3. TRACE METALS IN THE TRADITIONAL SEAFOODS OF THE TORRES STRAIT

BACKGROUND

The report of the Pilot Study of the Torres Strait Baseline Study (TSBS) included preliminary information on the levels of trace metals in some of the seafoods commonly eaten by Torres Strait Islanders (Dight and Gladstone 1993). Twenty six species of reef fishes, crustaceans and molluscs were collected, as well as green turtle and dugong, over a period of nine months from June 1991.

Levels of trace metals were low in most species, compared to the Maximum Permitted Concentrations (MPC; National Food Authority, 1994). There were some notable exceptions, however, including the culturally significant dugong and turtle. Cadmium, copper and mercury were high in some or all tissues tested (kidney, liver, intestine, muscle) from green turtles. A similar pattern emerged for dugong: cadmium, copper, mercury, selenium and zinc were high in some or all tissues. Cadmium was the metal most elevated in both turtle and dugong.

Two species of sardines had levels of cadmium and selenium which were high, but based on a limited number of specimens.

These samples were collected as part of the Pilot Study and consequently the number of specimens was small. For example, only one dugong and two turtles were collected. This suggestion of elevated levels led to more specimens and additional species being collected as part of the much larger Main Study. It is those results which are reported here.

METHODS AND MATERIALS

Sample Collection and Preparation

A total of 618 samples from 43 species were collected over two sampling periods: October-December 1992 and February-May 1993. Funding constraints limited the number of samples which could be analysed to 195 from 19 species (see table 3.1) collected between October and December 1992, from the locations shown in figure 3.1.

Specimens were collected by Torres Strait Islanders using their normal techniques, or from commercial fishermen who were capturing the same species. After collection, and unless stated otherwise, samples were handled in the following ways: samples were washed in clean seawater, double-bagged, labelled, then either frozen or placed on ice for transfer by air to the lab on Horn Island where they were frozen. Some samples of fish and crustacean (crayfish and mud crab) were cooked prior to freezing.

The different animal groups collected were handled in the following ways:

Fishes

Samples of fishes were captured by Islanders using either hand line, gill net, or by trolling, or were purchased from local markets. Species and locations are listed in table 3.1. Muscle portions for analysis were taken: from freshly caught specimens (the portion was immediately frozen); from whole and gutted fish which had been frozen immediately after capture; from fresh whole fish which had been grilled (the cooked portion was immediately frozen). Muscle portions from freshly caught fish were taken from the caudal peduncle; muscle overlying the rib

cage was taken from cooked samples. In one case a sample of gut was analysed from a fish which had been frozen whole.

Mangrove Cockle (Polymesoda erosa)

Mangrove cockles were collected by Islanders, by hand, in mangrove stands from eight different locations throughout the Torres Strait. Prior to chemical analysis the samples were thawed, opened, and the digestive tract opened and all mud washed out. Trace metal levels were determined for whole samples.

Mud Crab (Scylla serrata)

Five mud crabs were collected by hand from around Boigu Island. All specimens were boiled, to simulate the normal cooking procedure, then frozen. Muscle tissue from inside the carapace was tested for trace metal content.

Crayfish (Panulirus ornatus)

Crayfish were obtained from commercial collectors, who had speared them. Tails and heads were frozen immediately; a sub-sample of heads was boiled for fifteen minutes (to simulate cooking), then frozen prior to analysis. A portion of tail muscle was analysed for trace metal content; whole heads were ground up prior to analysis. A consequence of this technique is that the metal load detected for crayfish heads will be a combination of the metal loads of the shell and the soft tissues. However, it is the hepatopancreas which is eaten from the heads. The metal content of hepatopancreas was estimated separately by subtracting estimates of shell metal loads (reported in Evans-Illidge *in prep*) from total sample metal loads.

Dugong (Dugong dugon)

Samples of dugong tissue were collected from animals which had been recently harpooned from the locations listed in table 3.1, or from animals for sale in the Daru market. The following commonly eaten tissues were analysed: muscle (taken just posterior to the anus), kidney, liver (from the left lobe), intestine (from the middle portion).

Green Turtle (Chelonia mydas)

Samples of plastron muscle, liver, kidney and intestine were taken from green turtles which had been freshly caught either by hand of by spearing, from the locations listed in table 3.1.

Trace Metal Analysis

Trace metal analysis was undertaken by the Animal Research Institute of the Queensland Department of Primary Industries. Inductively Coupled Mass Spectrometry (ICP-MS) was used to determine concentrations of aluminium (Al), total arsenic (As), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg), manganese (Mn), nickel (Ni), lead (Pb), selenium (Se), silver (Ag), strontium (Sr), uranium (U) and zinc (Zn). The complete analytical procedures are detailed in appendix 7. Metal levels on both a wet and dry weight basis were determined; however, wet weight levels only are reported here.

Metal levels of some samples were below detection limits. When calculating mean metal levels of a number of samples which included samples where levels were below the detection limits, a value for these samples midway between the detection limit and zero was substituted. This is in

agreement with the procedures used in the Market Basket Survey (Stenhouse 1991) and the Pilot Study (Dight and Gladstone 1993).

Comparisons with Standards

Reporting and discussion will concentrate on those metals normally considered to be relevant to human health and for which appropriate standards exist. These metals are arsenic, cadmium, copper, lead, mercury, selenium and zinc.

The potential health implications of high levels of some trace metals were assessed by calculating the amounts of each tissue which could be consumed in one week without exceeding the Provisional Tolerable Weekly Intake (PTWI) for that metal. PTWI values (in µg/kg body weight/week) used in this report were: cadmium 7; lead 25; copper 3500; mercury 5 (Stenhouse 1992). WHO (1987) recommends a selenium intake of 50-200 µg per day for adults; for this study a conservative 125 µg daily intake was used (i.e. maximum safe weekly intake of 0.875 mg). Calculations were done for the following age and sex weight categories: adult male 75.0 kg; adult female 59.1 kg; 12 year old boy 39.78 kg; 12 year old girl 41.53 kg (Stenhouse 1992). Calculations for cadmium and mercury take into account the intake of these metals from other dietary sources (from the 1990 Market Basket Survey, Stenhouse 1991). Maximum safe levels of consumption for turtle and dugong tissues were calculated by combining the results of the Pilot (Dight and Gladstone 1993) and Main studies, because of the small number of samples of each. Arithmetic means were calculated when sample sizes exceeded one.

Metal levels are also compared with, but for reference only, the Maximum Permitted Concentration (the MPC) for each metal as set out in Food Standard A12 (National Food Authority 1994). MPC values are only relevant for foods which are sold and are not designed for use as a health standard. MPC values exist for fish, crustacean, and molluscs; however, no values exist for samples of meat and offal taken from dugong and turtle. The MPC value used for these samples was the 'All other foods' category for each metal. The MPC for arsenic is based on inorganic arsenic; however, total arsenic was measured in this study. For the purposes of this Study it was assumed that inorganic arsenic represents 1.3% of total arsenic, which is the average of a range of percentages reported by Edmonds and Francesconi (1993) for a similar range of marine animals (fishes, crustaceans, molluscs).

RESULTS

Summary results of the levels of metals relevant to human health, for the different food groups, are in appendices 18 to 22 at the end of this chapter, and safe levels of consumption are in appendix 23.

Fishes

Samples from 15 species of fishes were analysed, representing a total of 44 samples. Appendix 18 is a summary of the results for the metal levels of all fishes sampled, for those metals relevant to human health. Metal levels are low in most species and tissues tested, including cooked specimens. The only exceptions to this are mercury in barramundi (*Lates calcarifer*) muscle; cadmium and copper in parrotfish (*Scarus dimidiatus*) muscle; and selenium in mullet (*Valamugil seheli*) gut. If these tissues were sold commercially the levels of these metals would exceed the MPC values. Weekly consumption of between 9 and 25 g of parrotfish muscle, between 112 and 203 g of barramundi muscle, and 673 g of mullet gut, will equal the PTWI for cadmium, mercury and selenium respectively (appendix 23). However, these results should be treated cautiously as they are derived from only 1-2 specimens of each species.

Mangrove Cockle (*Polymesoda erosa*)

A total of 120 mangrove cockles were collected from eight locations in the central and northern Torres Strait (appendix 19). Mean levels of all metals were low. Selenium levels of some individual specimens (e.g. from Warukuik Creek and Daru) were high; however, the infrequency of such specimens in the total number collected suggests that they probably have insignificant health implications.

Crustaceans

Mud Crab (Scylla serrata)

Mean levels of all metals were low (appendix 20). However, as the ranges show, copper in two specimens (9.1 mg/kg, 11.0 mg/kg) and selenium in two specimens (1.2 mg/kg, 1.0 mg/kg) were at or near the respective MPC values of 10.0 and 1.0 mg/kg.

Crayfish (Panulirus ornatus)

Metal levels varied with tissue type and cooking. In crayfish tail muscle the mean and individual levels of all metals were low (appendix 20). Total arsenic levels in crayfish tails were the highest recorded amongst all specimens analysed for this study; however, when total arsenic was converted to inorganic arsenic the values were low.

Cadmium in fresh crayfish heads was greater than the levels in tail muscle. There was, however, a great difference between the two specimens analysed (2.1 mg/kg and 0.02 mg/kg) which elevated the mean value. All other metals in fresh crayfish heads were low.

Cooking of crayfish heads elevated the levels of cadmium, copper and zinc (appendix 20). If boiled crayfish heads were sold commercially the levels of cadmium, copper and possibly selenium would exceed the MPC values for these metals. The major source of metals in crayfish heads is the hepatopancreas, which in the Torres Strait is commonly eaten whole after cooking. The concentration of metals in the hepatopancreas can be approximated by subtracting the metal contents of shell for cadmium (0.01 mg/kg) and copper (1.27 mg/kg) from the total head loads (from values reported in Evans-Illidge in *prep*). This approximation does not take into account the levels of these metals in gill tissue (Rainbow and Moore 1986) and may bias the result upwards; however, no information is available on gill levels in this species.

Although the copper levels in the hepatopancreas are high, they are unlikely to have health implications as between 36.9 and 69.7 kg would need to be consumed in one week to put the consumer at the PTWI (appendix 23). However, smaller quantities, between 79 and 222 g per week (depending on the consumer's sex and weight), will put consumers at the PTWI for cadmium.

Dugong (*Dugong dugon*)

Tissues from three dugong collected from different locations throughout the Torres Strait were analysed. Cadmium, copper, selenium and zinc levels were high in one or more tissues (appendix 21). Levels of these metals varied amongst the five tissue types; however, levels in liver and kidney were generally higher than other tissue types. The relative levels of metals for which there is an MPC, in the different tissues, is shown below:

Arsenic:	muscle<intestine<kidney<liver<muscle+fat
Cadmium:	muscle<muscle+fat<intestine<liver<kidney
Copper:	muscle<intestine<kidney<muscle+fat<liver
Mercury	muscle=muscle+fat=intestine<kidney<liver
Lead:	muscle+fat<intestine<muscle<kidney<liver
Selenium:	muscle<intestine<muscle+fat<liver<kidney
Zinc:	muscle+fat<muscle<intestine<kidney<liver

Levels of cadmium, copper, selenium and zinc in liver; cadmium and selenium in kidney; cadmium in intestine, and possibly mercury in liver would preclude these tissues from sale as food because of violations of the MPC for these metals.

Copper, selenium and zinc levels, although high, were unlikely to have health implications, because of the large quantities of tissue that must be eaten each week for these metals to exceed the PTWI (appendix 23). However, consumption of quite small quantities of liver (between 17 and 47 g per week) and kidney (between 13 and 37 g per week) will put the consumer at the PTWI for cadmium (appendix 23).

Green Turtle (*Chelonia mydas*)

Tissue samples from five turtles collected from different locations throughout the Torres Strait were tested. Cadmium, copper, mercury, and selenium levels were high in one or more of the different tissue types (appendix 22). Levels varied amongst the four tissue types; however, the mean levels were always greatest in either kidney or liver, or both. The relative levels of metals for which there is an MPC, in the different tissues, are:

Arsenic:	kidney<muscle<liver<intestine
Cadmium:	muscle<intestine<liver<kidney
Copper:	intestine<muscle<kidney<liver
Mercury	muscle<kidney<intestine<liver
Lead:	intestine<kidney<muscle<liver
Selenium:	muscle<intestine<kidney<liver
Zinc:	muscle<intestine<kidney<liver

All turtle tissues would be unfit for sale because they exceed the MPC for one or more of the following metals: cadmium, copper, mercury and selenium.

The levels of copper, mercury and selenium are unlikely to have health implications because of the large quantities of tissue which must be consumed each week for the intake of these metals to exceed the PTWI (appendix 23). However, weekly consumption of between 4 and 11 g of kidney, or between 10 and 28 g of liver will give the consumer a cadmium intake equal to the PTWI. In comparison, weekly consumption of between 93 and 262 g of turtle muscle will give the consumer a cadmium intake equal to the PTWI.

DISCUSSION

Comparisons with the Pilot Study

This Main Study surveyed the levels of trace metals in a number of the traditional seafoods consumed in the Torres Strait. The majority of specimens tested had low levels of trace metals, supporting the preliminary findings reported in the Pilot Study (Dight and Gladstone 1993). To summarise the present results, 13 of the 15 species of fishes tested had low levels of all metals. A single specimen of parrotfish had elevated levels of cadmium and copper; a single specimen

of barramundi showed elevated levels of mercury. This parrotfish (*Scarus dimidiatus*) was not tested in the Pilot Study and mercury was not elevated in a single specimen of barramundi tested in the Pilot Study. These results should be treated as being inconclusive until more specimens are tested.

Amongst the fishes tested for the Pilot Study three specimens of Murray Island sardine (*Harengula ovalis*) showed high levels of cadmium and selenium. The same species was tested for the Main Study using a larger sample size (N = 15), but collected at Horn Island. Individual and mean levels of all metals were low; cadmium levels, except for one sample, were all below the detection limits. The Pilot Study results caused concern amongst the inhabitants of Murray Island who frequently eat this species (V McGrath pers. comm.), and so it is worthwhile exploring these differences in some detail. The difference in results between the Pilot and Main Studies could reflect a true geographic difference in metal levels between Murray and Horn Islands. Other results, however, from the Pilot Study revealed no difference in the sediment levels of cadmium and selenium between two stations close to Murray and Horn Islands (Dight and Gladstone 1993). In addition, fishes are efficient regulators of most metals and their tissues do not normally reflect geographic trends in metal levels (Phillips 1980). The observed difference could be caused by contamination of the Murray Island samples during collection or storage. Alternatively, as food is a major source of metals in fishes (Bryan 1984), there could be a difference in the diet of *H. ovalis* between Horn and Murray Islands as these specimens were tested whole (i.e. including the gut). Locational differences in cadmium levels have been attributed to diet variations for another species of fish on the Great Barrier Reef (Burdon-Jones and Denton 1984). Further testing of specimens collected from Murray Island is warranted.

Mean levels of all metals were low in mangrove cockles, mud crabs, and fresh crayfish tails, supporting the results for mangrove cockles and crayfish tails reported in the Pilot Study (mud crabs were not investigated in the Pilot Study). The results for fresh crayfish tails also agree with results from the Commercial Fisheries study (Evans-Illidge *in prep*) where a much larger sample size was tested.

There was some concern expressed in the Pilot Study about the high levels of total arsenic in the tail muscle of two species of crayfish. However, applying the conversion of 1.3% inorganic arsenic (Edmonds and Francesconi 1993), the levels of inorganic arsenic in *P. ornatus* tails were low, but the level in a single specimen of *P. versicolor* is higher, and approached the MPC.

Fresh crayfish heads had high levels of cadmium, and cooked heads had higher cadmium and copper levels (crayfish heads were not investigated in the Pilot Study). The high levels of metals in the head reflect the importance of the hepatopancreas as a metal storage organ, especially for copper to be used in haemocyanin (Rainbow 1988). Damage to the hepatopancreas is the most likely reason for increased levels of copper in cooked specimens. Increases following cooking in body muscle cadmium content (often exceeding the MPC) have also been reported for spanner crabs (Rayment 1988; Slattery et al 1992).

Dugong liver had high levels of cadmium, copper, selenium, zinc and possibly mercury. Kidney samples had elevated levels of cadmium and selenium; and one sample of intestine had high cadmium levels. Except for zinc in liver tissue, the same trends were reported in the Pilot Study from analysis of tissues from one animal.

All turtle tissues showed elevated levels of one or more metals; liver specimens had high levels of cadmium, copper, mercury and selenium; kidney specimens had high levels of cadmium, selenium, and possibly mercury; some samples of intestine and muscle had elevated mercury.

Only cadmium, copper and mercury were elevated in two specimens examined for the Pilot Study.

Health Implications

Heavy metal levels in large marine animals are important because of the potential health effects (Black 1988) in traditional societies where these animals are still hunted. It is beyond the scope of this report to comment on the potential impacts on human health from consuming traditional seafoods in the Torres Strait. However, because these results represent the first extensive survey of metal levels in the traditional seafoods of the Torres Strait, they should be utilised to highlight potential areas for concern and future action by appropriate specialists.

Potential health implications were assessed by reference to the PTWI for those foods where metal levels were high (summarised in appendix 23). The following foods were identified with high levels of some trace metals: barramundi and parrotfish muscle, mullet gut, Murray Island sardines, boiled crayfish heads, dugong liver and kidney, and all turtle tissues.

Single specimens only of barramundi and parrotfish were investigated. The parrotfish tested here (*Scarus dimidiatus*) was not recorded in an extensive survey of the fishes commonly caught and eaten by Torres Strait Islanders and probably does not require further investigation; similarly, barramundi (*Lates calcarifer*) represented only 1.7% of total catch (Harris et al 1994). Barramundi is, however, an important commercial and recreational species in the fisheries of northern Australia and therefore deserves further investigation. Other studies have determined elevated levels of mercury in barramundi from Papua New Guinea (Kyle and Ghani 1985, Currey et al 1992).

Boiled crayfish heads were identified as a source of high levels of cadmium, most of which originated in the hepatopancreas. Torres Strait Islanders sell the high value crayfish tails, then boil the heads and eat the hepatopancreas whole (V McGrath pers. comm.). Crayfish caught most frequently by Torres Strait Islanders are between 100 and 115 mm carapace length, with average weights of between 877.0 g and 1098.5 g (R. Pitcher, unpublished data). The hepatopancreas represents approximately 10% of total body weight (R. Pitcher pers. comm.), and consumption of small amounts could lead to high intake of some trace metals. Actual consumption rates are unknown.

Weekly consumption of relatively small quantities of dugong liver and kidney, and of all tissues of the green turtle, will exceed the PTWI for cadmium. The levels of metals in the turtle and dugong samples collected for this Study are probably representative of the levels to which Torres Strait Islanders are exposed, because the sizes of turtle and dugong sampled are within the size ranges of the usual catches for both species (Johannes and MacFarlane 1991; Harris et al 1994). Previous studies (cited in Johannes and MacFarlane 1991) have determined the daily consumption rates of dugong and turtle muscle at several locations in the Torres Strait. The results suggest that at the time of those studies weekly consumption of dugong muscle at three locations (Boigu Island: 0.233 kg per week; Yorke Island: 0.042 kg per week; Badu, Moa and Mabuiag Islands: 1.89 kg per week) did not exceed the PTWI for any metal. By contrast, weekly consumption of turtle muscle at Yorke Island (0.69 kg) exceeded the PTWI for cadmium; Mabuiag Island consumption (0.91 kg) exceeded the PTWI for cadmium and selenium; Boigu Island consumption (0.82 kg) exceeded the PTWI for cadmium and possibly selenium; Kubin community consumption (1.96 kg) exceeded the PTWI for cadmium, selenium, and was near the PTWI for copper for boys and girls. Average weekly consumption of turtle muscle throughout the Torres Strait (0.87 kg) exceeded the PTWI for cadmium and selenium.

The studies referred to in the preceding paragraph contained data only on the consumption of muscle. Current consumption rates of the muscle and other tissues are unknown but can be estimated using data from a recent study on catch rates of turtle in the Torres Strait (Harris et al 1994), and organ weights as a percentage of total body weight (Rebel 1974; unfortunately, comparative information of the relative weights of dugong tissues is not available). This data (see table 3.2) shows that, on average, sufficient quantities of all turtle tissues, except kidney, are available each week in the Torres Strait for consumers to exceed the PTWI for cadmium, but not for copper, mercury or selenium.

These results should be interpreted cautiously and not taken to indicate that a public heath problem currently exists in the Torres Strait. The current limitations of these results include: (1) small sample size. Additional samples were collected for the Main Study; however even when the Pilot and Main Study results were combined to estimate safe weekly consumption rates (appendix 23), data from only three dugong and seven turtles were available. Further samples were collected for the Main Study and are still in storage but were not analysed because of funding constraints; (2) the calculation of safe levels of consumption does not take into account the levels of consumption of other foods, which are also sources of trace metals; (3) interactions with other chemicals. Studies have shown that absorption of cadmium is influenced by other dietary factors such as the gut concentrations of protein, calcium, vitamin D and zinc (Black 1988, Koh 1988) and also the age and sex of the consumer (Koh 1988); (4) consumption rates of these foods are unknown. Health problems associated with consuming excess levels of heavy metals will occur when the PTWI is consistently exceeded. Catch rate data from two studies (Johannes and MacFarlane 1991; Harris et al 1994) has shown that catches of both turtle and dugong vary considerably between locations in the Torres Strait, and vary over time. Information on actual consumption rates collected over a long period of time is urgently needed. This information needs to be complemented by information on the consumption rates of all other foods to obtain a more realistic calculation of actual trace metal intake.

Sources of Elevated Trace Metals

An important reason for establishing the TSBS was to investigate the concern expressed by Torres Strait communities that their traditional seafoods could eventually become contaminated with trace metals from the Fly River. Investigating this involves establishing the levels of trace metals in traditional seafoods, identifying the potential source(s) of those metals with elevated levels using other information collected as part of the TSBS, and a consideration of the natural history of those animals with elevated metal levels in their tissues.

Naturally occurring elevated levels of trace metals in tissues of other large marine animals have been attributed to dietary sources (Miles and Hills 1994). Dugong and green turtle are herbivores feeding on seagrasses and some algae. It is possible that the elevated levels of cadmium in these two animals originate from high levels in dietary items and the incidental ingestion of sediment. Cadmium levels in three species of seagrass common in the Torres Strait, *Halophila ovalis* (Denton et al 1980), *Thalassia hemprichii* and *Thalassodnedron ciliatum* (Dight and Gladstone 1993) are low, and close to levels in terrestrial angiosperms and pasture grasses (Denton et al 1980). Sediment levels of cadmium in the Torres Strait are below the levels considered to be normal for unpolluted tropical areas (this report and Dight and Gladstone 1993). Elevated levels of cadmium in these animals could therefore be due to high levels of consumption over a long lifespan.

Sediment results from this study and the Pilot Study indicated that cadmium in the Torres Strait is primarily associated with coarse-grained carbonate sediments of marine origin; in particular, cadmium levels close to the Fly River were the lowest in the Torres Strait.

Comparisons with other studies reveals that the levels of cadmium in dugong and turtle tissues from the Torres Strait are comparable to levels detected in these same tissues from unpolluted areas outside the Torres Strait. Cadmium levels in dugong offal from the Torres Strait are within the range of values reported for dugong from north Queensland coastal waters outside the Torres Strait (Denton et al 1980). Cadmium in dugong tissues exceeds the levels found in other marine mammals (see Denton et al 1980 and references therein, Pena et al 1988, Taylor et al 1989). By comparison, cadmium in dugong muscle occurs at lower levels than in the muscle tissue of sheep and cattle, but it occurs in liver and kidney at levels of at least one order of magnitude greater than in the same tissues of sheep and cattle (Langlands 1988).

Levels of cadmium in Torres Strait green turtle tissues are within the range of values reported for this species in Hawaiian waters (Aguirre et al 1994). No other information on metal levels exists for this species.

In summary, although cadmium levels are elevated in turtle and dugong tissues from the Torres Strait, they are similar to levels reported for the same species from other localities, and it is reasonable to conclude that these high levels are a natural phenomenon. However, the health implications associated with consuming large quantities of food itemes which are naturally high in trace metals needs to be investigated.

Table 3.1. Specimens of community seafoods analysed for the Main Study

GROUP	SPECIES	NAME	ISLAND NAME	LOCATION
FISHES	*Scomberoides commersonianus*	Talang queenfish	Kabar	Warraber Is
	Scomberomorus commerson	Spanish Mackerel	Dubui	Warraber Is
	Caranx ignoblis	Giant trevally	Mathai/gaigee	Warraber Is
	Mugil georgii	Fantail mullet	Murgudlai	Warraber Is
	M. cephalus	Sea mullet	Makerr	Saibai Is
	Choerodon cyanodus	Blue tuskfish	Billa	Warraber Is
	Lutjanus carponotatus	Stripey	Thanab	Warraber Is
	Lethrinus laticaudis	Grass emperor	Poeyad	Bet Is
	Harengula ovalis	Murray Is sardine		Horn Is
	Lates calcarifer	Barramundi		Saibai Is
	Scarus dimidiatus	Yellowbarred parrotfish	Bira	Kokope Rf
	Gnathanodon speciosus	Golden trevally	Kabaro	Kokope Rf
	Amniataba caudavittatus	Yellowtailed perch	Jurrum	Bobo Is
	Hemiramphus far	Garfish	Jabere	Bobo Is
	Valamugil seheli	Bluetailed mullet	Kaworo	Daru
MOLLUSCS	*Polymesoda erosa*	Mangrove cockle	Akul	Sassic Is Kussa Is Boigu Is Saibai Is Warukuik Ck Bobo Is Parama Is Daru
CRUSTACEANS	*Scylla serrata*	Mud crab	Gitalai	Boigu Is
	Panulirus ornatus	Crayfish	Kaiar	Saibai Is Mabuiag Is
SEA TURTLE	*Chelonia mydas*	Green turtle	Waru	Warraber Is Boigu Is Saibai Is Daru
MAMMAL	*Dugong dugon*	Dugong	Dangal	Mabuiag Is Boigu Is Daru

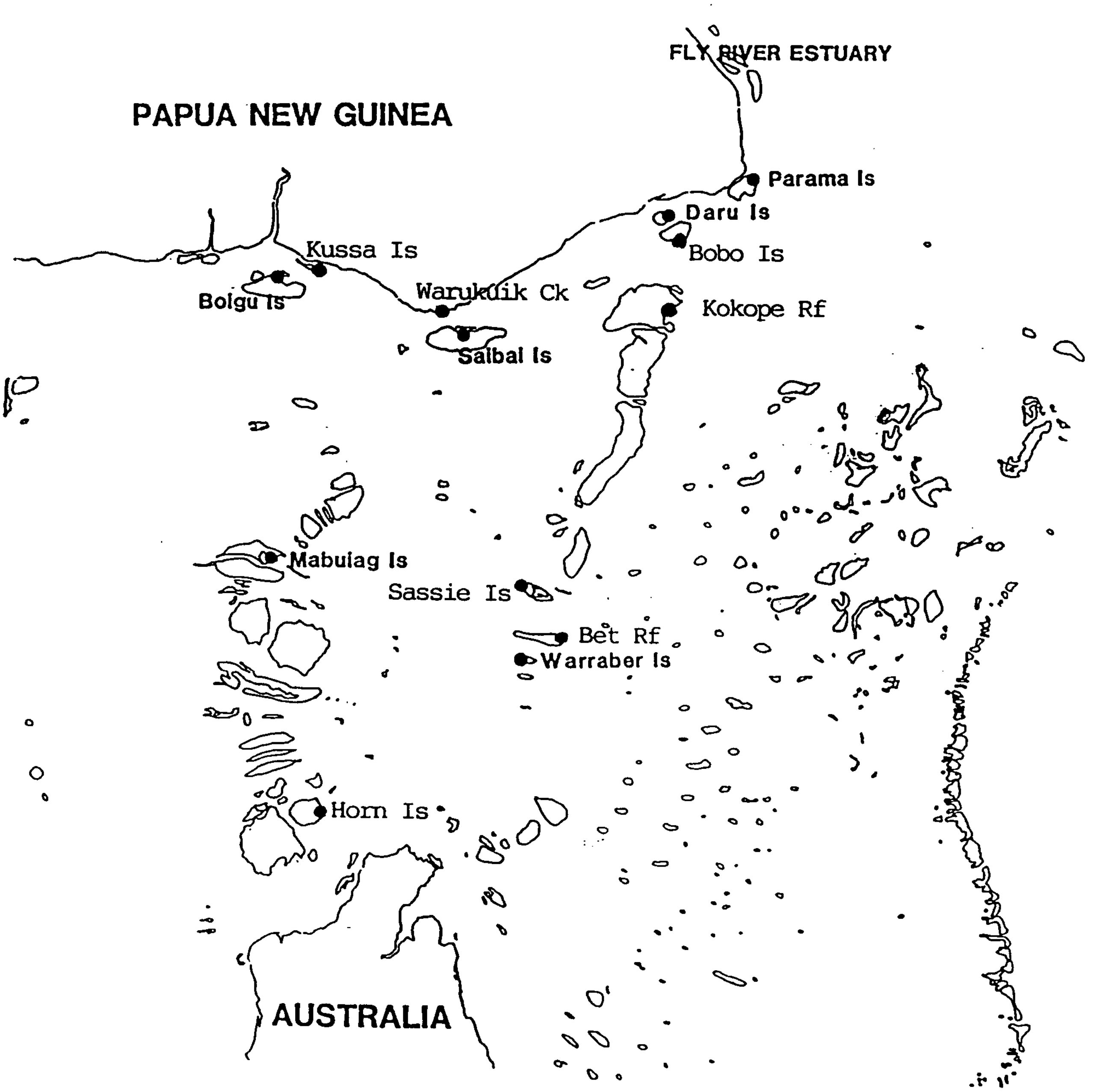

Figure 3.1. Map of the Torres Strait showing locations from which samples were collected

Table 3.2. The potential consumption rates of turtle tissues in the Torres Strait, based on a daily catch of 594 kg (Harris et al 1994); relative organ weights (Rebel 1974), and an estimated population for the outer islands of 3000 persons.

Tissue	Amount available per week (kg)	Maximum potential consumption rate (kg/person/week)
Muscle	2071	0.69
Kidney	7.5	0.0025
Liver	99.8	0.03
Intestine	354.1	0.115