14,9	1,78	0,72	0,17	16,3	0,42
F	2,00	0,19	10,5	15,9	3,49	0,64	0,21	14,9	0,37
F	3,00	0,28	9,3	13,4	4,05	0,59	0,24	15,8	0,47
F	2,65	0,26	9,8	17,7	2,78	0,62	0,18	11,4	0,51
F	3,05	0,32	10,5	15,8	1,83	0,67	0,16	20,0	0,90
F	1,59	0,17	10,7	16,1	2,66	0,48	0,22	17,3	0,43

<u>*Choromytilus meridionalis*</u>. Tissue-metal concentrations following 3 weeks exposure to 0, 50, 100 and 200 µg/l cadmium at different salinities (T=24°C)

Sex	Wet. mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
				Zn	Cd	Cu	Pb	Fe	Mn
	Cadmium, 0 µg/l; salinity 35°/oo								
F	8,22	1,52	18,5	17,7	0,29	1,19	0,06	6,4	1,66
F	4,78	0,75	15,7	15,5	0,27	1,02	0,16	5,9	1,94
F	5,49	0,91	16,6	16,6	0,38	1,11	0,23	7,1	1,45
F	4,80	0,85	17,7	15,6	0,18	1,18	0,25	6,7	1,47
F	13,30	2,04	15,3	11,4	0,27	1,03	0,13	5,0	0,93
F	5,65	1,07	18,9	16,8	0,24	1,41	0,08	6,0	0,53
F	15,10	2,40	15,9	11,6	0,27	1,09	0,16	5,3	1,37
F	7,60	1,08	14,2	14,6	0,19	1,25	0,17	5,1	1,15
M	11,84	2,16	18,2	10,1	0,32	1,06	0,12	6,3	0,65
M	4,77	0,78	16,4	13,4	0,31	1,24	0,16	7,3	1,74
	Cadmium, 0 µg/l; salinity 30,6°/oo								
M	8,68	1,52	17,5	9,7	0,17	1,08	0,11	5,3	1,46
M	13,15	2,43	18,5	14,4	0,22	0,68	0,21	9,3	0,72
M	10,23	1,48	14,5	11,0	0,10	0,94	0,24	7,4	0,65
F	8,08	1,25	15,5	12,6	0,36	1,32	0,29	9,7	0,85
F	12,48	1,49	11,9	16,9	0,26	1,05	0,18	9,4	1,57
F	9,45	1,27	13,4	14,7	0,23	0,98	0,24	3,7	1,86
F	12,61	1,80	14,3	21,2	0,21	1,04	0,16	8,3	1,18
F	11,64	1,70	14,6	15,6	0,18	1,19	0,20	5,2	1,40
F	5,52	0,79	14,3	11,8	0,25	1,38	0,30	6,7	1,25
F	4,85	0,68	14,0	13,5	0,14	1,47	0,28	6,6	0,95
	Cadmium, 0 µg/l; salinity 26,3°/oo								
F	7,87	1,02	13,0	11,4	0,15	1,68	0,33	5,1	0,98
F	7,32	1,09	14,9	11,9	0,19	0,92	0,35	6,6	1,70
F	7,31	1,01	13,8	11,6	0,20	1,36	0,30	6,0	1,58
M	12,45	1,56	12,5	9,0	0,34	0,60	0,26	5,4	1,13
M	6,11	0,89	14,6	12,3	0,19	1,34	0,37	6,4	1,84
M	8,23	1,22	14,8	10,1	0,15	1,56	0,28	5,0	1,08
M	9,42	1,29	13,7	11,8	0,18	1,18	0,36	4,9	1,24
M	6,43	0,97	15,1	10,9	0,17	1,44	0,35	5,4	1,05
	Cadmium, 0 µg/l; salinity 21,9°/oo								
F	15,28	2,03	13,3	10,7	0,24	1,00	0,24	4,5	0,92
F	8,68	1,17	13,5	13,1	0,14	1,49	0,40	5,4	1,37
F	8,11	1,13	13,9	13,4	0,17	1,84	0,33	5,5	1,71
M	6,52	1,00	15,3	12,7	0,21	0,62	0,44	5,8	1,21
M	6,99	1,02	14,6	11,2	0,21	1,34	0,60	6,2	1,21
M	9,39	1,36	14,5	10,6	0,20	1,27	0,54	4,9	1,08
M	11,55	1,72	14,9	10,9	0,19	1,09	0,33	4,3	1,23
	Cadmium, 50 µg/l; salinity 35°/oo								
F	10,60	1,50	14,2	14,9	0,57	0,85	0,10	5,2	1,41
F	11,12	1,62	14,6	12,5	0,65	1,05	0,07	5,8	1,06
F	6,43	0,83	12,9	12,9	0,52	0,82	0,13	5,4	1,32
M	6,52	0,96	14,7	10,0	0,64	0,95	0,10	5,5	1,16
M	11,65	1,82	15,6	9,6	0,44	1,08	0,08	4,4	0,86
M	13,50	1,96	14,5	7,9	0,71	0,78	0,07	5,3	0,87
M	8,61	1,41	16,4	10,2	0,55	0,70	0,14	4,6	1,05

Choromytilus meridionalis. Tissue-metal concentrations following 3 weeks exposure to 0, 50, 100 and 200 µg/l cadmium at different salinities (T=24°C) (continued)

Sex	Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
				Zn	Cd	Cu	Pb	Fe	Mn
Cadmium, 50 µg/l; salinity 30,6°/oo									
F	4,82	0,58	12,0	11,6	0,53	1,26	0,18	5,4	1,20
F	5,49	0,76	13,8	12,8	0,58	1,11	0,27	5,1	1,56
F	5,47	0,73	13,4	12,4	0,53	1,06	0,21	4,9	1,44
F	12,86	2,12	16,5	14,5	0,56	1,42	0,19	5,0	1,02
M	11,97	1,91	16,0	9,9	0,49	1,03	0,15	4,9	0,71
M	14,47	2,07	14,3	8,7	0,52	1,00	0,17	5,1	1,07
M	5,08	0,78	15,4	11,2	0,76	1,41	0,31	6,5	1,37
M	4,63	0,66	14,3	12,1	0,73	1,07	0,34	5,4	1,20
Cadmium, 50 µg/l; salinity 26,3°/oo									
F	11,14	1,52	13,6	14,4	0,66	1,19	0,34	6,6	1,19
F	10,31	1,15	11,2	10,0	0,48	1,16	0,27	4,7	1,18
F	5,87	0,74	12,6	11,1	0,54	1,20	0,37	6,0	1,80
F	11,69	1,58	13,5	12,4	0,50	1,44	0,26	5,2	1,12
M	12,09	1,49	12,3	11,1	0,59	1,19	0,35	5,2	1,04
M	9,34	1,11	11,9	8,6	0,52	1,08	0,31	4,8	1,47
M	4,40	0,56	12,7	11,4	0,61	1,04	0,38	6,8	1,63
M	6,78	0,88	13,0	11,4	0,53	1,34	0,35	6,0	1,10
M	9,20	1,24	13,5	10,9	0,56	0,95	0,30	5,0	1,00
Cadmium, 50 µg/l; salinity 21,9°/oo									
M	11,40	1,70	14,9	8,7	0,68	1,08	0,35	3,7	0,83
M	5,32	0,72	13,5	13,2	1,06	1,16	0,37	6,0	1,67
M	9,28	1,29	13,9	10,2	0,88	1,20	0,40	5,6	1,28
F	8,08	0,97	12,0	18,1	1,21	1,15	0,32	4,6	1,29
F	7,37	0,89	12,1	12,5	0,37	1,00	0,28	5,0	1,53
F	11,00	1,25	11,3	9,5	0,52	1,02	0,36	4,2	0,97
F	7,69	0,91	11,8	12,6	0,58	1,05	0,42	4,9	1,43
Cadmium, 100 µg/l; salinity 35°/oo									
M	3,35	0,66	19,7	13,7	1,67	1,01	0,15	9,6	1,09
M	3,43	0,60	17,5	13,1	1,49	1,05	0,12	8,7	1,29
M	4,47	0,71	15,9	14,5	1,45	0,98	0,16	7,8	1,37
M	2,54	0,37	14,6	16,9	1,22	0,87	0,04	11,4	1,26
M	3,86	0,66	17,1	12,7	1,22	1,01	0,08	9,1	1,74
M	3,27	0,60	18,4	13,5	1,38	0,95	0,03	8,9	1,53
F	10,65	1,98	18,6	16,2	1,41	1,01	0,18	7,0	1,48
F	8,85	1,68	19,0	17,5	1,60	1,18	0,19	8,4	1,57
F	3,39	0,48	14,2	16,2	1,27	0,97	0,15	8,6	1,40
F	2,12	0,35	16,5	16,0	1,27	0,90	0,09	10,8	1,65
Cadmium, 200 µg/l; salinity 35°/oo									
F	9,57	1,30	13,6	18,3	2,31	1,19	0,22	7,0	1,39
F	7,05	1,25	17,7	15,4	1,89	1,08	0,17	11,4	2,08
F	5,91	0,88	14,9	15,8	1,62	0,94	0,11	9,9	1,47
F	9,62	1,51	15,7	14,9	1,26	1,18	0,24	7,8	1,04
F	9,60	1,08	16,6	17,6	1,57	1,24	0,15	6,6	1,61
M	7,15	1,29	18,0	13,1	1,91	1,09	0,17	5,5	1,14
M	8,93	1,30	14,6	15,2	2,32	1,20	0,19	4,3	1,28
M	8,47	1,48	17,5	14,3	1,88	1,15	0,15	5,9	1,10
M	4,42	0,78	17,6	13,5	1,59	0,87	0,22	7,1	1,35
M	5,64	1,07	19,0	12,2	2,04	0,99	0,14	8,8	1,50

Crassostrea gigas. Tissue-metal concentrations after 3 weeks exposure to 50 µg/l cadmium in the presence of other metals (T=24 °C)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue Zn	Cd	Cu	Pb	Fe	Mn
Cadmium, 0 µg/l								
8,43	0,71	8,4	178	0,39	9,7	<0,05	17,6	2,97
4,82	0,50	10,4	191	0,52	5,7	<0,05	24,9	2,08
3,00	0,24	8,0	100	0,77	8,7	<0,05	28,7	2,00
6,66	0,64	9,6	112	0,42	15,5	<0,05	21,0	2,01
4,47	0,43	9,6	114	0,63	11,0	0,13	34,5	1,90
3,83	0,31	8,1	119	0,68	12,0	0,13	23,2	2,22
6,09	0,62	10,2	153	0,54	13,5	<0,05	19,5	1,81
4,00	0,33	8,3	170	0,63	14,0	<0,05	30,3	1,75
7,31	0,63	8,6	115	0,48	7,3	<0,05	16,6	1,64
3,83	0,31	8,1	166	0,63	14,6	<0,05	24,5	1,96
Cadmium, 0 µg/l; zinc 50 µg/l								
7,94	0,70	8,8	142	0,38	11,1	0,06	11,5	1,86
14,92	1,51	10,1	191	0,36	14,6	0,01	9,8	1,86
11,40	0,89	7,8	83	0,31	5,1	0,03	11,6	1,63
8,26	0,81	9,8	219	0,39	17,7	0,02	12,3	1,95
15,26	1,42	9,3	95	0,27	7,5	0,02	8,9	1,31
9,63	1,00	10,4	152	0,38	11,2	0,06	12,0	1,33
8,40	0,80	9,5	136	0,42	12,4	0,02	12,4	1,70
5,28	0,66	12,5	290	0,51	24,2	0,11	20,3	1,70
8,84	0,68	7,6	80	0,32	7,0	0,06	10,9	1,58
12,46	1,28	10,3	152	0,36	13,4	0,02	11,1	1,75
Cadmium, 0 µg/l; zinc 200 µg/l								
5,00	0,76	15,2	182	0,64	9,6	0,08	21,0	1,66
8,36	1,13	13,5	188	0,48	11,4	0,07	15,9	2,44
8,48	1,07	12,6	87	0,45	3,3	0,06	30,7	1,96
7,61	0,78	10,2	175	0,53	11,4	0,07	17,6	2,22
8,90	0,88	9,9	146	0,36	8,4	0,03	12,8	1,29
5,31	0,52	9,8	75	0,45	4,4	0,04	17,3	1,30
6,68	0,54	8,1	69	0,54	3,4	0,10	15,3	1,29
7,34	0,75	10,2	181	0,52	12,9	0,07	14,6	1,95
8,91	1,02	11,4	192	0,52	12,5	0,07	15,4	1,90
6,73	0,80	11,9	175	0,48	20,2	0,06	15,9	2,6
Cadmium, 0 µg/l; copper 50 µg/l								
10,10	0,92	9,1	127	0,35	15,3	0,04	15,1	1,93
8,21	0,72	8,8	119	0,40	18,9	0,06	13,0	1,41
9,65	0,67	6,9	38	0,32	8,1	0,02	10,8	1,51
10,16	0,90	8,9	105	0,34	19,9	0,02	10,9	1,62
15,42	1,07	6,9	41	0,28	5,9	0,01	7,1	1,11
6,64	0,52	7,8	62	0,33	8,1	0,06	11,4	1,25
11,54	1,35	11,7	158	0,37	17,8	0,03	13,3	1,72
7,74	0,88	11,4	123	0,39	21,1	0,05	15,8	1,81
8,57	0,94	11,0	118	0,39	17,2	0,04	16,8	2,72
18,15	0,89	10,9	41	0,15	6,3	0,01	16,0	0,94
Cadmium, 0 µg/l; copper 200 µg/l								
8,80	0,75	8,5	114	0,39	42,8	0,08	18,2	2,11
6,68	0.65	9,7	207	0,54	49,1	0,04	22,5	3,47
7,66	0,63	8,2	155	0,53	44,1	0,04	22,2	2,40
4,76	0,42	8,8	126	0,42	37,4	0,02	17,3	2,12
5,31	0,62	11,7	81	0,52	41,2	0,08	33,9	3,30
4,95	0,53	10,7	152	0,42	59,0	0,10	28,3	2,65
5,45	0,53	9,7	57	0,51	39,1	0,04	27,5	2,97
6,70	0,58	8,7	39	0,52	36,9	0,06	19,3	3,21
7,90	0,73	9,2	82	0,41	33,5	0,04	27,8	1,29
4,92	0,42	8,5	24	0,55	14,4	0,02	24,4	0,89

Crassostrea gigas. Tissue-metal concentrations after 3 weeks exposure to 50 µg/l cadmium in the presence of other metals (T=24°C) (continued)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
Cadmium, 0 µg/l; lead 50 µg/l								
8,18	0,68	8,3	129	0,82	5,1	0,81	7,0	1,61
5,61	0,65	11,6	148	0,43	6,3	0,90	11,3	0,65
6,54	0,82	12,5	141	0,39	5,3	0,73	10,6	0,90
8,04	0,87	10,8	75	0,52	6,2	0,65	16,4	2,31
8,47	0,78	9,2	108	0,73	14,8	0,76	14,8	2,25
9,25	1,04	11,2	86	0,64	7,0	0,58	8,5	1,30
6,29	0,61	9,7	93	0,65	8,8	0,30	12,1	1,74
8,84	0,99	11,2	48	0,28	12,1	0,51	15,8	0,94
9,90	1,11	11,2	69	0,32	9,4	0,33	11,4	2,57
6,19	0,54	8,7	108	0,47	10,6	0,63	12,9	1,76
Cadmium, 0 µg/l; lead 200 µg/l								
11,96	1,51	12,6	108	0,42	6,1	2,97	22,2	2,96
9,54	1,03	10,8	88	0,63	5,4	1,21	13,7	0,60
10,65	1,03	9,7	181	0,59	6,4	1,85	16,5	0,48
15,04	1,69	11,2	116	0,64	5,2	4,05	15,0	1,01
8,80	1,00	11,4	176	0,28	4,9	2,39	14,5	1,14
7,92	0,73	9,2	142	0,38	6,2	2,92	7,0	2,47
16,79	1,42	8,5	150	0,25	5,9	2,06	19,8	2,96
11,59	1,52	13,1	83	0,30	9,0	3,81	13,7	1,13
2,26	0,23	10,2	229	0,34	13,8	5,72	11,2	3,36
4,01	0,48	12,0	170	0,45	7,5	2,21	14,4	1,10
Cadmium, 50 µg/l								
5,91	0,71	12,0	218	3,55	5,4	0,03	19,3	4,06
7,99	0,80	10,0	86	4,63	10,1	0,05	16,3	3,82
3,88	0,41	10,6	253	5,15	17,4	0,03	23,2	1,55
3,86	0,45	11,7	293	8,29	15,0	0,05	26,7	1,95
4,79	0,61	12,7	94	3,97	7,5	0,09	26,3	1,67
5,33	0,60	11,3	289	4,69	13,3	0,04	20,8	2,03
4,07	0,43	10,6	143	3,44	16,0	0,20	23,8	2,09
5,98	0,69	11,5	246	4,52	15,8	0,08	21,4	1,84
6,94	0,80	11,5	143	3,60	11,2	0,10	19,0	3,03
4,92	0,63	12,8	238	5,69	10,1	0,06	22,8	2,44
Cadmium, 50 µg/l; zinc 50 µg/l								
10,75	1,12	10,4	141	3,72	11,4	0,05	10,3	2,17
10,62	1,20	11,3	157	3,01	15,4	0,04	11,5	2,28
7,74	1,18	15,3	265	5,17	22,1	0,05	19,0	2,95
4,24	0,59	13,9	83	8,02	3,4	0,12	21,5	2,78
6,28	0,80	12,7	223	4,14	17,4	0,06	20,2	1,88
4,11	0,47	11,4	153	3,31	9,0	0,07	24,6	1,58
8,09	0,74	9,2	141	4,70	11,5	0,02	14,6	1,37
5,51	0,55	10,0	85	3,27	8,4	0,04	17,8	1,32
14,64	1,43	9,8	85	3,14	5,6	0,07	18,4	1,67
8,48	0,74	8,7	66	2,59	4,6	0,04	12,3	2,02
Cadmium, 5o µg/l; copper 50 µg/l								
10,00	0,82	8,2	74	2,1	10,0	0,04	12,1	1,72
13,79	1,51	10,9	119	2,8	13,4	0,04	12,3	1,81
9,79	1,17	12,0	120	3,9	18,2	0,03	16,0	1,42
13,98	1,39	9,9	51	3,3	12,1	0,04	11,7	1,55
12,13	0,92	7,6	142	2,2	13,1	0,04	24,7	2,04
15,76	1,23	7,8	98	2,4	9,7	0,03	12,0	1,86
13,72	1,25	9,1	126	2,3	16,6	0,01	10,8	1,75
12,10	1,15	9,5	80	3,8	11,4	0,04	13,0	1,71
8,83	1,04	11,8	176	2,8	18,6	0,04	18,7	2,33
10,96	1,20	11,0	98	3,6	11,4	0,04	14,1	2,25
Cadmium, 50 µg/l; lead 50 µg/l								
6,81	0,84	12,8	195	6,75	16,7	0,73	19,7	3,83
10,64	1,44	13,5	184	4,89	15,4	0,45	29,1	2,49
8,13	0,92	11,3	202	5,66	17,5	0,47	17,5	2,94
11,12	1,14	10,3	85	5,22	6,0	0,59	11,6	1,78
10,00	1,10	11,0	94	3,20	6,6	0,31	14,1	2,58
6,93	0,74	10,7	131	4,33	8,7	0,55	17,2	2,12
4,49	0,60	13,4	140	5,35	10,5	0,67	22,1	2,63
7,33	0,90	12,3	142	4,37	10,6	0,52	17,2	2,22
7,14	1,11	15,6	157	4,76	12,0	0,42	17,9	1,75
6,54	0,91	13,9	179	3,67	14,7	0,40	18,5	2,05

Crassostrea margaritacea. Tissue-metal concentrations after 3 weeks exposure to 50 µg/l cadmium in the presence of other metals. (T=24°C)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
Cadmium, 0 µg/l.								
4,55	0,60	13,2	110	0,88	1,36	0,11	6,2	0,97
4,16	0,44	10,6	123	1,11	1,13	0,10	4,6	0,31
6,01	0,70	11,7	107	1,08	1,21	0,03	4,2	0,17
4,83	0,49	10,1	155	0,91	1,12	0,04	3,7	0,33
3,41	0,37	10,9	111	1,41	1,11	0,09	7,9	0,32
4,71	0,65	13,8	110	0,87	1,38	0,08	6,8	1,15
2,92	0,32	11,0	116	1,54	1,99	0,14	7,5	0,31
6,47	0,78	12,1	90	1,23	2,04	0,06	5,1	0,40
Cadmium, 0 µg/l; zinc, 50 µg/l.								
6,42	0,66	10,3	164	1,32	0,75	0,05	5,1	0,39
7,46	0,73	9,8	82	0,94	1,83	0,04	5,1	0,23
14,58	0,96	6,6	127	0,56	1,39	0,10	6,4	0,40
5,43	0,70	12,9	74	1,05	2,08	0,08	5,2	0,55
5,78	0,86	14,9	92	1,63	1,09	0,05	7,8	0,30
7,85	0,96	12,2	173	0,99	2,52	0,11	4,1	0,21
10,12	1,29	12,7	120	1,10	1,87	0,07	4,9	0,18
9,27	1,25	13,5	85	1,06	1,05	0,12	4,2	0,20
8,92	1,31	14,7	96	1,46	1,36	0,06	6,1	0,20
8,43	1,09	12,9	95	1,26	1,32	0,15	6,2	0,22
Cadmium, 0 µg/l; zinc, 200 µg/l.								
6,81	0,85	12,5	75	1,06	2,24	0,13	4,6	0,44
9,76	1,18	12,1	111	0,99	2,55	0,05	4,6	0,26
7,34	1,11	15,1	134	1,05	1,94	0,07	6,8	0,22
8,65	1,01	11,7	81	0,88	1,69	0,04	4,1	0,26
8,30	1,23	14,8	117	1,13	1,63	0,08	3,5	0,21
8,68	1,06	12,2	146	1,05	2,35	0,10	5,2	0,19
6,40	0,93	14,5	138	1,31	1,08	0,08	8,0	0,23
2,38	0,28	11,8	80	1,05	1,13	0,05	7,6	0,23
5,18	0,77	14,9	93	1,08	1,83	0,05	6,2	0,23
10,84	1,40	12,9	158	0,98	0,85	0,03	3,0	0,18
Cadmium, 0 µg/l; copper, 50 µg/l.								
4,98	0,71	14,3	133	1,20	4,47	0,10	5,8	0,25
4,64	0,61	13,1	112	1,12	11,70	0,10	6,7	0,25
8,54	1,28	15,0	131	0,46	2,84	0,03	6,8	0,26
10,27	1,35	13,1	90	1,20	3,66	0,08	5,4	0,34
4,89	0,71	14,5	92	1,23	4,70	0,07	8,6	0,24
9,18	1,32	14,4	83	0,37	3,68	0,12	4,9	0,21
5,43	0,69	12,7	151	0,93	4,03	0,07	5,3	0,19
7,03	0,86	12,2	81	1,17	2,09	0,07	5,1	0,29
7,49	1,20	16,0	123	0,75	2,50	0,03	7,5	0,24
8,66	1,08	12,5	92	1,04	4,65	0,06	5,0	0,32
Cadmium, 0 µg/l; copper, 200 µg/l.								
7,65	1,05	13,7	133	1,02	10,9	0,10	5,2	0,22
5,63	0,65	11,4	158	1,23	19,2	0,03	6,6	0,22
9,00	0,95	10,6	98	1,08	13,9	0,14	2,7	0,33
8,00	0,77	9,6	132	0,98	22,2	0,06	4,6	0,37
5,49	0,71	12,9	144	1,22	17,1	0,10	7,1	0,26
5,21	0,61	11,7	109	1,55	30,3	0,11	6,3	0,26
4,37	0,62	14,2	103	1,21	16,5	0,08	7,6	0,45
12,27	1,61	13,1	92	0,85	15,6	0,07	4,8	0,23
3,65	0,49	13,4	148	1,29	30,1	0,02	7,7	0,28
7,66	0,97	12,7	158	0,97	15,7	0,09	7,8	0,22
Cadmium, 50 µg/l; lead 50 µg/l								
4,75	1,00	21,1	217	4,15	1,03	0,80	7,6	0,27
9,15	1,34	14,6	97	2,32	0,91	0,66	5,1	0,19
6,86	0,79	11,5	147	2,19	1,92	0,35	6,0	0,39
9,00	1,12	12,4	104	1,31	1,11	0,39	3,8	0,29
4,69	0,56	11,9	154	2,24	2,99	0,32	6,2	0,65
6,98	0,93	13,3	159	2,01	1,63	0,74	6,6	0,22
5,48	0,93	17,0	124	4,38	3,81	0,57	6,4	0,50
6,76	0,87	12,9	99	1,35	1,27	0,34	4,0	0,43
8,27	1,34	16,2	89	2,99	1,22	0,78	5,3	0,20
7,81	1,11	14,2	105	1,37	1,72	0,23	5,0	0,23

Crassostrea margaritacea. Tissue-metal concentrations after 3 weeks exposure to 50 µg/l cadmium in the presence of other metals. (T=24°C) (continued)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
Cadmium, 0 µg/l; lead, 50 µg/l.								
2,52	0,24	9,5	187	1,15	0,85	0,37	7,5	0,42
1,70	0,20	11,8	120	1,45	0,70	0,57	8,0	0,35
2,17	0,28	12,9	151	1,41	1,94	0,21	7,0	0,17
2,44	0,21	8,6	74	0,97	0,89	0,66	5,9	0,14
1,03	0,07	6,8	76	1,06	1,24	0,35	10,2	0,30
2,53	0,25	9,9	136	0,42	2,39	0,22	8,9	0,33
3,31	0,29	8,8	182	1,13	1,17	0,32	8,2	0,40
2,70	0,24	8,9	97	0,77	0,81	0,19	5,4	0,42
8,89	0,66	7,4	49	0,86	2,08	0,16	4,7	0,69
7,86	0,88	11,2	154	1,09	1,87	0,18	5,3	1,03
Cadmium, 0 µg/l; lead, 200 µg/l.								
4,41	0,53	12,0	110	0,84	0,90	1,81	4,5	0,41
3,64	0,41	11,3	110	0,96	0,85	4,00	7,8	0,18
3,42	0,35	10,2	91	0,77	1,08	3,42	9,6	0,40
2,82	0,25	8,8	186	0,98	0,76	2,28	16,1	0,16
3,87	0,43	11,1	161	1,34	1,20	2,36	4,2	0,32
5,31	0,55	10,4	130	0,91	2,11	3,47	7,6	0,33
7,49	0,81	10,8	78	1,59	1,58	1,08	3,5	0,35
9,86	1,08	11,0	122	1,50	1,81	1,88	8,1	0,81
7,47	0,82	11,0	87	1,16	1,19	2,72	8,4	0,62
5,90	0,65	11,0	134	0,92	0,64	1,37	3,8	0,51
Cadmium, 50 µg/l.								
6,03	0,79	13,1	161	1,38	0,83	0,07	5,0	0,76
5,20	0,65	12,5	129	1,27	2,77	0,04	5,4	0,25
4,36	0,46	10,6	101	2,91	2,68	0,07	4,6	0,34
5,73	0,60	10,5	110	1,08	1,82	0,03	4,0	0,33
2,84	0,35	12,3	211	2,39	1,88	0,14	8,1	0,32
4,26	0,53	12,4	68	1,38	0,85	0,07	4,2	0,35
4,37	0,53	12,1	158	1,37	2,91	0,07	5,7	0,39
4,18	0,53	12,7	124	3,54	2,32	0,10	5,7	0,91
7,83	1,01	12,9	134	1,44	1,86	0,08	5,1	1,28
Cadmium, 50 µg/l; zinc, 50 µg/l.								
10,16	1,10	10,8	94	1,61	0,85	0,05	4,9	0,65
12,15	1,27	10,4	67	1,42	1,09	0,03	3,3	0,33
7,06	0,77	10,9	82	1,91	1,86	0,02	4,1	0,36
5,03	0,59	11,7	165	2,25	1,37	0,10	6,2	0,28
11,06	1,45	13,1	130	1,84	1,08	0,11	5,2	0,17
15,65	1,75	11,2	92	0,85	1,67	0,07	3,3	0,14
7,29	0,82	11,2	103	1,88	1,11	0,09	5,2	0,20
8,44	1,03	12,2	120	3,79	2,20	0,11	4,7	0,19
4,53	0,66	14,6	137	3,66	0,95	0,06	7,3	0,25
14,70	1,89	12,9	141	1,73	1,24	0,02	4,8	0,19
Cadmium, 50 µg/l; copper 50 µg/l.								
5,30	0,64	12,1	121	2,55	8,51	0,14	5,4	0,23
10,79	1,19	11,0	135	2,21	2,86	0,06	4,2	0,17
6,90	0,97	14,1	141	3,04	5,53	0,07	4,9	0,20
6,67	0,74	11,1	78	3,89	5,30	0,11	4,8	0,19
8,11	1,14	14,1	120	1,68	4,22	0,09	5,7	0,20
9,24	1,16	12,6	141	1,46	2,60	0,05	6,1	0,23
6,57	0,92	14,0	172	3,56	3,87	0,06	8,8	0,25
6,39	0,73	11,4	103	2,97	6,00	0,09	4,5	0,28
10,20	1,08	10,6	77	2,05	2,52	0,03	4,0	0,41
8,33	1,07	12,8	80	1,78	3,89	0,04	5,5	0,40

Perna perna. Tissue-metal concentrations after 3 weeks exposure to 50 µg/l cadmium in the presence of other metals (T=24°C)

Sex	Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
				Zn	Cd	Cu	Pb	Fe	Mn
Cadmium, 0 µg/l									
F	5,02	0,41	8,2	17,8	0,85	0,77	0,25	19,1	0,21
F	3,74	0,44	11,8	14,2	0,90	0,85	0,20	17,6	0,34
F	3,70	0,28	7,6	13,0	0,56	0,59	0,18	11,9	0,24
F	6,28	0,67	10,7	12,4	0,38	1,01	0,23	9,6	0,27
F	5,98	0,54	9,0	12,2	0,42	0,83	0,30	13,5	0,18
M	5,40	0,57	10,6	10,9	0,40	0,66	0,22	9,8	0,27
M	3,02	0,34	11,3	13,9	0,66	0,73	0,13	12,3	0,20
M	3,51	0,39	11,1	6,8	0,54	0,55	0,25	13,1	0,45
M	4,96	0,43	8,7	8,5	0,40	0,62	0,24	10,1	0,32
M	4,58	0,48	10,5	10,3	0,56	0,78	0,19	10,9	0,30
Cadmium, 0 µg/l; zinc 50 µg/l									
F	1,73	0,16	9,3	12,1	0,58	0,98	0,23	24,3	0,52
F	2,22	0,24	10,8	19,9	0,50	0,72	0,18	19,8	0,50
F	2,12	0,26	12,3	19,8	0,52	1,13	0,19	20,3	0,52
F	3,00	0,38	12,7	16,3	0,77	1,33	0,17	24,3	0,57
F	2,29	0,19	8,3	21,4	1,31	1,05	0,22	25,3	0,44
F	4,89	0,78	16,0	14,9	0,88	0,82	0,10	17,4	0,37
F	3,27	0,41	12,5	18,7	0,70	0,89	0,21	20,8	0,61
F	1,90	0,20	10,5	13,7	0,68	0,84	0,21	20,5	0,68
M	2,26	0,29	12,8	9,3	0,84	0,80	0,09	23,9	0,40
M	3,70	0,47	12,7	12,7	0,76	0,86	0,16	19,2	0,38
Cadmium, 0 µg/l; zinc, 200 µg/l									
F	2,45	0,29	11,8	12,2	0,45	0,69	0,24	17,6	0,37
F	3,89	0,51	13,1	13,9	0,44	0,77	0,13	14,7	0,41
F	5,24	0,53	10,1	11,3	0,44	0,63	0,08	10,5	0,23
F	3,89	0,38	9,8	12,6	0,59	0,62	0,08	14,9	0,21
F	3,48	0,38	10,9	10,3	0,46	0,63	0,16	13,8	0,29
F	3,09	0,33	10,7	9,4	0,58	0,58	0,06	16,8	0,29
F	3,24	0,33	10,2	12,0	0,43	0,71	0,12	12,3	0,31
M	3,07	0,33	10,7	13,4	0,52	0,52	0,10	14,0	0,26
M	2,98	0,35	11,7	14,1	0,40	0,74	0,13	13,4	0,30
M	2,54	0,27	10,6	13,8	0,39	0,63	0,16	23,2	0,31
Cadmium, 0 µg/l; copper, 50 µg/l									
F	3,74	0,43	11,5	14,4	0,61	1,20	0,13	25,4	0,43
F	4,46	0,54	12,1	17,6	0,56	0,90	0,24	12,6	0,34
F	2,20	0,20	9,1	16,4	0,73	1,41	0,15	21,8	0,41
F	2,76	0,33	12,0	10,1	0,54	1,30	0,14	17,0	0,40
F	3,57	0,42	11,8	7,6	0,70	1,09	0,17	14,3	0,28
F	3,48	0,40	11,5	10,6	0,57	1,18	0,09	18,4	0,29
F	1,98	0,27	13,6	13,6	0,51	1,21	0,20	16,7	0,35
F	3,41	0,38	11,1	11,4	0,47	0,29	0,12	17,0	0,38
F	2,63	0,25	9,5	18,0	0,49	0,99	0,21	18,6	0,38
M	3,00	0,35	11,7	13,3	0,76	1,00	0,10	25,7	0,33
Cadmium, 0 µg/l; copper 200 µg/l									
F	3,05	0,43	14,1	15,1	0,72	6,39	0,16	17,4	0,33
F	2,94	0,39	13,3	12,2	0,71	6,46	0,17	17,0	0,41
F	1,97	0,24	12,2	16,7	0,56	5,79	0,20	20,3	0,51
F	3,52	0,50	14,2	8,2	0,77	7,19	0,20	23,9	0,43
F	3,07	0,41	13,4	14,4	0,49	5,19	0,10	13,7	0,46
F	5,80	0,69	11,9	12,0	0,57	8,45	0,09	15,7	0,53
F	2,69	0,36	13,4	18,6	1,23	5,72	0,22	21,9	0,48
F	4,10	0,52	12,7	15,1	0,73	7,07	0,15	15,6	0,54
M	2,33	0,30	12,9	8,2	0,43	5,48	0,13	17,2	0,43
M	2,69	0,38	14,1	12,3	0,78	5,35	0,23	17,5	0,41
Cadmium, 50 µg/l; lead, 50 µg/l									
F	2,64	0,27	10,2	18,0	1,02	0,80	0,95	18,6	0,53
F	3,27	0,40	12,2	18,7	1,16	0,92	1,07	15,6	0,73
F	2,11	0,28	13,3	14,7	1,04	0,71	1,28	17,5	0,47
F	1,96	0,33	16,8	21,4	1,63	1,33	1,99	27,0	0,66
F	2,21	0,29	13,1	15,4	2,63	1,09	1,27	28,1	0,63
M	1,90	0,23	12,1	8,9	1,63	0,74	1,16	19,5	0,42
M	4,31	0,51	11,8	11,8	1,23	0,77	1,14	15,1	0,30
M	5,88	0,83	14,1	12,1	1,73	0,48	0,92	13,8	0,29
M	4,22	0,47	11,1	11,4	1,49	0,76	0,83	17,1	0,31
M	3,14	0,32	10,2	12,1	1,37	0,54	0,99	15,9	0,38

Perna perna. Tissue-metal concentrations after 3 weeks exposure to 50 µg/l cadmium in the presence of other metals (T=24°C)(Continued)

Sex	Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue				
				Zn	Cd	Cu	Pb	Fe	Mn
	Cadmium, 0 µg/l; lead, 50 µg/l								
M	3,05	0,31	10,2	12,8	0,72	0,73	1,48	12,8	0,27
M	0,59	0,60	10,2	11,2	0,66	0,75	1,18	14,2	0,76
M	1,59	0,14	8,8	13,0	0,44	0,61	2,00	15,9	0,69
F	2,00	0,20	10,0	19,9	0,78	0,41	1,63	21,4	0,40
F	1,25	0,14	11,2	11,2	0,61	0,36	1,25	29,0	0,42
F	2,85	0,27	9,5	12,0	0,36	0,66	1,68	18,6	0,18
F	3,83	0,37	9,7	17,8	0,45	0,42	1,49	17,5	0,16
F	2,60	0,26	10,0	18,9	0,41	0,44	1,31	12,9	0,55
F	2,90	0,29	10,0	11,1	0,66	0,78	1,35	11,8	0,42
F	4,34	0,42	9,7	14,2	0,58	0,69	1,50	15,4	0,31
	Cadmium, 0 µg/l; lead, 200 µg/l								
F	3,79	0,39	10,3	10,5	0,59	0,43	3,93	16,7	0,41
F	2,89	0,27	9,3	18,4	0,75	0,73	4,23	20,6	0,42
F	0,60	0,06	10,0	12,8	0,44	0,62	4,68	15,1	0,25
M	1,62	0,15	9,3	11,1	0,78	0,41	2,11	21,4	0,20
M	1,89	0,17	9,0	10,1	0,46	0,74	4,59	29,2	0,15
M	1,75	0,16	9,1	9,5	0,65	0,38	6,08	17,1	0,24
M	3,44	0,32	9,3	11,7	0,57	0,66	4,38	16,2	0,32
M	2,68	0,25	9,3	11,3	0,36	0,45	4,13	14,8	0,41
M	3,00	0,28	9,3	9,4	0,21	0,41	3,17	13,3	0,21
M	1,40	0,14	10,0	10,5	0,60	0,35	7,59	20,4	0,36
	Cadmium, 50 µg/l								
M	5,56	0,44	7,9	7,9	1,13	0,46	0,19	11,7	0,23
F	4,22	0,49	11,6	17,5	0,99	0,66	0,18	13,0	0,45
F	3,39	0,32	9,4	11,2	1,74	0,88	0,17	15,6	0,26
F	2,81	0,29	10,3	14,6	1,42	0,81	0,21	10,0	0,39
M	3,82	0,35	9,2	12,9	1,07	0,39	0,15	16,5	0,20
M	3,02	0,30	9,9	11,9	1,78	0,86	0,33	14,6	0,36
M	4,91	0,51	10,4	12,4	0,99	0,63	0,20	9,4	0,22
M	6,12	0,60	9,8	11,3	1,17	0,42	0,22	11,9	0,21
M	3,40	0,37	10,9	7,4	1,61	0,70	0,28	15,6	0,38
	Cadmium, 50 µg/l; zinc, 50 µg/l								
F	3,24	0,46	14,2	14,5	1,39	1,36	0,15	24,4	0,90
F	4,63	0,76	16,4	22,5	1,36	1,49	0,17	17,9	0,68
F	3,27	0,46	14,1	24,8	1,68	0,83	0,15	15,6	0,58
F	2,93	0,39	13,3	20,1	1,81	0,89	0,17	15,0	0,48
F	4,04	0,52	12,9	13,9	1,16	0,77	0,12	15,3	0,40
F	3,30	0,42	12,7	13,6	1,21	0,79	0,12	20,3	0,42
M	2,78	0,36	12,9	13,3	1,15	0,61	0,17	16,2	0,36
M	3,50	0,49	14,0	16,6	1,66	0,77	0,09	16,6	0,37
M	2,16	0,24	11,1	12,5	1,48	0,69	0,14	22,2	0,51
M	3,00	0,43	14,3	10,3	1,63	0,53	0,13	16,0	0,40
	Cadmium, 50 µg/l; copper 50 µg/l								
F	4,36	0,50	11,5	11,2	1,47	1,35	0,16	14,9	0,41
F	2,87	0,39	13,6	14,1	1,64	1,18	0,13	19,5	0,45
F	4,83	0,63	13,0	13,7	0,85	1,47	0,18	13,7	0,68
F	3,26	0,46	14,1	10,7	1,10	1,35	0,19	14,1	0,58
F	3,70	0,41	11,1	10,0	1,59	1,49	0,14	21,1	0,35
F	2,37	0,30	12,7	10,5	1,39	1,31	0,08	19,0	0,51
F	4,88	0,52	10,7	7,4	0,94	1,29	0,10	12,3	0,25
F	4,12	0,49	11,9	11,4	1,34	1,17	0,10	18,2	0,36
M	4,21	0,58	13,8	12,6	1,76	1,24	0,12	19,7	0,33
M	3,41	0,43	12,6	15,2	1,96	1,06	0,15	16,7	0,35

Choromytilus meridionalis. Tissue-metal concentrations after 3 weeks exposure to 50 µg/l cadmium in the presence of other metals (T=24°C)

	Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue Zn	Cd	Cu	Pb	Fe	Mn
	Cadmium, 0 µg/l								
F	8,22	1,52	18,5	17,7	0,29	1,19	0,06	6,4	1,66
F	4,78	0,75	15,7	15,5	0,27	1,02	0,16	5,9	1,94
F	5,49	0,91	16,6	16,6	0,38	1,11	0,23	7,1	1,45
F	4,80	0,85	17,7	15,6	0,18	1,18	0,25	6,7	1,47
F	13,30	2,04	15,3	11,4	0,27	1,03	0,13	5,0	0,93
F	5,65	1,07	18,9	16,8	0,24	1,41	0,08	6,0	0,53
F	15,10	2,40	15,9	11,6	0,27	1,09	0,16	5,3	1,37
F	7,60	1,08	14,2	14,6	0,19	1,25	0,17	5,1	1,15
M	11,84	2,16	18,2	10,1	0,32	1,06	0,12	6,3	0,65
M	4,77	0,78	16,4	13,4	0,31	1,24	0,16	7,3	1,74
	Cadmium, 0 µg/l; zinc, 50 µg/l								
F	9,77	1,34	13,7	12,7	0,36	1,04	0,14	4,9	1,61
F	5,09	0,77	15,1	16,9	0,41	1,16	0,05	6,1	1,56
F	7,28	0,98	13,5	12,8	0,26	0,83	0,20	4,9	1,67
F	6,52	1,15	17,6	15,6	0,28	1,32	0,17	5,5	1,88
F	5,94	0,85	14,3	13,6	0,51	1,26	0,16	8,1	1,51
M	9,07	1,30	14,3	9,3	0,32	0,93	0,11	5,3	1,08
M	5,59	0,85	15,2	12,7	0,30	0,95	0,08	5,5	0,78
M	6,51	1,18	18,1	10,6	0,22	1,06	0,12	5,7	1,02
M	7,05	1,08	15,3	9,6	0,28	1,08	0,07	5,5	1,32
M	5,75	0,95	16,5	12,2	0,28	1,06	0,16	6,4	1,59
	Cadmium, 0 µg/l; zinc, 200 µg/l								
F	8,94	1,37	15,3	15,1	0,31	0,95	0,08	5,7	1,80
F	8,39	1,29	15,4	14,0	0,30	0,93	0,14	5,0	1,62
F	8,36	1,32	15,8	15,0	0,25	1,04	0,11	5,3	1,59
F	5,98	0,93	15,6	15,2	0,27	1,02	0,13	5,5	1,25
F	7,60	1,13	14,9	12,4	0,34	1,16	0,12	6,6	1,50
F	8,80	1,15	13,1	14,3	0,25	1,13	0,07	6,5	1,68
M	7,11	1,12	15,8	10,7	0,25	1,04	0,07	6,6	1,48
M	6,83	1,21	17,7	11,3	0,29	1,02	0,12	6,0	1,48
M	4,55	0,67	14,7	10,6	0,26	1,03	0,07	6,6	1,10
M	5,00	0,75	15,0	11,0	0,26	1,06	0,06	6,6	1,14
	Cadmium, 0 µg/l; copper, 50 µg/l								
F	6,53	1,00	15,3	13,8	0,29	1,01	0,07	6,4	1,22
F	5,03	0,93	18,5	16,5	0,42	1,37	0,06	7,8	2,15
F	4,66	0,74	15,9	16,1	0,36	1,65	0,11	11,6	1,39
F	4,43	0,78	17,6	18,1	0,43	1,42	0,09	7,7	1,75
F	9,15	1,74	19,0	17,3	0,26	1,16	0,10	6,6	2,08
F	4,37	0,71	16,3	17,6	0,32	1,30	0,12	6,4	1,98
M	6,68	1,25	18,7	13,8	0,31	1,08	0,14	5,7	1,23
M	6,57	1,05	16,0	12,3	0,41	1,05	0,15	7,9	1,04
M	6,29	1,03	16,4	12,6	0,32	1,00	0,05	7,0	1,47
M	5,18	0,83	16,0	14,1	0,25	1,12	0,17	6,9	1,61
	Cadmium, 0 µg/l; copper, 200 µg/l								
F	4,98	0,94	18,9	15,6	0,20	4,1	0,14	6,0	1,50
F	9,04	1,61	17,8	15,4	0,47	2,6	0,15	5,5	1,44
F	4,33	0,54	12,5	17,8	0,32	3,2	0,04	9,2	1,63
M	5,22	1,04	19,9	12,3	0,22	3,7	0,13	7,7	1,26
M	7,10	1,30	18,3	12,1	0,26	3,1	0,05	7,0	1,14
M	8,75	1,56	17,8	13,0	0,22	3,4	0,05	5,7	1,08
M	7,05	1,15	16,3	13,0	0,18	2,9	0,07	5,7	1,13
M	6,84	1,22	17,8	12,3	0,29	2,9	0,17	5,8	1,28
M	4,00	0,70	17,5	14,5	0,32	4,7	0,12	7,5	1,10
M	5,90	1,05	17,8	11,7	0,18	4,3	0,11	5,1	1,25

Choromytilus meridionalis. Tissue-metal concentrations after 3 weeks exposure to 50 µg/l cadmium in the presence of other metals (T=24°C) (continued)

Sex	Wet mass g	Dry mass g	Dry mass %	Zn	Cd	Cu	Pb	Fe	Mn
				µg metal/g wet tissue					
	Cadmium, 0 µg/l; lead, 50 µg/l								
F	7,01	1,14	16,3	17,1	0,24	1,27	1,26	9,9	1,50
F	11,42	1,82	15,9	15,8	0,30	0,87	1,11	4,6	1,52
F	9,88	1,72	17,4	15,9	0,33	0,88	1,06	5,7	1,25
M	7,83	1,21	15,5	12,5	0,31	0,63	1,03	8,9	1,62
M	10,04	1,91	19,0	14,8	0,35	0,90	0,85	7,0	1,03
M	6,62	1,22	18,4	15,4	0,46	0,86	0,95	4,1	1,39
M	8,12	1,74	21,4	9,9	0,38	0,86	0,78	6,4	1,73
M	5,47	1,05	19,2	15,4	0,52	0,95	1,05	5,4	1,21
M	4,31	0,54	12,5	14,8	0,43	0,87	1,07	4,4	1,02
	Cadmium, 0 µg/l; lead, 200 µg/l								
F	7,87	1,41	17,9	20,0	0,47	0,93	5,39	7,5	0,91
F	8,05	1,31	16,3	14,9	0,31	1,35	4,93	5,3	1,52
F	8,55	1,35	15,8	17,1	0,46	0,53	5,05	5,4	0,76
F	13,15	1,96	14,9	18,0	0,43	1,06	5,11	7,3	1,72
F	7,90	1,38	17,5	13,3	0,57	0,96	4,37	5,3	1,45
M	8,00	1,27	15,9	10,6	0,56	0,72	4,64	6,6	1,11
M	8,02	1,34	16,7	13,2	0,71	0,85	5,52	5,7	0,65
M	6,71	0,95	14,2	13,5	0,38	0,95	5,84	7,1	1,53
M	8,60	1,50	17,4	11,9	0,49	0,90	6,49	5,6	1,44
	Cadmium, 50 µg/l								
F	10,60	1,50	14,2	14,9	0,57	0,85	0,10	5,2	1,41
F	11,12	1,62	14,6	12,5	0,65	1,05	0,07	5,8	1,06
F	6,43	0,83	12,9	12,9	0,52	0,82	0,13	5,4	1,32
M	6,52	0,96	14,7	10,0	0,64	0,95	0,10	5,5	1,16
M	11,65	1,82	15,6	9,6	0,44	1,08	0,08	4,4	0,86
M	13,50	1,96	14,5	7,9	0,71	0,78	0,07	5,3	0,87
M	8,61	1,41	16,4	10,2	0,55	0,70	0,14	4,6	1,05
	Cadmium, 50 µg/l; zinc, 50 µg/l								
F	8,49	1,31	15,4	16,4	0,68	0,71	0,07	5,9	1,38
F	5,36	0,84	15,7	14,7	0,85	1,02	0,09	7,5	1,77
F	6,05	0,96	15,9	13,9	0,56	0,74	0,18	8,3	1,45
F	6,84	1,16	17,0	17,8	0,61	1,05	0,17	7,3	1,69
F	3,92	0,69	17,6	17,3	0,68	1,12	0,10	10,2	1,53
F	5,50	0,85	15,5	14,9	0,61	0,87	0,13	7,3	1,80
M	7,10	1,18	16,6	12,3	0,56	0,77	0,15	7,0	1,15
M	5,06	0,84	16,6	12,5	0,81	0,86	0,13	5,9	1,32
M	6,99	1,27	18,2	13,7	0,65	0,81	0,10	5,7	1,05
M	5,75	1,02	17,7	12,5	0,73	0,73	0,06	8,7	1,32
	Cadmium, 50 µg/l; copper, 50 µg/l								
F	3,69	0,62	16,8	17,9	0,67	1,13	0,12	8,1	1,73
F	5,21	0,88	16,8	16,9	0,80	1,07	0,17	7,7	2,01
F	8,37	1,46	17,4	13,9	0,66	1,08	0,08	6,0	2,24
F	9,00	1,58	17,6	13,0	0,54	1,95	0,07	5,6	1,60
F	7,03	1,15	16,4	12,1	0,55	1,13	0,09	8,5	1,46
M	7,03	1,30	18,5	11,5	0,59	1,91	0,11	8,5	1,05
M	7,90	1,22	15,4	9,2	0,58	0,87	0,13	6,3	0,94
M	10,68	1,75	16,4	11,3	0,63	1,77	0,07	4,7	0,81
M	8,91	1,49	16,7	11,7	0,74	0,79	0,08	5,6	0,92
	Cadmium, 50 µg/l; lead, 50 µg/l								
F	7,43	1,04	14,0	12,5	0,65	1,06	0,59	5,9	1,21
F	4,23	0,76	18,0	17,3	0,92	1,09	0,87	8,3	1,83
M	3,61	0,63	17,5	12,7	0,80	1,11	0,94	6,6	2,04
M	4,70	0,92	19,6	11,7	0,81	1,13	0,94	7,4	1,56
M	6,50	1,18	18,2	13,2	0,74	1,03	1,12	6,2	1,61
M	9,54	1,89	19,8	18,8	1,26	1,31	0,90	6,9	1,23
M	8,31	1,39	16,7	9,9	0,76	0,95	0,75	5,4	1,81
M	6,31	1,06	16,8	10,5	0,86	1,08	0,86	6,3	0,94
M	5,14	0,88	17,1	12,1	0,66	1,03	0,70	6,4	2,30

Crassostrea gigas. Tissue-metal concentrations after 3 weeks exposure to cadmium, manganese and iron in the presence of some organic compounds (T=24°C)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
Control								
8,43	0,71	8,4	178	0,39	9,7	<0,05	17,6	2,97
4,82	0,50	10,4	191	0,52	5,7	<0,05	24,9	2,08
3,00	0,24	8,0	100	0,77	8,7	<0,05	28,7	2,00
6,66	0,64	9,6	112	0,42	15,5	<0,05	21,0	2,01
4,47	0,43	9,6	114	0,63	11,0	0,13	34,5	1,90
3,83	0,31	8,1	119	0,68	12,0	0,13	23,2	2,22
6,09	0,62	10,2	153	0,54	13,5	<0,05	19,2	1,81
4,00	0,33	8,3	170	0,63	14,0	<0,05	30,3	1,75
7,31	0,63	8,6	115	0,48	7,3	<0,05	16,6	1,64
3,83	0,31	8,1	166	0,63	14,6	<0,05	24,5	1,96
Cadmium, 0 µg/l; sodium citrate								
9,36	0,66	7,1	85	0,32	6,5	0,05	13,1	1,50
11,47	0,84	7,3	119	0,30	17,6	<0,05	12,0	2,05
6,43	0,57	8,9	179	0,45	16,2	<0,05	22,4	1,40
10,49	0,80	7,6	81	0,28	8,9	<0,05	12,1	1,53
8,28	0,80	9,7	127	0,40	9,1	<0,05	14,6	1,33
10,76	0,65	6,0	167	0,29	18,1	<0,05	13,4	1,16
11,78	0,92	7,8	160	0,33	12,5	<0,05	14,8	2,17
13,39	1,19	8,9	78	0,31	4,7	<0,05	12,2	1,01
10,52	0,74	7,0	122	0,29	10,0	<0,05	13,1	1,14
13,62	0,90	6,6	44	0,29	9,4	<0,05	10,1	0,96
Cadmium, 0 µg/l; sodium acetate								
3,32	0,41	12,3	166	0,24	6,3	<0,05	14,8	0,80
7,82	0,81	10,4	135	0,40	5,2	0,05	15,1	1,26
7,26	0,88	12,1	135	0,30	6,1	<0,05	15,3	1,19
6,49	0,76	10,5	106	0,28	4,1	<0,05	14,0	1,01
5,17	0,67	13,0	120	0,46	4,2	<0,05	13,8	1,08
6,98	0,83	11,9	114	0,44	6,5	0,05	13,7	1,71
5,81	0,60	10,3	151	0,49	10,4	<0,05	17,7	1,02
15,81	1,74	11,0	159	0,63	12,3	0,10	16,1	1,36
9,54	0,96	10,1	143	0,56	4,7	<0,05	14,6	1,52
10,06	1,70	16,9	99	0,47	3,7	<0,05	15,5	1,83
Cadmium, 0 µg/l; sodium diethyldithiocarbamate								
12,14	1,23	10,1	186	0,33	4,6	0,15	19,5	1,11
6,34	0,59	9,3	75	0,36	13,9	0,24	13,3	0,92
4,30	0,41	9,5	111	0,28	1,7	0,20	16,1	2,08
7,88	0,82	10,4	153	0,47	9,9	0,43	20,6	1,20
4,20	0,47	11,2	120	0,25	12,0	0,21	20,8	2,17
5,55	0,55	9,9	194	0,24	6,8	0,17	15,6	1,33
Cadmium, 0 µg/l; ethylene diaminetetraacetic acid								
14,24	1,22	8,6	82	0,42	5,3	0,04	10,6	0,97
12,34	1,28	10,4	101	0,38	8,2	0,03	13,9	1,13
4,07	0,51	12,5	126	0,36	10,1	0,04	15,1	1,03
6,14	0,57	9,3	114	0,21	11,9	0,02	13,9	1,40
7,83	0,63	8,0	188	0,17	15,5	0,09	22,3	1,28
7,07	0,72	10,2	152	0,29	5,1	0,03	10,2	1,56
7,44	0,72	9,7	156	0,37	3,1	0,04	19,4	1,80
5,21	0,60	11,5	139	0,53	12,9	0,05	12,7	1,39
7,64	0,77	10,1	173	0,32	5,8	0,02	18,7	1,73
2,66	0,25	9,4	90	0,30	12,6	0,04	16,0	0,68
Iron, 100 µg/l								
3,75	0,30	8,0	192	0,56	17,6	<0,05	20,8	1,66
13,47	1,23	9,1	131	0,33	10,5	<0,05	10,8	1,55
4,69	0,36	7,7	186	0,49	21,3	<0,05	17,7	1,68
10,26	0,83	8,1	130	0,31	21,9	<0,05	11,6	1,42
9,31	0,84	9,0	64	0,26	5,6	<0,05	12,9	2,03
8,57	0,72	8,4	134	0,36	23,8	0,06	13,0	1,28
6,35	0,57	9,0	83	0,44	5,5	<0,05	14,5	2,09
10,92	0,85	13,4	63	0,29	7,2	<0,05	10,5	2,06
10,85	0,96	8,9	166	0,36	13,1	0,07	12,7	1,79
9,45	0,82	8,7	90	0,32	7,2	<0,05	12,5	1,80
Iron, 100 µg/l; sodium citrate								
8,28	0,67	8,1	76	0,30	9,2	0,06	12,8	1,84
7,72	0,71	9,2	97	0,39	11,8	0,09	17,1	2,12
7,21	0,56	7,8	154	0,42	14,8	0,17	14,8	1,54
4,54	0,51	11,2	238	0,55	17,7	0,22	23,6	1,19
14,52	1,01	7,0	99	0,29	7,2	0,04	10,9	0,82
6,52	0,78	12,0	156	0,48	16,1	0,26	21,3	2,12
8,31	0,99	11,9	179	0,43	25,2	0,06	22,7	1,64
10,03	0,73	7,3	102	0,32	7,7	0,14	12,3	1,38
4,51	0,52	11,5	64	0,51	4,7	0,16	20,8	1,53
5,91	0,51	8,6	173	0,46	15,1	0,17	21,5	0,98

Crassostrea gigas. Tissue-metal concentrations after 3 weeks exposure to cadmium, manganese and iron in the presence of some organic compounds (T=24°C) (continued)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
Cadmium, 100 µg/l								
8,03	0,83	10,3	178	9,0	14,2	0,06	21,2	2,28
7,24	0,77	10,6	113	9,5	11,3	0,12	20,7	2,42
4,89	0,53	10,8	106	10,8	7,7	0,12	32,7	1,53
7,68	0,84	10,9	107	10,5	12,1	0,09	22,1	1,94
7,97	1,11	13,9	92	7,7	23,0	0,10	30,1	1,76
8,25	1,04	12,6	204	12,0	16,5	0,02	23,0	1,94
8,25	0,97	11,8	188	9,3	21,2	0,04	23,0	2,08
7,10	0,75	10,6	75	10,7	7,0	0,08	22,5	2,07
7,58	0,94	12,4	104	9,8	8,2	0,09	33,0	3,36
14,46	1,73	12,0	177	6,8	11,4	0,04	19,4	1,60
Cadmium, 100 µg/l; sodium citrate								
8,19	1,06	12,9	81	7,57	5,9	0,09	22,0	1,70
10,58	1,24	11,7	161	8,03	14,4	0,07	17,0	1,52
5,49	0,69	12,6	126	10,0	9,1	0,11	45,5	1,89
4,84	1,23	25,4	94	13,4	11,6	0,14	45,5	4,26
10,75	1,05	9,8	125	5,5	10,5	0,07	17,7	2,26
8,48	0,83	9,8	172	9,6	11,3	0,08	23,6	2,46
7,92	0,77	9,7	143	13,1	9,8	0,08	24,0	1,73
9,18	0,94	10,2	124	7,7	15,0	0,07	20,7	2,75
4,83	0,57	11,8	217	10,1	22,4	0,04	29,0	2,15
6,56	0,84	12,8	146	5,9	14,3	0,11	24,4	1,86
Cadmium, 100 µg/l; sodium acetate								
15,67	1,63	10,4	100	7,47	9,6	0,01	10,0	1,38
5,35	0,48	9,0	125	7,66	11,2	0,04	14,6	3,23
9,81	1,08	11,0	145	9,68	11,7	0,08	12,6	2,58
8,76	1,16	13,2	97	9,47	7,4	0,05	17,7	2,64
8,58	0,92	10,7	98	7,46	8,5	0,07	7,8	2,72
6,39	0,59	9,2	69	6,73	5,4	0,05	15,8	2,24
8,00	1,09	13,6	218	11,00	18,3	0,08	30,0	2,65
7,81	0,76	9,1	87	9,22	7,8	0,02	12,3	1,42
5,19	0,55	10,6	114	12,10	7,6	0,17	27,1	2,72
11,94	1,46	12,2	225	6,34	27,1	0,04	19,3	2,09
5,88	0,67	11,4	255	13,4	19,9	0,07	27,2	3,23
Cadmium, 100 µg/l; sodium diethyldithiocarbamate								
5,00	0,42	8,4	140	21,2	14,2	0,40	28,0	1,47
Cadmium, 100 µg/l; ethylene diaminetetraacetic acid								
7,41	0,81	10,9	248	2,22	9,3	0,04	19,6	2,16
6,89	0,89	12,9	99	1,80	7,0	0,03	17,9	2,74
5,90	0,54	9,2	93	1,90	6,6	0,05	13,6	2,03
8,04	0,88	10,9	151	1,76	10,2	0,06	14,1	1,79
8,87	0,91	10,3	215	2,16	14,5	0,02	17,3	2,38
11,27	1,32	11,7	160	1,76	10,4	0,02	13,7	2,56
10,24	1,03	10,1	144	1,56	9,2	0,03	14,6	1,49
3,00	0,26	8,7	163	2,87	14,3	0,03	25,7	1,70
7,38	0,70	9,5	136	1,68	11,3	0,03	14,8	1,82
6,00	0,76	12,7	240	2,50	13,3	0,03	20,0	2,22
Manganese, 100 µg/l								
10,57	0,69	6,5	151	0,26	20,3	0,05	11,1	1,14
7,32	0,49	6,7	180	0,44	12,2	<0,05	19,3	1,98
10,80	0,89	8,2	119	0,35	8,6	<0,05	12,5	1,95
6,05	0,51	8,4	198	0,51	18,0	<0,05	21,8	1,73
6,72	0,36	5,4	91	0,42	6,4	<0,05	14,4	1,63
6,67	0,43	6,4	57	0,36	4,6	<0,05	14,7	1,65
13,06	0,86	6,6	77	0,26	9,6	<0,05	10,5	2,22
9,52	0,56	5,9	92	0,32	7,5	<0,05	11,0	0,84
7,70	0,65	8,4	145	0,36	13,8	<0,05	16,0	1,89
8,93	0,59	6,6	52	0,26	3,9	<0,05	12,0	0,95
Manganese, 100 µg/l; sodium citrate								
7,53	0,67	8,9	102	0,35	9,7	0,13	18,6	2,65
7,97	0,63	7,9	92	0,36	8,8	0,13	15,1	2,01
6,66	0,72	10,8	188	0,45	20,2	0,15	25,5	1,65
9,76	0,83	8,5	142	0,33	15,4	0,04	13,3	2,15
6,03	0,54	9,0	55	0,36	4,1	0,05	24,9	1,91
10,74	0,91	8,5	97	0,34	9,6	0,06	18,6	1,68
6,38	0,60	9,4	62	0,15	8,5	0,02	7,6	0,53
10,94	0,95	8,7	48	0,31	5,8	0,04	15,5	1,15
7,40	0,62	8,4	119	0,39	18,4	0,03	18,9	1,62
11,21	0,99	8,8	75	0,30	6,2	0,01	15,2	1,43

Crassostrea margaritacea. Tissue-metal concentrations after exposure to cadmium, manganese and iron in the presence of some organic compounds. ($T=24^{\circ}C$)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
Control								
4,55	0,60	13,2	110	0,88	1,36	0,11	6,2	0,97
4,16	0,44	10,6	123	1,11	1,13	0,10	4,6	0,31
6,01	0,70	11,7	107	1,08	1,21	0,03	4,2	0,17
4,83	0,49	10,1	155	0,91	1,12	0,04	3,7	0,33
3,41	0,37	10,9	111	1,41	1,11	0,09	7,9	0,32
4,71	0,65	13,8	110	0,87	1,38	0,08	6,8	1,15
2,92	0.32	11,0	116	1,54	1,99	0,14	7,5	0,31
6,47	0,78	12,1	90	1,23	2,04	0,06	5,1	0,40
Control; sodium citrate								
5,07	0,61	12,0	120	0,95	0,83	0,04	4,3	0,28
4,06	0,48	11,8	113	0,91	0,44	0,05	6,2	0,42
6,01	0,64	10,7	80	0,93	1,10	0,10	5,3	0,23
4,66	0,54	11,6	133	0,79	1,67	0,02	5,6	0,24
2,66	0,38	14,3	94	1,32	1,47	0,03	7,9	0,64
2,10	0,33	15,7	133	1,33	1,43	0,05	11,0	0,67
5,77	0,69	12,0	82	1,21	0,88	0,09	8,5	0,90
3,25	0,35	10,8	100	0,71	1,75	0,09	7,1	0,52
Control; sodium acetate								
6,32	0,71	11,2	129	0,96	2,47	0,03	7,8	0,38
6,65	0,75	11,3	149	0,89	1,21	0,11	5,8	0,24
5,28	0,41	7,7	150	0,90	1,30	0,02	9,2	0,20
7,01	0,65	9,3	112	1,14	0,77	0,04	6,8	0,29
5,91	0,50	8,5	152	0,82	0,92	0,05	7,8	0,18
7,69	0,67	8,7	182	0,84	1,35	0,02	6,2	0,35
9,42	0,98	10,4	108	1,65	0,48	0,10	5,9	0,30
5,04	0,44	8,7	88	0,75	1,38	0,14	4,1	0,26
4,14	0,39	9,4	86	0,76	2,06	0,06	3,6	0,36
5,63	0,63	11,2	83	0,92	1,18	0,07	3,6	0,14
Control; sodium diethyldithiocarbamate								
4,47	0,43	9,6	131	2,00	1,97	0,08	3,6	0,26
5,65	0,56	9,9	138	1,25	2,48	0,41	7,0	0,66
8,28	0,83	10,0	196	0,97	6,14	0,33	4,4	0,27
6,04	0,52	8,6	189	0,84	3,17	0,45	6,6	0,16
4,60	0,50	10,9	150	0,89	2,58	0,16	5,1	0,25
5,47	0,51	9,3	69	0,85	2,92	0,22	4,8	0,26
3,06	0,28	9,2	84	0,74	5,13	0,23	6,2	0,33
6,41	0,68	10,6	76	1,17	1,47	0,28	4,5	0,30
3,70	0,32	8,6	100	1,22	2,21	0,18	6,0	0,20
6,03	0,63	10,4	85	1,31	2,72	0,34	4,8	0,41
Control; ethylene diaminetetraacetic acid								
4,18	0,42	10,0	136	0,79	1,17	0,04	5,6	0,37
3,85	0,45	11,7	73	1,29	4,16	0,02	3,5	0,35
3,91	0,58	14,8	218	0,50	3,02	0,12	3,3	0,32
4,27	0,50	11,7	78	0,85	0,89	0,04	6,6	0,23
3,83	0,50	13,1	143	1,19	1,25	0,02	5,8	0,18
6,26	1.01	16,1	105	0,75	2,35	0,03	5,8	0,20
4,87	0,60	12,3	98	1.14	0,64	0,05	5,0	0,23
5,25	0,63	12,0	122	1,34	4,00	0,07	4,8	0,26
7,01	0,65	9,3	144	0,96	2,72	0,09	6,2	0,15
6,04	0,80	13,2	116	1,29	1,64	0,08	4,8	0,25
Iron, 100 µg/l								
8,11	0,70	8,6	143	0,78	1,62	0,04	4,3	0,46
5,33	0,45	8,4	180	0,91	0,49	0,04	4,9	0,19
5,86	0,80	13,7	90	1,03	1,28	0,14	7,3	0,23
4,79	0,58	12,1	115	1,02	0,96	0,04	8,1	0,25
4,30	0,34	7,9	102	0,84	2,23	0,09	9,7	0,56
4,10	0,41	10,0	102	1,17	0,63	0,02	6,6	0,27
7,47	0,81	10,8	64	0,92	1,77	0,09	5,9	1,12
4,98	0,61	12,3	114	1,10	0,70	0,20	10,4	0,32
5,23	0,48	9,2	170	1,32	2,18	0,20	6,5	0,23
Iron, 100 µg/l; sodium citrate								
7,76	0,90	11,6	137	0,97	0,68	0,05	5,8	0,18
6,57	0,93	14,2	131	1,18	2,60	0,13	8,1	0,22
2,57	0,36	14,0	66	0,81	2,76	0,15	6,6	0,23
3,19	0,36	11,3	65	0,87	2,19	0,12	6,3	0,38
5,07	0,56	11,0	83	1,14	0,43	0,07	5,7	0,19
4,84	0,41	8,5	145	0,49	2,44	0,02	5,8	0,18
6,01	0,59	9,8	183	0,71	1,34	0,04	5,3	0,34
6,51	0,67	10,3	121	0,70	1,64	0,10	5,1	0,26
5,00	0,42	8,4	108	1,50	1,02	0,02	6,2	0,22
4,51	0,50	11,1	67	0,68	1,68	0,04	8,2	0,24
4,84	0,51	10,5	81	0,99	0,61	0,08	6,0	0,22

Crassostrea margaritacea. Tissue-metal concentrations after exposure to cadmium, manganese and iron in the presence of some organic compounds. (T=24°C) (continued)

Wet	Dry	Dry		µg metal/g wet tissue				
mass	mass	mass	Zn	Cd	Cu	Pb	Fe	Mn
g	g	%						
Cadmium, 100 µg/l								
6,80	0,79	11,6	165	2,68	1,68	<0,05	6,8	0,34
6,41	0,75	11,7	123	3,68	2,89	<0,05	4,8	0,26
6,66	0,76	11,4	204	2,04	0,41	<0,05	6,0	0,34
9,13	1,04	11,4	106	5,04	0,89	<0,05	4,1	0,29
5,82	0,64	11,0	117	2,37	3,67	<0,05	6,9	0,27
7,66	0,83	10,8	85	4,96	3,62	<0,05	3,5	0,20
8,83	1,36	15,4	129	3,67	0,84	<0,05	6,1	0,26
9,85	1,33	13,5	112	2,46	2,28	<0,05	4,6	0,41
4,63	0,70	15,1	119	5,08	2,59	<0,05	7,3	0,32
4,48	0,53	11,8	69	4,80	0,83	<0,05	4,5	0,21
Cadmium, 100 µg/l;			sodium citrate					
5,44	0,63	11,6	191	1,95	2,48	<0,02	4,2	0,27
8,66	1,16	13,4	126	1,89	1,47	0,05	4,4	0,22
6,85	0,79	11,5	84	2,54	1,21	0,02	3,8	0,19
6,60	0,75	11,4	98	2,41	1,20	0,06	6,1	0,21
7,38	0,99	13,4	95	2,78	2,47	0,03	6,6	0,19
11,56	1,55	13,4	142	1,22	1,32	0,02	9,1	0,17
4,63	0,68	14,7	99	4,34	2,00	0,10	5,2	0,23
9,00	1,06	11,8	72	3,53	3,00	0,08	7,6	0,27
5,32	0,51	9,5	98	2,07	4,50	0,06	3,8	0,22
7,48	0,83	11,1	94	4,99	1,58	0,05	4,1	0,29
Cadmium, 100 µg/l;			sodium acetate					
7,79	1,20	15,4	191	2,09	0,87	0,19	5,5	0,21
5,60	0,83	14,8	127	2,80	2,95	0,10	6,1	0,23
6,03	0,89	14,8	141	8,12	1,83	0,07	7,3	0,20
8,64	1,00	11,6	103	2,55	1,44	0,03	5,1	0,48
6,14	0,77	12,5	191	4,86	2,42	0,09	11,2	0,21
7,78	1,00	12,9	111	2,20	1,14	0,06	6,3	0,23
7,53	1,12	14,9	88	4,12	2,51	0,11	4,8	0,21
9,92	1,35	13,6	60	2,62	1,17	0,05	4,0	0,35
6,65	1,00	15,0	120	3,76	1,71	0,03	7,7	0,60
4,45	0,69	15,5	154	8,09	1,21	0,04	4,9	0,35
Cadmium, 100 µg/l;			sodium diethyldithiocarbamate					
5,35	0,58	10.8	108	10,34	7,91	0,37	3,6	0,16
6,48	0,71	11,0	82	14,81	8,56	0,34	5,7	0,17
5,77	1,04	18,0	85	6,67	3,50	0,40	7,6	0,31
5,20	0,77	14,8	158	6,90	9,72	0,37	6,9	0,28
6,96	0,86	12,4	114	9,82	6,14	0,30	5,6	0,41
7,12	0,92	12,9	138	6,74	4,65	0,35	5,9	0,56
6,99	0,87	12,4	139	4,44	4,55	0,26	5,1	0,25
11,26	1,54	13,7	136	5,16	2,52	0,25	5,0	0,19
8,54	1,10	12,9	152	7,63	3,46	0,39	8,8	0,24
5,49	0,64	11,7	98	13,78	2,58	0,44	5,3	0,29
Cadmium, 100 µg/l;			ethylene diaminetetraacetic acid					
7,49	0,99	13,2	96	1,59	4,40	0,06	4,8	0,38
6,32	0,78	12,3	93	4,19	2,26	0,11	4,6	0,36
7,20	1,05	14,6	82	1,71	1,81	0,03	6,4	0,41
8,25	0,82	9,9	108	0,90	0,98	0,08	5,9	0,22
7,59	1,00	13,2	78	3,12	0,65	0,14	4,7	0,29
11,17	1,42	12,7	179	1,35	1,12	0,05	5,1	0,24
4,55	0,55	12,1	125	2,13	4,61	0,05	6,2	0,21
6,81	0,81	11,9	90	1,32	2,78	0,06	7,0	0,20
9,00	0,97	10,8	122	1,23	5,23	0,09	5,2	0,21
8,82	0,86	9,8	87	2,09	4,75	0,03	3,3	0,23
Manganese, 100 µg/l								
4,29	0,51	11,9	63	1,25	1,16	0,09	6,1	0,44
6,69	0,62	9,3	149	1,28	0,65	0,04	6,9	0,24
2,00	0,23	11,5	85	1,10	2,35	0,20	7,5	0,40
6,29	0,66	10,5	86	0,74	0,58	0,02	5,1	0,62
8,61	0,77	8,9	173	0,98	0,91	0,10	3,9	0,36
7,89	0,63	8,0	95	0,69	0,36	0,11	5,2	0,21
6,99	0.83	11,9	110	0,80	0,81	0.15	6,4	0,24
3,51	0.34	9,7	126	1,48	1,19	0,17	8,3	0,71
Manganese, 100 µg/l;			sodium citrate					
2,25	0,31	13,8	133	0,91	2,62	0,12	9,3	0,36
2,54	0,35	13,8	71	0,71	1,91	0,14	14,2	0,47
3,26	0,40	12,3	89	0,56	1,13	0,11	8,3	0,37
5,62	0,72	12,8	75	0,68	1,60	0,09	5,7	0,51
2,29	0,23	10,0	122	0,66	1,35	0,16	8,7	0,31
5,97	0,75	12,6	92	0,80	1,66	0,03	5,4	0,35
5,28	0,69	13,1	144	1,14	0,87	0,08	6,4	0,34
2,66	0,31	11,7	109	0,43	1,43	0,05	8,6	0,38
3,84	0,35	9,1	96	1,17	1,17	0,09	6,5	0,65
4,00	0,46	11,5	110	1,35	0,55	0,03	6,8	0,40

<u>Choromytilus meridionalis</u>. Tissue-metal concentrations after 3 weeks exposure to cadmium, manganese and iron in the presence of some organic compounds (T=24°C)

Sex	Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
				Zn	Cd	Cu	Pb	Fe	Mn
	Control								
F	8,22	1,52	18,5	17,7	0,29	1,19	0,06	6,4	1,66
F	4,78	0,75	15,7	15,5	0,27	1,02	0,16	5,9	1,94
F	5,49	0,91	16,6	16,6	0,38	1,11	0,23	7,1	1,45
F	4,80	0,85	17,7	15,6	0,18	1,18	0,25	6,7	1,47
F	13,30	2,04	15,3	11,4	0,27	1,03	0,13	5,0	0,93
F	5,65	1,07	18,9	16,8	0,24	1,41	0,08	6,0	0,53
F	15,10	2,40	15,9	11,6	0,27	1,09	0,16	5,3	1,37
F2	7,60	1,08	14,2	14,6	0,19	1,25	0,17	5,1	1,15
M	11,84	2,16	18,2	10,1	0,32	1,06	0,12	6,3	0,65
M	4,77	0,78	16,4	13,4	0,31	1,24	0,16	7,3	1,74
	Control;	sodium citrate							
M	8,25	1,19	14,4	9,8	0,32	0,66	0,09	4,6	1,17
M	3,69	0,53	14,4	10,8	0,37	0,70	0,13	6,0	1,30
M	3,60	0,59	16,4	15,6	0,61	0,86	0,22	7,5	1,52
M	9,40	1,35	14,4	8,5	0,32	0,72	0,11	5,4	0,98
M	4,38	0,76	17,4	13,7	0,43	0,68	0,09	5,9	1,36
F	12,78	1,80	14,1	10,3	0,32	0,69	0,10	4,8	1,19
F	3,72	0,50	13,4	12,4	0,37	1,02	0,13	5,9	1,20
F	9,74	1,24	12,7	10,7	0,26	0,64	0,09	4,7	0,81
F	7,26	1,07	14,7	13,1	0,26	0,71	0,12	5,0	1,46
	Control;	sodium acetate							
M	3,04	0,56	18,4	12,7	0,36	0,88	0,11	10,0	1,27
M	6,82	1,50	22,0	14,5	0,45	1,11	0,07	6,9	1,08
M	4,61	0,54	11,7	12,7	0,70	1,08	0,13	5,8	1,07
M	3,01	0,56	18,6	10,7	0,45	0,91	0,19	6,5	1,23
F	10,74	1,42	13,2	15,6	0,81	1,41	0,11	7,5	1,56
F	5,67	1,05	18,5	14,4	0,44	0,87	0,08	4,6	1,44
F	5,18	0,68	13,1	11,2	0,21	1,54	0,06	7,3	1,27
F	5,52	0,75	13,6	19,0	0,17	1,23	0,14	7,8	1,21
F	4,69	0,60	12,8	15,6	0,36	1,13	0,08	5,6	1,03
	Control;	sodium diethyldithiocarbamate							
F	13,81	1,96	14,2	22,7	0,45	1,36	0,35	3,0	1,30
F	11,42	1,86	16,3	11,2	0,72	1,31	0,22	6,1	1,61
F	12,20	1,74	14,3	20,1	0,84	1,51	0,12	5,8	1,18
M	10,94	1,56	14,3	25,0	0,30	0,96	0,16	5,4	0,78
M	8,32	1,22	14,7	17,5	0,37	1,16	0,17	7,1	0,92
M	12,91	1,98	15,3	16,7	0,35	2,25	0,06	4,8	1,71
M	9,72	1,56	16,0	13,9	0,65	0,85	0,15	5,6	0,99
M	13,52	2,00	14,8	17,5	0,28	1,24	0,29	6,8	0,86
M	11,71	1,80	15,4	23,2	0,38	1,16	0,32	7,2	1,12
	Control;	ethylene diaminetetraacetic acid							
M	7,42	1,28	17,3	18,6	0,62	1,25	0,12	5,8	1,18
F	13,20	1,91	14,5	12,2	0,23	0,74	0,14	8,1	1,22
F	9,04	1,54	17,0	19,4	0,77	0,98	0,11	7,3	1,38
F	8,67	1,35	15,6	12,8	0,83	0,69	0,09	6,7	1,44
F	10,51	1,67	15,9	14,2	0,31	0,80	0,15	6,3	1,24
M	9,32	1,36	14,6	13,8	0,40	0,91	0,10	6,2	1,36
M	8,24	1,29	15,7	12,3	0,75	1,14	0,09	8,2	1,24
M	9,54	1,35	14,2	11,7	0,51	1,17	0,08	6,0	0,71
M	9,00	1,50	16,7	10,5	0,46	0,87	0,08	7,5	1,51
	Iron, 100 µg/l								
F	10,18	1,59	15,6	19,3	0,33	1,27	0,21	6,3	1,94
F	7,45	1,13	15,2	15,3	0,26	1,42	0,08	6,0	2,20
F	5,59	0,90	16,1	17,2	0,35	0,87	0,13	7,0	1,91
F	4,48	0,81	18,1	16,5	0,31	1,18	0,24	8,0	1,36
F	4,39	0,82	18,7	16,6	0,36	1,11	0,19	7,5	1,27
F	3,54	0,59	16,7	16,1	0,36	1,24	0,25	10,2	1,25
M	2,71	0,44	16,2	14,4	0,33	1,07	0,11	10,3	1,73
M	3,91	0,60	15,3	11,3	0,23	1,12	0,12	6,6	1,12
M	4,24	0,69	16,3	13,4	0,37	0,87	0,08	6,6	1,13
M	6,89	0,99	14,4	11,3	0,30	0,91	0,17	5,4	1,22
	Iron, 100 µg/l;	sodium citrate							
M	8,16	1,29	15,8	12,1	0,25	0,89	0,06	6,6	1,33
M	10,20	1,56	15,3	12,9	0,29	0,57	0,20	6,1	1,34
M	7,11	1,19	16,7	13,4	0,26	0,78	0,19	6,6	0,98
M	3,59	0,50	13,9	16,2	0,52	0,77	0,27	7,8	1,42
M	4,24	0,63	14,9	15,1	0,42	0,77	0,14	8,7	1,53
M	3,33	0,53	15,9	15,3	0,48	0,96	0,30	10,2	1,50
F	4,43	0,62	14,0	13,8	0,29	0,72	0,22	7,2	1,06
F	8,27	1,22	14,8	16,0	0,27	0,87	0,33	6,3	1,93
F	7,89	1,28	16,2	16,9	0,21	0,95	0,15	5,8	1,58

Choromytilus meridionalis. Tissue-metal concentrations after 3 weeks exposure to cadmium, manganese and iron in the presence of some organic compounds (T=24°C) (continued)

Sex	Wet mass g	Dry mass g	Dry mass %	Zn	µg metal/g wet tissue Cd	Cu	Pb	Fe	Mn
Cadmium, 100 µg/l									
F	4,30	1,24	16,8	19,3	1,56	2,00	0,07	7,4	1,99
F	6,12	1,03	16,8	17,2	0,95	1,08	0,11	5,7	1,70
F	5,82	0,65	11,2	19,8	1,86	0,82	0,18	4,3	1,38
F	8,91	1,38	15,5	16,0	1,00	1,18	0,14	5,2	1,64
F	2,68	0,67	25,0	23,5	1,68	1,79	0,09	8,2	1,27
M	5,63	0,96	17,1	10,5	1,33	1,03	0,12	5,3	1,66
M	5,07	0,94	18,5	14,8	1,40	1,10	0,21	5,3	1,43
M	3,65	0,63	17,3	14,0	1,89	1,18	0,18	6,3	2,18
M	8,86	1,58	17,8	11,5	1,68	1,37	0,17	7,2	1,68
M	7,29	1,38	18,9	12,5	1,44	1,11	0,10	6,7	0,83
Cadmium, 100 µg/l; sodium citrate									
F	9,53	1,31	13,7	13,3	0,80	0,90	0,07	4,5	1,18
F	9,32	1,42	15,2	15,7	0,76	1,21	0,15	5,5	1,98
F	7,85	1,13	14,4	12,1	0,99	0,85	0,15	5,7	1,22
F	7,94	1,26	15,9	15,6	0,94	0,98	0,15	6,0	1,46
F	8,09	1,18	14,6	11,7	0,73	1,04	0,11	5,9	1,76
F	5,61	0,71	12,7	14,6	1,16	1,19	0,11	9,8	0,92
M	9,46	1,56	16,5	12,6	1,07	0,98	0,12	5,3	1,28
M	9,40	1,03	10,9	9,9	1,31	1,17	0,10	5,7	0,34
M	8,72	1,28	14,7	10,6	0,73	0,85	0,11	6,3	1,41
M	6,76	1,21	17,9	12,0	0,96	1,02	0,10	6,1	1,41
Cadmium, 100 µg/l; sodium acetate									
F	12,71	1,76	13,8	12,6	0,72	0,88	0,04	5,4	1,01
F	7,25	1,16	16,0	17,9	0,91	1,03	0,19	6,8	2,02
F	6,37	1,09	17,1	18,8	0,96	1,00	0,06	6,4	1,38
F	5,81	1,07	18,4	20,7	1,08	1,00	0,11	7,1	1,50
F	3,55	0,61	17,2	15,8	1,01	1,13	0,20	7,6	2,07
F	7,13	0,92	12,9	10,8	0,80	0,93	0,13	4,8	1,17
M	5,37	0,95	17,7	13,2	0,86	0,86	0,09	6,5	1,88
M	9,31	1,69	18,2	11,9	0,77	1,02	0,14	5,8	1,09
M	9,17	1,70	18,5	9,3	0,85	1,00	0,09	6,3	1,03
M	6,40	1,14	17,8	14,5	1,25	1,17	0,13	6,6	2,07
Cadmium, 100 µg/l; sodium diethyldithiocarbamate									
F	5,56	0,86	15,5	23,2	15,8	1,56	0,10	6,5	1,37
F	3,00	0,50	16,7	30,0	23,0	2,17	0,27	8,3	1,77
F	9,18	1,28	13,9	21,8	16,2	1,64	0,22	5,1	1,15
F	7,07	1,26	17,8	26,0	16,3	2,07	0,31	6,1	1,47
M	5,19	0,86	16,6	22,5	16,0	1,89	0,33	6,7	1,60
M	6,07	1,10	18,1	23,4	12,2	1,86	0,11	6,4	1,61
M	8,33	1,18	14,2	25,1	17,0	1,75	0,20	5,9	1,12
M	3,84	0,61	15,9	23,2	26,0	2,84	0,13	8,3	1,90
M	6,90	1,12	16,2	20,3	19,7	2,01	0,23	5,1	1,78
M	9,04	1,53	16,9	18,9	15,7	1,67	0,12	4,6	1,32
Cadmium, 100 µg/l; ethylene diaminetetraacetic acid									
F	7,75	1,05	13,5	13,4	0,46	0,85	0,11	5,2	1,71
F	7,28	1,14	15,7	16,1	0,57	0,78	0,04	6,9	1,23
F	7,27	1,21	16,6	13,5	0,44	0,86	0,14	5,5	1,14
M	5,21	0,89	17,1	14,2	0,63	0,82	0,03	3,8	1,61
M	4,86	0,80	16,5	11,7	0,45	0,84	0,02	8,2	1,89
M	8,00	1,36	17,0	11,9	0,50	0,66	0,05	6,3	1,36
M	4,47	0,75	16,8	12,5	0,53	1,09	0,16	6,7	1,11
M	6,80	1,22	17,9	11,9	0,51	0,88	0,15	5,9	1,38
F	4,06	0,62	15,3	13,1	0,56	0,68	0,12	7,4	1,67
F	5,32	1,01	19,0	17,3	0,60	1,20	0,11	7,5	2,29
Manganese, 100 µg/l									
F	4,55	0,62	13,6	16,7	0,26	0,83	0,04	8,1	2,10
F	5,93	0,80	13,4	14,2	0,33	0,82	0,11	6,6	1,39
F	6,20	0,99	16,0	14,4	0,24	1,16	0,20	6,9	2,17
F	3,59	0,45	12,5	15,9	0,27	0,97	0,12	8,1	1,19
F	5,16	0,70	13,6	16,5	0,32	0,81	0,27	7,2	2,09
M	4,46	0,67	15,0	10,8	0,40	0,69	0,20	7,8	1,45
M	3,20	0,48	15,0	11,9	0,34	0,90	0,25	8,1	1,62
M	3,29	0,60	18,2	12,8	0,39	0,88	0,09	11,9	1,18
M	11,83	1,87	15,8	11,1	0,22	1,00	0,16	5,7	1,21
M	3,61	0,64	17,7	10,8	0,33	0,72	0,30	7,5	1,14
Manganese, 100 µg/l; sodium citrate									
M	8,33	1,44	17,4	10,9	0,22	0,72	0,12	7,4	1,23
M	8,04	1,43	17,8	14,4	0,26	0,81	0,10	10,2	1,49
M	7,68	1,28	16,7	11,5	0,17	0,63	0,13	7,7	1,19
M	4,62	0,73	15,8	16,9	0,28	0,80	0,45	9,7	1,19
M	3,11	0,55	17,7	14,8	0,29	0,74	0,23	9,3	1,96
F	7,27	1,07	14,7	11,8	0,17	0,72	0,04	6,5	1,54
F	7,81	1,17	15,0	15,2	0,22	0,78	0,04	6,7	1,46
F	3,30	0,49	14,9	17,3	0,30	0,91	0,15	9,1	1,78
F	3,26	0,49	15,0	17,8	0,34	0,83	0,15	10,4	1,67

Perna perna. Tissue-metal concentrations following 3 weeks exposure to cadmium, iron and manganese in the presence of some organic compounds (T=24°C)

Sex	Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
				Zn	Cd	Cu	Pb	Fe	Mn
	Control								
F	5,02	0,41	8,2	17,8	0,85	0,77	0,25	19,1	0,21
F	3,74	0,44	11,8	14,2	0,90	0,85	0,20	17,6	0,34
F	3,70	0,28	7,6	13,0	0,56	0,59	0,18	11,9	0,24
F	6,28	0,67	10,7	12,4	0,38	1,01	0,23	9,6	0,27
F	5,98	0,54	9,0	12,2	0,42	0,83	0,30	13,5	0,18
M	5,40	0,57	10,6	10,9	0,40	0,66	0,22	9,8	0,27
M	3,02	0,34	11,3	13,9	0,66	0,73	0,13	12,3	0,20
M	3,51	0,39	11,1	6,8	0,54	0,55	0,25	13,1	0,45
M	4,96	0,43	8,7	8,5	0,40	0,62	0,24	10,1	0,32
M	4,58	0,48	10,5	10,3	0,56	0,78	0,19	10,9	0,30
	Control; sodium citrate								
F	6,00	0,51	8,5	16,5	0,65	0,43	0,28	11,0	0,28
M	1,43	0,12	8,4	11,2	0,62	0,48	0,34	13,3	0,41
M	1,29	0,13	10,1	9,3	0,46	1,08	0,38	14,7	0,38
M	4,64	0,43	9,3	15,7	0,64	0,34	0,25	11,4	0,21
M	1,39	0,16	11,5	12,2	0,57	0,50	0,30	14,4	0,35
M	1,55	0,17	11,0	11,0	0,58	0,38	0,32	13,5	0,38
M	2,21	0,22	9,9	8,6	0,76	0,49	0,29	18,1	0,31
M	3,79	0,38	10,0	12,7	0,87	0,55	0,31	17,7	0,26
M	6,38	0,64	10,0	10,3	0,72	0,26	0,20	10,2	0,38
M	7,41	0,76	10,3	9,7	0,75	0,36	0,22	9,6	0,18
	Control; sodium acetate								
F	3,28	0,51	15,5	14,4	0,27	0,64	0,20	13,5	0,39
F	5,79	0,48	8,3	11,1	0,46	0,53	0,16	17,4	0,43
M	2,19	0,24	11,0	11,8	0,76	0,72	0,18	18,9	0,27
M	5,28	0,54	10,2	11,2	0,69	1,06	0,16	19,1	0,20
F	2,07	0,21	10,1	11,3	0,40	0,99	0,16	19,4	0,23
F	2,45	0,29	11,8	10,9	0,42	0,96	0,17	17,2	0,36
F	2,84	0,43	15,1	12,7	0,58	0,72	0,15	13,3	0,22
M	2,91	0,36	12,4	12,0	0,42	0,99	0,23	12,1	0,38
M	3,74	0,37	9,9	15,2	0,67	0,74	0,08	12,8	0,27
M	1,98	0,20	10,1	13,3	0,95	0,72	0,10	9,9	0,20
	Control; sodium diethyldithiocarbamate								
F	4,08	0,42	10,3	16,1	1,08	1,34	0,32	17,3	0,23
F	3,86	0,39	10,1	34,1	1,06	0,68	0,44	29,1	0,41
M	4,78	0,49	10,3	17,2	1,89	2,53	0,17	17,4	0,32
M	4,19	0,43	10,3	19,4	0,99	1,75	0,27	15,8	0,39
M	3,59	0,35	9,7	20,1	1,68	2,39	0,35	18,3	0,42
M	2,89	0,29	10,0	19,4	0,86	1,24	0,29	21,1	0,43
M	3,28	0,31	9,5	17,0	1,85	2,05	0,37	14,6	0,73
M	2,54	0,24	9,4	18,0	0,93	1,90	0,32	17,1	0,55
F	2,51	0,26	10,4	15,2	0,58	1,29	0,59	13,8	0,64
F	1,98	0,21	10,6	18,4	0,76	0,82	0,37	14,7	0,43
	Control; ethylene diaminetetraacetic acid								
F	4,44	0,46	10,4	15,7	0,74	1,11	0,22	14,1	0,53
F	4,62	0,46	10,0	15,0	0,89	0,65	0,27	22,4	0,59
F	4,61	0,45	9,8	18,1	0,91	1,15	0,19	12,7	0,44
F	4,00	0,38	9,5	13,9	0,72	0,99	0,18	18,5	0,23
F	3,25	0,33	10,2	14,6	0,43	1,49	0,13	20,5	0,47
M	3,93	0,41	10,4	10,7	0,26	0,93	0,18	22,9	0,22
M	4,00	0,41	10,3	13,2	0,40	0,60	0,20	17,9	0,24
M	2,91	0,30	10,3	10,3	0,39	0,79	0,12	17,0	0,43
M	3,92	0,40	10,2	12,4	0,49	0,86	0,24	19,9	0,53
M	2,63	0,27	10,3	9,3	0,22	1,06	0,15	11,8	0,40
	Manganese, 100 µg/l								
M	3,42	0,51	14,9	12,3	0,47	0,64	0,26	11,4	0,41
M	3,25	0,31	9,5	12,9	0,43	0,52	0,22	16,0	0,40
M	5,39	0,34	6,3	7,8	0,64	0,39	0,16	12,6	0,28
M	4,23	0,29	6,9	5,2	0,50	0,40	0,14	22,0	0,37
M	3,04	0,40	13,2	12,2	0,43	0,76	0,10	17,1	0,43
F	6,48	0,55	8,5	16,0	0,56	0,65	0,11	14,7	0,35
F	3,19	0,20	6,3	8,9	0,47	0,44	0,09	15,0	0,34
F	4,00	0,27	6,8	11,3	0,73	0,57	0,18	15,8	0,35
	Manganese, 100 µg/l; sodium citrate								
F	4,13	0,39	9,4	13,8	0,60	0,75	0,14	15,0	0,46
F	4,18	0,43	10,3	18,1	0,35	0,59	0,21	13,9	0,38
M	2,46	0,27	11,0	9,3	0,32	0,44	0,14	10,6	0,48
M	1,96	0,20	10,2	8,4	0,51	1,02	0,15	20,9	0,51
M	1,52	0,16	10,5	13,2	0,26	0,78	0,19	20,4	0,32
M	2,38	0,23	9,7	10,9	0,46	0,46	0,08	18,5	0,33
M	3,21	0,36	11,2	12,8	0,37	0,65	0,21	16,8	0,37
M	4,06	0,49	12,1	11,1	0,44	0,39	0,24	13,3	0,29
M	2,08	0,22	10,6	10,1	0,33	0,57	0,19	20,7	0,38
M	3,59	0,38	10,6	9,5	0,44	0,36	0,16	14,8	0,27

Perna perna. Tissue-metal concentrations following 3 weeks exposure to cadmium, iron and manganese in the presence of some organic compounds (T=24°C) (continued)

Sex	Wet mass g	Dry mass g	Dry mass g	µg metal/g wet tissue Zn	Cd	Cu	Pb	Fe	Mn
	Cadmium, 100 µg/l								
F	2,38	0,31	13,0	15,5	3,29	0,63	0,21	16,8	0,48
F	4,41	0,57	12,9	16,6	2,25	0,73	0,14	15,6	0,59
F	3,67	0,46	12,5	11,7	1,63	0,60	0,11	16,6	0,41
F	4,99	0,57	11,4	12,0	1,82	0,66	0,12	14,4	0,40
F	3,54	0,42	11,9	14,4	1,86	0,68	0,18	15,3	0,59
F	3,27	0,42	12,8	11,0	2,32	0,89	0,26	18,3	0,67
F	3,22	0,38	11,8	9,3	2,48	0,90	0,12	20,8	0,34
M	2,63	0,31	11,8	11,0	2,36	0,76	0,15	17,1	0,42
M	2,64	0,32	12,1	10,6	1,97	0,76	0,11	15,2	0,38
M	2,29	0,28	12,2	12,7	1,92	0,61	0,14	16,2	0,31
	Cadmium, 100 µg/l;			sodium citrate					
F	3,25	0,43	13,2	15,7	2,22	0,74	0,15	17,2	0,55
F	3,33	0,40	12,0	11,4	2,91	1,26	0,21	18,9	0,54
F	2,68	0,37	13,8	12,7	2,13	0,78	0,19	17,9	0,34
F	3,14	0,45	14,3	15,3	2,26	0,57	0,16	15,6	0,35
F	2,64	0,33	12,5	11,0	2,23	0,83	0,11	22,3	0,34
F	2,66	0,32	12,0	9,8	2,03	0,53	0,14	16,2	0,45
F	2,28	0,34	14,9	15,4	2,76	0,79	0,09	17,5	0,53
M	3,44	0,45	13,1	11,6	2,09	0,47	0,12	15,7	0,29
M	1,74	0,27	15,5	12,6	1,90	0,75	0,11	23,0	0,40
M	2,90	0,41	14,1	11,7	2,90	0,79	0,17	15,9	0,34
	Cadmium, 100 µg/l;			sodium acetate					
F	2,73	0,36	13,2	13,9	2,86	0,84	0,18	15,4	0,37
F	4,48	0,51	11,4	17,6	2,21	0,56	0,07	14,7	0,27
F	2,05	0,19	9,3	18,8	1,95	0,78	0,20	17,6	0,44
F	3,13	0,35	11,2	10,2	3,00	0,83	0,16	16,9	0,58
F	3,77	0,35	9,2	12,5	1,30	0,66	0,11	15,9	0,34
M	2,60	0,26	10,0	10,0	2,08	1,00	0,28	18,1	0,46
M	2,80	0,39	13,9	13,9	2,57	0,64	0,14	23,2	0,54
M	2,36	0,33	14,0	11,4	2,88	0,81	0,18	17,8	0,38
M	4,36	0,57	13,1	8,1	1,93	0,55	0,16	17,0	0,30
M	3,55	0,41	11,6	7,0	2,51	0,51	0,13	14,6	0,28
	Cadmium, 100 µg/l;			sodium diethyldithiocarbamate					
F	2,20	0,30	13,6	46,4	20,9	2,00	0,41	17,3	0,41
F	1,76	0,25	14,2	28,4	13,9	1,70	0,28	17,6	0,40
F	3,64	0,37	10,2	25,0	12,6	1,61	0,32	12,1	0,62
M	1,48	0,25	16,9	18,9	15,4	1,96	0,27	12,2	0,41
M	3,28	0,32	9,8	31,2	16,7	1,89	0,32	15,7	0,41
	Cadmium, 100 µg/l;			ethylenediaminetetraacetic acid					
F	2,32	0,29	12,5	14,7	1,81	1,21	0,14	19,0	0,60
F	2,78	0,38	13,7	12,6	1,58	1,22	0,17	21,2	0,54
F	3,67	0,48	13,1	15,3	1,93	0,84	0,05	20,4	0,46
F	2,68	0,36	13,4	19,0	1,94	0,94	0,11	24,6	0,71
F	2,19	0,32	14,6	18,3	1,87	1,00	0,09	24,2	0,55
F	3,00	0,32	10,7	13,7	1,20	1,00	0,07	19,7	0,43
F	2,60	0,38	14,6	15,0	1,69	1,08	0,12	21,9	0,96
F	2,31	0,25	10,8	12,1	1,17	0,87	0,09	20,3	0,74
M	3,11	0,35	11,3	10,9	1,19	0,58	0,10	13,3	0,35
M	3,30	0,38	11,5	10,0	1,09	0,48	0,16	14,8	0,33
	Iron, 100 µg/l								
F	3,72	0,41	11,0	14,2	0,58	0,77	0,24	18,0	0,26
F	6,29	0,57	9,1	16,0	0,52	0,65	0,12	13,4	0,22
F	3,66	0,31	8,5	17,9	0,68	0,54	0,10	17,2	0,35
F	3,68	0,37	10,1	14,4	0,54	0,48	0,19	12,2	0,32
F	3,92	0,39	9,9	17,4	0,45	0,69	0,17	19,1	0,30
M	3,33	0,39	11,7	6,5	0,57	0,60	0,18	13,2	0,27
M	2,67	0,27	10,1	8,6	0,48	0,41	0,18	11,6	0,29
M	5,30	0,50	9,4	8,7	0,47	0,37	0,13	11,9	0,24
M	3,50	0,35	10,0	7,0	0,40	0,36	0,16	11,7	0,30
M	2,89	0,34	11,8	15,2	0,65	0,58	0,24	22,1	0,34
	Iron, 100 µg/l;		sodium citrate						
M	2,11	0,27	12,8	11,4	0,33	0,61	0,14	17,1	0,28
M	1,79	0,20	11,2	15,1	0,27	0,39	0,15	16,2	0,27
M	1,54	0,20	13,0	11,7	0,32	0,64	0,19	21,4	0,25
M	4,66	0,46	9,9	12,0	0,38	0,47	0,27	13,5	0,23
M	6,80	0,76	11,2	11,0	0,36	0,54	0,23	15,1	0,20
F	5,75	0,69	12,0	16,0	0,53	0,69	0,17	13,6	0,33
F	4,15	0,40	9,6	18,7	0,48	0,65	0,14	16,6	0,26
F	4,23	0,42	9,9	7,1	0,23	0,66	0,23	18,0	0,26
F	1,65	0,18	10,9	16,7	0,72	0,42	0,36	20,6	0,30
F	1,68	0,16	9,5	13,1	0,41	0,41	0,29	16,7	0,41

Crassostrea gigas. Tissue-metal concentrations after 3 weeks exposure to cadmium absorbed onto clay (T=24°C)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
Control (<0,1 µg/l cadmium)								
14,97	1,16	7,5	132	0,4	3,0	<0,05	16,0	1,06
8,33	0,58	7,0	122	0,6	2,3	0,12	10,3	1,32
13,53	1,21	8,9	50	0,6	2,6	0,07	14,8	0,90
10,64	1,30	12,2	181	0,6	18,1	<0,05	18,8	2,45
8,80	0,65	7,4	55	0,6	3,4	0,06	18,2	1,85
8,41	0,84	10,0	155	0,6	15,0	<0,05	17,8	1,35
7.35	0,54	7,3	132	0,6	2,3	<0,05	15,0	1,02
13,30	1,12	8,4	96	0,6	7,8	<0,05	12,0	0,70
10,27	1,18	11,5	74	0,7	5,6	<0,05	21,4	2,08
12,12	1,19	9,8	90	0,6	8,6	<0,05	15,7	1,65
Sediment (17 µg/l cadmium)								
7,24	0,79	10,9	82	18,8	4,7	<0,05	15,5	2,22
4,56	0,70	15,4	197	25,3	10,0	<0,05	29,2	1,63
8,33	0,77	9,2	139	14,4	10,7	0,05	15,4	0,94
7,16	0,69	9,6	133	14,9	5,8	<0,05	16,3	1,11
6,87	0,58	8,4	93	19,4	9,9	0,07	20,1	1,51
4,25	0,38	8,9	127	28,8	3,4	<0,05	20,9	1,56
5,56	0,45	10,6	49	15,8	11,4	<0,05	22,1	0,70
12,46	1,05	8,4	119	15,3	15,3	<0,05	10,8	1,11
10,27	1,08	10,5	77	12,4	11,9	<0,05	13,0	1,11
8,88	0,90	10,1	146	11,8	9,1	<0,05	14,9	1,06
Sediment (34 µg/l cadmium)								
13,04	0,93	7,1	46	24,8	4,6	<0,05	9,9	0,66
16,80	1,42	8,5	127	28,1	2,7	<0,05	18,0	1,62
11,00	1,03	9,4	54	42,9	4,1	<0,05	9,0	0,93
8,84	0,76	8,6	57	20,5	3,8	<0,05	12,2	1,59
11,98	1,04	8,7	98	55,3	11,6	0,05	10,9	0,72
17,78	1,47	8,3	132	26,6	2,4	<0,05	11,4	1,28
7,39	0,74	10,0	150	31,4	13,9	<0,05	13,3	0,77
13,21	1,32	9,9	140	38,5	17,9	<0,05	8,4	1,47
8,19	0,69	8,4	165	50,8	14,3	<0,05	16,4	1,08
12,19	1,01	8,3	59	35,4	3,4	<0,05	19,1	0,59

Crassostrea margaritacea. Tissue metal concentrations after 3 weeks exposure to cadmium absorbed onto clay. (T=24°C)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
Control, (<0,1 µg/l cadmium)								
13,11	1,44	11,0	70	1,9	0,95	<0,05	3,0	0,49
7,41	0,93	7,1	72	3,3	1,43	0,13	5,2	0,86
5,40	0,72	13,3	80	1,9	2,06	<0,05	5,5	0,24
11,97	1,79	15,0	86	3,9	0,63	0,17	5,7	0,18
9,27	0,98	10,6	111	1,4	1,28	0,11	4,6	0,14
7,19	1,05	14,6	67	1,8	0,61	<0,05	5,1	0,18
8,73	1,06	12,1	148	2,7	0,82	<0,05	5,0	0,25
7,28	1,25	17,2	100	1,9	2,00	<0,05	5,5	0,20
9,19	1,17	12,7	86	1,7	1,89	0,05	4,1	0,26
6,72	1,07	15,9	143	2,2	2,05	0,07	7,6	0,26
Sediment, (17 µg/l cadmium)								
8,97	1,12	12,5	165	3,8	0,81	<0,05	6,4	0,21
9,74	1,01	10,4	47	3,4	0,81	<0,05	3,3	0,30
8,92	1,12	12,6	82	4,6	1,65	<0,05	7,0	0,21
7,36	0,97	13,2	113	8,2	1,01	<0,05	5,3	0,23
6,58	0,84	12,8	85	4,6	1,88	<0,05	4,6	0,59
7,67	1,02	13,3	47	3,2	1,88	<0,05	5,0	0,24
8,04	0,96	11,9	67	7,5	0,54	<0,05	4,2	0,18
7,40	0,90	12,2	92	6,4	0,78	<0,05	5,9	0,18
6,52	0,87	13,3	104	5,2	2,51	<0,05	6,6	0,29
13,10	1,44	11,0	73	3,1	0,81	<0,05	3,6	0,25
Sediment, (34 µg/l cadmium)								
8,79	1,19	13,5	81	8,1	2,55	<0,05	5,3	0,25
10,60	1,48	13,9	99	13,6	1,74	<0,05	4,5	0,24
7,83	1,03	13,2	119	7,0	2,19	<0,05	6,5	0,22
7,69	0,95	12,4	139	8,3	1,56	<0,05	6,5	0,18
13,49	1,72	12,8	83	5,3	0,82	<0,05	6,5	0,18
10,14	1,59	15,7	95	6,5	1,48	<0,05	5,0	1,37
5,24	0,75	14,3	95	10,1	1,29	<0,05	10,3	0,27
9,57	1,22	12,7	72	9,8	1,36	0,08	3,6	0,15
8,41	1,32	15,7	90	7,4	1,19	<0,05	5,6	0,21
7,84	0,99	12,6	56	14,1	2,00	0,05	4,1	0,37

Perna perna. Tissue-metal concentrations after 3 weeks exposure to cadmium absorbed onto clay (T=24°C)

Sex	Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
				Zn	Cd	Cu	Pb	Fe	Mn
	Control (<0,1 µg/l cadmium)								
F	2,41	0,33	13,7	12,2	0,91	0,75	<0,05	19,5	0,62
F	2.08	0,28	13,5	12,1	2,02	0,77	<0,05	20,7	0,41
F	4,68	0,54	11,4	10,5	1,84	0,53	<0,05	13,3	0,57
F	2,99	0,38	12,7	9,8	0,87	0,54	<0,05	12,0	0,30
F	3,16	0,42	14,0	15,2	1,52	0,73	<0,05	16,1	0,32
F	5,29	0,55	18,4	7,8	0,76	0,53	<0,05	11,7	0,41
M	2,96	0,34	11,5	8,0	1,72	0,98	<0,05	20,6	0,32
M	3,04	0,45	15,2	9,5	1,45	0,66	<0,05	18,4	0,26
M	3,89	0,44	11,3	10,8	1,11	0,57	<0,05	20,8	0,22
M	3,67	0,38	10,4	8,4	0,65	0,71	<0,05	16,6	0,37
	Sediment (17 µg/l cadmium)								
F	3,33	0,37	11,1	18,6	9,9	0,93	<0,05	15,6	0,50
F	4,36	0,40	9,2	10,8	4,6	1,35	<0,05	13,3	0,28
M	4,64	0,50	10,8	7,5	4,0	0,53	<0,05	10,6	0,25
M	3,59	0,43	12,0	11,1	5,7	0,56	0,14	13,9	0,29
F	2,92	0,23	7,9	5,9	3,9	1,06	0,07	15,1	0,27
F	3,85	0,45	11,7	15,3	7,0	0,96	<0,05	15,1	0,52
F	2,48	0,20	8,1	10,1	4,1	0,65	<0,05	18,1	0,35
F	4,18	0,41	9,8	12,0	6,4	0,72	<0,05	13,9	0,42
F	2,11	0,28	13,3	19,4	3,4	0,85	0,12	22,3	0,52
M	1,69	0,21	12,4	14,4	9,9	0,95	<0,05	15,4	0,42
	Sediment (34 µg/l cadmium)								
M	6,05	0,55	9,1	5,3	6,8	0,55	<0,05	10,2	0,20
F	3,62	0,35	9,7	8,2	12,4	0,72	<0,05	10,2	0,13
F	2,57	0,29	11,3	10,1	15,2	0,86	<0,05	15,2	0,24
F	2,79	0,19	6,8	12,6	12,5	0,90	0,13	19,4	0,24
F	3,02	0,31	10,3	11,9	10,3	0,63	<0,05	14,9	0,32
F	4,73	0,51	10,8	12,1	15,6	0,68	<0,05	12,7	0,31
F	1,50	0,21	14,0	10,2	18,0	1,47	<0,05	18,7	0,28
M	2,53	0,28	11,1	8,8	16,2	0,87	<0,05	14,2	0,30
F	2,44	0,26	10,7	5,5	13,9	0,86	<0,05	16,0	0,27
F	2,43	0,31	12,8	11,4	17,3	0,95	<0,05	16,0	0,33

Choromytilus meridionalis. Tissue-metal concentrations after 3 weeks exposure to cadmium absorbed onto clay (T=24°)

Sex	Wet mass g	Dry mass g	Dry mass %	µg/g in wet tissue					
				Zn	Cd	Cu	Pb	Fe	Mn
	Control (<0,1 µg/l cadmium)								
F	8,93	1,36	15,2	16,6	0,49	0,84	<0,05	6,83	1,18
F	10,04	1,35	13,4	13,4	0,44	0,66	<0,05	4,58	0,90
F	5,92	0,88	8,8	13,5	0,25	1,09	<0,05	5,24	1,83
F	5,83	0,99	16,9	14,6	0,46	1,05	<0,05	6,00	1,52
F	5,84	0,82	14,0	13,5	0,48	0,96	<0,05	5,99	1,44
M	4,94	0,71	14,4	9,9	0,20	0,83	<0,05	5,47	1,43
M	5,77	0,92	15,9	10,6	0,28	0,85	0,07	6,59	0,90
M	4,21	0,73	17,3	10,0	0,24	0,93	<0,05	6,18	1,53
M	3,49	0,61	17,4	12,0	0,40	0,72	<0,05	7,45	1,66
M	4,05	0,62	15,3	11,4	0,30	0,81	<0,05	6,67	1,41
	Sediment (17 µg/l cadmium)								
F	5,40	0,80	14,8	13,5	6,3	0,96	<0,1	6,67	2,47
F	8,19	1,26	15,4	15,1	5,2	1,11	<0,1	6,72	1,08
F	7,87	1,19	15,1	14,9	4,1	0,97	<0,1	5,34	1,76
F	4,91	0,75	15,2	15,9	6,1	1,10	0,20	7,74	1,78
F	6,61	1,01	15,3	13,5	5,6	1,04	<0,1	2,87	1,78
F	7,78	1,08	13,9	14,3	5,3	0,94	<0,1	6,30	1,11
M	5,66	0,79	14,0	9,9	4,2	1,01	0,18	4,95	1,17
M	6,73	1,12	16,6	11,6	6,5	1,08	<0,1	6,24	0,91
F	5,15	0,71	13,8	12,2	3,7	0,91	<0,1	5,83	1,36
F	4,53	0,62	13,7	12,8	4,7	0,73	<0,1	6,18	0,93
	Sediment (34 Ug/l cadmium)								
F	6,63	0,91	13,7	12,2	10,9	0,86	0,08	5,13	1,54
F	5,11	0,79	15,5	15,1	15,3	1,00	0,10	6,26	1,30
F	9,32	1,36	14,6	12,6	12,3	1,05	0,05	5,90	1,19
F	5,73	0,91	15,9	14,3	14,1	1,08	<0,05	6,46	1,67
M	8,93	1,20	13,4	10,9	9,0	0,97	0,06	5,15	1,31
M	6,79	1,20	17,7	10,2	16,5	1,03	0,07	4,86	1,12
M	5,52	0,87	15,8	9,60	12,9	0,87	0,05	5,62	1,65
M	8,20	1,32	16,1	8,66	10,7	1,00	0,18	5,00	1,34
M	6,89	1,03	14,9	8,85	14,4	0,80	<0,05	4,35	0,90
M	12,76	1,83	14,3	8,93	18,0	0,86	<0,05	4,31	0,90

Uptake of cadmium from Phaeodactylum tricornutum.

CONTROL ALGAE				CADMIUM-RICH ALGAE			
Wet mass g	Cd µg/g	Wet mass g	Cd µg/g	Wet mass g	Cd µg/g	Wet mass g	Cd µg/g
Crassostrea gigas							
5,42	0,42	6,28	0,46	14,23	2,10	5,04	2,57
7,18	0,13	9,00	0,41	8,71	3,21	8,24	3,03
5,42	0,44	6,70	0,46	6,80	1,91	6,59	4,40
8,90	0,43	4,78	0,66	6,54	2,75	11,59	2,24
7,13	0,43	9,47	0,36	6,13	5,38	5,92	3,54
5,43	0,44	7,12	0,42	6,17	3,07	7,27	4,26
7,10	0,73	7,49	0,49	10,36	2,89	7,64	2,74
5,90	0,47	7,80	0,46	9,99	4,30	12,34	2,99
8,26	0,39	8,56	0,31	8,90	3,48	10,30	1,65
8,05	0,48	5,23	0,47	9,94	3,21	7,82	4,60
8,75	0,41	5,56	0,41	5,43	8,10	11,71	2,64
7,97	0,42	6,32	0,49	7,96	2,88	6,22	3,69
5,74	0,52			6,74	2,96		
Crassostrea margaritacea							
1,12	0,35	8,21	0,36	9,36	0,32	8,07	3,34
6,57	0,30	8,77	0,23	8,94	1,14	8,10	0,60
5,10	0,25	9,43	0,22	5,61	0,71	5,89	2,17
7,31	0,36	6,59	0,28	6,04	2,40	5,36	0,55
8,19	0,28	6,96	0,33	6,11	0,36	6,42	1,55
9,55	0,27	8,67	0,21	4,80	1,47	8,49	0,47
8,28	0,25	5,60	0,35	6,47	0,27	6,00	0,43
5,33	0,24	11,11	0,14	5,02	5,37	13,15	1,24
7,13	0,23	3,95	0,60	8,93	0,43	7,70	0,33
4,71	0,29	3,93	0,40	10,51	1,28	4,42	3,84
10,91	0,24	8,47	0,25	7,49	0,62		
7,82	0,26	12,84	0,20	9,02	2,10		
8,22	0,25			6,56	0,53		

Crassostrea gigas. Tissue-metal concentrations after 3 weeks exposure to each of 9 elements at 100 μg/l. (T=24°C)

Wet mass g	Dry mass g	Dry mass %	Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
			μg metal/g wet tissue								
Control											
8,43	0,71	8,4	178	0,39	9,7	<0,05	17,6	2,97	0,02	0,01	0,22
4,82	0,50	10,4	191	0,52	5,7	<0,05	24,9	2,08	0,03	0,02	0,18
3,00	0,24	8,0	100	0,77	8,7	<0,05	28,7	2,00	0,07	0,01	0,26
6,66	0,64	9,6	112	0,42	15,5	<0,05	21,0	2,01	0,07	0,01	0,09
4,47	0,43	9,6	114	0,63	11,0	0,13	34,5	1,90	0,05	0,01	0,12
3,83	0,31	8,1	119	0,68	12,0	0,13	23,2	2,22	0,04	0,02	0,23
6,09	0,62	10,2	153	0,54	13,5	<0,05	19,5	1,81	0,10	0,01	0,17
4,00	0,33	8,3	170	0,63	14,0	<0,05	30,3	1,75	0,03	0,01	0,19
7,31	0,63	8,6	115	0,48	7,3	<0,05	16,6	1,64	0,02	0,01	0,26
3,83	0,31	8,1	166	0,63	14,6	<0,05	24,5	1,96	0,04	0,03	0,21
Cadmium											
13,58	1,01	7,4	127	4,50	14,1	0,08	11,8	1,73	0,05	0,08	0,29
6,90	0,52	7,5	86	6,52	7,2	0,09	10,6	1,80	0,04	0,04	0,23
11,72	0,97	8,3	91	6,66	7,3	0,10	11,5	1,28	0,10	0,05	0,34
11,80	1,07	9,1	120	3,56	9,8	0,08	14,2	1,93	0,08	0,03	0,37
11,15	0,98	8,8	154	7,26	10,9	0,03	12,0	1,47	0,06	0,04	0,29
8,82	0,69	7,8	141	3,74	12,7	0,10	11,8	0,85	0,04	0,02	0,30
10,44	0,83	8,0	134	4,89	13,9	0,05	13,0	1,37	0,10	0,05	0,32
4,00	0,32	8,0	48	11,25	16,3	0,05	17,3	0,75	0,03	0,02	0,14
8,15	0,66	8,1	65	6,87	6,8	0,03	12,5	1,74	0,14	0,03	0,20
6,56	0,59	9,0	131	7,93	11,1	0,09	13,4	0,63	0,20	0,06	0,26
Zinc											
6,64	0,19	2,9	116	0,38	9,2	0,08	19,6	0,91	0,05	0,02	0,26
9,62	0,56	5,8	113	0,32	8,2	0,07	12,2	1,20	0,02	0,01	0,14
9,45	0,52	5,5	127	0,30	9,3	0,08	13,0	2,07	0,02	0,01	0,22
11,08	0,74	6,7	73	0,32	5,7	0,03	12,8	1,89	0,09	0,01	0,21
8,68	0,38	4,4	130	0,36	12,3	0,07	14,9	1,33	0,07	0,01	0,16
12,79	0,79	6,2	45	0,25	4,1	0,04	9,4	1,45	0,02	0,01	0,15
6,88	0,33	4,8	201	0,45	18,8	0,07	4,8	1,46	0,03	0,01	0,17
11,92	0,69	5,8	157	0,31	16,9	0,02	19,3	1,93	0,02	0,01	0,13
7,54	0,41	5,4	167	0,32	14,4	0,04	18,6	2,19	0,01	0,01	0,26
10,61	0,57	5,4	193	0,29	20,6	0,03	15,1	1,65	0,02	0,01	0,09
Copper											
5,00	0,32	6,4	112	0,44	20,2	<0,05	13,8	1,20	0,04	0,01	0,31
9,93	0,74	7,5	147	0,37	30,0	<0,05	15,6	1,76	0,08	0,02	0,22
7,70	0,55	7,1	109	0,78	27,4	0,05	28,8	1,69	0,07	0,02	0,27
11,19	0,60	5,4	113	0,36	19,1	<0,05	9,9	1,07	0,02	0,01	0,18
8,43	0,49	5,8	45	0,47	24,2	<0,05	13,4	0,71	0,06	0,01	0,15
8,57	0,74	8,6	126	0,43	24,0	<0,05	13,1	0,88	0,03	0,02	0,19
8,44	0,67	7,9	62	0,41	24,5	<0,05	14,5	1,07	0,04	0,01	0,20
13,68	0,96	7,0	79	0,32	18,1	<0,05	10,7	1,43	0,09	0,04	0,26
12,10	0,95	7,9	44	0,55	23,6	<0,05	11,1	1,65	0,14	0,01	0,25
12,42	0,96	7,7	152	0,35	21,6	<0,05	10,5	1,61	0,07	0,05	0,19
Lead											
9,32	0,59	6,3	101	0,34	8,0	0,65	11,6	2,42	0,13	0,03	0,25
13,48	0,92	6,8	66	0,23	9,5	0,51	9,2	1,63	0,08	0,01	0,24
10,27	0,78	7,6	123	0,37	9,2	0,67	11,3	2,29	0,07	0,01	0,16
10,12	0,79	7,8	113	0,36	9,7	1,12	13,0	1,13	0,04	0,01	0,31
5,78	0,46	8,0	83	0,42	4,3	4,65	14,7	1,82	0,07	0,02	0,25
7,65	0,56	7,3	95	0,38	9,0	0,81	15,6	1,70	0,03	0,02	0,37
13,94	1,18	8,5	103	0,32	8,1	0,92	10,7	1,15	0,05	0,03	0,22
11,12	0,76	6,8	23	0,23	4,3	2,06	11,1	0,72	0,05	0,01	0,14
6,80	0,46	6,8	106	0,44	10,3	1,21	16,5	1,77	0,04	0,01	0,21
9,93	0,83	8,4	129	0,41	13,3	0,76	14,7	1,61	0,09	0,02	0,23

Crassostrea gigas. Tissue-metal concentrations after 3 weeks exposure to each of 9 elements at 100 µg/l. (T=24°C) (continued)

Wet mass g	Dry mass g	Dry mass %	Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
			µg metal/g wet tissue								
Iron											
3,75	0,30	8,0	192	0,56	17,6	<0,05	20,8	1,66	0,04	0,01	0,17
13,47	1,23	9,1	131	0,33	10,5	<0,05	10,8	1,55	0,04	0,01	0,18
4,69	0,36	7,7	186	0,49	11,3	<0,05	17,7	1,68	0,03	0,05	0,36
10,26	0,83	8,1	130	0,31	11,9	<0,05	11,6	1,42	0,10	0,02	0,28
9,31	0,84	9,0	64	0,26	5,6	<0,05	12,9	2,03	0,14	0,01	0,26
8,57	0,72	8,4	134	0,36	13,8	<0,05	13,0	1,28	0,06	0,01	0,22
6,35	0,57	9,0	83	0,44	5,5	<0,05	14,5	2,09	0,07	0,03	0,19
10,92	0,85	13,4	63	0,29	7,2	<0,05	10,5	2,06	0,05	0,01	0,20
10,85	0,96	8,9	166	0,36	13,1	<0,05	12,7	1,79	0,04	0,02	0,20
9,45	0,82	8,7	90	0,32	7,2	<0,05	12,5	1,80	0,09	0,02	0,15
Manganese											
10,57	0,69	6,5	151	0,26	20,3	0,05	11,1	1,14	0,08	0,04	0,23
7,32	0,49	6,7	180	0,44	12,2	<0,05	19,3	1,98	0,01	0,01	0,20
10,80	0,89	8,2	119	0,35	8,6	<0,05	12,5	1,95	0,03	0,02	0,27
6,05	0,51	8,4	198	0,51	18,0	<0,05	21,8	1,73	0,03	0,01	0,10
6,72	0,36	5,4	91	0,42	6,4	<0,05	14,4	1,63	0,02	0,02	0,13
6,67	0,43	6,4	57	0,36	4,6	<0,05	14,7	1,65	0,01	0,01	0,11
13,06	0,86	6,6	77	0,26	9,6	<0,05	10,5	2,22	0,01	0,02	0,13
9,52	0,56	5,9	92	0,32	7,5	<0,05	11,0	0,84	0,01	0,05	0,35
7,70	0,65	8,4	145	0,36	13,8	<0,05	16,0	1,89	0,01	0,01	0,28
8,93	0,59	6,6	52	0,26	3,9	<0,05	12,0	0,95	0,01	0,01	0,20
Nickel											
6,83	0,30	4,4	85	0,31	7,2	0,06	19,0	1,47	0,35	0,01	0,32
7,32	0,27	3,7	141	0,33	2,1	0,10	20,5	0,82	0,56	0,01	0,22
4,54	0,11	2,4	120	0,42	0,7	0,04	30,8	1,76	1,12	0,02	0,33
12,91	0,75	5,8	50	0,26	4,2	0,02	12,4	1,20	0,39	0,01	0,11
7,35	0,58	7,9	88	0,38	7,2	0,05	19,0	2,45	0,38	0,03	0,41
11,97	1,03	8,6	136	0,35	11,7	0,02	17,5	1,85	0,30	0,01	0,29
6,21	0,46	7,4	127	0,39	10,3	0,11	20,9	1,85	0,39	0,02	0,27
11,90	0,83	7,0	50	0,25	5,8	0,03	13,4	1,10	0,34	0,01	0,17
11,26	0,89	7,9	79	0,29	7,5	0,05	15,1	1,65	0,45	0,01	0,21
11,93	1,02	8,6	97	0,30	12,0	0,04	14,2	1,20	0,45	0,01	0,15
Cobalt											
7,96	0,51	6,4	108	0,38	10,8	0,05	18,0	1,67	0,11	0,64	0,21
9,72	0,62	6,4	97	0,36	8,6	0,08	12,7	1,49	0,04	0,44	0,12
8,89	0,46	5,2	52	0,34	4,6	0,06	16,3	1,86	0,06	0,31	0,16
11,45	0,74	6,5	137	0,35	18,8	0,05	12,0	1,63	0,04	0,47	0,12
11,39	0,82	7,2	145	0,36	15,8	0,10	13,3	2,33	0,06	0,29	0,10
10,33	0,63	6,1	95	0,34	12,0	0,05	12,4	1,79	0,05	0,31	0,14
6,51	0,18	2,8	45	0,34	3,5	0,09	18,4	0,92	0,06	0,35	0,14
14,59	1,15	7,9	129	0,24	2,3	0,06	17,1	1,54	0,03	0,37	0,21
9,32	0,51	5,5	130	0,30	2,1	0,10	11,9	1,67	0,04	o,53	0,17
11,17	0,85	7,6	107	0,33	13,3	0,06	18,8	1,17	0,03	0,36	0,13
Chromium											
7,94	0,85	10,7	191	0,50	19,0	0,10	21,4	2,21	0,10	0,01	0,52
11,32	1,04	9,2	129	0,36	12,2	0,08	15,0	1,50	0,04	0,01	0,47
1,58	0,12	7,6	139	0,89	14,0	0,06	25,9	1,26	0,02	0,01	1,20
11,36	1,11	9,8	131	0,34	15,3	0,04	22,9	1,89	0,03	0,02	0,66
4,46	0,42	9,4	215	0,47	16,2	0,03	31,4	1,91	0,07	0,02	0,78
9,14	0,91	10,0	114	0,42	6,7	0,04	20,8	1,10	0,02	0,01	0,38
5,57	0,58	10,4	199	0,54	9,9	0,01	32,3	2,61	0,04	0,02	0,70
10,46	0,85	8,1	113	0,32	14,4	0,06	15,3	1,53	0,02	0,01	0,48
7,95	0,67	8,4	166	0,35	15,8	0,08	18,9	1,45	0,03	0,01	0,67
7,89	0,61	7,7	153	0,38	14,0	0,05	17,7	1,21	0,09	0,04	0,68

Crassostrea margaritacea. Tissue-metal concentrations after 3 weeks exposure to each of 9 elements at 100 μg/l. (T=24°C)

Wet mass g	Dry mass g	Dry mass %	μg metal/g wet tissue								
			Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
Control											
4,55	0,60	13,2	110	0,88	1,36	0,11	6,2	0,97	<0,02	0,02	0,20
4,16	0,44	10,6	123	1,11	1,13	0,10	4,6	0,31	<0,02	<0,02	0,24
6,01	0,70	11,7	107	1,08	1,21	0,03	4,2	0,17	0,02	<0,02	0,23
4,83	0,49	10,1	155	0,91	1,12	0,04	3,7	0,33	0,03	<0,02	0,28
3,41	0,37	10,9	111	1,41	1,11	0,09	7,9	0,32	0,03	<0,02	0,32
4,71	0,65	13,8	110	0,87	1,38	0,08	6,8	1,15	0,04	<0,02	0,11
2,92	0,32	11,0	116	1,54	1,99	0,14	7,5	0,31	0,07	<0,02	0,17
6,47	0,78	12,1	90	1,23	2,04	0,06	5,1	0,40	0,03	<0,02	0,13
Cadmium											
4,94	0,50	10,1	130	4,03	0,91	<0,02	4,5	0,24	0,04	<0,02	0,28
4,36	0,49	11,2	161	1,81	0,76	0,21	7,8	0,37	<0,02	<0,02	0,30
7,18	0,59	8,2	118	4,00	0,57	0,10	3,3	0,19	0,11	<0,02	0,26
4,77	0,48	10,1	78	1,55	1,85	0,04	4,8	0,57	0,02	<0,02	0,22
4,88	0,41	8,4	92	3,16	0,70	<0,02	7,2	0,20	0,06	<0,02	0,33
4,84	0,45	9,3	171	2,22	0,45	0,02	4,3	0,21	0,03	<0,02	0,19
4,45	0,40	9,0	99	2,16	0,98	0,09	5,6	0,29	<0,02	<0,02	0,23
5,45	0,61	11,2	86	2,36	0,95	0,03	5,1	0,66	0,04	<0,02	0,29
3,40	0,32	9,4	112	2,21	1,94	0,08	6,8	0,35	0,03	<0,02	0,15
4,05	0,40	9,9	96	3,47	1,33	0,15	8,4	0,32	<0,02	<0,02	0,19
Zinc											
8,80	0,97	11,0	110	0,90	1,36	0,11	6,6	0,22	0,02	<0,02	0,56
4,86	0,60	12,3	97	0,92	0,61	0,12	4,5	0,94	0,02	<0,02	0,40
5,87	0,57	9,7	83	0,85	0,42	0,17	4,7	0,32	0,05	<0,02	0,69
7,14	0,94	13,2	146	0,93	2,59	0,07	5,7	0,23	0,11	<0,02	0,81
3,51	0,34	9,7	134	1,08	1,50	0,19	8,0	0,51	<0,02	<0,02	0,37
6,10	0,63	10,3	188	0,70	2,91	0,21	4,8	0,19	<0,02	<0,02	0,20
3,53	0,42	11,9	159	0,76	1,24	0,12	5,9	0,28	0,05	<0,02	0,42
4,32	0,38	8,8	118	1,20	0,92	0,20	6,7	0,16	0,02	<0,02	0,58
5,37	0,52	9,7	115	0,93	0,72	0,05	5,0	0,14	0 07	<0,02	0,22
Copper											
3,44	0,45	13,1	70	1,42	11,40	0,15	10,5	0,99	0,02	<0,02	0,34
4,25	0,47	11,1	99	1,08	3,26	0,05	4,2	0,26	0,11	0,05	0,26
5,37	0,77	14,3	171	0,99	9,15	0,07	6,3	1,17	0,09	0,06	0,37
4,20	0,49	11,7	107	1,17	5,14	0,04	6,4	0,71	0,02	0,02	0,26
4,79	0,65	13,6	203	0,80	12,90	0,06	10,0	0,29	0,02	<0,02	0,23
4,36	0,50	11,5	83	1,12	6,87	0,05	6,7	0,48	0,05	<0,02	0,23
6,55	0,67	10,2	208	1,28	11,71	0,05	5,2	0,41	0,02	0,02	0,20
3,30	0,28	8,5	67	0,82	5,27	0,05	6,7	0,27	0,09	<0,02	0,21
4,18	0,58	13,9	132	1,27	3,29	0,02	6,7	0,19	0,06	<0,02	0,15
3,43	0,39	11,4	111	1,34	4,64	0,09	6,4	0.20	0,06	0,09	0,26
Lead											
4,01	0,55	13,7	205	1,25	1,82	1,10	9,0	0,62	<0,02	<0,02	0,17
4,97	0,55	11,1	145	1,53	0,38	1,54	4,0	0,20	<0,02	<0,02	0,08
4,49	0.48	10,7	223	1,09	1,76	1.71	6,7	0.22	0,07	<0.02	0,31
3,60	0,48	13,3	94	1,03	1,67	1,28	7,2	0,25	0,06	<0,02	0,33
1,99	0,21	10,6	75	0,95	0,85	3,57	6,5	0,25	0,10	<0,02	0,15
3,20	0,40	12,5	138	1,31	1,53	2,41	6,9	0,25	0,03	<0,02	0,25
4,83	0,46	9,5	110	1,16	2,06	1,89	5,0	0,29	0,08	<0,02	0,17
3,12	0,39	12,5	151	1,38	1,95	1,28	8,3	0,32	<0,02	<0,02	0,29
5,14	0,53	10,3	64	0,76	1,60	1,21	4,9	1,19	<0,02	<0,02	0,27

Crassostrea margaritacea. Tissue-metal concentrations after 3 weeks exposure to each of 9 elements at 100 µg/l. (T=24°C) (continued)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue								
			Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
Iron											
8,11	0,70	8,6	143	0,78	1,62	0,04	4,3	0,46	<0,02	0,02	0,35
5,33	0,45	8,4	180	0,91	0,49	0,04	4,9	0,19	0,05	<0,02	0,14
5,86	0,80	13,7	90	1,03	1,28	0,14	7,3	0,23	<0,02	<0,02	0,34
4,79	0,58	12,1	115	1,02	0,96	0,04	8,1	0,25	0,02	<0,02	0,27
4,30	0,34	7,9	102	0,84	2,23	0,09	9,7	0,56	0,04	<0,02	0,40
4,10	0,41	10,0	102	1,17	0,63	0,02	6,6	0,27	0,07	<0,02	0,32
7,47	0,81	10,8	64	0,92	1,77	0,05	5,9	1,12	0,02	<0,02	0,21
4,98	0,61	12,3	114	1,10	0,70	0,02	10,4	0,32	<0,02	<0,02	0,26
5,23	0,48	9,2	170	1,32	2,18	0,02	6,6	0,23	<0,02	<0,02	0,19
Manganese											
4,29	0,51	11,9	63	1,25	1,16	0,09	6,1	0,44	0,06	<0,02	0,81
6,69	0,62	9,3	149	1,28	0,65	0,04	6,9	0,24	0,10	<0,02	0,80
2,00	0,23	11,5	85	1,10	2,35	0,11	7,5	0,40	0,05	<0,02	0,70
6,29	0,66	10,5	86	0,74	0,58	0,02	5,1	0,62	0,02	<0,02	0,27
8,61	0,77	8,9	73	0,98	0,91	0,10	3,9	0,36	0,02	<0,02	0,37
7,89	0,63	8,0	95	0,69	0,36	0,11	5,2	0,21	<0,02	<0,02	0,62
6,99	0,83	11,9	110	0,80	0,81	0,15	8,4	0,24	0,11	0,02	0,24
3,51	0,34	9,7	125	1,48	1,19	0,17	8,3	0,71	0,21	0,02	0,22
Nickel											
3,76	0,43	11,4	191	1,12	0,66	0,17	6,7	0,35	0,35	<0,02	0,31
5,56	0,66	11,9	74	0,94	1,03	0,13	9,5	0,62	0,36	<0,02	0,32
2,41	0,39	16,2	41	1,70	1,04	0,11	10,4	0,46	0,21	<0,02	0,28
4,75	0,57	12,0	112	0,76	3,54	0,15	6,5	0,29	0,25	<0,02	0,34
5,00	0,43	8,6	98	0,88	1,30	0,10	5,4	0,58	0,20	<0,02	0,24
4,73	0,63	13,3	76	0,89	1,21	0,13	6,3	0,27	0,42	<0,02	0,30
4,58	0,47	10,3	76	0,96	0,61	0,04	5,7	0,37	0,22	<0,02	0,15
5,75	0,59	10,3	119	0,85	1,50	0,19	5,2	0,57	0,36	<0,02	0,28
5,05	0,48	9,5	139	0,99	2,73	0,10	5,5	0,24	0,27	<0,02	0,30
4,77	0,60	12,6	80	1,09	0,75	0,10	5,5	0,80	0,15	<0,02	0,26
Cobalt											
3,11	0,30	9,7	119	1,06	1,09	0,12	8,7	0,32	<0,02	0,03	0,57
2,98	0,39	13,1	97	1,20	1,27	0,16	7,4	0,73	<0,02	0,06	0,57
4,09	0,43	10,5	220	1,44	2,32	0,09	5,9	0,75	<0,02	0,09	0,25
4,30	0,47	10,9	105	0,83	2,93	0,10	5,6	0,27	<0,02	0,06	0,26
5,07	0,50	9,9	209	0,94	1,24	0,11	8,1	0,31	0,02	0,05	0,28
5,54	0,54	9,7	69	0,84	0,68	0,09	4,9	0.45	0,02	0,05	0,25
4,82	0,50	10,4	126	1,12	1,26	0,08	7,3	0,26	0,04	0,12	0,35
5,42	0,53	9,8	72	0,77	1,38	0,12	5,0	0,22	0,03	0,07	0,36
Chromium											
3,89	0,30	7,7	147	1,38	0,82	0,07	6,7	0,41	0,02	<0,02	0,66
5,47	0,88	16,1	110	1,22	1,35	0,10	9,5	0,62	<0,02	<0,02	0,45
4,05	0,48	11,9	128	0,61	1,88	0,09	5,7	0,22	0,02	<0,02	0,46
3,12	0,33	10,6	138	1,18	0,70	0,12	7,4	0,28	0,02	<0,02	0,67
3,68	0,45	12,2	103	1,44	1,08	0,16	4,9	0,27	<0,02	<0,02	0,43
3,82	0,52	13,6	104	1,28	2,40	0,02	10,5	0,43	0,02	<0,02	0,73
3,40	0,44	12,9	97	0,91	2,00	0,05	7,9	0,35	0,05	<0,02	0,76
4,74	0,54	11,4	89	0,67	1,84	0,14	4,4	0,25	0,02	<0,02	0,63
3,42	0,40	11,7	149	1,19	2,63	0,03	9,9	0,35	0,03	<0,02	0,67

Perna perna. Tissue-metal concentrations following exposure to 9 elements each at 100 µg/l. (T=24°C)

Sex	Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue								
				Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
Control												
F	5,02	0,41	8,2	17,8	0,85	0,77	0,25	19,1	0,21	0,39	<0,02	0,33
F	3,74	0,44	11,8	14,2	0,90	0,85	0,20	17,6	0,34	0,42	<0,02	0,32
F	3,70	0,28	7,6	13,0	0,56	0,59	0,18	11,9	0,24	0,51	<0,02	0,35
F	6,28	0,67	10,7	12,4	0,38	1,01	0,23	9,6	0,27	0,29	<0,02	0,29
F	5,98	0,54	9,0	12,2	0,42	0,83	0,30	13,5	0,18	0,25	<0,02	0,23
M	5,40	0,57	10,6	10,9	0,40	0,66	0,22	9,8	0,27	0,27	<0,02	0,20
M	3,02	0,34	11,3	13,9	0,66	0,73	0,13	12,3	0,20	0,46	0,03	0,23
M	3,51	0,39	11,1	6,8	0,54	0,55	0,25	13,1	0,45	0,38	<0,02	0,34
M	4,96	0,43	8,7	8,5	0,40	0,62	0,24	10,1	0,32	0,28	<0,02	0,26
M	4,58	0,48	10,5	10,3	0,56	0,78	0,19	10,9	0,30	0,58	<0,02	0,21
Cadmium												
M	5,89	0,55	9,3	8,8	1,34	0,45	0,18	12,1	0,27	0,23	<0,02	0,23
M	5,60	0,64	11,4	8,9	1,75	0,75	0,26	10,9	0,30	0,35	<0,02	0,46
M	5,88	0,73	12,4	11,4	1,68	0,62	0,35	15,6	0,28	0,58	<0,02	0,34
M	3,71	0,49	13,2	10,0	1,53	0,67	0,35	16,7	0,29	0,81	<0,02	0,37
M	1,71	0,25	14,6	9,6	2,39	0,64	0,35	20,5	0,23	0,40	0,04	0,52
M	2,44	0,34	13,9	10,7	2,41	0,77	0,28	13,5	0,40	0,53	0,08	0,45
M	1,38	0,25	18,1	10,9	3,18	0,94	0,21	15,4	0,50	0,50	<0,02	0,43
M	3,85	0,41	10,7	9,6	2,24	0,70	0,18	17,9	0,23	0,33	<0,02	0,33
M	2,14	0,32	15,0	9,3	2,05	0,56	0,24	15,9	0,32	0,46	0,03	0,60
F	1,47	0,23	15,7	8,2	1,90	0,89	0,24	14,5	0,54	0,61	0,04	0,58
Zinc												
F	2,30	0,31	13,5	17,4	0,30	0,73	0,23	13,0	0,32	0,43	<0,02	0,27
F	5,40	0,40	7,4	9,4	0,35	0,42	0,24	10,4	0,20	0,42	0,02	0,24
F	8,20	0,73	8,9	17,2	0,36	0,62	0,26	8,9	0,30	0,58	<0,02	0,37
F	2,19	0,20	9,1	17,8	0,41	0,41	0,22	12,3	0,36	0,36	<0,02	0,41
F	4,59	0,43	9,4	10,5	0,41	0,74	0,30	10,0	0,21	0,52	0,04	0,32
M	4,08	0,38	9,3	6,6	0,44	0,29	0,32	13,2	0,24	0,24	0,03	0,22
M	2,63	0,19	7,2	16,1	0,45	0,38	0,27	12,9	0,30	0,41	<0,02	0,38
M	2,64	0,26	9,9	9,8	0,64	0,34	0,33	17,8	0,26	0,69	<0,02	0,30
M	3,17	0,42	13,3	9,8	0,31	0,66	0,29	14,2	0,34	0,52	0,02	0,28
Copper												
F	3,19	0,45	14,1	14,7	0,47	2,22	0,16	13,2	0,32	0,18	<0,02	0,50
F	2,43	0,30	12,4	11,1	0,61	1,31	0,20	18,9	0,37	0,74	0,03	0,41
F	3,86	0,49	12,7	16,6	0,59	4,01	0,28	15,8	0,33	0,58	<0,02	0,44
F	10,44	0,89	8,5	16,5	0,87	1,93	0,18	14,2	0,17	0,21	0,06	0,26
M	5,74	0,60	10,5	11,5	0,34	1,88	0,15	8,2	0,24	0,67	<0,02	0,26
M	3,26	0,42	12,9	16,9	0,70	1,65	0,15	19,6	0,39	0,79	<0,02	0,42
M	3,35	0,31	9,3	9,9	0,38	1,04	0,18	14,0	0,29	0,42	<0,02	0,44
M	2,92	0,23	7,9	13,0	0,44	0,99	0,10	13,7	0,37	0,43	<0,02	0,41
M	2,87	0,22	7,7	11,5	0,41	1,01	0,27	17,1	0,34	0,73	<0,02	0,59
M	3,00	0,21	7,0	9,3	0,40	1,90	0,16	18,3	0,36	0,43	<0,02	0,43
Lead												
M	3,91	0,34	8,7	8,7	0,66	0,40	2,22	18,2	0,23	0,79	<0,02	0,35
M	3,00	0,23	7,7	7,7	0,90	0,26	2,70	19,3	0,33	0,43	<0,02	0,26
M	5,27	0,54	10,3	8,3	0,44	0,34	4,15	9,7	0,24	0,20	0,03	0,28
M	4,03	0,32	7,9	12,7	0,52	0,49	3,54	10,4	0,22	0,52	<0,02	0,19
M	2,94	0,24	8,1	8,2	0,30	0,57	2,99	9,9	0,23	0,65	0,05	0,20
M	3,69	0,33	8,9	9,8	0,56	0,35	1,92	18,7	0,21	0,48	0,03	0,21
M	3,69	0,38	10,3	8,1	0,43	0,62	2,84	16,8	0,27	0,40	<0,02	0,33
F	4,49	0,43	9,6	12,2	0,59	0,80	3,16	15,4	0,31	0,42	<0,02	0,17
F	4,02	0,34	8,5	14,2	0,66	0,39	2,53	14,2	0,29	0,37	<0,02	0,24
F	3,18	0,30	9,4	9,1	0,52	0,37	3,20	17,0	0,56	0,22	<0,02	0,27

Perna perna. Tissue-metal concentrations following exposure to 9 elements each at 100 µg/l. (T=24°C) (continued)

Sex	Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue								
				Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
Iron												
F	3,72	0,41	11,0	14,2	0,58	0,77	0,24	18,0	0,26	0,39	<0,02	0,29
F	6,29	0,57	9,1	16,0	0,52	0,65	0,12	13,4	0,22	0,44	<0,02	0,23
F	3,66	0,31	8,5	17,9	0,68	0,54	0,10	17,2	0,35	0,84	<0,02	0,32
F	3,68	0,37	10,1	14,4	0,54	0,48	0,19	12,2	0,32	0,30	<0,02	0,32
F	3,93	0,39	9,9	17,4	0,45	0,69	0,17	19,1	0,30	0,58	<0,02	0,38
M	3,33	0,39	11,7	6,5	0,57	0,60	0,18	13,2	0,27	0,62	0,03	0,48
M	2,67	0,27	10,1	8,6	0,48	0,41	0,18	11,6	0,29	0,44	<0,02	0,44
M	5,30	0,50	9,4	8,7	0,47	0,37	0,13	11,9	0,24	0,26	<0,02	0,32
M	3,50	0,35	10,0	7,0	0,40	0,36	0,16	11,7	0,30	0,26	0,03	0,26
M	2,89	0,34	11,8	15,2	0,65	0,58	0,24	22,1	0,34	0,69	<0,02	0,49
Manganese												
M	3,42	0,51	14,9	12,3	0,47	0,64	0,26	11,4	0,41	0,36	<0,02	0,37
M	3,25	0,31	9,5	12,9	0,43	0,52	0,22	16,0	0,40	0,42	<0,02	0,25
M	5,39	0,34	6,3	7,8	0,64	0,39	0,16	12,6	0,28	0,21	<0,02	0,41
M	4,23	0,29	6,9	5,2	0,50	0,40	0,14	22,0	0,37	0,61	0,03	0,28
M	3,04	0,40	13,2	12,2	0,43	0,76	0,10	17,1	0,43	0,38	<0,02	0,34
F	6,48	0,55	8,5	16,0	0,56	0,65	0,11	14,7	0,35	0,30	0,02	0,50
F	3,19	0,20	6,3	8,9	0,47	0,44	0,09	15,0	0,34	0,25	<0,02	0,43
F	4,00	0,27	6,8	11,3	0,73	0,57	0,18	15,8	0,35	0,51	0,02	0,26
Nickel												
M?	2,93	0,32	10,9	11,9	0,64	0,64	0,20	11,9	0,27	0,61	<0,02	0,10
M?	2,57	0,25	9,7	8,6	0,50	0,62	0,15	14,4	0,31	0,46	<0,02	0,19
M?	2,15	0,22	10,2	7,0	0,46	0,60	0,18	21,4	0,32	1,32	0,04	0,32
M?	3,42	0,38	11,1	14,3	0,58	0,73	0,20	14,6	0,32	1,05	0,03	0,24
M?	4,75	0,53	11,2	8,8	0,86	0,67	0,25	13,1	0,29	1,01	0,03	0,25
M?	2,74	0,27	9,9	11,3	0,79	0,72	0,21	16,4	0,32	0,94	<0,02	0,40
M?	2,13	0,25	11,7	9,9	0,61	0,61	0,17	11,7	0,37	0,51	0,02	0,32
M?	2,50	0,24	9,6	10,4	0,84	0,56	0,20	12,8	0,40	0,32	0,02	0,36
M?	3,88	0,36	9,3	16,2	0,52	0,44	0,21	8,6	0,53	1,18	<0,02	0,41
Cobalt												
M	3,23	0,43	13,3	10,8	0,83	0,74	0,32	17,0	0,30	0,26	0,52	0,55
M	4,43	0,43	9,7	10,6	0,88	0,49	0,42	19,4	0,18	0,52	0,46	0,40
M	1,74	0,28	16,1	10,0	0,63	0,68	0,40	20,1	0,34	0,41	0,68	0,63
M	5,01	0,53	10,6	10,0	0,39	0,59	0,43	13,2	0,29	0,81	0,45	0,35
M	2,67	0,30	11,2	9,4	0,44	0,48	0,26	15,7	0,29	0,48	0,44	0,56
M	3,51	0,40	11,4	11,7	1,02	0,39	0,28	19,4	0,25	0,31	0,51	0,37
M	2,91	0,31	10,7	9,6	0,44	0,51	0,30	17,2	0,27	0,60	0,30	0,30
M	1,73	0,24	13,9	8,5	0,92	0,40	0,34	14,1	0,28	0,25	0,52	0,52
F	3,73	0,42	11,3	9,3	0,61	0,56	0,37	16,1	0,21	0,61	0,26	0,34
Chromium												
F	1,46	0,21	14,4	11,6	0,54	0,82	0,34	17,8	0,54	0,36	0,06	1,09
F	4,79	0,53	11,1	11,9	0,40	0,83	0,27	18,4	0,33	0,29	0,14	0,66
M	5,01	0,59	11,8	11,4	0,73	0,69	0,17	11,8	0,27	0,67	0,09	0,47
M	3,93	0,44	11,2	5,9	0,35	0,53	0,25	12,0	0,27	0,27	<0,02	0,55
M	4,16	0,47	11,3	8,4	0,52	0,64	0,23	12,3	0,26	0,57	<0,02	0,48
M	2,11	0,23	10,9	9,5	0,53	0,42	0,33	15,2	0,28	0,56	0,04	0,75
M	1,73	0,22	12,7	13,3	0,34	0,46	0,28	15,0	0,40	0,75	0,05	1,24
M	1,83	0,22	12,0	13,7	0,32	0,43	0,20	18,0	0,32	0,65	<0,02	0,92
M	1,58	0,24	15,2	9,5	0,37	0,69	0,35	15,2	0,44	0,25	0,06	1,11

Choromytilus meridionalis. Tissue-metal concentrations after 3 weeks exposure to each of 9 elements at 100 µg/l. (T=24°C)

Sex	Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue								
				Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
Control												
F	8,22	1,52	18,5	17,2	0,29	1,19	0,06	6,4	1,66	0,03	0,01	0,24
F	4,78	0,75	15,7	15,5	0,27	1,02	0,16	5,9	1,94	0,06	0,04	0,20
F	5,49	0,91	16,6	16,6	0,38	1,11	0,23	7,1	1,45	0,07	0,01	0,20
F	4,80	0,85	17,7	15,6	0,18	1,18	0,25	6,7	1,47	0,06	0,02	0,34
F	13,30	2,04	15,3	11,4	0,27	1,03	0,13	5,0	0,93	0,05	0,01	0,14
F	5,65	1,07	18,9	16,8	0,24	1,41	0,08	6,0	0,53	0,11	0,03	0,21
F	15,10	2,40	15,9	11,6	0,27	1,09	0,16	5,3	1,37	0,11	0,02	0,13
F	7,60	1,08	14,2	14,6	0,19	1,25	0,17	5,1	1,15	0,06	0,01	0,18
M	11,84	2,16	18,2	10,1	0,32	1,06	0,12	6,3	0,65	0,23	0,01	0,40
M	4,77	0,78	16,4	13,4	0,31	1,24	0,16	7,3	1,74	0,12	0,02	0,31
Cadmium												
M	3,35	0,66	19,7	13,7	1,67	1,01	0,15	9,6	1,09	0,15	0,03	0,30
M	3,43	0,60	17,5	13,1	1,49	1,05	0,12	8,7	1,29	0,20	0,03	0,26
M	4,47	0,71	15,9	14,5	1,45	0,98	0,16	7,8	1,37	0,18	0,02	0,34
M	2,54	0,37	14,6	16,9	1,22	0,87	0,04	11,4	1,26	0,04	0,04	0,21
M	3,86	0,66	17,1	12,7	1,22	1,01	0,08	9,1	1,74	0,16	0,03	0,32
M	3,27	0,60	18,4	13,5	1,38	0,95	0,03	8,9	1,53	0,09	0,03	0,21
F	10,65	1,98	18,6	16,2	1,41	1,01	0,18	7,0	1,48	0,09	0,01	0,21
F	8,85	1,68	19,0	17,5	1,60	1,18	0,19	8,4	1,57	0,15	0,01	0,41
F	3,39	0,48	14,2	16,2	1,27	0,97	0,15	8,6	1,40	0,06	0,03	0,47
F	2,12	0,35	16,5	16,0	1,27	0,90	0,09	10,8	1,65	0,14	0,05	0,47
Zinc												
M	2,47	0,40	16,2	15,8	0,36	0,69	0,20	8,1	1,28	0,04	0,04	0,32
M	2,55	0,43	16,9	15,3	0,47	0,75	0,04	9,8	0,59	0,04	0,04	0,42
M	3,58	0,55	15,4	13,7	0,25	0,73	0,14	7,8	1,11	0,08	0,03	0,28
M	2,49	0,46	18,5	14,9	0,24	1,08	0,08	9,6	1,91	0,08	0,04	0,44
M	8,69	1,69	19,2	13,5	0,25	0,75	0,18	7,0	1,31	0,15	0,01	0,31
M	8,04	1,22	15,2	11,9	0,24	0,70	0,21	6,7	0,94	0,15	0,01	0,24
F	3,57	0,54	15,1	19,0	0,36	0,81	0,20	8,1	1,26	0,17	0,03	0,34
F	3,39	0,55	16,2	16,5	0,38	0,94	0,29	9,7	1,62	0,18	0,03	0,27
F	4,28	0,67	15,6	17,5	0,30	0,98	0,19	8,2	1,47	0,10	0,02	0,47
F	3,74	0,61	16,3	20,3	0,32	0,94	0,08	8,8	1,57	0,05	0,03	0,34
Copper												
M	3,94	0,62	15,7	13,7	0,36	1,22	0,13	7,6	1,53	0,08	0,03	0,15
M	2,76	0,47	17,0	13,4	0,36	1,59	0,07	9,4	1,92	0,25	0,04	0,36
M	7,40	1,25	16,9	12,6	0,22	1,32	0,04	5,9	1,69	0,07	0,01	0,12
M	4,27	0,64	15,0	11,9	0,37	1,52	0,19	7,0	1,08	0,12	0,02	0,19
M	6,06	0,94	15,5	11,1	0,26	1,37	0,10	7,8	1,35	0,05	0,02	0,33
M	3,98	0,66	16,6	12,3	0,30	1,41	0,18	7,8	1,42	0,03	0,03	0,23
M	3,54	0,58	16,4	13,0	0,38	1,53	0,03	9,3	1,75	0,08	0,03	0,45
M	3,51	0,56	16,0	11,4	0,26	1,45	0,09	8,0	1,56	0,14	0,03	0,37
F	3,71	0,51	13,8	12,9	0,40	1,51	0,05	8,6	1,24	0,08	0,03	0,46
F	14,52	2,21	15,2	11,9	0,21	1,51	0,11	5,9	1,38	0,14	0,01	0,12
Lead												
M	13,07	1,80	13,8	9,0	0,27	0,62	1,82	6,3	0,63	0,17	0,02	0,16
M	7,63	1,22	16,0	9,4	0,46	0,94	3,29	5,9	0,92	0,17	0,01	0,29
F	4,00	0,47	11,8	11,8	0,33	0,78	3,25	15,5	0,73	0,20	0,03	0,43
F	4,88	0,66	13,5	12,1	0,35	0,70	2,44	7,4	1,17	0,04	0,02	0,25
F	3,43	0,52	15,2	18,7	0,35	0,96	3,91	9,0	1,79	0,06	0,03	0,44
F	2,51	0,40	15,9	16,7	0,32	0,84	3,71	9,2	1,12	0,04	0,04	0,68
F	5,17	0,76	14,7	14,3	0,21	1,01	3,87	6,2	1,32	0,06	0,02	0,25
F	3,71	0,58	15,6	13,7	0,32	0,84	3,80	8,6	1,04	0,13	0,03	0,38
F	3,89	0,59	15,2	13,6	0,28	0,74	3,08	7,5	1,49	0,15	0,03	0,21
F	2,80	0,49	17,5	13,9	0,32	1,07	4,07	9,6	1,81	0,04	0,04	0,29

Choromytilus meridionalis. Tissue-metal contentrations after 3 weeks exposure to each of 9 elements at 100 µg/l. (T=24 °C) (continued)

Sex	Wet mass g	Dry mass g	Dry mass %	Zn	Cd	Cu	µg metal/g wet tissue Pb	Fe	Mn	Ni	Co	Cr
Iron												
F	10,18	1,59	15,6	19,3	0,33	1,27	0,21	6,3	1,94	0,12	0,02	0,26
F	7,45	1,13	15,2	15,3	0,26	1,42	0,08	6,0	2,20	0,08	0,02	0,29
F	5,59	0,90	16,1	17,2	0,35	0,87	0,13	7,0	1,91	0,03	0,03	0,33
F	4,48	0,81	18,1	16,5	0,31	1,18	0,24	8,0	1,36	0,04	0,01	0,15
F	4,39	0,82	18,7	16,6	0,36	1,11	0,19	7,5	1,27	0,11	0,02	0,24
F	3,54	0,59	16,7	16,1	0,36	1,24	0,25	10,2	1,25	0,08	0,03	0,38
M	2,71	0,44	16,2	14,4	0,33	1,07	0,11	10,3	1,73	0,13	0,03	0,25
M	3,91	0,60	15,3	11,3	0,23	1,12	0,12	6,6	1,12	0,06	0,04	0,27
M	4,24	0,69	16,3	13,4	0,37	0,87	0,18	6,6	1,13	0,13	0,02	0,31
M	6,89	0,99	14,4	11,3	0,30	0,91	0,17	5,4	1,22	0,12	0,01	0,34
Manganese												
F	4,55	0,62	13,6	16,7	0,26	0,83	0,04	8,1	2,10	0,24	0,04	0,16
F	5,93	0,80	13,4	14,2	0,33	0,82	0,11	6,6	1,39	0,16	0,03	0,17
F	6,20	0,99	16,0	14,4	0,24	1,16	0,20	6,9	2,17	0,17	0,03	0,38
F	3,59	0,45	12,5	15,9	0,27	0,97	0,12	8,1	1,19	0,09	0,03	0,26
F	5,16	0,70	13,6	16,5	0,32	0,81	0,27	7,2	2,09	0,13	0,02	0,26
M	4,46	0,67	15,0	10,8	0,40	0,69	0,20	7,8	1,45	0,11	0,03	0,21
M	3,20	0,48	15,0	11,9	0,34	0,90	0,25	8.1	1,62	0,11	0,01	0,36
M	3,29	0,60	18,2	12,8	0,39	0,88	0,09	11,9	1,18	0,14	0,02	0,22
M	11,83	1,87	15,8	11,1	0,22	1,00	0,16	5,7	1,21	0,21	0,03	0,18
M	3,61	0,64	17,7	10,8	0,33	0,72	0,30	7,5	1,14	0,17	0,02	0,21
Nickel												
F	4,34	0,72	16,6	16,8	0,41	1,12	0,18	6,9	1,56	0,76	0,02	0,35
F	6,60	1,23	18,6	17,0	0,28	1,03	0,10	6,8	1,80	0,60	0,04	0,24
F	11,22	1,93	17,2	15,5	0,25	1,24	0,26	5,4	1,18	0,65	0,02	0,12
M	3,95	0,58	14,7	11,4	0,40	0,88	0,17	7,3	1,87	0,60	0,02	0,46
M	3,88	0,60	15,5	12,9	0,33	0,82	0,20	7,5	1,34	0,46	0,02	0,59
M	2,48	0,46	18,6	15,7	0,44	1,12	0,23	9,3	0,97	0,48	0,04	0,57
M	6,76	1,16	17,2	12,0	0,29	0,78	0,15	6,2	1,42	0,71	0,01	0,19
M	2,66	0,56	21,1	18,4	0,32	1,31	0,26	9,8	0,99	0,82	0,03	0,27
M	5,19	0,93	17,9	13,1	0,40	1,36	0,25	6,2	1,25	0,59	0,01	0,32
M	2,68	0,49	18,3	14,6	0,48	1,09	0,17	9,0	1,86	0,85	0,03	0,86
Cobalt												
F	15,35	1,62	10,6	10,2	0,22	0,78	0,13	4,8	1,40	0,14	0,22	0,33
F	11,15	1,74	15,1	13,2	0,26	0,85	0,21	5,9	1,24	0,14	0,26	0,46
F	4,88	0,72	14,8	12,7	0,36	0,65	0,14	6,6	1,47	0,16	0,57	0,28
F	4,13	0,66	16,0	13,1	0,26	0,87	0,24	6,8	1,45	0,12	0,38	0,19
F	4,72	0,68	14,4	14,4	0,23	0,74	0,15	6,4	1,75	0,06	0,44	0,23
F	3,91	0,48	12,3	11,3	0,30	0,74	0,25	6,4	1,58	0,15	0,40	0,17
F	3,12	0,44	14,1	15,7	0,38	0,89	0,18	6,4	1,66	0,12	0,44	0,36
F	3,86	0,60	15,5	14,2	0,33	0,98	0,23	6,2	1,26	0,18	0,28	0,18
F	5,18	0,81	15,6	13,3	0,28	0,75	0,15	6,0	1,67	0,13	0,44	0,25
F	3,50	0,55	15,7	15,1	0,42	0,80	0,22	8,3	1,57	0,12	0,40	0,47
Chromium												
M	3,80	0,49	12,9	11,3	0,21	0,57	0,13	6,3	1,00	0,05	0,02	0,52
M	5,28	0,76	14,4	11,9	0,22	0,68	0,13	6,1	1,55	0,17	0,01	0,37
M	7,60	1,22	16,1	10,4	0,22	0,75	0,15	7,1	1,65	0,07	0,01	0,84
F	3,87	0,59	15,3	14,5	0,31	0,74	0,12	8,0	1,96	0,12	0,02	0,31
F	10,70	1,47	13,7	13,4	0,20	0,85	0,09	5,1	1,25	0,11	0,01	0,28
F	6,57	0,96	14,6	19,6	0,24	0,93	0,18	7,8	1,10	0,08	0,03	0,64
F	10,19	1,73	17,0	15,1	0,21	0,90	0,05	7,2	1,06	0,09	0,01	0,53
F	3,76	0,59	15,7	15,7	0,29	0,96	0,13	7,4	1,59	0,03	0,03	0,66
F	4,34	0,62	14,3	14,3	0,30	0,85	0,12	8,8	1,17	0,07	0,02	0,51

<u>*Crassostrea gigas*</u>. Tissue-metal concentrations after 3 weeks exposure to zinc, cadmium and copper at 0, 10, 25 and 50 μg/l (T=24°C)

Wet mass g	Dry mass g	Dry mass %	μg metal/g wet tissue Zn	Cd	Cu	Pb	Fe	Mn
Control								
8,50	0,78	9,2	136	0,47	25,2	<0,1	15,2	0,89
8,58	0,82	9,6	191	0,42	22,9	<0,1	16,0	1,16
8,56	0,85	9,9	141	0,43	18,2	<0,1	16,9	1,56
9,63	1,16	12,0	111	0,43	17,1	<0,1	18,5	1,45
11,44	1,05	9,2	84	0,37	12,2	<0,1	11,1	1,02
10,37	0,90	8,7	60	0,31	10,5	<0,1	11,1	1,09
6,97	0,75	10,8	159	0,43	28,4	<0,1	18,2	1,54
7,20	0,73	10,1	172	0,49	29,2	<0,1	18,6	0,79
3,42	0,33	9,6	184	0,56	32,7	<0,1	29,2	1,04
10,05	0,97	9,7	128	0,33	16,5	<0,1	11,8	1,37
17,22	1,80	10,5	41	0,28	7,5	<0,1	11,5	0,81
6,77	0,74	10,9	112	0,46	18,6	<0,1	18,5	1,41
7,48	0,79	10,6	155	0,47	21,7	<0,1	15,6	1,49
7,19	0,63	8,8	164	0,43	19,9	<0,1	15,2	1,79
5,00	0,58	11,6	100	0,44	19,0	<0,1	19,8	1,35
9,85	0,91	9,2	184	0,42	25,5	<0,1	12,1	2,01
6,83	0,54	7,9	69	0,40	11,0	<0,1	18,6	0,78
7,39	0,68	10,0	93	0,51	16,6	<0,1	12,9	1,03
4,40	0,42	9,5	164	0,48	23,0	<0,1	19,5	2,18
12,02	1,24	10,3	119	0,37	12,4	<0,1	12,8	1,71
11,23	1,28	11,4	89	0,24	17,6	<0,1	11,8	0,75
8,76	0,84	9,6	130	0,38	14,3	<0,1	15,6	1,69
6,08	0,76	12,5	174	0,54	36,7	<0,1	21,1	1,48
10,52	0,68	6,5	104	0,45	9,5	<0,1	12,5	1,03
6,86	0,68	9,9	74	0,39	9,2	<0,1	18,5	1,34
11,57	1,02	8,8	135	0,43	11,6	<0,1	12,2	1,94
9,98	0,59	5,9	172	0,34	18,9	<0,1	12,4	1,44
6,76	0,32	4,7	203	0,47	30,5	<0,1	17,0	1,12
8,22	0,55	6,7	124	0,51	14,7	<0,1	20,4	2,22
11,21	0,84	7,5	173	0,43	26,3	<0,1	14,5	1,16
2,54	0,30	11,8	150	0,51	30,7	<0,1	29,9	0,75
8,81	0,58	6,6	182	0,49	18,5	<0,1	17,0	1,75
5,70	0,41	7,2	186	0,65	34,2	<0,1	23,0	1,29
10,40	0,81	7,8	161	0,46	19,6	<0,1	18,2	1,93
8,25	0,94	11,4	133	0,38	16,8	<0,1	13,6	1,60
9,06	0,86	9,4	129	0,42	18,5	<0,1	13,2	1,19
5,54	0,65	11,7	278	0,49	37,4	<0,1	21,5	1,31
8,38	0,79	9,4	125	0,41	16,0	<0,1	11,5	1,09
7,45	0,91	12,2	181	0,52	18,0	<0,1	19,3	2,94
8,50	0,95	11,2	193	0,41	20,2	<0,1	16,7	3,13
5,52	0,63	11,4	132	0,58	16,5	<0,1	23,7	1,91
14,10	1,43	10,1	137	0,44	12,8	<0,1	15,2	1,39
5,91	0,62	10,4	179	0,49	20,8	<0,1	17,3	1,77
11,21	1,10	9,8	108	0,36	10,8	<0,1	12,5	1,28
7,19	0,69	9,6	211	0,46	23,5	<0,1	17,8	1,95
10,19	1,12	11,0	132	0,43	12,4	<0,1	13,2	1,52
8,23	1,01	12,3	171	0,49	21,5	<0,1	21,9	2,49
12,12	1,44	11,9	101	0,37	18,3	<0,1	12,8	1,91
12,65	1,51	12,0	142	0,36	14,6	<0,1	15,8	1,71
7,86	0,86	10,9	148	0,46	14,8	<0,1	14,9	2,31
0,57	0,06	10,9	148	0,60	69,0	0,15	19,6	0,98
0,43	0,04	9,3	175	0,64	58,0	0,10	20,0	0,76
0,37	0,04	10,8	214	0,57	71,0	0,15	17,6	1,25
0,29	0,03	10,3	197	0,62	63,0	0,10	21,0	1,76

Crassostrea gigas. Tissue-metal concentrations after 3 weeks exposure to zinc, cadmium and copper at 0, 10, 25 and 50 µg/l (T=24°C) (continued)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue Zn	Cd	Cu	Pb	Fe	Mn
Zinc, cadmium and copper, each at 10 µg/l								
8,18	0,97	11,9	112	8,3	61	<0,1	20,8	1,05
10,32	1,09	10,6	120	5,5	41	<0,1	17,4	1,76
5,66	0,75	13,3	200	8,8	78	<0,1	24,7	1,68
9,45	0,91	9,6	94	6,3	30	<0,1	21,2	1,81
7,06	0,67	9,5	154	8,6	52	<0,1	26,9	2,06
10,00	1,12	11,2	231	7,9	63	<0,1	14,5	1,40
7,65	0,83	10,9	165	6,3	51	<0,1	19,9	2,20
9,77	0,95	9,7	118	5,1	33	<0,1	17,5	1,82
8,52	1,01	11,9	150	5,5	45	<0,1	18,4	1,60
5,46	0,53	9,7	154	7,5	60	<0,1	28,0	1,05
7,32	0,61	8,3	173	3,6	36	<0,1	16,9	1,29
8,86	0,79	8,9	148	5,0	45	<0,1	15,0	1,55
5,86	0,66	11,3	155	5,5	48	<0,1	18,4	2,00
7,05	0,66	9,4	206	6,4	69	<0,1	20,7	1,19
8,65	0,76	8,8	216	6,4	72	<0,1	15,2	1,39
8,16	0,76	9,3	143	5,6	43	<0,1	17,8	1,33
7,30	0,76	10,4	190	5,2	41	<0,1	20,4	1,70
13,86	1,24	8,9	83	6,0	32	<0,1	10,9	0,65
4,69	0,50	10,7	211	9,2	85	<0,1	23,2	1,13
9,30	0,92	9,9	127	7,6	49	<0,1	16,0	1,95
5,93	0,62	10,5	121	5,9	29	<0,1	23,9	2,31
5,79	0,62	10,7	193	8,8	79	<0,1	21,9	4,83
8,24	0,78	9,5	81	5,5	36	<0,1	14,4	2,18
8,94	0,97	10,9	235	7,7	60	<0,1	17,3	1,33
6,15	0,65	10,6	270	7,0	68	<0,1	7,6	1,26
8,50	0,74	8,71	118	4,6	32	<0,1	15,1	1,22
4,87	0,52	10,68	216	10,1	76	<0,1	23,7	1,66
4,81	0,52	10,81	146	8,5	48	<0,1	20,4	1,79
4,84	0,55	11,4	248	8,3	52	<0,1	19,8	1,82
5,00	0,43	8,6	64	12,0	18	<0,1	23,8	1,92
7,69	0,81	10,5	229	10,1	74	<0,1	26,8	2,02
7,69	0,78	10,1	72	7,3	40	<0,1	16,6	1,37
3,98	0,36	9,0	118	3,8	125	<0,1	20,6	1,40
9,41	0,77	8,2	137	5,0	29	<0,1	11,5	1,19
6,70	0,65	9,7	145	4,8	36	<0,1	16,7	1,44
15,65	1,52	9,7	132	3,3	31	<0,1	10,6	1,71
4,66	0,44	9,4	311	4,9	56	<0,1	20,8	1,39
11,32	1,15	10,2	164	7,1	55	<0,1	12,5	1,10
3,72	0,33	8,9	91	4,8	32	<0,1	33,3	1,37
11,45	1,32	11,5	84	5,7	38	<0,1	14,6	0,92
5,90	0,59	10,0	207	8,3	64	<0,1	19,2	1,58
11,44	1,26	11,0	153	9,1	52	<0,1	13,2	1,26
6,28	0,60	9,6	91	7,3	38	<0,1	18,3	1,39
11,85	1,25	10,5	129	6,8	39	<0,1	13,9	1,39
10,81	0,87	8,0	217	6,2	57	<0,1	13,1	1,17
7,52	0,69	9,2	134	7,3	44	<0,1	20,6	2,07
5,40	0,44	8,1	87	9,8	30	<0,1	14,1	1,51
11,03	1,11	10,1	147	6,0	38	<0,1	13,2	1,89
9,68	0,69	7,1	101	4,7	31	<0,1	15,0	1,43
10,96	0,80	7,3	151	4,0	36	<0,1	11,4	1,31
8,36	0,74	8,9	179	8,4	74	<0,1	14,0	1,61
15,44	1,61	10,4	106	4,7	27	<0,1	16,7	1,61
0,29	0,03	10,3	312	7,4	89	0,15	17,3	0,87
0,56	0,06	10,7	208	3,6	163	0,15	19,1	0,99
0,44	0,04	9,1	190	5,0	77	0,20	14,7	1,61
0,37	0,04	10,8	179	4,8	112	0,15	20,0	1,51

Crassostrea gigas. Tissue-metal concentrations after 3 weeks exposure to zinc, cadmium and copper at 0, 10, 25 and 50 µg/l (T=24°C) (continued)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue Zn	Cd	Cu	Pb	Fe	Mn
Zinc, cadmium and copper, each at 25µg/l								
7,24	1,07	14,8	170	20,7	170	<0,1	20,7	1,75
11,39	1,22	10,7	97	15,1	119	<0,1	14,9	1,04
5,78	0,69	11,9	256	14,0	133	<0,1	31,1	3,49
8,65	0,75	8,7	118	9,6	88	<0,1	19,7	1,05
10,49	1,03	9,8	169	11,7	102	<0,1	20,0	1,82
9,86	0,89	9,0	143	10,6	95	<0,1	17,2	0,96
7,30	0,81	11,1	178	12,7	129	<0,1	23,3	1,54
10,42	1,02	9,8	137	10,7	113	<0,1	17,3	0,89
4,05	0,45	11,1	274	11,9	151	<0,1	34,6	2,32
17,61	2,80	15,9	139	8,2	72	<0,1	14,8	1,45
10,15	1,00	9,9	163	12,9	116	<0,1	18,7	0,97
10,60	1,03	9,7	115	14,9	101	<0,1	18,9	0,83
4,61	0,54	11,7	215	15,0	139	<0,1	34,7	2,01
15,52	1,70	11,0	101	14,1	108	<0,1	16,8	1,37
7,27	0,86	11,8	195	12,8	125	<0,1	16,5	1,75
12,52	1,32	10,5	118	14,1	86	<0,1	13,6	1,45
5,33	0,69	12,9	197	18,0	68	<0,1	28,1	1,63
14,17	1,62	11,4	186	13,7	97	<0,1	12,5	1,45
8,08	0,84	10,4	151	9,0	98	<0,1	18,6	1,41
12,13	1,28	10,6	73	10,7	74	<0,1	15,7	1,51
4,08	0,53	13,0	110	15,0	83	<0,1	31,9	1,04
11,28	1,30	11,5	141	11,3	99	<0,1	16,8	1,77
6,38	0,76	11,9	96	12,5	102	<0,1	23,5	1,61
9,93	1,20	12,1	195	15,1	153	<0,1	17,1	0,87
9,16	0,77	8,4	168	11,8	107	<0,1	18,6	1,42
9,60	0,93	9,7	169	13,6	97	<0,1	17,7	1,33
7,25	0,75	10,3	171	13,9	103	<0,1	23,4	1,51
9,51	0,95	10,0	101	10,0	76	<0,1	17,9	0,89
6,00	0,62	10,3	153	10,8	107	<0,1	23,3	1,36
9,00	0,90	10,0	142	11,9	80	<0,1	20,0	1,68
5,00	0,45	9,0	162	12,8	104	<0,1	26,0	1,86
17,64	1,86	10,5	151	12,6	98	<0,1	13,6	1,38
7,26	0,67	9,2	186	14,2	105	<0,1	22,0	1,99
9,28	0,90	9,7	150	12,9	114	<0,1	17,2	1,37
7,00	0,74	10,6	160	15,6	101	<0,1	21,4	1,47
6,00	0,63	9,0	183	16,8	146	<0,1	23,3	0,82
5,93	0,64	10,8	206	13,7	115	<0,1	25,3	2,31
5,87	0,48	8,2	187	13,3	129	<0,1	23,9	1,08
8,68	0,72	8,3	183	9,7	73	<0,1	19,6	1,33
5,77	0,50	8,7	135	15,3	120	<0,1	19,1	1,61
5,91	0,57	9,6	124	19,3	68	<0,1	22,0	1,25
14,57	1,74	11,9	177	12,1	127	<0,1	14,4	1,04
8,65	1,03	11,9	96	8,9	67	<0,1	13,9	1,14
12,59	1,31	10,4	125	8,7	68	<0,1	18,3	1,65
7,00	0,51	7,3	121	14,4	119	<0,1	20,0	1,35
10,21	1,08	10,6	166	17,7	153	<0,1	19,6	1,36
4,56	0,48	10,5	241	19,7	182	<0,1	26,3	1,58
7,09	0,74	10,4	216	16,2	148	<0,1	19,7	0,98
5,77	0,64	11,1	286	17,5	153	<0,1	22,5	1,79
6,61	0,66	10,0	157	12,7	101	<0,1	21,2	2,41
7,59	0,84	11,1	245	12,6	111	<0,1	25,0	1,48
5,70	0,60	10,5	214	18,2	137	<0,1	22,8	1,06
1,96	0,22	11,2	321	43,4	413	<0,1	35,7	1,51
1,63	0,19	11,7	276	36,2	325	<0,1	30,7	1,12
0,26	0,03	11,5	342	48,7	143	0,15	27,6	1,18
0,61	0,06	9,8	231	37,9	379	<0,1	23,2	0,58
0,48	0,05	9,4	253	51,2	333	0,15	19,0	1,50
0,34	0,03	8,8	198	44,4	440	0,20	30,4	1,61
0,26	0,03	11,5	342	48,7	385	0,15	27,6	1,18

<u>Crassostrea</u> <u>gigas</u>. Tissue-metal concentrations after 3 weeks exposure to zinc, cadmium and copper at 0, 10, 25 and 50 µg/l (T=24°C) (continued)

Wet mass g	Dry mass g	Dry mass %	Zn	Cd	Cu	Pb	Fe	Mn
			µg metal/g wet tissue					
Zinc, cadmium and copper, each at 50 µg/l								
8,81	0,80	9,1	135	21,3	244	<0,1	10,4	0,91
9,66	0,80	8,3	106	11,6	138	<0,1	9,8	1,19
5,54	0,53	9,6	245	12,6	195	<0,1	17,9	0,81
12,23	1,13	9,2	146	15,2	141	<0,1	10,4	0,90
8,08	0,74	9,2	215	15,3	225	<0,1	14,7	1,17
13,31	1,18	8,9	116	20,9	183	<0,1	10,4	0,94
9,42	0,76	8,1	143	11,4	188	<0,1	14,5	0,89
10,32	1,02	9,9	169	17,9	207	<0,1	12,6	0,94
4,62	0,38	8,2	119	22,3	214	<0,1	18,2	0,42
10,92	1,03	9,4	141	22,2	234	<0,1	12,7	0,99
10,45	0,97	9,3	206	18,1	215	<0,1	13,8	0,67
8,00	0,77	9,6	160	18,6	263	<0,1	14,0	1,14
7,15	0,66	9,2	241	16,6	235	<0,1	17,2	1,21
11,03	1,10	10,0	198	16,6	227	<0,1	13,5	1,53
8,49	0,71	8,4	153	16,0	194	<0,1	14,8	1,23
10,16	0,84	8,3	139	16,1	214	<0,1	12,5	1,03
8,20	0,74	9,0	152	15,7	190	<0,1	14,1	0,95
7,93	0,69	8,7	144	18,2	266	<0,1	13,4	0,71
9,70	0,85	8,8	167	14,7	240	<0,1	11,0	1,65
14,48	1,41	9,7	113	17,8	181	<0,1	9,2	1,27
4,11	0,39	9,5	190	21,7	307	<0,1	20,7	1,40
18,10	1,76	9,7	150	12,7	154	<0,1	9,9	1,22
8,82	0,79	9,0	141	21,0	277	<0,1	13,5	0,73
8,99	0,78	8,7	130	16,4	142	<0,1	13,1	0,58
11,24	0,97	8,6	181	13,5	195	<0,1	12,1	0,93
11,20	1,04	9,3	134	18,0	189	<0,1	13,5	0,90
9,91	0,83	8,4	119	14,6	174	<0,1	13,6	0,95
10,80	0,89	8,2	87	9,6	119	<0,1	9,7	0,63
6,38	0,73	11,4	295	22,9	259	<0,1	23,8	2,62
12,25	1,23	10,0	150	15,3	143	<0,1	16,0	1,74
2,18	0,22	10,1	257	32,6	339	<0,1	24,3	1,36
18,67	1,60	8,6	85	15,1	133	<0,1	9,0	1,00
8,20	0,81	9,9	174	21,0	172	<0,1	13,0	1,06
12,11	1,08	8,9	157	15,5	156	<0,1	12,9	1,53
10,39	1,01	9,7	196	17,0	227	<0,1	11,5	1,78
11,80	1,11	9,4	218	18,9	174	<0,1	11,9	1,13
7,36	0,63	8,6	179	12,4	164	<0,1	14,4	1,08
7,63	0,72	9,4	244	16,9	199	<0,1	16,1	1,67
9,01	0,74	8,2	176	16,3	211	<0,1	13,2	0,81
7,08	0,67	9,5	202	16,5	192	<0,1	12,0	0,74
7,72	0,79	10,2	337	23,1	205	<0,1	13,6	1,28
11,97	1,11	9,3	141	13,3	197	<0,1	13,0	1,58
8,36	0,76	9,1	199	14,5	185	<0,1	15,1	1,19
8,67	0,75	8,7	258	15,7	220	<0,1	18,3	1,58
9,61	1,02	10,6	256	21,2	248	<0,1	13,8	1,74
14,27	1,51	10,6	145	12,8	150	<0,1	12,0	1,41
11,72	1,07	9,1	57	15,4	200	<0,1	11,6	0,85
8,24	0,57	6,9	212	9,7	175	<0,1	13,2	0,92
9,55	0,89	9,3	143	15,3	150	<0,1	10,9	0,87
8,78	0,90	10,3	84	24,4	202	<0,1	18,2	1,16
1,41	0,15	10,6	170	51,0	429	<0,1	15,6	1,44
1,00	0,07	7,0	216	47,2	538	<0,1	18,6	0,28
0,77	0,07	9,1	131	46,4	556	<0,1	20,9	0,36
0,47	0,04	9,2	242	38,5	418	<0,1	14,8	0,33
0,25	0,03	12,0	200	48,0	535	0,15	21,1	1,45
0,27	0,03	11,1	274	55,0	488	0,15	17,8	0,98

Crassostrea margaritacea. Tissue metal concentrations after 3 weeks exposure to 0, 10, 25 and 50 µg/l. of a mixture of zinc, cadmium and copper. (T=24°C)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
Control								
6,32	0,70	11,1	130	0,96	0,79	0,03	5,1	0,33
7,15	0,83	11,6	144	0,81	3,81	0,01	6,3	0,39
6,05	0,55	9,1	149	0,89	0,84	0,01	4,5	0,38
5,85	0,55	9,4	140	1,29	2,97	0,03	5,0	0,58
6,65	0,76	11,4	150	0,90	1,21	0,06	5,3	0,27
8,67	0,83	9,6	142	1,00	1,30	0,02	3,3	0,25
5,28	0,42	8,0	112	1,14	1,85	0,01	5,5	0,22
6,80	0,70	10,3	75	0,73	1,60	0,01	6,2	0,14
6,42	0,69	10,7	153	0,82	0,77	0,06	4,8	0,17
7,01	0,65	9,3	146	1,14	4,05	0,04	6,3	0,51
4,87	0,50	10,3	183	0,84	5,72	0,08	6,8	0,36
6,64	0,67	10,1	108	0,82	2,39	0,01	4,8	0,22
7,69	0,67	8,7	88	0,74	1,07	0,03	6,0	0,13
5,03	0,38	7,6	181	0,65	1,35	0,05	4,6	0,13
8,75	0,78	8,9	86	0,75	1,38	0,10	6,4	0,22
6,66	0,58	8,7	116	0,85	2,92	0,01	4,5	0,33
5,91	0,51	8,6	83	0,76	2,06	0,01	4,9	0,21
9,42	0,98	10,1	176	0,82	1,82	0,04	5,4	0,22
Zinc, cadmium and copper, each at 10 µg/l								
4,82	0,66	13,7	145	3,11	10,4	0,02	5,2	0,37
4,69	0,62	13,2	105	1,64	2,9	0,04	6,2	0,25
4,04	0,45	11,1	158	3,26	9,4	0,07	6,4	0,22
2,54	0,26	10,2	161	1,05	13,4	0,03	7,5	0,23
4,26	0,45	10,6	157	3,07	9,4	0,02	5,9	0,18
6,40	0,76	11,9	219	2,31	10,8	0,06	6,1	0,20
3,37	0,47	13,9	104	3,38	7,4	0,08	11,3	0,26
9,48	0,99	10,4	113	1,42	2,5	0,06	3,6	0,36
5,71	0,54	9,5	138	2,24	3,1	0,05	3,7	0,14
7,02	0,61	8,7	95	1,23	1,1	0,04	2,7	0,11
5,21	0,47	9,0	146	2,20	8,4	0,01	4,8	0,23
5,08	0,51	10,0	134	1,81	2,3	0,03	5,5	0,29
4,86	0,62	12,8	163	9,05	25,3	0,08	10,1	0,24
5,04	0,45	8,9	141	3,03	12,9	0,05	5,2	0,27
4,14	0,40	9,7	156	2,48	8,7	0,04	6,3	0,26
5,65	0,65	11,5	104	3,30	9,0	0,03	4,4	0,17
4,67	0,53	11,3	77	2,80	5,1	0,08	9,6	0,19
5,61	0,68	12,1	89	3,88	14,3	0,10	4,5	0,17
6,45	0,72	11,2	76	2,69	6,4	0,04	3,7	0,31
5,91	0,65	10,9	176	2,53	8,6	0,03	5,4	0,23
3,86	0,36	9,3	280	3,16	11,4	0,07	10,6	0,25

Crassostrea margaritacea. Tissue metal concentrations after 3 weeks exposure to 0, 10, 25 and 50 µg/l. of a mixture of zinc, cadmium and copper. (T=24°C) (continued)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
Zinc, cadmium and copper, each at 25 µg/l								
4,47	0,42	9,4	262	4,5	26,4	0,04	5,6	0,08
5,67	0,56	9,9	123	4,8	37,9	0,01	3,5	0,14
8,30	0,83	10,0	86	4,9	22,5	0,01	3,3	0,20
6,06	0,56	9,2	101	2,8	12,0	0,01	5,6	0,19
4,61	0,48	10,4	93	7,8	41,4	0,02	4,8	0,28
5,42	0,50	9,2	105	5,9	28,8	0,01	4,8	0,35
3,00	0,23	7,7	143	6,0	20,3	0,03	6,0	0,20
6,39	0,69	10,8	121	7,5	39,0	0,06	4,5	0,26
3,71	0,34	9,2	78	5,1	9,7	0,02	6,2	0,26
6,04	0,64	10,6	219	5,8	41,6	0,01	4,8	0,24
4,13	0,41	9,9	73	7,5	30,3	0,02	5,1	0,26
4,24	0,52	12,3	137	9,0	49,5	0,02	6,6	0,66
5,17	0,44	8,5	139	3,1	13,0	0,03	4,4	0,17
6,04	0,82	13,6	136	4,1	19,7	0,03	7,0	0,16
7,03	0,60	8,5	117	2,8	6,3	0,02	3,6	0,15
5,25	0,60	11,4	114	3,2	14,5	0,03	3,6	0,36
5,42	0,53	9,8	144	3,3	14,6	0,01	4,1	0,33
4,88	0,61	12,5	207	5,5	24,0	0,02	5,9	0,40
6,16	1,05	17,0	96	8,8	43,7	0,12	6,2	0,40
3,33	0,50	15,0	177	10,8	61,0	0,06	7,8	0,41
4,28	0,51	11,9	180	6,8	33,9	0,04	6,8	0,51
3,93	0,60	15,3	155	4,1	13,0	0,02	9,2	0,68
5,87	0,67	11,4	210	3,1	22,3	0,01	5,8	0,28
3,83	0,47	12,3	144	5,7	30,8	0,02	7,8	0,31
Zinc, cadmium and copper, each at 50 µg/l								
4,28	0,66	15,4	131	7,9	57,2	0,04	9,6	0,23
4,28	0,48	11,2	138	5,8	35,3	0,04	7,0	1,16
4,42	0,60	13,6	199	5,7	34,8	0,02	8,8	0,36
2,48	0,49	19,8	190	12,1	149,2	0,04	12,1	0,76
3,79	0,46	12,1	150	5,0	22,2	0,02	9,0	0,47
2,47	0,30	12,1	198	8,5	65,6	0,04	11,3	0,32
4,62	0,50	10,8	169	5,8	42,2	0,02	6,7	0,28
4,28	0,53	12,4	129	6,1	57,2	0,02	5,1	0,61
3,86	0,50	13,0	69	8,0	56,7	0,05	10,6	0,28
4,35	0,50	11,5	92	5,7	33,6	0,04	9,4	0,22
4,02	0,52	12,9	90	7,5	48,5	0,04	7,7	0,14
2,96	0,41	13,9	146	7,8	58,4	0,03	9,1	0,23
3,43	0,41	12,0	146	6,7	44,6	0,11	6,4	0,32
4,46	0,65	14,6	204	4,9	23,5	0,08	7,4	0,65
4,65	0,67	14,4	107	7,3	81,7	0,04	7,1	0,90
6,26	0,81	12,9	174	4,8	32,2	0,05	10,1	0,62
6,59	0,93	14,1	116	5,1	28,9	0,11	8,2	0,35
5,43	0,70	12,9	162	4,7	53,5	0,10	9,5	0,74
6,84	0,90	13,2	133	4,2	47,6	0,08	9,6	0,48
7,99	1,02	12,8	138	2,70	38,8	0,05	11,4	0,39
9,23	1,21	13,1	141	3,08	31,4	0,06	9,8	0,24

Perna perna. Tissue-metal concentrations after 3 weeks exposure to zinc, cadmium and copper at 0, 10 and 25 µg/l (T=24°C)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
Control								
5,38	0,47	8,7	6,7	0,70	0,98	0,03	13,0	0,16
3,30	0,34	10,3	8,2	1,00	1,03	0,06	21,2	0,27
5,17	0,47	9,1	8,3	0,75	1,51	0,05	21,1	0,24
2,15	0,26	12,1	10,7	0,51	1,44	0,18	18,6	0,27
1,50	0,15	10,0	8,0	0,40	0,93	0,06	20,0	0,26
6,90	0,70	10,1	14,2	0,83	0,97	0,09	19,9	0,22
7,12	0,63	8,9	6,6	0,55	0,73	0,05	22,2	0,31
1,88	0,20	10,6	13,3	0,63	0,90	0,11	26,6	0,31
1,87	0,19	10,2	10,7	0,90	0,85	0,10	26,7	0,26
1,77	0,20	11,3	8,5	0,33	1,01	0,11	11,3	0,67
1,44	0,13	9,0	13,2	0,41	1,04	0,06	27,8	0,55
2,02	0,23	11,4	10,4	0,84	0,79	0,14	24,8	0,44
1,50	0,17	11,3	9,3	0,60	0,73	0,06	20,0	0,20
3,61	0,34	9,4	5,5	0,99	0,96	0,11	24,9	0,27
3,34	0,38	11,4	7,5	0,62	0,80	0,08	17,9	0,26
2,55	0,21	8,2	13,9	0,66	0,58	0,03	19,6	0,19
2,21	0,21	9,5	7,7	0,58	0,63	0,04	18,1	0,27
2,00	0,15	7,5	10,0	0,30	0,80	0,03	20,0	0,35
1,82	0,15	8,2	9,9	0,49	0,87	0,16	21,9	0,38
1,70	0,13	7,6	7,1	0,35	0,64	0,17	17,6	0,29
1,37	0,18	13,1	9,4	0,51	1,02	0,14	21,8	0,43
3,35	0,37	11,0	12,2	0,71	0,80	0,14	23,8	0,32
5,64	0,72	12,8	8,1	0,60	0,92	0,10	21,2	0,24
2,94	0,35	11,9	10,5	0,54	0,71	0,06	20,4	0,30
2,45	0,26	10,6	6,9	0,65	1,14	0,12	20,4	0,28
2,86	0,26	9,1	4,8	0,83	0,80	0,03	20,9	0,24
2,25	0,22	9,8	9,3	0,66	0,80	0,04	22,2	0,26
2,20	0,28	12,7	7,7	0,68	1,04	0,09	13,6	0,22
0,86	0,10	11,6	8,1	0,81	1,16	0,11	34,8	0,23
1,88	0,24	12,7	11,7	0,58	0,79	0,05	15,9	0,26
7,31	0,83	11,3	11,0	0,83	0,97	0,08	25,9	0,41
2,92	0,34	11,6	16,7	0,54	0,99	0,03	17,1	0,44
1,38	0,08	5,8	13,0	0,65	1,45	0,04	31,9	0,47
Zinc, cadmium and copper, each at 10 µg/l								
4,80	0,67	14,0	21,8	2,35	3,54	0,14	12,5	0,41
6,44	0,86	13,4	19,3	2,20	2,26	0,12	15,5	0,31
5,13	0,60	11,7	18,3	2,34	3,61	0,16	23,4	0,32
10,09	1,16	11,5	14,9	1,63	3,12	0,10	17,8	0,25
5,23	0,63	12,1	11,9	2,07	3,48	0,10	20,3	0,35
3,87	0,58	15,0	21,7	2,19	3,35	0,07	15,5	0,43
4,09	0,58	14,2	8,1	2,12	3,47	0,04	19,6	0,39
5,00	0,54	10,8	8,8	1,64	3,26	0,05	23,4	0,38
10,15	1,15	11,3	7,9	1,80	1,99	0,04	20,1	0,29
4,43	0,54	12,2	13,8	2,30	3,95	0,07	17,2	0,35
6,61	0,75	11,4	6,8	1,71	2,59	0,07	16,8	0,24
6,54	0,73	11,2	11,8	2,35	2,98	0,11	24,3	0,29
5,10	0,58	11,4	16,7	2,25	3,04	0,10	19,1	0,27
4,34	0,72	16,6	9,2	2,10	2,13	0,08	19,1	0,18
5,19	0,95	18,3	12,5	2,10	2,52	0,05	19,1	0,28
6,34	0,84	13,2	15,5	2,83	4,57	0,12	14,2	0,28
3,89	0,48	12,3	19,8	3,13	5,19	0,20	18,0	0,33
4,05	0,37	9,1	18,0	3,53	6,05	0,08	30,4	0,47
3,44	0,47	13,7	15,4	3,02	5,64	0,09	30,8	0,74
2,34	0,26	11,1	12,0	2,39	3,88	0,08	17,1	0,32
Zinc, cadmium and copper each at 25 µg/l								
1,00	0,15	15,0	15,0	5 ,6	27,3	0,30	23,0	1,10
1,02	0,11	10,8	18,6	6 ,1	16,4	0,19	21,6	0,29
0,34	0,04	11,8	14,7	4 ,4	29,7	0,18	38,2	1,17
2,39	0,24	10,0	12,1	3 ,8	18,1	0,09	16,5	0,33
5,37	0,50	9,3	11,4	4 ,9	20,0	0,14	20,0	0,58
6,41	0,63	9,8	8,8	3 ,2	17,5	0,08	14,6	0,91
3,85	0,39	10,1	14,3	3 ,9	11,9	0,17	21,9	0,62

Choromytilus meridionalis. Tissue-metal concentrations after 3 weeks exposure to zinc, cadmium and copper at 0, 10, 25 and 50 µg/l (T=24°C)

Wet mass g	Dry mass g	Dry mass %	µg metal/g wet tissue					
			Zn	Cd	Cu	Pb	Fe	Mn
Control								
5,34	0,77	14,4	12,2	0,24	1,77	0,07	5,4	0,93
18,88	2,59	13,7	9,1	0,39	1,21	0,06	6,6	0,63
7,17	1,08	15,1	10,6	0,22	1,26	0,02	5,9	0,93
5,04	0,76	15,1	12,1	0,23	1,30	0,01	7,9	0,97
5,37	0,69	12,8	10,1	0,24	1,26	0,03	5,4	0,76
4,00	0,57	14,3	11,8	0,25	1,25	0,10	7,3	0,67
4,93	0,73	14,8	12,4	0,26	2,47	0,02	4,9	1,31
2,96	0,50	16,9	12,5	0,33	1,65	0,03	9,1	1,41
5,92	0,82	13,9	10,6	0,28	1,31	0,03	5,7	0,77
Zinc, cadmium, and copper, each at 10 µg/l								
7,10	0,76	10,7	9,3	0,95	1,74	0,09	5,6	1,35
5,68	0,74	13,0	10,6	0,91	1,95	0,19	6,3	1,67
5,75	0,69	12,0	12,5	0,90	3,27	0,12	6,1	1,15
5,56	0,75	13,5	12,6	0,90	3,92	0,23	5,0	0,54
4,07	0,61	15,0	14,0	0,96	3,56	0,10	6,9	1,57
2,85	0,39	13,7	13,0	0,91	4,25	0,18	8,8	1,23
0,84	0,11	13,1	10,7	1,31	4,17	0,71	15,5	1,79
2,00	0,28	14,0	11,0	1,35	2,90	0,20	8,0	1,23
2,32	0,30	13,0	14,2	1,25	2,93	0,17	11,2	0,82
3,84	0,53	13,8	11,5	1,22	2,21	0,31	6,5	1,41
3,93	0,53	13,5	10,2	0,89	4,27	0,20	8,1	1,17
5,09	0,74	14,5	11,4	1,04	3,14	0,18	7,9	1,02
5,48	0,75	13,7	11,7	0,89	2,34	0,07	6,9	1,31
15,50	1,93	12,5	9,1	0,95	1,12	0,04	4,6	0,98
Zinc, cadmium and copper, each at 25 µg/l								
8,65	1,28	14,8	16,1	1,45	13,0	0,10	5,9	1,13
1,82	0,21	11,5	11,0	2,31	12,6	0,16	9,9	1,04
3,03	0,48	15,8	14,9	1,88	17,0	0,07	8,6	1,39
4,69	0,58	12,4	9,2	1,83	9,1	0,06	7,0	0,81
3,00	0,35	11,7	10,0	1,97	21,3	0,03	9,3	0,40
3,32	0,47	14,2	16,6	1,57	12,0	0,09	8,4	1,26
4,78	0,57	11,9	10,7	2,07	13,4	0,04	9,8	0,59
5,16	0,68	13,2	10,9	1,39	8,7	0,03	6,2	0,91
4,21	0,51	12,1	12,4	2,80	22,3	0,07	7,4	1,02
5,47	0,54	9,9	9,3	1,95	9,9	0,01	5,9	0,73
5,46	0,66	12,1	9,5	1,90	14,5	0,07	6,4	0,61
10,61	1,28	12,1	10,7	2,18	19,2	0,34	6,2	1,21
3,79	0,45	11,9	11,3	2,21	17,9	0,23	6,6	1,50
4,72	0,64	13,6	10,2	1,52	16,1	0,08	7,0	1,65
2,24	0,27	12,1	11,2	1,87	12,7	0,04	9,4	1,02
0,51	0,06	11,8	13,7	2,35	25,1	0,08	13,5	2,54

<u>Crassostrea margaritacea</u>. Accumulation of metals complexed with EDTA

Wet mass g	Dry mass g	Dry mass %	µg metal / g wet tissue							
			Zn	Cd	Cu	Pb	Ca	Mg	Na	K
Control										
6,09	1,11	18,2	120	1,26	7,55	0,45	400	290	6896	2003
7,60	1,19	15,7	97	1,07	7,50	0,40	160	290	7368	1474
8,56	1,21	14,1	96	0,98	9,46	0,51	210	290	7710	1600
7,04	1,22	17,3	104	1,29	7,38	0,39	170	300	7386	1832
4,43	0,72	16,3	151	1,37	5,64	1,42	420	290	7900	1557
5,36	0,74	13,8	110	1,06	9,51	0,55	180	330	8582	1660
6,08	0,97	16,0	49	0,54	2,46	0,34	80	130	3125	822
5,71	0,87	15,2	112	1,20	6,83	0,33	190	310	8406	1524
6,53	0,99	15,2	150	1,25	10,87	0,27	250	320	8269	1485
0,93	0,14	15,1	64	1,72	13,97	0,96	570	430	8602	3225
Control - EDTA										
9,51	1,59	16,7	183	1,16	1,26	0,15	250	290	7676	1440
9,41	1,49	15,8	94	1,09	7,12	0,28	160	310	8076	1583
7,05	1,11	15,7	188	1,64	2,69	0,26	190	330	7801	1560
6,46	1,10	17,0	128	1,13	2,16	0,10	170	310	7895	1656
4,86	0,73	15,0	92	1,09	3,29	0,16	230	330	8642	1584
9,37	1,72	18,4	84	1,03	5,65	0,14	280	300	7577	1676
8,93	1,94	21,7	54	1,43	0,91	0,33	320	290	6943	1993
6,47	1,10	17,0	113	1,39	8,19	0,30	280	310	7573	1777
10,53	1,62	15,4	172	1,50	2,46	0,32	180	310	8072	1529
3,81	0,46	12,1	68	0,91	5,51	0,13	330	310	8661	1496
Zinc 200 µg/l										
11,76	1,60	13,6	129	0,92	2,80	1,49	210	290	8333	1445
15,90	1,99	12,5	131	0,84	10,06	1,49	200	290	8239	1226
8,19	1,14	13,9	150	1,05	7,08	2,03	170	290	7936	1514
10,01	1,17	11,7	101	0,75	9,39	2,59	230	300	8891	1209
7,31	0,97	13,3	107	0,80	13,67	0.76	130	270	7934	1272
10,38	1,31	12,6	203	1,09	8,95	2,08	170	330	8767	1464
12,85	1,92	14,9	136	0,84	5,21	0,44	140	290	7938	1478
9,54	1,33	13,9	161	1,32	6,07	2,13	170	290	7862	1446
11,81	1,61	13,6	212	1,05	6,60	0,99	220	300	8044	1507
11,58	1,56	13,5	160	0,92	8,89	1,71	200	280	7772	1511
EDTA - Zinc 200 µg/l										
8,24	1,04	12,6	103	1,05	8,13	0,09	190	340	9102	1784
10,65	1,60	15,0	107	1,10	1,03	0,11	310	270	7511	1606
11,48	1,65	14,4	72	0,70	7,66	0,09	190	230	8711	993
4,68	0,81	17,3	241	2,30	13,03	0,19	310	600	15811	3098
4,54	0,76	16,7	66	1,05	3,74	0,17	440	420	16299	1453
13,25	1,85	14,0	35	0,36	2,03	0,02	40	100	2264	581
13,19	1,81	13,7	51	0,47	3,10	0,05	100	200	5610	804
8,43	1,06	12,6	92	1,17	2,01	0,13	100	210	4745	1909
10,22	1,24	12,1	96	0,66	2,83	0,03	110	220	5577	1076
9,82	1,58	16,1	149	0,84	4,27	0,07	300	380	14154	1670
Cadmium 200 µg/l										
9,96	1,45	14,5	85	7,63	5,62	0,19	240	310	8333	1425
8,28	1,17	14,1	87	11,35	2,41	0,15	160	310	8212	1618
10,38	1,36	13,1	98	15,31	3,46	0,21	170	320	8863	1368
9,07	1,49	16,4	114	15,76	6,28	0,23	140	290	7607	1599
12,02	1,35	11,2	154	15,64	1,66	0,19	160	320	9068	1156
9,83	1,54	15,7	72	7,73	2,03	0,14	180	280	7935	1607
4,43	0,84	18,9	90	1,39	5,19	0,11	420	290	6095	2641
9,76	1,06	10,9	122	7,68	2,15	0,09	190	340	8914	1240
9,24	1,32	14,3	97	19,91	7,68	0,19	150	300	8441	1515
12,38	1,89	15,3	144	8,96	5,41	0,11	150	300	7916	1680
EDTA - Cadmium 200 µg/l										
8,24	1,04	12,6	115	3,39	7,40	0,10	200	310	8252	1237
10,65	1,60	15,0	237	3,84	7,13	0,08	260	310	7793	1436
11,48	1,65	14,4	65	2,17	8,27	0,06	200	290	7927	1559
4,68	0,81	17,3	141	10,47	3,84	0,14	220	280	6410	2158
4,54	0,76	16,7	79	1,60	6,16	0,11	180	260	7048	1497
13,25	1,85	14,0	92	1,96	4,83	0,09	180	290	8151	1494
13,19	1,81	13.7	92	2,88	8,79	0.06	180	290	7960	1493
8,43	1,06	12,6	97	3,32	11,26	0,05	160	310	8659	1352
10,22	1,24	12,1	138	2,25	4,79	0,10	240	310	8121	1203
9,82	1,58	16,1	174	3,97	5,09	0,07	130	280	7434	1782

Crassostrea margaritacea. Accumulation of metals complexed with EDTA (continued)

Wet mass g	Dry mass g	Dry mass %	µg metal / g wet tissue Zn	Cd	Cu	Pb	Ca	Mg	Na	K
Copper 200 µg/l										
8,04	1,45	18,0	97	1,10	16,09	0,11	430	330	9577	1356
5,49	0,88	16,0	104	1,18	15,84	0,65	320	330	8014	1494
7,58	0,87	11,5	87	1,29	14,51	0,29	410	330	8707	1214
5,70	0,79	13,9	82	0,75	29,82	0,40	280	310	7895	1368
7,87	1,05	13,3	114	1,15	48,28	0,68	260	320	8259	1461
8,41	1,19	14,1	99	0,97	43,99	0,79	150	290	8323	1522
10,73	1,56	14,5	61	0,96	6,52	0,34	350	290	7735	1575
11,28	2,09	18,5	79	1,05	34,57	0,42	130	270	7092	1924
7,98	1,05	13,2	103	1,05	90,22	0,66	270	310	8271	1504
9,65	1,38	14,3	124	1,26	50,77	0,56	150	290	7565	1523
EDTA - Copper 200 µg/l										
7,22	1,57	21,7	145	1,48	2,21	0,06	770	260	6371	2465
8,51	1,38	16,2	124	0,89	3,99	0,10	140	270	7286	1528
15,66	2,11	13,5	73	0,82	3,70	0,05	150	280	8174	1418
9,89	1,31	13,2	99	1,15	5,96	0,09	200	260	7583	1415
5,90	0,68	11,5	157	1,08	6,69	0,08	360	340	11525	915
8,36	1,29	15,4	155	0,94	6,10	0,10	240	290	10167	1483
6,43	0,96	14,9	104	1,04	9,48	0,12	180	310	11042	1571
7,22	1,00	13,9	83	1,01	5,54	0,04	190	290	11219	1343
14,25	2,24	15,7	163	0,80	7,64	0,07	200	270	7017	1649
3,76	0,50	13,3	109	1,27	10,90	0,07	190	290	8245	1436
1,94	0,31	16,0	88	1,39	6,18	0,15	190	260	9794	1649
1,83	0,32	17,5	76	1,20	7,65	0,21	200	270	9289	1913
1,89	0,32	16,9	68	1,48	7,40	0,10	220	260	10053	1746
Lead 200 µg/l										
8,62	1,65	19,1	90	1,26	4,29	1,33	240	310	7424	1821
8,30	1,06	12,8	84	1,03	3,25	5,75	200	310	8313	1169
9,81	1,75	17,8	116	1,18	8,05	2,58	160	320	7747	1927
3,93	0,55	14,0	170	1,67	3,81	4,02	150	360	8142	1425
10,14	1,38	13,6	99	0,89	3,45	1,48	240	320	8284	1104
5,99	1,00	16,7	105	1,05	5,34	3,50	190	320	8347	1653
6,53	1,15	17,6	83	1,20	4,13	2,29	220	290	7810	1807
8,33	0,98	11,8	204	1,42	5,76	3,43	380	320	8523	1273
6,63	1,09	16,4	136	1,22	9,50	3,37	230	320	7692	1674
4,89	0,76	15,5	110	1,37	4,49	4,53	210	330	8384	1493
EDTA - Lead 200 µg/l										
7,83	1,01	13,0	129	0,88	1,27	0,19	610	310	8174	1469
7,06	1,10	15,6	108	1,00	7,93	0,29	340	300	11756	1331
10,11	1,58	15,6	123	0,97	3,85	0,20	240	270	7122	1414
7,14	0,97	13,6	87	0,98	7,56	0,29	170	290	8263	1372
10,23	1,87	18,3	178	1,11	2,93	0,22	290	330	10166	1642
9,78	0,93	9,5	77	0,68	0,56	0,19	440	370	13496	757
6,59	1,22	18,5	65	1,12	2,27	0,44	280	300	11381	1639
8,93	1,48	16,6	77	0,79	4,47	0,19	290	320	12094	1411
8,65	1,24	14,3	132	1,22	3,35	0,21	600	300	7630	1422
7,03	1,02	14,5	97	0,99	7,96	0,29	220	280	7397	1394

Crassostrea gigas. Accumulation of metals complexed with EDTA.

Wet mass g	Dry mass g	Dry mass %	µg metal / g wet tissue							
			Zn	Cd	Cu	Pb	Ca	Mg	Na	K
Control										
9,09	0,78	8,6	157	0,58	16,9	0,72	220	340	10451	836
7,62	0,61	8,0	236	0,66	45,9	0,35	440	350	11024	761
8,41	0,61	7,3	177	0,52	16,2	0,24	190	340	10939	785
7,14	0,69	9,7	167	0,70	30,1	0,56	210	340	9804	1008
4,44	0,41	9,2	288	0,74	30,6	0,54	170	340	10135	991
3,70	0,34	9,2	197	1,02	24,3	0,51	180	350	10000	919
7,59	0,63	8,3	259	0,73	34,1	1,11	300	340	10145	817
8,47	0,53	6,3	168	0,42	22,5	0,27	220	360	11334	673
5,70	0,46	8,1	133	0,59	13,1	0,35	270	330	9474	807
6,19	0,52	8,4	194	0,59	19,5	0,37	210	350	10824	969
6,62	0,46	6,9	189	0,60	20,0	1,29	190	330	10725	785
3,51	0,28	8,0	293	0,91	33,0	0,76	320	370	10826	826
4,62	0,39	8,4	320	0,86	49,5	1,75	230	350	9957	866
6,25	0,53	8,5	309	0,88	75,2	0,57	350	370	10720	736
EDTA - Control										
6,30	0,53	8,4	113	0,95	20,1	0,53	193	360	11111	841
9,43	1,05	11,1	173	0,99	25,9	0,91	174	350	10604	1060
3,93	0,37	9,4	165	0,91	36,6	1,06	160	330	9669	916
5,43	0,56	10,3	171	1,03	25,7	1,06	178	350	9760	939
6,86	0,64	9,3	93	0,88	22,3	0,17	180	360	11224	845
7,65	0,62	8,1	132	1,45	16,8	0,82	469	390	12418	745
7,16	0,50	7,0	92	0,64	21,3	1,10	192	360	11592	782
6,69	0,65	,9,7	196	1,01	29,5	1,22	171	360	10762	986
6,93	0,81	11,7	265	1,28	36,7	1,38	210	370	10389	996
8,67	0,92	10,6	142	0,64	21,6	0,38	186	380	10727	980
Zinc, 200 µg/l										
4,25	1,46	34,3	346	0,96	24,0	2,75	130	400	9412	706
8,45	0,79	9,3	368	0,73	27,8	2,91	180	340	9704	793
4,80	0,50	10,4	573	0,79	30,0	3,02	140	380	10000	604
4,97	0,51	10,3	402	1,20	76,0	3,68	140	380	9658	684
6,51	0,75	11,5	476	1,16	30,8	4,59	160	370	10138	937
7,58	0,70	9,2	369	0,80	27,5	3,31	130	320	8179	765
4,44	0,45	10,1	372	0,99	24,0	3,33	600	400	10360	788
11,04	0,90	8,1	264	0,63	18,2	1,87	180	340	10236	770
12,87	1,03	8,0	280	0,62	22,1	3,06	180	330	10023	723
EDTA - Zinc, 200 µg/l										
7,59	0,86	11,3	111	0,38	15,2	0,46	100	350	5138	132
5,14	0,44	8,6	149	0,48	23,7	0,44	160	370	5447	140
4,72	0,53	11,2	150	0,46	18,0	0,42	200	440	10805	657
6,01	0,52	8,7	77	0,39	8,1	0,16	260	380	10981	682
4,86	0,48	9,9	160	0,55	25,9	0,18	190	330	8642	761
7,09	0,53	7,5	72	0,36	9,0	0,21	180	370	11001	592
6,48	0,48	7,4	88	0,43	9,4	0,18	180	380	11882	663
6,29	0,51	8,1	87	0,55	7,7	0,17	170	350	10175	525
8,88	0,81	9,1	117	0,45	13,7	0,12	160	350	10247	833
Cadmium, 200 µg/l										
4,78	0,51	10,7	387	119	32,4	0,79	160	380	9205	607
6,11	0,70	11,4	186	75	16,2	0,55	160	340	8838	818
3,57	0,30	8,4	101	90	4,7	0,44	150	420	10924	448
3,75	0,31	8,3	149	88	9,8	0,56	110	350	8267	560
6,14	0,55	8,9	155	57	13,6	0,35	170	370	10749	700
6,16	0,56	9,1	133	63	18,3	0,37	160	360	10227	763
5,53	0,57	10,3	96	69	6,6	0,34	150	340	9584	796
4,31	0,47	10,9	174	81	12,0	0,58	150	370	9513	742
8,27	0,63	7,6	138	70	7,1	0,24	160	350	10641	701
EDTA - Cadmium, 200 µg/l										
7,12	1,18	16,6	128	4,35	27,6	0,15	140	420	10112	365
4,19	0,68	16,2	84	7,39	14,0	0,21	100	400	9308	262
5,83	0,58	9,9	81	4,97	14,2	0,08	130	390	10977	99
6,66	0,88	13,2	183	7,20	21,1	0,15	110	330	8108	375
6,73	0,75	11,1	70	5,20	10,4	0,11	160	390	10698	163
9,07	0,96	10,6	86	4,85	13,4	0,09	140	370	10364	143
9,37	0,90	9,6	35	3,73	6,0	0,08	200	390	10992	149

Crassostrea gigas. Accumulation of metals complexed with EDTA (continued)

Wet mass g	Dry mass g	Dry mass %	µg metal / g wet tissue Zn	Cd	Cu	Pb	Ca	Mg	Na	K
Copper, 200 µg/l										
7,19	0,62	8,6	102	0,68	239	3,75	290	330	10153	542
6,18	0,58	9,4	288	0,88	345	4,04	160	350	11003	663
8,28	0,75	9,1	150	0,85	210	5,07	160	340	10266	749
9,93	0,90	9,1	165	0,73	214	2,52	210	330	10171	806
6,75	0,62	9,2	227	0,81	227	4,82	170	370	11111	711
7,48	0,67	9,0	195	0,66	191	1,63	210	380	11764	668
7,71	0,67	8,7	178	0,80	270	8,17	280	350	10765	674
EDTA - Copper, 200 µg/l										
5,66	0,61	10,8	210	0,72	38,5	0,05	157	320	8657	883
9,44	0,77	8,2	103	0,44	22,1	0,06	183	340	10487	826
5,14	0,45	8,8	193	0,93	22,7	0,09	151	310	9533	661
9,37	0,69	7,4	148	0,44	30,7	0,04	263	340	10885	683
7,25	0,46	6,3	66	0,35	15,3	0,06	188	340	11172	552
9,59	0,76	7,9	140	0,47	24,8	0,06	172	320	10219	803
10,54	0,67	6,4	110	0,46	17,4	0,05	197	320	10531	598
12,38	0,87	7,0	89	0,37	22,8	0,05	167	320	10420	686
5,19	0,51	9,8	200	0,77	31,7	0,13	177	330	10019	886
9,99	0,70	7,0	60	0,41	15,9	0,08	221	310	10010	671
Lead, 200 µg/l										
13,58	0,89	6,6	117	0,48	16,7	3,98	310	330	10383	670
8,63	0,69	8,0	188	1,18	22,4	6,32	220	370	11356	753
7,04	0,65	9,2	237	2,00	24,0	6,67	220	360	10227	781
5,33	0,48	9,0	221	1,50	49,7	6,92	230	370	10507	582
8,90	0,94	10,6	145	1,20	19,2	4,21	190	360	10674	1011
7,15	0,80	11,2	261	1,34	27,6	10,06	150	340	9510	1007
4,06	0,41	10,1	271	1,67	50,0	9,21	150	370	10344	837
8,66	0,71	8,2	245	1,13	31,5	7,22	180	370	11085	681
6,92	0,66	9,5	296	1,76	34,2	5,62	170	360	10694	766
4,41	0,40	9,1	272	1,40	26,9	6,03	150	360	11111	635
EDTA - Lead, 200 µg/l										
7,53	0,59	7,8	77	0,42	10,2	3,61	163	320	9960	744
4,47	0,43	9,6	179	0,51	21,7	3,24	152	290	8277	738
9,40	0,67	7,1	178	0,37	22,0	2,70	194	340	11063	670
4,39	0,40	9,1	189	0,61	22,0	5,23	161	320	9567	774
6,46	0,56	8,7	158	0,49	19,9	3,06	167	320	10371	836
6,92	0,54	7,8	158	0,41	20,0	4,32	229	330	10405	780
4,47	0,40	8,9	279	0,58	32,4	5,12	185	340	10291	805
5,82	0,47	8,1	199	0,51	18,5	3,88	183	340	10653	739
7,83	0,53	6,8	130	0,37	16,4	1,80	185	320	10472	677
6,84	0,49	7,2	108	0,36	13,1	2,19	195	360	11696	716

Crassostrea margaritacea. Major element concentrations in Belvedere oysters

Wet mass g	Dry mass g	µg metal/g wet tissue				Wet mass g	Dry mass g	µg metal/g wet tissue			
		Ca	Mg	Na	K			Ca	Mg	Na	K
2,52	0,48	873	1031	4880	2777	6,56	1,56	792	1326	7012	1981
1,70	0,30	764	1176	6176	2705	5,85	0,68	957	1487	8376	1829
2,17	0,38	553	1013	4608	2350	7,22	1,13	747	1218	6232	2382
2,44	0,40	573	819	4139	2049	6,45	0,81	759	1612	9302	2372
1,03	0,17	3980	1165	6019	2718	7,49	1,28	747	1174	6275	1896
2,53	0,50	2845	592	3122	2338	12,90	1,82	682	930	4806	2015
3,31	0,59	574	634	4531	2749	6,37	1,23	2668	1726	8634	2496
2,70	0,47	703	1074	5296	2296	6,14	0,97	1140	1270	6677	2312
3,10	0,53	4516	1064	5096	2322	7,47	1,20	1740	1164	6024	2128
3,53	0,51	821	1189	5949	2266	5,90	0,85	627	1152	6101	2220
3,20	0,47	1312	1125	5375	2343	11,18	1,39	939	1520	7692	1932
4,14	0,58	531	676	2753	1932	3,66	0,71	519	1038	4808	3087
2,71	0,50	1402	701	3062	2583	16,60	2,58	536	1807	8850	928
4,43	0,72	1083	970	5191	2325	24,85	3,26	583	647	7605	684
3,13	0,54	2971	1214	5527	2555	13,19	1,67	720	1637	8263	1592
4,53	0,87	927	949	4304	3046	33,09	3,82	492	722	7736	634
4,69	0,70	554	1194	6183	2089	24,14	2,93	693	252	8492	746
5,23	1,03	1395	994	4588	2810	26,84	3,91	502	972	4619	745
3,61	0,59	2077	1163	5706	2243	14,77	1,29	717	419	8259	1354
1,96	0,21	1632	714	3163	1581	23,73	3,40	522	606	7416	884
4,41	0,53	816	1473	7936	1836	16,10	3,54	552	409	7080	1055
8,89	0,66	708	742	4049	1057	13,93	1,92	610	617	7465	1579
3,64	0,51	796	1236	6593	2390	16,31	2,67	600	478	6621	1287
3,42	0,75	9941	994	4502	2631	15,81	2,22	550	366	7400	1265
2,82	0,50	8510	1134	4858	2163	12,52	1,50	774	455	8067	1357
3,87	0,63	1550	981	4573	2506	9,17	1,54	588	839	6761	1853
4,20	0,64	619	1023	5047	2333	20,49	3,04	712	326	8052	1024
5,31	0,95	4896	1242	6214	2711	26,88	3,14	736	212	7663	520
7,86	1,38	1106	1157	5597	2480	17,22	2,36	482	505	7375	871
2,07	0,35	2318	966	4347	2463	16,66	2,66	612	468	7803	1080
1,96	0,37	13775	1173	5357	2040	28,55	3,57	497	378	7180	665
1,38	0,23	1304	869	3840	2536	18,39	3,29	674	320	7449	924
2,17	0,31	645	1105	6589	2764	18,91	2,76	565	232	6980	793
1,25	0,22	3760	1120	5040	2960	14,02	1,98	2032	649	5920	1547
3,07	0,40	4560	1433	7166	1824	14,70	2,06	2204	326	8367	1000
3,42	0,68	3099	935	3976	2602	16,78	2,11	840	212	7985	876
3,32	0,71	8132	1144	4156	2740	4,69	0,68	1788	505	7889	1556
						20,30	2,90	527	502	7241	822

Crassostrea margaritacea. Major element concentration variation with season.

Wet mass g	Dry mass g	µg metal/g wet tissue Ca	Mg	Na	K
JUNE, 1977					
12,29	2,23	480	854	5858	2156
8,16	1,04	453	1176	7352	2218
7,62	1,22	564	1115	8268	1575
12,28	1,22	537	1075	7899	1173
11,88	2,61	421	875	5892	2761
12,35	2,25	615	996	6721	1983
10,40	1,57	788	1076	7788	1692
13,63	2,42	602	1005	6456	1834
6,82	1,34	498	1114	7185	2229
9,05	0,87	497	1016	7845	1939
13,39	2,47	455	1098	7468	1979
15,02	2,12	766	1178	7856	1664
9,00	1,37	844	1100	7555	1555
14,41	2,63	493	1068	7495	2199
9,32	1,94	504	987	7081	2521
6,78	1,03	752	1150	8407	1726
5,48	1,43	737	1076	6204	2974
5,04	1,06	982	1111	7936	2460
4,99	0,93	864	1202	7816	2024
4,53	1,12	737	993	5960	3002
JULY, 1977					
9,15	1,23	743	1191	8306	1443
9,06	1,52	1049	1170	8499	2307
6,68	1,05	599	1078	7335	1946
10,45	1,50	718	1100	7847	1828
9,57	1,79	912	951	6061	2393
8,93	1,07	773	1064	7615	1557
10,45	1,40	507	1072	7751	1474
8,22	1,18	779	1059	7421	1727
10,37	1,24	579	1148	8293	1572
14,54	1,96	571	1073	7565	1740
9,41	1,62	563	1126	7545	2689
9,99	1,50	490	1021	7608	1662
3,95	0,49	861	1114	8861	1519
10,79	1,33	408	1057	7692	1520
8,47	1,20	543	1110	7910	1440
5,80	0,90	466	1052	7931	1707
7,66	1,53	431	1005	6789	2507
8,25	1,41	691	1055	7394	1964
6,33	0,98	742	1106	7583	1264
10,12	1,66	553	1028	7510	1769
AUGUST, 1977					
8,07	1,33	495	1078	7806	2317
6,40	1,50	1062	1125	7812	2953
6,91	0,89	997	1273	9406	1635
10,95	1,62	749	1132	9041	1845
7,24	1,29	345	1105	7873	2334
9,85	1,95	649	1086	7817	2741
5,56	1,13	539	989	6834	1824
6,22	1,12	804	1077	7877	2395
6,54	1,33	1238	1009	6728	1875
4,25	0,82	753	1082	7529	2494
2,62	0,50	633	1106	7522	2633
4,57	1,00	488	788	5252	2195
5,11	1,22	849	841	5284	2229
8,41	1,75	737	951	6778	1794
5,58	1,06	662	1147	7706	2348
4,77	0,79	482	1174	8595	2159
8,00	1,52	912	987	7000	2687
6,09	1,11	493	1001	7389	2512
3,77	0,75	663	981	6896	1891
6,30	1,27	413	1047	7143	2603

Wet mass g	Dry mass g	µg metal/g wet tissue Ca	Mg	Na	K
NOVEMBER, 1977					
7,02	1,47	410	755	4729	2977
11,78	2,20	417	968	5603	2199
6,43	1,24	669	855	5521	2737
4,49	0,90	445	690	5100	2917
7,50	1,44	547	893	5307	2547
12,58	2,41	628	850	5246	2679
5,18	1,07	618	791	5753	2432
9,03	2,16	421	786	6898	2200
6,10	1,42	803	688	4377	2197
3,03	0,57	343	792	5412	1805
8,74	1,50	561	881	5503	2368
6,14	1,08	586	879	5570	1883
7,70	1,86	325	779	6325	2532
7,16	1,35	1047	894	5559	2528
7,99	1,34	563	939	6133	2228
5,70	1,27	649	859	4667	2105
6,22	1,13	547	868	5675	1701
6,34	1,19	489	883	5599	1618
10,00	1,59	460	1030	6600	1730
9,24	2,19	681	757	4329	2030
6,81	1,73	925	837	4111	2790
DECEMBER, 1977					
6,53	0,73	490	1072	7060	2103
4,09	0,42	464	1076	7140	1929
6,00	0,58	450	1083	7133	1966
5,24	0,51	477	1050	7042	2030
6,07	0,64	412	1021	6936	1857
5,96	0,65	436	990	6409	2074
4,11	0,38	462	1095	7324	1924
3,98	0,50	703	1030	6432	1357
6,48	0,78	509	1080	6959	1296
2,87	0,53	592	976	6585	1777
5,05	0,46	436	1089	6832	1891
4,73	0,65	359	994	6321	2290
7,96	0,69	414	1068	7286	1842
4,25	0,65	965	1011	6047	1576
1,35	0,25	429	1111	5852	2000
6,42	0,71	498	1028	6464	2028
6,04	0,65	1159	1076	6920	2142
7,08	0,67	974	1116	7345	2031
4,89	0,44	757	1166	7689	1797
5,39	0,49	890	1150	7811	1909
3,56	0,41	1236	1011	6404	2143
JANUARY, 1978					
4,84	1,10	516	1012	5165	2665
11,00	2,50	800	964	5364	2636
8,63	1,12	533	1135	7184	2205
7,33	1,38	845	1064	5866	1773
8,95	1,12	815	1106	6816	1251
9,61	1,40	509	1093	6659	1353
5,68	1,30	475	1003	4929	2676
7,94	1,33	416	768	3652	1889
15,99	3,60	435	1012	5533	1648
8,86	1,92	474	982	4853	2415
10,47	1,47	525	1165	7163	1203
4,83	0,89	1201	1035	5590	2422
8,34	1,82	547	1067	5396	2122
10,02	2,41	748	838	4491	3293
7,80	1,16	743	1128	6795	1295
9,29	2,09	337	1055	5597	1927
9,31	2,08	548	1042	5048	2320
8,63	1,46	498	1101	5794	1518
4,70	0,72	1234	1148	6809	1809
10,16	1,59	571	984	6004	1585

Crassostrea margaritacea. Major element concentration variation with season. (continued)

		µg metal/g wet tissue						µg metal/g wet tissue			
Wet mass g	Dry mass g	Ca	Mg	Na	K	Wet mass g	Dry mass g	Ca	Mg	Na	K
SEPTEMBER, 1977						FEBRUARY, 1978					
5,78	0,96	550	1073	8304	1903						
6,54	1,09	627	963	7492	2079						
6,94	1,13	533	807	7060	2420	9,66	1,31	352	652	8385	2263
7,60	1,33	763	973	6579	2342	7,90	1,00	443	1076	7721	1418
13,13	1,56	822	1005	14547	1561	9,85	1,79	335	609	7411	1705
11,57	1,54	639	1054	7779	1780	6,42	0,75	436	685	8878	2044
8,81	1,35	431	885	6469	2497	10,51	2,32	552	561	6185	2169
6,44	1,18	373	869	5900	2981	18,66	4,16	279	632	7074	2286
6,11	1,84	540	966	7038	2128	7,10	0,88	338	1112	7746	2239
10,02	2,04	942	788	5489	2445	4,43	0,70	316	655	7675	2422
10,96	1,15	465	839	9033	1487	11,94	1,40	385	737	7789	2013
5,77	1,13	381	797	4679	3258	6,61	0,86	378	756	8169	2105
10,02	1,35	427	1008	8283	2056	12,21	2,35	262	721	6879	1622
9,96	1,45	612	1074	7630	2249	9,42	1,09	361	732	8705	2008
9,77	1,46	563	1044	7062	2334	10,10	1,93	327	713	6832	2089
11,17	1,19	537	1137	8147	1558	11,86	1,97	270	607	7335	2475
8,05	1,37	696	907	7205	2720	11,55	2,23	372	615	6840	1783
8,73	1,30	641	1008	7331	2165	7,83	0,73	357	753	9578	1741
6,58	0,84	866	1140	7751	2006	11,88	1,52	353	648	7996	1086
14,48	1,42	209	1264	9047	1312	12,29	2,14	236	675	7160	1782
1,18	0,04	1186	949	6101	2203	12,71	2,60	228	629	6845	2140
						15,46	2,78	285	595	6598	1931
OCTOBER, 1977						2,39	0,30	586	837	9205	1506
4,84	0,88	498	992	6446	2335	5,00	0,64	500	740	8600	1960
8,49	1,33	695	966	6478	1778						
7,67	1,06	404	965	6128	2108						
6,95	0,97	691	1007	6691	1223						
6,00	0,83	617	950	6517	2450						
1,44	0,38	833	833	5694	2500						
6,35	1,11	677	1039	7102	1874						
7,41	1,06	391	958	6464	2430						
6,61	0,67	529	1029	7005	2044						
9,36	1,01	481	1004	6837	2229						
6,37	0,72	549	910	6138	2146						
7,52	1,10	505	931	6303	1303						
5,86	0,97	464	911	6323	2426						
7,69	1,34	637	936	6073	1782						
5,88	1,15	629	952	5816	2143						
5,84	1,07	1044	976	6353	1866						
7,75	1,53	490	1006	6581	2181						
8,44	1,11	521	1173	7346	1576						
4,97	0,45	563	1267	8410	2569						
6,51	0,81	753	1029	6728	2152						
5,40	0,87	722	1074	7111	1685						

Crassostrea gigas Major element concentrations in samples transferred from Belvedere (Knysna) to the Blue Hole (Algoa Bay) in April 1977.

Wet mass g	Dry mass g	µg metal/g wet tissue			
		Ca	Mg	Na	K
AUGUST 1977, BLUE HOLE SITE A					
7,11	0,76	984	1378	8157	928
4,35	0,53	666	1379	8276	1172
4,73	0,58	528	1437	8668	1057
6,66	0,91	871	1382	7958	1231
3,89	0,43	797	1439	8997	1079
11,05	1,49	497	1167	7421	1421
5,23	0,74	918	1377	8222	1549
5,33	0,57	822	1388	8630	900
5,30	0,55	528	1321	8679	906
5,49	0,67	692	1311	7650	1129
OCTOBER 1977, BLUE HOLE SITE A					
11,57	1,94	666	985	6569	769
9,23	1,08	878	1083	7692	1257
8,29	1,11	965	1110	7479	1487
5,75	0,77	974	1078	7478	1426
20,08	2,66	483	956	6524	812
10,39	1,17	693	1126	7796	1270
10,51	1,67	580	1056	6565	846
10,99	2,03	637	1056	6187	702
8,55	1,20	550	1064	7485	1743
19,25	2,19	488	1039	7221	961
11,49	1,83	531	1097	7137	1628
17,30	2,37	1104	1006	7110	1318
20,95	1,53	1403	549	3532	678
9,50	1,77	1284	979	6632	1295
12,22	1,88	458	1039	6710	1718
12,54	1,79	853	997	7177	1533
8,20	1,12	878	1220	8293	1585
9,81	1,24	1814	1131	7747	1458
5,11	0,80	959	1115	7436	722
9,55	1,34	670	1131	7749	1632
15,04	2,41	658	971	4920	1383
5,59	0,63	755	1181	8587	1234
9,19	1,15	642	1143	7726	1371
6,27	0,84	909	1116	7815	579

Wet mass g	Dry mass g	µg metal/g wet tissue			
		Ca	Mg	Na	K
AUGUST 1977, BLUE HOLE SITE B					
7,74	0,96	349	891	5039	853
8,18	1,09	697	1320	8313	1161
8,26	1,10	460	1247	7748	1138
6,72	0,92	580	1295	7887	1146
9,64	1,30	446	1016	6224	892
8,92	1,25	336	784	4821	706
4,58	0,56	589	1354	8297	982
7,19	0,96	542	1238	7649	1099
4,51	0,46	532	1352	8204	953
2,85	0,27	561	1333	8070	666
OCTOBER 1977, BLUE HOLE SITE B					
13,05	1,85	444	1096	6054	1211
14,04	1,04	513	1111	7550	474
11,70	1,47	513	1060	7265	1393
9,69	1,07	857	1135	7740	1125
15,60	1,76	519	1160	7949	1449
13,17	1,76	486	1071	6986	579
13,60	1,63	375	794	4485	647
8,72	0,93	665	1135	8142	1170
10,34	1,34	957	1170	7930	1325
4,53	0,49	817	1214	8605	971
10,63	1,23	865	1223	8561	1326
7,87	0,84	572	1194	8259	1220
9,26	1,15	518	1123	7775	1479
25,03	2,65	455	1111	7551	627
11,77	1,31	518	1172	8071	1232
9,40	1,18	989	1170	8190	628
10,20	1,38	814	1108	7647	1461
4,64	0,60	560	1228	8836	358
5,79	0,86	484	1088	7599	1347
11,09	1,44	496	1028	6673	1398

Crassostrea margaritacea. Major element concentrations in samples transferred from Belvedere (Knysna) to the Blue Hole (Algoa Bay) in April, 1977

Wet mass g	Dry mass g	µg metal/g wet tissue			
		Ca	Mg	Na	K
AUGUST 1977, BLUE HOLE SITE A					
3,17	0,52	473	1135	6940	1388
4,59	0,70	370	1198	7189	1372
3,29	0,53	547	1337	7599	1185
4,22	0,55	450	1303	8294	1256
4,82	0,61	456	1141	7261	1037
5,09	0,62	412	1159	7073	943
5,35	0,74	411	1103	6542	991
6,73	1,06	446	1144	7132	1426
3,71	0,45	458	1239	7277	970
3,67	0,48	436	1226	7629	1063
OCTOBER 1977, BLUE HOLE SITE A					
4,57	0,72	722	1138	3435	1926
2,46	0,33	366	1016	8619	1382
3,23	0,49	495	1053	7059	1641
3,37	0,56	593	1098	7122	1810
12,91	1,72	457	953	6181	1409
4,88	0,52	738	1086	6783	1065
4,57	0,72	1028	1028	6039	1663
7,07	0,99	976	1032	6351	1344
5,97	0,87	536	1038	6398	1574
5,45	0,77	550	991	6183	1523
3,30	0,67	584	1091	5969	1909
4,64	0,72	603	1077	6056	1702
6,23	0,68	481	1156	7319	1059
10,11	1,28	801	1167	7201	1286
5,58	0,73	860	1057	4856	1219
4,55	0,66	527	1033	8747	1365
7,00	1,15	1243	971	6371	1828
8,06	1,50	484	943	4566	2196
5,36	0,75	522	1082	6306	1306
4,88	0,61	553	1127	7418	1168
5,74	0,90	819	1115	5348	1498
4,70	0,65	468	1064	4936	1511
4,03	0,62	794	1067	8064	1216
4,56	0,78	746	1162	7631	1272
5,15	0,74	718	913	4854	1650
6,32	0,88	506	1060	6725	1376

Wet mass g	Dry mass g	µg metal/g wet tissue			
		Ca	Mg	Na	K
AUGUST, 1977 BLUE HOLE SITE B					
5,63	1,06	408	1137	7105	1509
4,94	0,72	425	1154	7490	1336
3,92	0,60	459	1173	7143	1326
5,17	0,70	503	1218	7737	947
2,00	0,34	800	1350	8000	1200
1,88	0,31	532	1223	7447	1117
2,52	0,37	516	1190	7539	1151
3,36	0,50	828	1309	7738	1101
3,93	0,50	458	1272	8142	992
6,30	0,90	428	1238	7936	1333
OCTOBER 1977, BLUE HOLE SITE B					
3,31	0,44	423	876	6344	1057
2,68	0,35	381	634	4478	746
4,39	0,57	433	820	5011	797
5,36	0,16	360	765	5037	989
3,55	0,44	363	817	5352	958
5,80	0,80	1034	931	5862	1000
2,21	0,34	389	724	5068	905
1,89	0,23	450	847	5556	952
3,19	0,42	395	784	5298	658
3,94	0,49	404	761	5102	863
5,88	0,99	386	731	4422	1395
3,57	0,48	451	812	5350	1204
3,51	0,44	433	826	5413	940
3,70	0,38	370	811	5162	703
6,58	0,82	347	821	5319	1064
1,83	0,28	383	710	4536	1202
2,61	0,32	456	766	4713	996
6,25	0,70	499	914	5714	1257
3,07	0,34	417	717	4527	977
3,63	0,51	661	771	5179	743
5,07	0,81	434	749	4615	1183
3,02	0,40	410	828	5331	861

Crassostrea margaritacea. Major element concentrations in samples collected from the Blue Hole (Algoa Bay) in April, 1977 and transferred to Knysna

Wet mass g	Dry mass g	µg metal/g wet tissue			
		Ca	Mg	Na	K
APRIL, 1977 Initial sample					
14,23	2,55	766	1145	7238	1342
10,45	1,44	1052	2163	8038	1416
14,96	2,31	936	1036	8088	1350
9,37	1,23	3148	1398	8751	1142
7,79	0,92	950	3450	9114	1386
18,53	3,12	685	772	7393	1225
8,44	1,35	1102	3519	8412	474
19,56	1,99	562	219	8282	1129
2,29	0,21	2314	4279	10480	873
5,41	0,58	3364	2865	9797	1109
9,63	1,35	1028	498	8515	1703
7,25	1,56	73	1462	7310	1800
8,67	1,36	1776	1453	7728	1765
5,40	0,71	3333	1519	8333	1315
21,90	4,15	731	1169	5662	1073
13,45	2,60	959	1390	6245	1382
10,95	2,30	511	1388	6210	1410
16,66	2,64	360	1261	6963	1657
9,65	1,35	2207	1523	7668	1461
5,98	0,92	769	1538	7525	1522
12,31	2,15	609	1186	6661	1812
8,03	1,35	710	1445	6725	1005
11,75	1,40	1319	1583	8851	1277
10,23	1,56	1017	1505	7625	1584
0,64	0,07	8594	1641	7969	516
13,55	2,00	494	1424	7528	1454
6,18	0,70	712	1472	7929	1166
4,09	0,63	367	1198	6846	1394
6,70	0,90	866	1448	7761	1299
17,04	2,14	1719	1338	7805	1180
2,28	0,29	439	1745	9211	1447
21,32	2,19	497	1294	7364	1027
15,13	2,14	416	1553	7865	1540
15,05	2,33	1774	1375	7375	1209
13,67	2,18	475	1339	7388	1931
12,10	2,32	1421	1322	6612	1702
9,31	1,45	1289	1396	7197	1869
15,87	2,32	1802	1430	7246	901
4,23	0,61	733	1513	8274	1534
JUNE, 1977					
6,55	0,83	1237	1867	7939	840
8,14	1,30	528	1204	7616	1314
4,55	0,71	571	2142	7912	1319
10,12	1,15	524	1215	8794	1008
4,14	0,60	845	1449	9662	1497
8,90	1,69	3269	1966	6966	2168
5,09	0,45	963	1336	9626	727
5,37	0,66	521	1043	8194	949
7,36	0,95	883	1155	8152	1087
10,02	1,18	639	1618	8184	1018
JULY, 1977					
6,74	0,81	1445	1217	8902	1231
5,77	0,68	537	1179	8839	1213
2,48	0,32	524	1210	8468	1371
7,68	1,19	443	1042	7422	1810
7,48	1,10	642	1150	8155	1644
6,10	0,76	525	1197	8689	1328
6,60	0,73	545	1318	9394	1136
5,42	0,45	498	1384	10148	812
4,29	0,62	723	1142	8159	1772
8,70	1,05	598	1241	8736	1207
4,22	0,63	2701	1256	8531	1327
8,63	1,11	1429	1101	8227	1309
3,74	0,28	1455	1257	9626	615
8,73	1,16	527	1134	8133	1386
OCTOBER, 1977					
6,89	1,10	435	972	5515	1611
1,78	0,33	831	1236	4494	1966
11,05	1,47	416	1059	6244	1222
9,54	1,40	440	1006	6079	1331
8,41	1,25	273	737	3924	1046
3,30	0,52	727	1091	5454	1545
4,36	0,80	573	1009	5504	1949
14,89	1,63	685	1007	5701	927
8,38	1,54	811	1086	5728	1885
9,67	1,46	465	1055	5998	1365
2,59	0,46	579	1197	6177	1815
7,06	1,02	354	977	5382	1544
9,37	1,01	395	1046	5977	1089
9,45	1,71	476	1101	5714	1640
8,90	0,66	427	1179	6629	719
10,50	1,50	657	1105	6095	1267
9,25	1,92	627	962	4865	2422
12,65	1,92	403	972	5296	1288
7,58	1,22	554	1108	5805	1412
17,55	2,17	359	991	6666	1162
8,20	1,12	488	1036	6341	1305
11,29	1,70	354	1045	6997	1497
10,92	1,64	485	1080	6776	1566
NOVEMBER, 1977					
9,20	1,43	478	1000	6304	1522
11,18	1,68	385	1019	6530	1413
12,79	1,57	469	1047	6802	1157
7,52	1,18	625	1050	6782	1662
18,65	2,68	391	981	6541	1501
12,14	1,80	329	964	6178	1630
8,93	0,70	437	1019	7167	705
8,63	1,19	417	973	6257	1298
11,10	1,62	414	1009	6576	1423
11,29	1,76	487	894	5580	1798
18,60	2,55	607	963	6183	1236
4,57	0,69	569	1028	6696	3676
8,01	1,19	712	1024	6854	1448
12,64	2,21	498	846	5696	1946
9,38	1,59	479	1002	6791	1652
10,69	1,85	411	982	7802	1889
8,31	0,99	650	1011	8616	1167
8,95	1,65	514	860	6223	2078
11,33	1,87	995	918	6090	2074
13,70	2,32	365	839	5547	2153
9,36	1,62	438	897	5555	2169
15,27	1,68	511	995	3719	1552
10,81	2,01	1091	990	2886	1970
DECEMBER, 1977					
12,79	2,13	993	868	5786	1501
15,33	2,91	678	874	5545	1826
8,48	1,38	589	920	6014	1604
9,32	1,62	1041	890	5901	1921
8,76	1,55	970	845	6164	1792
5,18	0,77	1100	849	6351	1467
11,68	2,61	651	822	4623	2106
13,09	2,75	496	871	5424	1948
14,66	3,08	525	928	5389	2012
5,95	1,08	706	924	6185	1647
9,54	1,79	524	849	5451	1960
9,41	2,26	679	808	4166	1977
7,04	1,18	909	1065	6477	1676
7,12	1,03	632	871	6067	1489
13,27	2,45	995	889	5652	2004
12,72	2,71	550	943	5346	2154
15,02	3,33	539	799	5059	1784
12,56	2,36	613	876	5175	1895
18,73	3,19	560	843	4858	1586
6,25	1,37	992	816	5072	2848
7,53	1,53	730	876	5498	2191
9,60	2,20	719	760	4917	2583

Crassostrea margaritacea. Major element concentrations in samples collected from the Blue Hole (Algoa Bay) in April, 1977 and transferred to Knysna (continued)

Wet mass g	Dry mass g	µg metal/g wet tissue			
		Ca	Mg	Na	K
AUGUST, 1977					
10,89	1,55	854	1304	9642	1442
12,20	1,72	402	1139	8770	1418
9,69	1,48	743	1383	9804	1455
5,54	0,78	1534	2094	15343	2112
7,35	1,11	816	1265	9252	1701
9,40	1,51	2128	1298	9149	1457
9,82	1,25	672	1212	9063	1283
12,44	1,77	619	1222	9084	1584
11,68	1,50	625	1430	10616	1318
6,13	0,81	603	1289	9788	1387
5,18	0,90	984	1235	9459	1969
SEPTEMBER, 1977					
8,89	0,94	484	1136	8099	1743
9,19	0,62	751	1251	9357	968
8,05	0,85	981	1304	9192	1751
5,36	0,68	597	1157	7463	1978
6,31	0,47	555	1236	9191	1109
9,13	0,80	504	1227	9091	1238
8,66	0,86	416	1085	8083	1490
7,76	0,34	502	1327	10180	670
13,52	1,68	606	1095	7692	1598
8,19	0,84	659	1148	7692	1416
11,58	1,01	466	1131	8376	1183
8,02	0,86	760	1147	7980	1608
1,90	0,18	674	1105	7368	1947
0,62	0,06	1016	1322	9032	2210

Wet mass g	Dry mass g	µg metal/g wet tissue			
		Ca	Mg	Na	K
JANUARY, 1978					
2,81	0,63	854	783	5979	2384
9,81	1,71	734	856	5403	1927
14,83	3,16	957	762	3911	1767
11,01	2,36	608	799	4905	2525
14,22	2,75	598	816	5486	2208
15,27	2,13	550	825	6221	1297
5,59	1,09	715	859	5671	2147
5,84	1,41	633	753	4675	2603
13,91	2,21	194	740	4601	1445
7,92	1,70	593	833	5202	2513
FEBRUARY, 1978					
13,60	3,06	404	897	8294	2132
7,12	1,73	393	815	4073	2514
17,74	4,02	682	891	5017	1522
7,73	0,78	375	1203	7115	1905
11,27	2,64	435	914	5590	2839
9,77	2,10	379	1634	8322	2047

<u>Crassostrea margaritacea</u>. Tissue-metal concentrations in samples collected from the Blue Hole (Algoa Bay) in April 1977 and transferred to Knysna

Wet mass g	Dry mass g	Zn	Cd	µg metal / g wet tissue Cu	Pb	Fe	Mn	Ni	Co	Cr
April, 1977 Initial sample										
14,23	2,55	337	0,25	4,6	0,23	27	0,35	0,01	0,03	0,18
10,45	1,44	641	0,35	5,0	0,09	28	1,82	0,03	0,03	0,23
14,96	2,31	280	0,22	7,5	0,19	26	0,32	0,01	0,03	0,16
9,37	1,23	1600	0,40	1,4	0,20	21	0,53	0,02	0,03	0,18
7,79	0,92	513	0,39	2,7	0,08	21	0,30	0,04	0,04	0,14
18,53	3,12	458	0,21	14,7	0,21	22	0,26	0,03	0,01	0,13
8,44	1,35	699	0,28	10,5	0,23	27	2,84	0,01	0,02	0,24
19,56	1,99	75	0,42	2,2	0,13	17	0,53	0,01	0,01	0,14
2,29	0,21	786	0,31	7,5	0,17	69	0,68	0,04	0,09	0,48
5,41	0,58	702	0,26	1,3	0,02	29	0,64	0,05	0,02	0,20
9,63	1,35	758	0,39	9,7	0,07	40	0,40	0,11	0,01	0,22
7,25	1,56	427	0,18	21,1	0,28	33	0,45	0,07	0,01	0,21
8,67	1,36	622	0,30	4,6	0,17	38	0,48	0,05	0,01	0,21
5,40	0,71	611	0,20	8,5	0,15	37	0,43	0,04	0,02	0,33
21,90	4,15	456	0,34	6,1	0,12	10	2,85	0,02	<0,01	0,13
13,45	2,60	371	0,26	9,4	0,19	27	3,79	0,04	0,01	0,19
10,95	2,30	410	0,27	14,5	0,28	32	3,70	0,04	0,01	0,21
16,66	2,64	408	0,56	9,7	0,11	16	0,28	0,03	0,01	0,13
9,65	1,35	559	0,28	17,2	0,27	49	0,72	0,05	0,01	0,20
5,98	0,92	451	0,32	11,8	0,15	35	0,37	0,07	0,02	0,25
12,31	2,15	536	0,25	11,8	0,27	31	2,37	0,04	0,01	0,23
8,03	1,35	610	0,16	4,6	0,05	34	2,62	0,05	0,01	0,24
11,75	1,40	553	0,27	3,3	0,10	17	0,65	0,02	0,03	0,20
10,23	1,56	703	0,41	12,6	0,14	47	0,48	0,04	0,01	0,25
0,64	0,07	968	0,78	7,3	0,16	75	0,86	0,08	0,16	0,78
13,55	2,00	715	0,27	7,6	0,11	25	2,07	0,11	0,01	0,20
6,18	0,70	404	0,38	2,9	0,11	43	0,41	0,03	0,02	0,26
4,09	0,63	440	0,24	2,3	0,20	31	0,26	0,02	0,02	0,27
6,70	0,90	835	0,26	7,3	0,21	53	0,95	0,06	0,03	0,31
17,04	2,14	915	0,33	3,7	0,13	8	0,48	0,06	0,02	0,16
2,28	0,29	482	0,45	14,0	0,04	52	0,55	0,04	0,04	0,31
21,32	2,19	698	0,42	3,0	0,10	19	0,67	0,01	<0,01	0,13
15,13	2,14	350	0,26	8,6	0,10	15	2,64	0,03	0,01	0,15
15,05	2,33	524	0,45	7,1	0,13	14	1,46	0,03	0,01	0,17
13,67	2,18	548	0,15	10,6	0,16	21	0,35	0,03	0,01	0,18
12,10	2,32	347	0,38	5,3	0,13	22	3,51	0,01	0,02	0,20
9,31	1,45	580	0,27	3,1	0,14	26	0,37	0,01	0,01	0,19
15,87	2,32	535	0,24	3,8	0,05	25	2,02	0,04	0,01	0,17
4,23	0,61	472	0,24	16,7	0,14	47	1,47	0,07	0,02	0,31
June 1977										
6,55	0,83	535	0,38	13,9	0,17	15	0,44	0,01	<0,01	0,45
8,14	1,30	700	0,27	15,3	0,21	21	0,45	0,04	<0,01	0,31
4,55	0,71	662	0,39	12,3	0,20	17	0,44	0,11	<0,01	0,28
10,12	1,15	479	0,40	12,1	0,17	19	0,63	0,06	<0,01	0,37
4,14	0,60	459	0,44	6,9	0,24	18	0,82	0,03	<0,01	0,33
8,90	1,69	481	0,75	4,9	0,04	24	0,84	0,01	0,04	0,13
5,09	0,45	552	0,45	2,3	0,06	15	0,49	<0,01	0,03	0,27
5,37	0,66	737	0,58	8,5	0,07	42	0,92	0,02	0,07	0,60
7,36	0,95	625	0,45	9,2	0,10	15	0,89	0,04	<0,01	0,43
10,02	1,18	272	0,30	7,6	0,06	23	0,56	<0,01	0,04	0,38
July 1977										
6,74	0,81	663	0,36	8,5	0,19	24	0,46	0,06	0,01	0,30
5,77	0,68	515	0,42	7,8	0,19	41	0,78	0,05	0,03	0,33
2,48	0,32	278	0,23	6,9	0,32	39	0,49	0,08	0,04	0,81
7,68	1,19	329	0,49	15,1	0,20	33	0,61	0,03	<0,01	0,53
7,48	1,10	513	0,36	8,8	0,19	26	0,45	0,01	<0,01	0,21
6,10	0,76	480	0,43	5,9	0,23	26	0,49	0,10	<0,01	0,52
6,60	0,73	447	0,29	5,3	0,20	24	1,39	0,06	0,02	0,29
5,42	0,45	605	0,32	1,5	0,18	26	0,54	0,11	0,02	0,35
4,29	0,62	491	0,44	4,1	0,21	38	0,63	0,05	0,02	0,44
8,70	1,05	422	0,21	3,3	0,20	24	0,77	0,05	<0,01	0,52
4,22	0,63	604	0,36	4,9	0,21	19	1,35	0,07	0,02	0,81
8,63	1,11	493	0,42	6,8	0,14	18	0,34	0,09	<0,01	0,32
3,74	0,28	541	0,24	4,7	0,16	21	0,32	0,11	<0,01	0,48
8,73	1,16	492	0,31	4,8	0,13	24	1,17	0,01	0,01	0,46

Crassostrea margaritacea. Tissue-metal concentrations in samples collected from the Blue Hole (Algoa Bay) in April 1977 and transferred to Knysna (Continued).

Wet mass g	Dry mass g			µg metal/g wet tissue						
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
August 1977										
10,89	1,55	580	0,43	2,8	0,13	22	0,92	0,02	0,02	0,41
12,20	1,72	457	0,30	10,2	0,12	9	0,52	0,02	<0,01	0,21
9,69	1,48	519	0,34	12,8	0,13	15	0,78	<0,01	<0,01	0,29
5,54	0,78	712	0,78	9,6	0,18	41	1,73	0,05	<0,01	0,58
7,35	1,11	689	0,43	14,1	0,22	17	0,43	<0,01	0,02	0,37
9,40	1,51	677	0,39	11,1	0,17	13	0,34	<0,01	0,01	0,29
9,82	1,25	328	0,26	3,8	0,10	16	0,34	0,02	<0,01	0,24
12,44	1,77	527	0,44	7,2	0,14	19	0,40	0,03	0,02	0,20
11,68	1,50	662	0,44	14,5	0,19	32	0,96	<0,01	<0,01	0,21
6,13	0,81	601	0,46	5,1	0,20	19	0,52	<0,01	0,03	0,24
5,18	0,90	344	0,44	10,8	0,19	22	0,59	0,04	<0,01	0,52
September 1977										
8,89	0,94	323	0,34	10,1	0,10	21	0,46	0,04	0,01	0,16
9,19	0,62	257	0,30	2,3	0,07	14	0,29	0,04	0,01	0,19
8,05	0,85	394	0,35	3,6	0,10	25	1,14	0,07	0,01	0,22
5,36	0,68	562	0,59	9,9	0,09	16	2,20	0,04	0,02	0,29
6,31	0,47	311	0,13	11,3	0,08	9	0,31	0,09	0,01	0,16
9,13	0,80	452	0,34	2,6	0,09	17	0,35	0,07	0,03	0,20
8,66	0,86	441	0,39	6,9	0,15	30	0,43	0,03	0,03	0,33
7,76	0,34	354	0,12	11,3	0,05	18	0,27	<0,01	0,03	0,27
13,52	1,68	488	0,27	11,2	0,13	14	0,39	<0,01	0,01	0,20
8,19	0,84	712	0,33	14,2	0,15	23	1,00	<0,01	0,03	0,28
11,58	1,01	570	0,35	4,4	0,09	14	0,69	<0,01	0,04	0,22
8,02	0,86	329	0,40	7,0	0,08	24	0,65	0,03	0,02	0,29
1,90	0,18	326	0,79	6,8	0,26	41	0,74	0,02	0,02	0,15
0,62	0,06	474	0,32	8,2	0,10	10	1,29	<0,01	<0,01	0,13
October 1977										
6,89	1,10	247	0,60	3,9	0,05	47	0,42	0,08	0,01	0,31
1,78	0,33	449	0,67	4,2	0,05	18	2,24	0,12	0,01	0,41
11,05	1,47	344	0,51	3,5	0,05	39	0,96	0,08	0,04	0,31
9,54	1,40	545	0,70	2,8	0,06	34	0,49	0,05	0,03	0,25
8,41	1,25	202	0,42	3,8	0,04	35	0,36	0,09	0,02	0,28
3,30	0,52	636	0,90	3,8	0,09	48	1,45	0,14	0,03	0,87
4,36	0,80	459	1,05	6,9	0,04	62	0,75	0,01	0,02	0,34
14,89	1,63	262	0,27	3,2	0,16	61	0,75	0,12	0,02	0,59
8,38	1,54	418	1,39	7,4	0,17	74	0,75	0,04	0,02	0,45
9,67	1,46	310	0,65	12,4	0,05	37	0,81	0,05	0,04	0,22
2,59	0,46	540	0,81	5,3	0,11	62	1,50	0,18	0,03	0,27
7,06	1,02	382	0,69	5,1	0,09	39	0,43	0,08	0,02	0,31
9,37	1,01	405	0,59	12,0	0,04	23	0,38	0,06	0,01	0,17
9,45	1,71	540	0,91	8,3	0,08	52	1,77	0,09	0,02	0,33
8,90	0,66	202	0,42	12,2	0,01	20	0,29	0,03	<0,01	0,23
10,50	1,50	390	0,70	7,9	0,03	27	0,86	0,08	0,01	0,37
9,25	1,92	908	1,03	19,9	0,08	24	1,10	0,09	0,02	0,30
12,65	1,92	87	0,49	10,8	0,03	18	0,85	0,05	0,02	0,26
7,58	1,22	369	0,88	3,2	0,10	59	0,67	0,02	0,02	0,31
17,55	2,17	285	0,35	9,2	0,05	16	0,82	0,09	0,01	0,23
8,20	1,12	500	0,57	2,4	0,06	28	1,18	0,04	0,03	0,36
11,29	1,70	292	0,59	4,7	0,03	18	0,37	0,03	0,03	0,21
10,92	1,64	439	0,66	10,9	0,07	13	1,20	0,07	<0,01	0,39
12,49	2,01	344	0,55	10,2	0,06	28	0,42	0,05	0,01	0,32
11,54	1,91	373	0,61	6,4	0,06	42	0,77	0,04	<0,01	0,20
10,88	1,46	441	0,65	3,0	0,05	37	0,44	0,06	<0,01	0,32

Crassostrea margaritacea. Tissue-metal concentrations in samples collected from the Blue Hole (Algoa Bay) in April 1977 and transferred to Knysna (continued).

Wet mass g	Dry mass g	µg metal/g wet tissue								
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
November 1977										
9,20	1,43	630	0,78	6,6	0,07	34	1,18	0,07	0,01	0,30
11,18	1,68	402	0,56	6,9	0,07	42	0,96	0,06	0,01	0,29
12,79	1,57	418	0,16	7,7	0,08	33	0,45	0,08	<0,01	0,25
7,52	1,18	519	0,46	10,1	0,06	44	0,31	0,07	0,05	0,29
18,65	2,68	305	0,29	6,2	0,05	29	0,27	0,03	0,01	0,25
12,14	1,80	387	0,51	5,4	0,07	38	0,88	0,04	0,04	0,26
8,93	0,70	157	0,32	1,7	0,01	21	0,26	0,05	0,04	0,23
8,63	1,19	243	0,29	2,7	0,06	36	0,67	0,02	0,03	0,17
11,10	1,62	576	0,20	12,9	0,09	39	0,44	0,04	0,02	0,23
11,29	1,76	416	0,26	7,9	0,06	38	0,98	0,07	0,01	0,29
18,60	2,55	441	0,38	14,2	0,09	23	0,61	0,04	0,02	0,19
4,57	0,69	648	0,54	9,0	0,20	12	1,40	<0,01	0,06	0,24
8,01	1,19	660	0,28	11,5	0,19	14	1,36	0,11	0,02	0,38
12,64	2,21	365	0,40	16,9	0,16	8	0,82	0,06	0,02	0,21
9,38	1,59	496	0,37	16,5	0,10	13	1,37	0,06	0,03	0,29
10,69	1,85	223	0,23	10,9	0,15	11	1,96	0,18	0,01	0,27
8,31	0,99	740	0,38	9,9	0,06	9	0,32	0,07	<0,01	0,28
8,95	1,65	352	0,12	16,2	0,15	13	0,34	0,11	0,02	0,30
11,33	1,87	515	0,31	12,4	0,12	9	0,36	0,06	0,02	0,24
13,70	2,32	449	0,21	5,7	0,12	7	0,27	0,01	0,04	0,18
9,36	1,62	477	0,42	6,9	0,19	11	0,40	0,07	0,01	0,25
15,27	1,68	506	0,39	14,3	0,03	9	1,21	0,02	0,02	0,20
10,81	2,01	319	0,31	11,4	0,14	10	0,90	<0,01	0,02	0,25
December 1977										
12,79	2,13	450	0,31	5,1	0,10	21	1,61	0,11	<0,01	0,20
15,33	2,91	349	0,33	7,2	0,07	22	1,54	0,03	0,01	0,18
8,48	1,38	627	0,41	2,5	0,08	25	0,73	0,02	<0,01	0,27
9,32	1,62	350	0,32	2,4	0,13	28	0,46	0,02	0,02	0,21
8,76	1,55	269	0,26	3,0	0,07	28	0,44	0,03	0,03	0,22
5,18	0,77	359	0,34	2,7	0,07	10	0,38	0,13	0,01	0,21
11,68	2,61	445	0,16	5,7	0,11	36	1,90	0,10	0,02	0,23
13,09	2,75	503	0,38	3,5	0,12	21	1,70	0,06	0,02	0,20
14,66	3,08	314	0,34	3,8	0,07	12	2,40	0,04	0,02	0,15
5,95	1,08	323	0,36	2,7	0,06	31	0,52	0,05	<0,01	0,30
9,54	1,79	186	0,39	3,7	0,09	33	0,47	0,11	0,05	0,22
9,41	2,26	436	0,18	5,5	0,13	35	1,86	0,14	0,01	0,20
7,04	1,18	376	0,26	1,7	0,09	38	2,20	0,08	0,02	0,28
7,12	1,03	626	0,26	3,4	0,09	6	0,37	0,13	0,02	0,16
13,27	2,45	383	0,12	2,0	0,08	11	0,35	0,11	<0,01	0,18
12,72	2,71	364	0,20	7,5	0,08	13	1,08	0,10	0,03	0,14
15,02	3,33	360	0,15	5,2	0,13	28	0,47	0,03	0,01	0,18
12,56	2,36	364	0,17	1,5	0,07	34	0,36	0,11	0,03	0,21
18,73	3,19	253	0,27	5,7	0,08	23	1,24	0,05	0,02	0,15
6,25	1,37	283	0,24	5,4	0,11	30	0,54	0,17	0,03	0,28
7,53	1,53	165	0,24	3,6	0,14	50	0,62	0,11	<0,01	0,27
9,60	2,20	594	0,39	2,2	0,09	21	0,57	0,03	<0,01	0,19
January 1978										
2,81	0,63	463	0,30	4,3	0,10	38	0,71	0,07	<0,01	0,32
9,81	1,71	314	0,23	2,8	0,10	16	0,47	0,06	0,01	0,24
14,83	3,16	397	0,29	9,8	0,12	25	1,71	0,08	0,01	0,17
11,01	2,36	428	0,27	5,9	0,11	23	0,47	0,06	<0,01	0,22
14,22	2,75	207	0,30	7,5	0,11	24	0,42	0,07	0,01	0,21
15,27	2,13	341	0,14	7,6	0,08	43	1,06	0,12	0,01	0,19
5,59	1,09	206	0,26	2,7	0,10	32	0,64	0,02	<0,01	0,05
5,84	1,41	349	0,27	3,6	0,11	11	0,58	0,06	0,01	0,15
13,91	2,21	344	0,26	1,7	0,05	28	0,37	0,03	<0,01	0,11
7,92	1,70	438	0,21	3,9	0,12	13	0,58	0,05	<0,01	0,18
2,77	0,64	176	0,52	1,3	0,03	18	0,25	0,05	0,02	0,20
February 1978										
13,60	3,06	301	0,40	6,2	0,05	20	0,38	0,04	0,02	0,09
7,12	1,73	463	0,20	5,6	0,05	21	0,36	0,14	<0,01	0,09
17,74	4,02	366	0,33	4,3	0,05	12	0,26	0,03	<0,01	0,17
7,73	0,78	543	0,32	1,9	0,03	8	0,28	0,10	<0,01	0,14
11,27	2,64	381	0,27	3,1	0,03	10	0,32	0,08	<0,01	0,10
9,77	2,10	634	0,20	6,1	0,04	12	0,31	0,08	<0,01	0,11

Crassostrea gigas. Tissue-metal concentrations in samples transferred from Belvedere (Knysna) to the Blue Hole (Algoa Bay) in April, 1977

Wet mass g	Dry mass g	µg metal / g wet tissue								
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
AUGUST, 1977 Blue Hole position A										
7,11	0,76	239	0,23	19,1	0,26	132	5,34	0,14	0,11	0,66
4,35	0,53	299	0,34	24,3	0,32	96	4,11	0,22	0,09	0,64
4,73	0,58	338	0,33	31,7	0,38	78	2,38	0,16	0,10	0,46
6,66	0,91	375	0,24	36,3	0,60	36	5,10	0,21	0,03	1,30
3,89	0,43	282	0,28	27,7	0,41	139	3,65	0,12	<0,02	0,79
11,05	1,49	163	0,20	13,3	0,20	61	2,44	0,07	<0,02	0,43
5,23	0,74	344	0,34	28,8	0,32	113	4,58	0,11	0,03	0,59
5,33	0,57	281	0,31	21,2	0,18	75	3,75	0,13	0,02	0,48
5,30	0,55	301	0,32	25,0	0,22	39	1,98	0,07	0,05	0,37
5,49	0,67	236	0,23	26,9	0,37	98	2,64	0,10	0,04	0,80
AUGUST, 1977 Blue Hole position B										
7,74	0,96	103	0,12	8,9	0,11	41	1,96	0,03	<0,02	0,42
8,18	1,09	256	0,23	28,4	0,26	68	3,54	0,11	<0,02	0,48
8,26	1,10	218	0,23	20,2	0,19	58	3,14	0,07	0,02	0,43
6,72	0,92	208	0,28	18,0	0,31	110	5,95	0,11	0,04	0,58
9,64	1,30	155	0,16	20,1	0,13	51	2,48	0,06	<0,02	0,36
8,92	1,25	89	0,11	12,9	0,12	58	2,24	0,07	0,02	0,32
4,58	0,56	218	0,32	26,9	0,28	100	3,82	0,08	<0,02	0,63
7,19	0,96	222	0,31	20,2	0,23	65	3,33	0,09	0,02	0,34
4,51	0,46	177	0,28	16,1	0,24	77	2,94	0,15	0,02	0,55
2,85	0,27	210	0,35	21,8	0,14	53	2,00	0,17	<0,02	0,59
OCTOBER, 1977 Blue Hole position A										
11,57	1,94	344	0,16	31	0,37	73	3,5	0,33	0,02	0,26
9,23	1,08	340	0,16	38	0,35	66	4,4	0,17	0,01	0,27
8,29	1,11	262	0,12	31	0,31	70	5,1	0,17	<0,01	0,25
5,75	0,77	320	0,14	30	0,42	103	3,7	0,16	0,02	0,40
20,08	2,66	261	0,09	16	0,21	43	3,1	0,10	<0,01	0,16
10,39	1,17	240	0,15	23	0,27	51	4,0	0,16	<0,01	0,21
10,51	1,67	264	0,14	27	0,41	66	7,8	0,16	0,02	0,27
10,99	2,03	379	0,18	37	0,33	57	8,6	0,35	0,01	0,19
8,55	1,20	336	0,15	30	0,41	91	3,7	0,26	<0,01	0,34
19,25	2,19	224	0,09	20	0,18	41	2,5	0,21	<0,01	0,14
11,49	1,83	362	0,17	34	0,42	88	6,1	0,16	0,03	0,28
17,30	2,37	229	0,10	22	0,21	54	4,1	0,39	0,01	0,17
20,95	1,53	266	0,09	24	0,20	36	3,6	0,26	0,01	0,12
9,50	1,77	326	0,17	34	0,48	102	3,2	0,16	0,03	0,34
12,22	1,88	288	0,16	30	0,29	61	5,9	0,14	0,01	0,18
12,54	1,79	338	0,14	36	0,30	55	4,1	0,18	0,02	0,18
8,20	1,12	304	0,15	28	0,29	63	3,8	0,13	<0,01	0,20
9,81	1,24	240	0,11	27	0,39	102	3,1	0,16	<0,01	0,35
5,11	0,80	227	0,16	22	0,63	155	5,7	0,18	<0,01	0,49
9,55	1,34	269	0,16	26	0,32	69	6,0	0,15	<0,01	0,22
15,04	2,41	492	0,10	47	0,29	67	6,3	0,09	0,01	0,20
5,59	0,63	299	0,13	22	0,29	77	4,8	0,07	<0,01	0,21
9,19	1,15	490	0,14	53	0,39	70	4,9	0,17	<0,01	0,26
6,27	0,84	219	0,19	40	0,37	78	4,0	0,20	0,02	0,26
OCTOBER, 1977 Blue Hole position B										
13,05	1,85	177	0,10	18	0,21	50	3,8	0,10	0,02	0,25
14,04	1,04	155	0,14	16	0,34	60	3,9	0,11	0,01	0,29
11,70	1,47	221	0,16	21	0,30	60	2,7	0,09	0,02	0,29
9,69	1,07	305	0,18	34	0,30	59	2,6	0,14	<0,01	0,31
15,60	1,76	201	0,10	22	0,21	37	2,4	0,10	0,01	0,17
13,17	1,76	175	0,11	49	0,34	78	4,1	0,17	0,01	0,33
13,60	1,63	86	0,05	23	0,15	48	1,5	0,10	<0,01	0,22
8,72	0,93	214	0,15	29	0,24	38	3,9	0,08	<0,01	0,25
10,34	1,34	208	0,15	23	0,41	93	3,7	0,12	<0,01	0,43
4,53	0,49	172	0,22	19	0,22	42	1,9	0,24	0,02	0,39
10,63	1,23	211	0,15	21	0,37	74	4,0	0,13	0,02	0,38
7,87	0,84	287	0,17	27	0,36	69	5,1	0,13	0,03	0,34
9,26	1,15	221	0,13	39	0,37	79	4,4	0,12	0,02	0,35
25,03	2,65	214	0,12	19	0,21	48	5,3	0,07	0,01	0,20
11,77	1,31	239	0,14	28	0,34	67	4,0	0,14	0,01	0,31
9,40	1,18	230	0,17	22	0,44	99	3,8	0,15	<0,01	0,48
10,20	1,38	258	0,15	35	0,32	55	3,6	0,21	0,01	0,28
4,64	0,60	304	0,13	56	0,41	56	3,9	0,30	<0,01	0,39
5,79	0,86	401	0,19	50	0,43	74	4,8	0,28	<0,01	0,40
11,09	1,44	187	0,15	25	0,30	70	2,6	0,13	0,01	0,41

Crassostrea margaritacea. Tissue-metal concentrations in samples transferred from Belvedere (Knysna) to the Blue Hole (Algoa Bay) in April 1977.

Wet mass g	Dry mass g	µg metal/g wet tissue								
		Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
AUGUST, 1977 Blue Hole position A										
3,17	0,52	126	1,04	2,7	0,12	31	0,50	0,15	<0,02	0,37
4,59	0,70	196	0,64	4,1	0,08	26	0,37	0,04	0,04	0,54
3,29	0,53	152	0,63	1,2	0,06	18	0,72	0,06	0,03	0,57
4,22	0,55	142	0,40	1,8	0,04	12	0,28	0,02	<0,02	0,47
4,82	0,61	166	0,31	3,9	0,12	40	0,70	0,08	<0,02	0,49
5,09	0,62	177	0,45	2,5	0,07	34	1,27	0,01	0,05	0,33
5,35	0,74	168	0,72	1,6	0,07	30	0,65	0,01	0,02	0,44
6,73	1,06	89	0,86	1,4	0,04	19	0,31	0,07	<0,02	0,40
3,71	0,45	323	0,56	4,7	0,05	16	0,45	0,05	0,05	0,59
3,67	0,48	218	0,51	2,2	0,08	13	0,32	0,02	<0,02	0,38
AUGUST, 1977 Blue Hole position B										
5,63	1,06	142	0,58	4,2	0,05	17	0,28	0,05	0,01	0,33
4,94	0,72	201	0,78	3,0	0,08	10	0,26	0,08	0,02	0,24
3,92	0,60	232	0,43	8,9	0,17	21	0,79	0,10	0,07	0,51
5,17	0,70	135	0,48	6,7	0,07	10	0,63	0,01	0,01	0,25
2,00	0,34	350	0,75	7,0	0,01	25	0,55	0,15	0,06	0,95
1,88	0,31	266	0,37	9,3	0,15	16	0,69	0,10	0,05	0,74
2,52	0,37	238	0,75	1,6	0,11	16	0,47	0,15	0,03	1,11
3,36	0,50	327	0,74	3,4	0,11	30	1,13	0,08	0,02	0,56
3,93	0,50	178	0,48	9,7	0,07	13	0,38	0,10	0,10	0,58
6,30	0,90	190	0,44	2,1	0,07	13	0,38	0,16	0,04	0,36
OCTOBER, 1977 Blue Hole position A										
4,57	0,72	337	0,24	15,5	0,54	10	1,46	0,24	0,02	1,02
2,46	0,33	138	0,20	2,8	0,16	44	0,77	0,28	<0,02	1,09
3,23	0,49	179	0,06	8,2	0,18	59	0,92	0,15	<0,02	0,80
3,37	0,56	208	0,17	7,7	0,29	30	0,77	0,17	0,02	0,89
12,91	1,72	487	0,10	22,5	0,26	27	0,58	0,05	<0,02	0,31
4,88	0,52	215	0,24	4,2	0,12	62	0,90	0,08	0,02	0,53
4,57	0,72	225	0,28	6,2	0,42	50	1,94	0,21	<0,02	0,61
7,07	0,99	197	0,19	5,7	0,28	51	1,31	0,11	<0,01	0,49
5,97	0,87	241	0,15	9,3	0,26	37	0,93	0,06	<0,01	0,43
5,45	0,77	213	0,31	4,6	0,36	64	0,91	0,11	<0,01	0,56
3,30	0,67	236	0,27	8,9	0,27	66	1,69	0,12	<0,03	0,84
4,64	0,72	220	0,23	7,5	0,36	28	1,01	0,08	0,06	0,58
6,23	0,68	260	0,59	2,4	0,21	27	0,38	0,08	0,01	0,40
10,11	1,28	422	0,10	5,2	0,20	43	0,70	0,19	0,02	0,50
5,58	0,73	433	0,23	6,7	0,41	30	1,21	0,19	0,01	0,75
4,55	0,66	281	0,21	5,4	0,37	28	0,90	0,17	0,02	0,83
7,00	1,15	290	0,37	5,0	0,35	41	1,04	0,21	0,05	0,65
8,06	1,50	197	0,73	4,9	0,39	28	0,83	0,11	0,03	0,49
5,36	0,75	315	0,26	9,3	0,29	40	1,10	0,26	<0,01	0,70
4,88	0,61	180	0,28	4,9	0,32	30	0,94	0,28	<0,02	1,00
5,74	0,90	204	0,22	4,3	0,33	27	0,80	0,50	<0,01	0,57
4,70	0,65	202	0,36	4,3	0,27	25	0,82	0,70	<0,02	0,65
4,03	0,62	293	0,54	4,5	0,37	39	1,21	0,14	<0,02	0,76
4,56	0,78	368	0,52	8,3	0,35	28	1,29	0,35	0,02	0,74
5,15	0,74	262	0,21	8,4	0,46	57	1,06	0,15	<0,01	0,67
6,32	0,88	166	0,17	3,8	0,39	39	1,69	0,07	0,03	0,66
OCTOBER, 1977 Blue Hole position B										
3,31	0,44	130	0,27	4,5	0,27	41	0,73	0,18	0,03	0,24
2,68	0,35	228	0,30	11,9	0,22	48	0,82	0,07	<0,02	0,26
4,39	0,57	280	0,32	12,5	0,36	21	1,14	0,07	<0,02	0,32
5,36	0,16	272	0,30	8,0	0,15	26	0,60	<0,02	<0,02	0,22
3,55	0,44	248	0,48	5,1	0,17	40	0,51	0,11	<0,03	0,23
5,80	0,80	217	0,36	3,3	0,14	23	1,72	0,03	<0,02	0,21
2,21	0,34	176	0,18	14,9	0,18	22	0,72	0,05	0,04	0,32
1,89	0,23	259	0,26	2,9	0,26	14	1,53	0,11	0,03	0,21
3,19	0,42	295	0,50	11,0	0,13	41	0,60	0,06	0,02	0,19
3,94	0,49	292	0,25	19,5	0,25	24	0,84	0,10	<0,02	0,25
5,88	0,99	150	0,27	8,7	0,26	29	0,63	0,09	0,03	0,26
3,57	0,48	272	0,39	12,0	0,28	39	0,84	0,08	<0,03	0,34
3,51	0,44	245	0,60	4,3	0,23	27	1,17	0,11	<0,02	0,34
3,70	0,38	238	0,51	11,4	0,19	19	0,54	0,03	0,02	0,22
6,58	0,82	293	0,21	5,6	0,12	18	0,46	<0,02	<0,03	0,11
1,83	0,28	186	0,16	9,8	0,16	21	0,87	<0,05	<0,01	0,27
2,61	0,32	310	0,42	7,7	0,22	13	0,80	0,22	0,02	0,29
5,25	0,70	277	0,26	3,4	0,11	13	0,80	0,21	0,02	0,33
3,07	0,34	241	0,32	5,1	0,26	42	0,60	<0,02	<0,03	0,35
3,63	0,51	248	0,33	13,5	0,13	8	0,32	0,12	<0,02	0,13
5,07	0,81	252	0,25	8,5	0,23	27	0,48	0,13	<0,02	0,19
3,02	0,40	262	0,46	3,0	<0,02	24	0,43	<0,02	<0,02	0,26

<u>*Crassostrea gigas*</u>. The effect of exposure to trace metals on major element concentrations.

Wet mass (g)	Dry mass (g)	Dry mass (%)	µg metal/g wet tissue							
			Zn	Cd	Cu	Pb	Ca	Mg	Na	K
Control										
9,60	1,22	12,7	207	1,05	10,3	0,36	552	635	8960	1170
8,91	0,90	10,1	148	0,84	11,2	0,33	337	617	8640	853
3,99	0,38	9,5	145	1,78	7,5	0,35	600	652	9270	677
13,39	2,50	18,7	140	0,67	7,3	0,18	217	358	4410	890
16,81	2,31	13,7	117	0,82	7,3	0,22	315	577	8330	1160
13,68	1,67	12,2	201	0,58	11,4	0,19	329	519	7460	1030
6,07	0,76	12,5	129	0,87	8,9	0,33	346	527	8570	1200
10,27	1,28	12,5	238	0,95	17,3	0,28	331	613	8570	1110
6,24	0,49	7,9	112	0,66	6,9	0,11	401	689	10260	560
12,81	1,85	14,4	143	0,88	5,9	0,20	320	570	7880	1340
Cadmium 250 µg/1										
6,75	0,79	11,7	136	56,3	7,9	0,15	474	607	8300	890
11,38	1,40	12,3	112	65,0	4,0	0,25	342	633	8880	950
5,14	0,56	10,9	117	91,4	3,9	0,33	350	661	8950	778
4,68	0,63	13,5	96	72,6	2,1	0,30	385	663	8120	1025
5,13	0,53	10,3	101	66,3	3,9	0,29	390	682	9360	760
14,03	1,61	11,5	67	61,3	2,9	0,21	378	599	8624	1100
15,25	1,93	12,7	143	76,7	4,6	0,22	315	597	8328	1056
3,42	0,30	8,8	216	52,6	8,9	0,18	380	731	9650	439
12,83	1,64	12,8	200	63,9	9,7	0,16	209	351	8496	1115
Cadmium 500 µg/1										
11,27	1,12	9,9	81	69,2	3,9	0,22	302	630	8696	780
7,15	0,79	11,1	159	93,7	6,4	0,31	462	601	7552	770
5,27	0,53	10,1	76	106,3	1,2	0,27	342	797	10440	797
6,57	0,69	10,5	110	106,5	3,5	0,35	304	669	8677	761
11,34	1,43	12,6	108	78,5	5,2	0,23	282	661	8995	1014
5,99	0,65	10,9	117	100,2	7,2	0,25	317	668	9015	851
7,14	0,89	12,5	127	82,6	7,7	0,29	280	658	8543	1092
Copper 250 µg/1										
13,10	1,72	13,1	134	1,03	177	0,20	221	587	8168	1100
9,83	1,19	12,1	136	0,94	325	0,34	142	640	8647	997
19,71	2,63	13,3	144	0,66	232	0,30	162	599	8118	1096
7,46	0,88	11,8	196	1,26	361	0,34	147	684	9250	1005
7,08	0,75	10,6	194	0,85	460	0,38	122	692	9463	791
14,33	1,87	13,1	153	1,21	216	0,22	105	586	7816	1158
9,47	0,85	9,0	95	0,36	132	0,13	201	644	9293	707
6,73	0,68	10,1	196	0,96	229	0,24	114	669	9212	906
7,50	0,79	10,5	165	0,85	149	0,17	139	693	9600	920
Copper 500 µg/1										
9,37	1,27	13,6	113	0,59	380	0,43	352	662	8538	1057
Lead 250 µg/1										
9,46	1,18	12,5	207	1,10	14,1	19,2	518	666	8774	1015
9,58	0,87	9,1	85	0,98	11,1	18,2	438	710	9499	752
10,87	0,87	8,0	62	0,62	4,7	13,8	340	626	8832	616
9,80	1,23	12,6	145	0,73	10,2	15,1	357	673	8979	1082
7,49	0,80	10,7	159	1,39	10,4	15,4	374	734	10013	908
8,81	1,33	15,1	138	0,78	7,6	20,5	226	636	7946	1442
14,15	1,45	10,3	146	0,60	12,0	12,2	318	622	8763	947
7,32	0,61	8,3	108	0,68	12,6	23,6	451	683	9563	505
8,61	1,02	11,9	185	0,79	10,4	13,1	360	662	9059	1173
8,04	0,74	9,2	97	0,99	7,3	23,0	398	697	9577	771

<u>Crassostrea</u> <u>gigas</u>. The effect of exposure to trace metals on major element concentrations. (continued)

Wet mass (g)	Dry mass (g)	Dry mass (%)	µg metal/g wet tissue							
			Zn	Cd	Cu	Pb	Ca	Mg	Na	K
Lead 500 µg/l										
10,28	1,22	11,9	106	0,60	5,4	54,5	331	612	8171	1051
9,50	1,03	10,8	154	0,97	13,6	60,0	363	674	9158	842
8,03	0,80	10,0	174	0,78	19,6	44,8	349	623	8468	697
8,21	1,03	12,6	114	0,84	8,4	70,6	341	658	8769	1011
9,51	0,91	9,6	75	0,58	4,5	39,9	369	705	9884	841
9,74	1,29	16,3	161	0,75	10,5	46,2	329	657	8522	1232
13,16	1,57	11,9	185	0,81	10,2	47,1	342	638	8815	1010
14,18	2,02	14,3	174	0,87	13,9	53,6	324	606	7969	1305
15,89	2,14	13,5	157	0,59	11,8	30,8	321	610	8307	1246
6,99	0,75	10,7	210	1,03	17,0	54,4	386	672	9013	830
Zinc 250 µg/l										
9,36	1,06	11,3	443	0,74	12,3	0,34	395	684	9081	1036
15,06	1,45	9,6	305	0,55	10,4	0,16	345	684	9495	910
8,44	0,83	9,8	307	0,47	15,0	0,19	367	664	8886	770
13,67	1,34	9,8	262	0,41	7,5	0,18	351	651	8851	899
6,70	0,53	7,9	234	0,48	14,2	0,24	358	672	9701	672
6,99	0,74	10,6	385	0,69	11,3	0,27	415	629	8870	1059
13,80	1,69	12,3	230	0,55	13,8	0,22	341	630	8768	1152
15,36	1,97	12,8	397	0,69	9,5	0,21	299	586	8008	1263
7,76	0,76	9,8	294	0,58	8,1	0,19	348	644	9278	863
11,11	0,93	8,4	230	0,38	9,1	0,17	333	639	9001	693
Zinc 500 µg/l										
8,95	0,96	10,7	392	0,87	9,8	0,20	346	670	9274	1017
10,03	1,15	11,5	371	1,17	8,9	0,20	329	618	8574	1097
13,05	1,21	9,3	247	0,97	4,5	0,18	352	636	8966	912
10,78	1,03	9,6	323	0,91	10,1	0,18	751	705	9740	891
10,97	1,19	10,9	472	1,60	11,7	0,21	346	638	8842	1067
8,16	0,82	10,1	241	0,98	8,8	0,12	441	662	9191	1005
13,39	1,35	10,1	635	1,94	3,7	0,26	433	665	9410	948
17,01	1,16	6,8	240	0,63	7,7	0,09	412	676	10112	653
11,63	1,05	9,0	339	0,79	16,0	0,20	369	653	9372	808
6,70	0,61	9,1	322	1,12	14,9	0,13	418	687	9701	791

Crassostrea margaritacea. The effect of exposure to trace metals on major element concentrations.

Wet mass (g)	Dry mass (g)	Dry mass (%)	µg metal/g wet tissue							
			Zn	Cd	Cu	Pb	Ca	Mg	Na	K
Control										
6,04	0,81	13,4	194	1,34	6,6	0,33	397	513	8278	993
4,48	0,56	12,5	154	1,18	2,9	0,20	469	558	8259	893
10,74	1,29	12,0	131	0,69	1,9	0,08	419	577	8194	940
5,91	0,75	12,7	93	1,03	1,7	0,10	389	558	7953	998
6,33	0,94	14,9	88	1,30	4,3	0,19	332	553	8215	1074
6,47	0,89	13,8	122	1,08	8,9	0,20	340	572	7883	1128
4,38	0,54	12,3	146	1,87	3,7	0,34	436	502	7991	822
7,02	0,87	12,4	67	1,20	1,7	0,21	399	598	8832	1140
9,60	1,41	14,7	108	1,24	3,9	0,14	416	573	7500	1292
5,04	0,68	13,5	149	0,89	3,2	0,14	417	555	7937	992
Cadmium 250 µg/l										
7,43	1,02	13,7	129	21,8	3,4	0,11	363	606	8883	995
8,38	0,93	11,1	86	27,3	5,0	0,12	382	597	8473	1026
6,38	0,90	14,1	133	23,9	3,0	0,20	392	549	7994	1207
10,16	1,03	10,1	102	16,1	1,0	0,06	404	649	9055	876
5,31	0,79	14,9	119	39,4	1,8	0,26	377	584	8286	1073
7,30	1,04	14,3	156	17,7	2,5	0,16	438	562	7945	1164
4,94	0,69	14,0	142	36,4	5,7	0,23	709	526	7895	972
6,54	0,78	11,9	131	26,2	2,9	0,26	612	581	8410	826
4,63	0,71	15,3	104	21,8	4,4	0,17	389	540	8207	1231
5,65	0,74	13,1	161	22,5	4,8	0,11	354	584	8673	1027
2,99	0,44	14,7	171	32,8	9,0	0,20	401	569	8361	1070
Cadmium 500 µg/l										
11,92	1,42	11,9	141	26,0	3,2	0,09	361	495	7969	973
5,83	0,82	14,1	132	29,8	6,2	0,17	737	549	7890	926
6,88	0,78	11,3	99	36,3	1,2	0,19	349	581	8721	1032
8,85	1,11	12,5	114	39,5	3,2	0,13	395	531	7797	972
6,77	0,95	14,0	151	50,2	1,9	0,31	310	546	7829	1447
7,16	0,82	11,5	135	39,1	1,8	0,15	433	531	8100	810
8,57	0,86	10,0	91	32,7	2,3	0,21	315	642	9452	840
9,86	1,18	12,0	106	34,5	3,3	0,15	567	639	8824	1136
5,29	0,70	13,2	155	39,7	5,5	0,17	302	586	8320	1115
0,57	0,11	19,3	123	61,4	7,4	0,37	491	579	8070	1263
Copper 250 µg/l										
6,77	0,84	12,4	95	0,93	9,3	0,15	251	546	7976	1078
7,80	0,97	12,4	122	0,92	22,3	0,17	179	602	8846	1064
7,73	0,97	12,6	107	0,89	31,0	0,16	362	582	8538	1087
10,05	1,25	12,4	115	0,94	30,8	0,15	249	547	8259	1174
6,23	0,84	13,5	96	0,99	17,7	0,18	273	610	8668	1139
12,02	1,21	10,1	91	0,62	28,3	0,10	233	599	9401	865
8,33	1,14	13,7	71	1,01	18,0	0,17	288	612	8523	1128
8,47	1,27	15,0	159	1,10	15,3	0,13	295	626	9209	1216
6,07	0,85	14,0	110	1,12	19,8	0,12	379	544	7908	1203
6,24	0,77	12,3	104	0,87	35,3	0,14	449	593	8333	1154
0,33	0,05	15,2	148	0,82	51,5	0,12	378	636	9697	1333
Copper 500 µg/l										
7,59	1,04	13,7	132	1,00	42,2	0,14	750	579	8169	1094
12,95	1,42	10,9	100	0,69	21,6	0,10	548	548	8339	903
4,16	0,52	12,5	142	1,51	43,3	0,14	409	577	8654	865
5,01	0,79	15,8	130	1,06	26,0	0,06	758	519	7385	1557
4,51	0,65	14,4	149	0,89	33,3	0,07	599	532	7761	1131
9,87	1,39	14,1	49	0,77	28,4	0,13	699	567	8105	1165
3,80	0,56	14,7	139	0,82	44,7	0,39	658	553	8158	1000
6,25	0,72	11,5	104	0,69	26,6	0,11	480	592	8960	864
6,95	1,03	14,8	121	0,81	25,9	0,12	691	604	9065	1036

Crassostrea margaritacea. The effect of exposure to trace metals on major element concentration.

Wet mass (g)	Dry mass (g)	Dry mass (%)	Zn	Cd	Cu	Pb	Ca	Mg	Na	K
			µg metal/g wet tissue							
Lead 250 µg/l										
6,47	0,89	13,8	111	1,55	1,9	7,1	371	541	6335	1129
4,14	0,34	8,2	203	1,09	1,5	4,1	531	604	9661	507
5,13	0,69	13,5	154	0,86	4,9	9,2	409	546	7992	1189
5,90	0,84	14,2	116	1,46	3,1	18,9	576	559	8136	1119
6,96	0,80	11,5	99	0,96	2,4	11,5	747	560	8477	905
3,72	0,45	12,1	83	1,02	2,4	10,5	1022	511	7796	995
6,82	0,90	13,2	149	1,09	2,1	9,5	367	557	7918	1070
9,42	1,03	10,9	93	0,97	2,2	6,1	425	552	8280	966
7,26	1,08	14,9	201	1,05	5,2	9,6	455	551	7576	1198
8,39	1,19	14,2	110	0,88	4,4	13,0	751	596	7867	1120
1,35	0,20	14,8	141	1,41	7,8	25,9	548	593	7852	1111
Lead 500 µg/l										
7,70	1,08	14,0	169	1,06	4,4	15,3	636	558	8571	1117
5,56	0,71	12,8	133	0,94	4,0	39,6	594	647	8453	971
4,39	0,60	13,7	150	0,89	4,1	27,3	433	569	7973	843
4,17	0,53	12,7	161	0,72	3,8	26,1	624	647	8633	815
6,77	0,55	8,1	93	0,52	1,8	17,9	620	576	8863	591
1,06	0,14	13,2	92	1,04	3,2	61,3	462	604	8302	1151
1,55	0,19	12,3	110	1,03	6,0	41,3	413	626	7742	903
0,40	0,05	12,5	110	1,50	6,8	80,0	1425	775	10500	1350
8,34	1,07	12,8	89	0,78	4,1	15,1	384	600	8153	1151
7,82	0,93	11,9	102	0,75	6,1	19,7	435	575	8312	959
4,22	0,59	14,0	142	0,92	4,7	32,2	498	592	7820	1113
10,00	1,23	12,3	208	0,79	3,8	10,7	410	670	9400	980
10,03	1,20	12,0	99	0,82	4,6	13,2	400	600	8900	1010
Zinc 250 µg/l										
12,85	1,75	13,6	184	0,79	4,5	0,19	428	599	7471	1167
10,18	0,95	9,3	82	0,75	0,3	0,09	422	619	8939	874
6,67	0,71	10,6	100	0,67	1,9	0,16	810	587	8095	930
8,00	0,99	12,4	116	0,70	2,8	0,11	413	638	8625	1050
6,34	0,65	12,3	156	0,84	4,3	0,14	442	552	9150	741
6,29	0,72	11,5	248	1,08	4,9	0,19	397	620	8426	922
7,54	1,03	13,7	223	1,07	3,3	0,21	292	557	7294	1114
5,17	0,63	12,2	221	0,93	3,1	0,19	542	561	8317	1392
6,34	0,81	12,8	167	0,76	4,1	0,14	410	583	7886	1025
8,69	1,26	14,5	107	0,82	2,8	0,13	449	564	7365	1346
Zinc 500 µg/l										
7,06	0,93	13,2	159	1,33	2,9	0,18	907	609	8074	892
9,05	1,11	12,3	175	1,04	2,8	0,11	387	564	7624	1116
7,23	0,70	9,7	115	0,62	2,1	0,15	664	664	9405	719
10,47	1,21	11,6	181	0,77	4,6	0,15	334	573	8214	1032
8,12	0,98	12,1	248	1,18	3,9	0,15	566	640	8744	936
6,80	0,89	13,1	244	1,00	1,8	0,09	515	588	8088	1058
8,63	1,09	12,6	267	1,01	4,5	0,16	477	568	7764	846
6,21	0,71	11,4	230	1,55	2,3	0,19	440	676	9339	805
8,76	1,09	12,4	249	1,10	4,0	0,15	411	628	9361	925