INTRODUCTION

The Torres Strait Baseline Study (TSBS) was instigated in response to concerns by Torres Strait Islanders, scientists and conservationists about possible heavy metal contamination within the Torres Strait (see Lawrence & Dight, 1991 for background to the study). This concern arose as a result of mining activities within the Fly River catchment of Papua New Guinea. The purpose of the study is to acquire data that will assist in determining the extent of influence of Fly River discharge and whether there is evidence of elevated metal concentrations within the Torres Strait.

The TSBS has four component programmes: community fisheries, commercial fisheries, sediment and biota; the last two programmes constitute the scientific programme. The scientific programme objectives, conceptual design and details of the pilot study are reported by Dight (1991). A principal aim of the programme is to establish the spatial extent of trace metal inputs resulting from Fly River discharge. In light of this aim, the study design will seek to identify a gradient of change in trace metal concentrations away from the mouth of the Fly River. As such, the sampling programme will be carried out along a series of transects radiating away from the mouth of the Fly River. The transects lie along transport pathways into the Torres Strait.

A pilot study was instigated on the basis that: (1) there was a very poor understanding of spatial and seasonal variation in trace metals within the Torres Strait; (2) the complexity of the environment and the likelihood that trace metals would not be distributed and deposited uniformly throughout the region; (3) the distribution and abundance of suitable indicator organisms was largely unknown; and (4) there were no suitable estimates of variance in trace metal concentrations on which to base a sampling strategy which would ensure that environmental differences could be detected. This approach is considered fundamental as a first step in baseline and monitoring studies (Gordon et al., 1980).

The pilot study objectives therefore included: (1) the identification of species which would be suitable <u>indicators of trace metal bio-availability</u>; (2) the <u>development of sampling strategies</u> for selected metals in biota and sediments; (3) a preliminary assessment of <u>spatial and temporal variation in trace metal concentrations in sediments and biota</u> from the Torres Strait; and (4) an assessment of the impacts of current levels of <u>trace metals in marine biota on the health of Torres Strait Islanders and coastal Papuans</u>. This report will present results which are of relevance to these four objectives.

Indicators of Trace Metal Bio-availability

Phillips (1980) identifies a number of prerequisites for the selection of species as indicators of trace metal bio-availability. These include:

(1) Bio-monitors should be sessile or sedentary, thus being representative of a location, be abundant throughout the study area, easy to identify and sample, and provide sufficient tissue for analysis of the contaminants of interest;

(2) Bio-monitors should be hardy, accumulate the trace metals of interest, tolerate high levels of these metals and be suitable for laboratory studies of pollutant kinetics; and

(3) A simple relationship should exist between the pollutant concentration found in the tissues of a bio-monitor and the average ambient pollutant concentration. This relationship should be the same at all study sites.

The usefulness of bivalve molluscs as indicators of trace metal bio-availability is well established (Phillips, 1980; Phillips & Segar, 1986). This is reflected in the many studies of anthropogenic sources of trace metal contamination in the marine environment using mussels, oysters and other bivalve molluscs (e.g. Harris et al., 1979; Peerzada & Dickinson, 1989; Talbot, 1985,1986; Talbot & Chegwidden, 1982; Ward et al., 1986 in the Australian context). Possibly equally numerous are experimental studies, in both the laboratory and field, concerned with the uptake and behaviour of trace metals in bivalve molluscs (e.g. Behrens & Duedall, 1981; Elliott et al., 1985; Coleman et al., 1986).

Several of the species that were collected as part of the pilot study have been surveyed previously for trace metal concentrations within the Great Barrier Reef (GBR) and Torres Strait (Burdon-Jones & Denton, 1984a,b; Denton & Heitz, 1991). These include the bivalve molluscs *Tridacna crocea*, *Tridacna maxima*, *Pinctata margaritifera* and *Hyotissa hyotis*, and the reef fish *Lutjanus carponotatus*. On the basis of field surveys and trace metal determinations in various tissues, the kidney of both *T. crocea* and *T. maxima* and the liver of *L. carponotatus* were identified as the most suitable tissues for metal analysis because they concentrate many metals to well above background levels and showed greatest inter-location variability which appeared to reflect differences in environmental concentrations (Burdon-Jones & Denton, 1984a,b).

The uptake and depuration kinetics of cadmium, copper, lead, mercury and zinc in *T. crocea* have been studied experimentally in both the field and laboratory (Denton &

Heitz, 1991). All five metals are reported to obey the first-order kinetics model, indicating that there is little or no metabolic regulation and that renal accumulation rates are directly proportional to environmental concentrations. Such an understanding of metal kinetics provides an opportunity to predict time-averaged, bioavailable concentrations in the water column. However, Denton and Heitz (1991) point out that episodic inputs of elevated trace metal concentrations coupled with the inability of the biomonitor to attain equilibrium can be a major shortcoming with respect to the estimation of environmental concentrations from biological concentration factors.

Potential sources of variation in metal concentrations in bivalves, and clams in particular, have been identified as temperature, salinity, season, sex, reproductive status, physiological activity, diet, age, growth rate and the genetic make-up of individuals (Phillips, 1980; Denton & Heitz, 1991). These all interact with environmental metal concentrations to affect the metal status of an organism (Phillips, 1980). While some sources of variation cannot be controlled (e.g. physiological activity, diet and the genetic make-up of individuals), others such as season, reproductive status, age and growth rates can be minimized by selective sampling.

Spatial and Temporal Variation in Trace Metal Concentrations in Sediments and Biota

Three methods are commonly used to quantify trace metal concentrations: the analysis of water, sediments and biota. Phillips (1980) identifies several disadvantages associated with the use of water analysis as an indicator of trace metal availability. In particular, he draws our attention to the difficulty of producing a time-integrated value of pollutant concentration at any specific location and the low concentrations of some metals which can give rise to problems of analytical sensitivity and sample contamination. This is in contrast to the analysis of sediments and biota which provide time-integrated concentrations that are generally much higher than in water.

Metals associated with the inorganic particulate component of sediments are generally considered to have low bio-availability, while the analysis of total metal concentrations provides no information on how readily mobilized surface bound metals may be. In contrast, a strength of biota sampling is that the analysis provides a direct measure of trace metal bio-availability. However, different organisms have different accumulation characteristics and tolerances, and respond to different portions (dissolved, organic and inorganic particulate forms) of the total trace metal load. Thus, trace metal profiles in one species will not necessarily match those of another species in the same location at

the same time. An assessment of seasonal variation in trace metal bio-availability is further complicated by variation in the uptake and depuration kinetics of trace metals as a consequence of reproduction and temperature/salinity changes in the water column.

In the Australian context, most studies have been conducted in temperate waters using species which are not present in the tropical waters of the Torres Strait. A notable exception is the extensive baseline survey of Burdon-Jones and Denton (1984a,b) which included algae, bivalve molluscs and fish from many locations within the Great Barrier Reef. This work provided a basis for the selection of potential indicator organisms and a reference with which to compare the concentrations of trace metals in selected biota from the Torres Strait.

Trace Metals in Marine Biota and the Health of Torres Strait Islanders and Papuans

All trace metals are found naturally in the environment and are incorporated to varying degrees into the tissues of all biota. However, while most also have known biological/metabolic functions, such as copper and iron in the transport of oxygen within the blood of crustaceans and fish respectively, others such as cadmium and mercury have no known biological function. In elevated concentrations and in large quantities, all trace metals (essential or not) become toxic and injurious to human health. The difference between levels that are beneficial and those that are harmful is sometimes small (WHO, 1973). Excessive metal intake is normally determined by comparison with Provisional Tolerable Weekly Intakes (PTWI) prepared by the Joint FAO/WHO Expert Committee on Food Additives. Maximum Permitted Concentration (MPC) refers to acceptable levels of metals in foods. It is set by individual nations and influenced by commercial trade considerations.

Broad-scale surveys of contaminants in foods, such as the Australian Market Basket Survey, are designed to monitor and assess the level of contaminants in 'typical' foods or diets, and in this way ensure that they do not cause concern from a public health point of view (NHMRC, 1991). However, population sub-groups who have unusual diets or consume large quantities of seafood are not well catered for in such surveys. Relatively little is known about the diet of Torres Strait Islanders and coastal Papuans and, in particular, how it varies from community to community. However, the importance of the marine resources to their diet is widely acknowledged (e.g. Fitzpatrick, 1991). Seafood consumption rates appear to be amongst the highest in the world (Johannes & MacFarlane, 1991) and include a very wide range of items, such as

turtle, dugong, many species of reef and pelagic fish, molluscs and crustaceans (Neitschmann, 1984; Johannes & MacFarlane, 1991; Poiner & Harris, 1991).