# Trace Element Profiles of Clams (*Tridacna crocea*) Gathered from Various Sites in Torres Strait

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## *Abstract*

*A total of 43 specimens of Tridacna crocea were collected from eight sites in the Torres Strait. After dissection and digestion cadmium (Cd), lead (Pb), mercury (Hg), copper (Cu) and zinc (Zn) were determined in samples of adductor muscle, mantle and visceral mass. The levels of lead, mercury, copper and zinc were not considered biologically significant and all levels were less than one tenth (1/10) of the relevant maximum permitted concentrations (MPC) in food intended for human consumption. Significant levels of cadmium (range 0.29 - 1.85 mg kg$^{-1}$ Fresh Weight) were found in adductor muscle and mantle tissue at all sites. However no adductor muscle or mantle tissue levels of cadmium exceeded the MPC of 2.0 mg kg$^{-1}$ Fresh Weight. The highest levels of cadmium (3.31 mg kg$^{-1}$ ) were found in visceral samples.*

## Introduction

This study was undertaken in response to the continuing uncertainty about the impact on the marine resources of the Torres Strait, of large scale mining operations in the Fly River catchment area of Papua New Guinea and within the strait itself (Horn Island). Its prime objective was to establish preliminary trace element profiles of suitable indicator species and to assess these results in terms of the standards established for food for human consumption.

The burrowing clams, *Tridacna maxima* and *T. crocea* are acknowledged (Denton and Heitz, 1990) as fulfilling several of the prerequisites for bio-indicators (Phillips, 1980).

In this paper we report the levels of cadmium (Cd), lead (Pb), Mercury (Hg), copper (Cu) and zinc (Zn) in *T. crocea* collected at a number of sites throughout the Torres Strait area.

## Materials and Methods

### Sample Collection

A total of 43 specimens of *T. crocea* were collected from eight sites within the Torres Strait during the period March to November 1989. The location of each site, its allocated site number, the date of sampling and the number of clams collected at that site, are given in Table 1.

Clams, 10 to 12 cm in length, were dislodged from their surroundings with a short steel bar. The level of force used was kept to a minimum to prevent damage to the clam. Once dislodged, clams were sealed in individual plastic (PVC) bags and snap frozen for transport to the analytical laboratory. On-board processing at the time of collection was considered but rejected as impracticable, due to the lack of appropriate facilities on the collection vessel. It should be noted that samples were collected opportunistically during scheduled prawn abundance research activities.

Table 1. Sampling demographics for *T. crocea* survey in the Torres Strait

| Site No. | Location | N° Clams collected (n= ) | Date |
|---|---|---|---|
| 1 | South Ledge | 10 | 27/04/89 |
| 2 | West Island | 5 | 28/04/89 |
| 3 | Horn Island (A) | 5 | 27/04/89 |
| 4 | Horn Island (B) | 5 | 27/04/89 |
| 5 | Caldbeck Reef | 6 | 25/03/89 |
| 6 | Coconut Island | 5 | 25/03/89 |
| 7 | Marakai Reef | 3 | 28/09/89 |
| 8 | Robert Island | 2 | 30/11/89 |
| 9 | Campbell Island | 2 | 01/12/89 |

### Sample preparation and analysis

Prior to analysis the shells of frozen (-40°C) clams were scrubbed free of any loosely adhering material using surgical nylon scrubbing brushes and ultrapure analytical grade water (>18 megohm $cm^{-1}$ resistivity). Clams were then placed in a horizontal laminar flowhood and partially thawed. In this condition (part frozen), the clams were physically opened and sub-samples of mantle and posterior adductor muscles were removed using plastic forceps and ground quartz scalpels. The digestive gland

was removed and a sample of the visceral mass but excluding the kidney tissue was collected. This required the use of stainless steel surgical scalpels. As stated, the tissue mass surrounding the kidney and the kidney *per se* were not sub-sampled due to the obvious tissue changes and consequent leakage of excreta into surrounding areas during the freezing and partial thawing process. At all times care was taken to prevent within and between sample cross contamination. Precautions included pre-soaking of all sample containers and dissection apparatus, including poly-propylene dissection boards, in 10% V/V A.R. nitric acid, and frequent washing/ rinsing of dissection apparatus in ultrapure analytical water. Disposable surgical gloves were worn at all stages of the sampling procedure.

Depending on the tissue sampled, one to two gram aliquots of material were weighed into PTFE digestion vessels, ultrapure nitric acid added, the vessel sealed and the sample digested in a microwave device (CEM Corporation, USA – Model MDS 81D). Analytes of interest were measured by appropriate atomic absorption spectroscopy techniques (Cu and Zn by flame; Hg by cold vapour; and Cd and Pb by graphite furnace) using a Varian Spectra 40 system.

Accuracy and reproducibility within and between analytical procedures were verified by the continuous use of a certified reference material (DORM-1 – National Research Council, Canada).

## Results

Table 2 shows the level of reporting (LOR) and the maximum permitted concentration (MPC) for each of the elements of interest. It should be noted that all results are expressed on an 'as received' fresh weight basis. This permits meaningful comparisons with the relevant MPC's. In addition, the LOR values for Cu and Zn of 0.5 mg $kg^{-1}$ F. Wt. were set with their respective MPCs in mind (70 and either 1000 or 150 mg $kg^{-1}$ F. Wt respectively). These higher LOR values (0.5 mg $kg^{-1}$) should not be confused with the respective detection limits which are typically 50 fold lower in the AAS system described in this paper.

Table 2. Reporting criteria for *T. crocea* analyses in the Torres Strait

| Element | Level of Reporting (LOR) (mg $kg^{-1}$ Fresh Wt.) | Maximum Permitted Concentration (MPC) (mg $kg^{-1}$ Fresh Wt.) |
|---|---|---|
| Cadmium | 0.005 | 2.0 |
| Mercury | 0.01 | 0.5 |
| Lead | 0.05 | 2.5 |
| Copper | 0.05 | 70.0 |
| Zinc | 0.05 | 1000.* |
| | | 150.** |

* MPC for molluscs ** MPC for fish

Tables 3, 4, 5, 6 and 7 indicate the mean concentration (±SD) of Cd, Pb, Hg, Cu and Zn respectively for each of the three tissue types at the various sampling locations.

With the exception of Cd, none of the elements analysed in either of the muscle portions or the visceral mass exceeded one tenth (1/10) of the MPC value. Clams from site 3 (Horn Island A) showed the highest Pb levels in both muscle and gut tissues. Comparable gut Pb levels were present at both sites 8 and 9 but these were not reflected in muscle samples. Horn Island samples (sites 3 and 4) were consistently high for Zn compared to the rest of the sampling locations, although the highest individual Zn levels were found in one clam from site 9 (Robert Island). In keeping with the distribution of Zn levels, Cu concentrations were highest at both of the Horn Island sites and also at Caldbeck Reef (site 5). Mercury levels appeared uniformly low at all sampling sites.

Significant Cd levels (≥1/2 MPC) were found in muscle tissues at four sites (West Island, Horn Island, Caldbeck Reef and Coconut Island). The highest muscle Cd level of 1.85 mg $kg^{-1}$ F. Wt. was found in mantle tissue from Caldbeck Reef. Visceral tissue Cd levels clearly indicate the origin of these relatively high muscle levels.

## Discussion

The opportunistic nature of this survey necessarily restricts the inferences that can be drawn from these results. Nevertheless the results do provide indicative profiles of some heavy metals and biologically critical trace elements in a wide range of environments.

The results for Cd are significant in the context of the MPCs for this element in food substances for human consumption (Rayment, 1990) and are in keeping with levels found in another species *(Penaeus esculentus)* from this general area (Murphy unpublished data). Given this background, it would seem prudent to determine with some priority the Cd status of other Torres Strait marine sourced products intended for either local or export consumption.

Sites 3 and 4 on Horn Island were adjacent to areas recently mined for gold. Associated activities are a plausible explanation for the Pb and Zn levels found in clams at these sites. However it is less evident as to what factor(s) may account for the Pb and Zn levels found at Robert and Campbell Islands. Originally these were included to represent pristine or at least minimally disturbed locations.

The Cu levels found in this survey appear to be consistent with the limited results for this element in *Tridacnid spp.* in other environments. Our limited sampling shows no evidence of any gross Cu accumulation at this juncture that might be attributed to large scale mining activities. However such assertions can only be substantiated through a much higher intensity sampling effort.

Overall this study does add support to Denton's proposed use of *T. crocea* as appropriate bio-indicators for this area (Denton and Heitz, 1990). Just as importantly, it has helped us establish manageable protocols for the retrieval of such indicators from remote areas and their subsequent transport to, and analysis in, appropriately equipped laboratory facilities.

Table 3. Mean (± SD) cadmium content of *T. crocea* sampled at various sites in the Torres Strait

| Mean Tissue Level (± SD) (mg kg⁻¹ Fresh Wt.) | | | |
|---|---|---|---|
| SITE (n=)* | Adductor | Mantle | Visceral Mass |
| 1 (n = 10) | 0.347 (.078) | 0.484 (.08) | 1.81 (.34) |
| 2 (n = 5) | 0.452 (.039) | 0.85 (.208) | 2.56 (.44) |
| 3 (n = 5) | 0.616 (.195) | 0.712 (.386) | 1.15 (.38) |
| 4 (n = 5) | 0.63 (.118) | 1.054 (.278) | 1.476 (.822) |
| 5 (n = 6) | 0.387 (.069) | 0.97 (.44) | 1.68 (.696) |
| 6 (n = 5) | 0.688 (.41) | 0.864 (.253) | 1.834 (.45) |
| 7 (n = 3) | 0.47 (.136) | 0.53 (.30) | 2.3 (.408) |
| 8 (n = 2) | 0.41, 0.30 | 0.52, 0.29 | 3.31, 1.35 |
| 9 (n =2) | 0.61, 0.31 | 0.57, 0.38 | 2.96, 1.63 |

* Where less that 3 samples were collected at any one site individual values are given.
** Maximum permissible concentration for human consumption is 2.0 mg $kg^{-1}$ Fresh Wt.

Table 4. Mean (± SD) lead content of *T. crocea* sampled at various sites in the Torres Strait

| Mean Tissue Level (± SD)** (mg kg⁻¹ Fresh Wt.) | | | |
|---|---|---|---|
| SITE (n=)* | Adductor | Mantle | Visceral Mass |
| 1 (n = 10) | ≤ 0.05 | <0.05 | ≤ 0.05 |
| 2 (n = 5) | <0.05 | <0.05 | ≤ 0.05 |
| 3 (n = 5) | 0.062 (.027) | 0.144 (.127) | 0.104 (.053) |
| 4 (n = 5) | ≤ 0.05 | ≤ 0.05 | <0.05, 0.09 [n=1] |
| 5 (n = 6) | ≤ 0.05 | ≤ 0.05, 0.11 [n=1] | <0.05 |
| 6 (n = 5) | ≤ 0.05 | 0.07, 0.10, <0.05 | <0.05 |
| 7 (n = 3) | ≤ 0.05 | ≤ 0.05 | ≤ 0.05 |
| 8 (n = 2) | 0.03, 0.05 | 0.01, 0.05 | 0.13, 1.28 |
| 9 (n = 2) | 0.03, 0.05 | 0.04, 0.05 | 0.12, 0.06 |

* Where less than 3 samples were collected at any one site individual values are given.
** Where no (Standard Deviation) is quoted, all samples contained ≤0.05 mg $kg^{-1}$ Fresh wt and statistical analysis was not carried out.
*** Maximum permissible concentration for human consumption is 2.5 mg $kg^{-1}$ Fresh Wt.

Table 5. Mean (± SD) mercury content of *T. crocea* sampled at various sites in the Torres Strait

| Mean Tissue Level (± SD)** (mg $kg^{-1}$ Fresh Wt.) | | | |
|---|---|---|---|
| SITE (n=)* | Adductor | Mantle | Visceral Mass |
| 1 (n = 10) | ≤ 0.01 | ≤ 0.01 | 0.016 (.008) |
| 2 (n = 5) | ≤ 0.01 | ≤ 0.01 | 0.024 (.005) |
| 3 (n = 5) | ≤ 0.01 | 0.016 (.005) | 0.026 (.011) |
| 4 (n = 5) | ≤ 0.01 | 0.012 (.004) | 0.026 (.011) |
| 5 (n = 6) | ≤ 0.01 | 0.014 (.008) | 0.013 (.005) |
| 6 (n = 5) | ≤ 0.01 | 0.016 (.009) | 0.014 (.005) |
| 7 (n = 3) | ≤ 0.01 | ≤ 0.01 | 0.03 (.01) |
| 8 (n = 2) | 0.02, <0.01 | <0.01, <0.01 | 0.03, 0.02 |
| 9 (n =2) | 0.01, <0.01 | 0.01, <0.01 | 0.01, 0.03 |

* Where less than 3 samples were collected at any one site individual values are given.
** Where no (Standard Deviation) is quoted, all samples contained ≤ 0.01 mg $kg^{-1}$ Fresh wt and statistical analysis was not carried out
*** Maximum permissible concentration for human consumption is 0.5 mg $kg^{-1}$ Fresh Wt.

Table 6. Mean (± SD) copper content of *T. crocea* sampled at various sites in the Torres Strait

| Mean Tissue Level (± SD)** (mg $kg^{-1}$ Fresh Wt.) | | | |
|---|---|---|---|
| SITE (n=)* | Adductor | Mantle | Visceral Mass |
| 1 (n = 10) | ≤ 0.5 | ≤ 0.5 | 1.19 (.384) |
| 2 (n = 5) | ≤ 0.5 | ≤ 0.5 | 1.26 (.261) |
| 3 (n = 5) | ≤ 0.5 | 0.6 (.12) | 1.46 (.95) |
| 4 (n = 5) | ≤ 0.5 | 0.78 (.31) | 1.36 (.48) |
| 5 (n = 6) | ≤ 0.5 | 0.86 (.66) | 1.34 (.21) |
| 6 (n = 5) | ≤ 0.5 | ≤ 0.5 | 1.06 (.182) |
| 7 (n = 3) | ≤ 0.5 | ≤ 0.5 | 1.77 (.058) |
| 8 (n = 2) | <0.5, <0.5 | <0.5, <0.5 | 3.0, 0.9 |
| 9 (n =2) | <0.5, <0.5 | <0.5, <0.5 | 1.1, 1.1 |

* Where less than 3 samples were collected at any one site individual values are given
** Where no (Standard Deviation) is quoted, all samples contained ≤ 0.5 mg $kg^{-1}$ Fresh wt and statistical analysis was not carried out.
*** Maximum permissible concentration for human consumption is 70.00 mg $kg^{-1}$ Fresh Wt.

Table 7. Mean (± SD) zinc content of *T. crocea* sampled at various sites in the Torres Strait

| Mean Tissue Level (± SD)** (mg kg$^{-1}$ Fresh Wt.) | | | |
|---|---|---|---|
| SITE (n=)* | Adductor | Mantle | Visceral Mass |
| 1 (n = 10) | 0.757 (.22) | 1.34 (.447) | 2.83 (.24) |
| 2 (n = 5) | 0.9 (.29) | 1.26 (.36) | 2.38 (.34) |
| 3 (n = 5) | 3.64 (1.49) | 2.84 (.83) | 4.38 (.98) |
| 4 (n = 5) | 3.24 (.55) | 2.58 (.327) | 3.34 (.68) |
| 5 (n = 6) | 1.03 (.585) | 1.67 (.58) | 2.67 (.78) |
| 6 (n = 5) | 1.36 (1.21) | 2.02 (1.02) | 2.94 (.658) |
| 7 (n = 3) | .93 (.75) | 1.00 (.7) | 2.83 (.50) |
| 8 (n = 2) | 2.1, 0.5 | 2.5, 1.0 | 7.7, 5.4 |
| 9 (n =2) | 6.4, 1.0 | 5.7, 0.8 | 7.6, 4.0 |

* Where less than 3 samples were collected at any one site individual values are given

** Where no (Standard Deviation) is quoted, all samples contained ≤ 0.5 mg kg$^{-1}$ Fresh wt and statistical analysis was not carried out.

*** Maximum permissible concentration for human consumption is 150 mg kg$^{-1}$ Fresh Wt.

## References

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