



Cooperative Research Centre  
for Torres Strait



# Torres Strait Research Program

## **Sustainability Assessment of the Torres Strait Sea Cucumber Fishery**

CRC-TS Project Task Number: T1.4

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**Timothy Skewes, Sascha Taylor, Darren Dennis, Michael Haywood,  
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CRC Torres Strait Research Task Final Report

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## NON-TECHNICAL SUMMARY

### PROJECT:

Sustainability Assessment of the Torres Strait Sea Cucumber Fishery: CRC Torres Strait Task T1.4

### PRINCIPAL INVESTIGATOR:

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### OBJECTIVES:

- 1) Survey sandfish abundance and environmental parameters at 50 repeated measures sample sites on Warrior Reef in Jan/Feb 2004, and survey all other species at 75 repeated measures sites in East Torres Strait in Jan/Feb 2005.
- 2) Provide information on stock status, population dynamics of fished species and recovery of closed species, and possible environmental effects of fishing.
- 3) Recommend sustainable management strategies to management and Islander bodies by September 2004 (sandfish) and September 2005 (all other species) for implementation in the fishery, and formulate future research and monitoring regimes, including a timetable for periodic surveys and fishery dependant data collection.

### NON-TECHNICAL SUMMARY:

The (modern) Torres Strait beche-de-mer fishery began in about 1990. Sandfish on Warrior Reef provided the bulk of the early catches in the fishery, until a stock survey in 1998 found that the population was severely depleted and the sandfish fishery was closed. Subsequent surveys in January 2000 and October 2002 found a small recovery in the population, especially of the breeding cohort, but it was still considered heavily depleted.

After 1998, the fishery mostly targeted black teatfish, white teatfish and surf redfish in east Torres Strait. However, a survey in March 2002 found that black teatfish and surf redfish were also overexploited, and a prohibition on the harvest of these species was introduced in January 2003. Other targeted species, such as white teatfish and prickly redfish, were not considered overexploited at the time, but it was recommended that their catches be restricted and the populations be closely monitored. Several other species, mostly of low value but often having a large standing stock, were considered to be at near virgin biomass levels.

This current research project was based on two population surveys, one of sandfish on Warrior Reef in January 2004 and one of all other species in east Torres Strait in January 2005. These surveys were designed to provide information on the stock status of fished species and recovery of depleted species. For the sandfish population, this survey will complete a series of 5 surveys since the first in 1995.

The results of the surveys showed that the three closed species, sandfish, black teatfish and surf redfish, had not recovered from their low densities observed in previous surveys. Sandfish density actually decreased to similar levels as in 1998, when the fishery was closed. While most of the decrease occurred in the juvenile sandfish population, the adult sandfish population had also declined since the previous survey in 2002. This result was quite unexpected given the relatively strong breeding cohort evident in 2002.

Black teatfish were also less abundant in 2005 than in 2002, and no surf redfish were observed at all during the 2005 survey. Even though the repeated surveys had less precision than expected, and problems with species identification may have confounded the surf redfish result, we can be reasonably certain that these two species have not recovered to an extent that we can recommend that they be reopened to fishing. Allowing a take of the closed populations would result in even lower densities and probably result in a longer period to full recovery.

Of the remaining fished species, prickly redfish and white teatfish showed decreases in average density and/or average size. However, given the likelihood of very low catches since the 2002 survey, we do not propose any changes to the recommended TACs (which are quite conservative in any case) for these species at this stage. However, these targeted species do require close monitoring by the collection of spatial catch data and regular population surveys.

The information from the project has added to the developing knowledge on the population dynamics of sea cucumber populations; in particular, it has shown that depleted populations do not recover quickly. The reasons for this are still not known, however, there is likely to be some depensatory mechanisms acting on recruitment, such as dilution (or Allee) effects decreasing the fertilization success of the gametes in the water column. It is also possible that the recruitment patterns for sea cucumber populations are characterised by infrequent large recruitments. More research on this aspect of sea cucumber population biology is required to develop sustainable harvest strategies.

During the surveys, we also collected more information on the fishery ecology of sea cucumbers, and collected habitat data for comparison with previous years. The habitat data showed that important ecosystem components such as seagrass on Warrior Reef were stable in comparison with historical data. However, we did observe a reduction in the cover of live coral in east Torres Strait, and some evidence of localised crown-of-thorns starfish outbreaks.

## Recommendations for management

1. Maintain closures for the currently closed species (sandfish, black teatfish and surf redfish).
2. Implement and monitor individual TACs for at least the higher value and/or targeted species.
3. Integrate research and management for the Warrior Reef sandfish fishery with PNG.
4. Produce a comprehensive identification guide for Torres Strait sea cucumbers.

### Outcomes Achieved

The surveys carried out as part of this project showed that the depleted sea cucumber populations in Torres Strait (sandfish, black teatfish and surf redfish) have not recovered since they were closed to fishing, and that the remaining fished species were either stable or at slightly lower than average densities. This information has been reported to the relevant management agency (AFMA, PZJA) and was used to formulate management arrangements for the fishery. The closed species remained closed, and individual TACs have been implemented for two high value targeted species; white teatfish and prickly redfish (reduced from a possible take of 260 t to 15 t and 20 t respectively).

The results of the surveys were also communicated back to stakeholders through fishery forums and were used in a summary pamphlet produced by AFMA with assistance from CSIRO for distribution to the affected Islander communities.

The project highlighted the need for additional information on the catches of sea cucumbers in Torres Strait. This has been addressed by AFMA through the recently implemented processors logbook program. It also highlighted the need for information on possible illegal fishing of closed populations, especially for sandfish on Warrior Reef.

This research has highlighted the need for cooperation with PNG for the management of the Warrior Reef sandfish fishery. CSIRO researchers have had discussions with their PNG counterparts about possible collaboration to manage this fishery.

**KEYWORDS:** sea cucumber, holothurians, beche-de-mer, sustainable fisheries, stock surveys

# 1. INTRODUCTION

## 1.1. BACKGROUND

The modern sea cucumber fishery in Torres Strait began in about 1990 when Papua New Guinea (PNG) nationals started fishing sandfish (*Holothuria scabra*) on the northern Warrior Reefs (Figure 1-1). The fishery was closed in 1993 due to concerns about overfishing. The PNG catch during this time ranged between 109 t and 192 t of processed beche-de-mer (equivalent to approximately 1160 t and 2040 t gutted weight respectively (Skewes *et al.*, 2004b)), mainly consisting of sandfish. The closure remained in force until October 1995, and the fishery then operated under a management plan which included a 40 t (processed weight)/year TAC, a closed season and minimum sizes (Kinch, 2004).

The fishery began on the Australian side of Torres Strait around 1992, mainly targeting black teatfish (*H. whitmaei*) in east Torres Strait and sandfish on the southern Warrior Reef (Figure 1-1). Australian fishery catches peaked at over 1200 t (gutted weight) in 1995, and averaged about 70 t per year during 1996-2002 with a landed value of approximately \$250,000 being returned mainly to local Islanders. The recent catch has probably dropped to below 20t per year, due mainly to the closure of several previously targeted species and a lack of buyer/processor interest in the fishery (for available catch data, see Section 3.2.2).

Sandfish on Warrior Reef provided the bulk of the early catches and was heavily exploited over a three-year period from 1994 to 1996, with 1200 to 1400 tonnes (wet weight) estimated being caught in 1995 (Williams *et al.*, 1999). The first fishery independent survey of the sandfish population was carried out in late 1995 (Long *et al.*, 1996) and found that the density of the breeding year-class (2+ years old) was relatively low. A second survey in January 1998 found that the population density was 63% to 86% lower than in 1995 and that both recruiting (1 y.o.) and breeding year-classes (2+ y.o.) were depleted (Skewes *et al.*, 1998). The fishery was closed in January 1998. The population was surveyed again in January 2000 by repeated measures (49 sites) and absolute abundance sampling (165 sites) (Skewes *et al.*, 2000). This survey found that the population was still 53% to 81% smaller than 1995, but with a mean increase of 36% over 1998. The resulting stock size estimate indicated that it was unlikely that the standing stock was greater than 100 tonnes wet gutted weight (c.f. ~1400 tonnes caught in 1995).

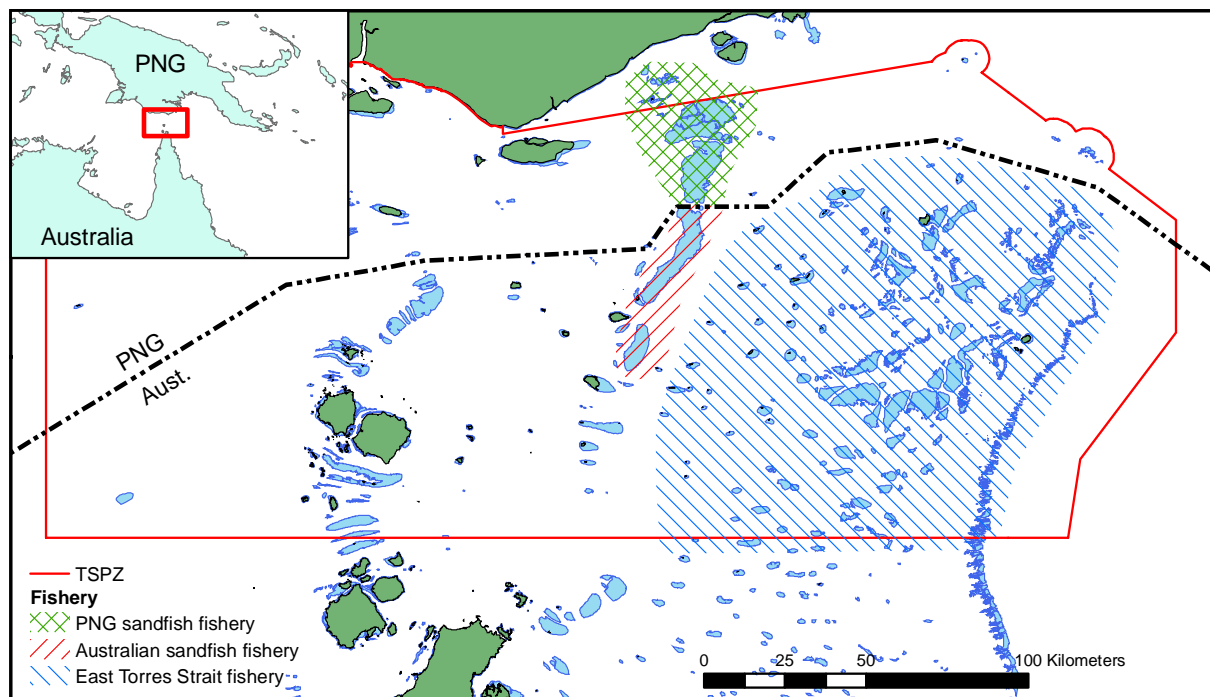
The most recent survey was done in January 2002 (Skewes *et al.*, 2004a). This found that the average density of sandfish was 21.4% greater than in 2000, and 70% greater than the extremely low abundance recorded in 1998, but was still less than half that observed in 1995. However, the abundance trend was complicated by changes in the distribution of sandfish in 2002; there were more sandfish than ever in the southern half of Warrior Reef whereas the northern half had a much lower abundance. Unlike previous surveys, the bulk of the population was made up of larger 2 y.o. sandfish, with very low numbers of recruiting 1 y.o. animals, and represented the highest density of breeding animals observed since surveys began in 1995. It was hoped that this might provide the basis for a strong recruitment to the fishery by early 2004.

After the sandfish closure in 1998, the fishery targeted several species in east Torres Strait, in particular black and white teatfish (*H. whitmaei* and *H. fuscogilva*) and surf redfish (*Actinopyga mauritiana*). However, by 2002 there has been some evidence of at least local depletion of the east Torres Strait fishery, i.e. quotas have not been reached, fishermen have report decreased catch rates and limited catch data indicated declining CPUE for some high value species.

A full scale survey of the east Torres Strait fishery was carried out in March 2002 (Skewes *et al.*, 2004a). The results of that survey indicated that the two most recently targeted species, surf redfish and black teatfish, were overexploited. They were significantly less abundant in 2002 compared with the 1995 survey and their standing stock estimates were low compared to estimates of the catch. This conclusion is reinforced by the analysis of logbook data from the fishery (QFS), which showed a recent decrease in the catch rates (CPUE) of both species. While there are other potential biases that could cause a decrease in density due to increased cryptic behaviour, especially of black teatfish, the fact that the other non exploited species are similar in densities to 1995, and that the populations have been heavily targeted in recent years suggested that the decline in abundance is caused by fishing

pressure, rather than by observer bias. Additionally, some fishers at least have reported a drastic decline in abundance in some areas. It was recommended that these species be closed to fishing and they were subsequently closed in January 2003.

Other targeted species, such as white teatfish and prickly redfish (*Thelenota ananus*) were not considered overexploited, but it was recommended that their catches be restricted and the populations closely monitored. Several other species, mostly of low value but often having a large standing stock, were considered to be at near virgin biomass levels. TACs for each species were formulated from simple stock assessment models and conservative decision rules (Table 1-1). The recommended TACs included zero take for several of the *Actinopyga* species (e.g. redfishes, blackfish, stonefish) due to their patchy distribution and uncertain identification.



**Figure 1-1.** Map of Torres Strait showing the approximate location of the three sea cucumber fisheries in Torres Strait mentioned in this report.

**Table 1-1.** Based on a survey in 2002, for each species of commercial sea cucumbers, and for all species, the value, estimated landed (gutted) weight, model biomass (B) being the lower 90% confidence interval of the survey standing stock estimate, an assessment of stock status, estimated natural mortality rate, estimated maximum sustainable yield (MSY<sub>1</sub>) using the surplus production model  $MSY = 0.2 MB_0$ , estimated MSY<sub>2</sub> using the optimal fishing mortality model  $F_{opt} = 0.6M$ , and a recommended TAC based on the model outputs, stock status and decision rules (from Skewes *et al.*, 2004a).

Species	Value category	Landed weight (t)	B (t)	Stock status (level of exploitation)	Est. mortality rate (M)	MSY <sub>1</sub> (t)	MSY <sub>2</sub> (t)	Rec. TAC (t)
Commercial	Mixed	8204.5	6260.0	Mixed	0.8	1001.6	1694.8	356
<i>H. whitmaei</i>	High	376.8	197.4	Overexploited	0.6	23.7	45.7	0
<i>H. fuscogilva</i>	High	431.2	251.0	Exploited	0.6	30.1	58.1	15
<i>T. ananas</i>	High	663.3	399.3	Exploited	0.6	47.9	92.4	20
<i>T. anax</i>	Low	648.2	322.1	Unexploited	0.6	38.7	74.5	32
<i>A. mauritiana</i>	Medium	85.6	18.8	Overexploited	0.8	3.0	5.1	0
<i>A. echinites</i>	Medium	55.9	5.9	Exploited	0.8	0.9	1.6	0
<i>A. lecanora</i>	Medium	2.2	0	Unknown	0.8	0.0	-0.1	0
<i>A. miliaris</i>	Medium	100.0	9.6	Exploited	0.8	1.5	2.6	0
<i>B. argus</i>	Medium	711.2	466.6	Exploited	0.8	74.7	126.3	34
<i>B. graeffei</i>	Low	61.9	36.0	Unexploited	0.8	5.8	9.7	0
<i>B. marmorata</i>	Low	2.2	0	Exploited	0.8	0.0	-0.1	0
<i>H. atra</i>	Low	1550.9	988.0	Unexploited	1.0	197.6	295.7	100
<i>H. coluber</i>	Low	244.7	46.7	Unexploited	1.0	9.3	14.0	0
<i>H. edulis</i>	Low	245.5	170.3	Unexploited	1.0	34.1	51.0	17
<i>H. fuscipunctata</i>	Low	870.2	541.3	Exploited	0.6	65.0	125.3	30
<i>H. leucospilota</i>	-	927.9	94.6	Non comm.	1.0	18.9	28.3	-
<i>S. chloronotus</i>	Medium	570.7	269.4	Exploited	1.0	53.9	80.6	25
<i>S. vastus</i>	Low	438.5	240.7	Unknown	0.8	38.5	65.2	0
<i>S. hermanni</i>	Medium	1191.5	829.3	Unexploited	0.8	132.7	224.5	83

## 1.2. NEED

The population dynamics and fishery ecology of sea cucumbers is poorly understood. The recovery of depleted populations has proven to be slow and sporadic, and the dynamics of exploited populations is poorly understood and poorly modelled. Fundamental to this is research on recruitment processes and the stock-recruitment relationship. Fishery-dependant data (logbooks) for the fishery have proven extremely difficult to obtain and are unreliable, with stock surveys the only viable method for determining the size and status of fished populations, and for providing data on fundamental fishery parameters.

Management agencies (AFMA, QFS) and Islander bodies in Torres Strait recognised an urgent need for research on this fishery to formulate sustainable management strategies to ensure the long-term viability of the fishery. There was also a strong desire by Torres Strait Islanders and their representative bodies, such as the TSRA, for research to assess the fishery status of closed and open species on a continuing basis.

A research program was formulated based on two population surveys, one of sandfish on Warrior Reef in early 2004 and a survey of the east Torres Strait fishery in early 2005. The survey data would provide estimates of the distribution and abundance of all commercial species in the fishery, and high resolution estimates of trends in density for comparison with previous surveys. For the Warrior Reef sandfish population, the survey would complete a series of 5 surveys between 1995 and 2004. The results would be used to formulate robust sustainable management strategies, and for designing optimal strategies for future monitoring. The surveys would also gather information on gross environmental parameters, not only for assessing the effects of fishing, but for mapping and monitoring the environment in general.

While it is generally recognised that the sandfish fishery in Torres Strait is a shared stock with PNG, the relationship between the two fisheries is yet to be fully determined. This research has direct relevance to PNG and the sustainable use of their resource, and of the stock as a whole. PNG and

Australian researchers have carried out joint surveys of sea cucumber in Torres Strait in the past and there is the potential to formulate complimentary management strategies between the two countries for the sandfish fishery. The outputs from this project will have relevance to the management of sea cucumber fisheries in other areas of Australia (the same species are currently considered overexploited on the GBR and Coral Sea) and in the South Pacific.

### 1.3. A note on the taxonomy of sea cucumber species

The names for the two teatfish species used in this report follows that suggested by the most recent, and by far most comprehensive, study on the phylogeny of the Indo-Pacific teatfishes (Uthicke *et al.*, 2004) as follows:

White teatfish; *Holothuria fuscogilva* (Cherbonnier, 1980). This species was called *Holothuria nobilis* in the previous Torres Strait sea cucumber assessment report (Skewes *et al.*, 2004a).

Pacific black teatfish; *Holothuria whitmaei* (Bell, 1887). This species is now considered distinct from a third teatfish species, the Indian Ocean black teatfish, *Holothuria nobilis*.

### 1.4. OBJECTIVES

- 1) Survey sandfish abundance and environmental parameters at 50 repeated measures sample sites on Warrior Reef in Jan/Feb 2004, and survey all other species at 75 repeated measures sites in East Torres Strait in Jan/Feb 2005.
- 2) Provide information on stock status, population dynamics of fished species and recovery of depleted species, and possible environmental effects of fishing.
- 3) Recommend sustainable management strategies to management and Islander bodies by September 2004 (sandfish) and September 2005 (all other species) for implementation in the fishery, and formulate future research and monitoring regimes, including a timetable for periodic surveys and fishery dependant data collection.

## 2. METHODS

The research is based on two surveys in early 2004 (sandfish on Warrior Reef) and early 2005 (east Torres Strait). The timing of the surveys coincided with the seasonal and lunar phase timing of previous surveys in an attempt to reduce differences in survey observer rates caused by changes in burrowing rates caused by seasonal and tidal factors.

The sampling was done using an efficient repeated measures design that is powerful for detecting change in sea cucumber population abundance. This method has been previously used to assess the relative status of the sandfish fishery in Torres Strait (Skewes *et al.*, 2004a) and Moreton Bay (CSIRO, unpublished data). Based on previous survey results, the proposed number of sample samples, 50 for sandfish and 75 for other species in east Torres Strait, should have provided enough power to detect a 35% change in density of sandfish and black teatfish with 80% power. The choice of sample sites was based on a compromise between maximising the ability to detect change for key species, and on achieving a broad spatial coverage for representative sampling to provide a wide coverage of monitored parameters.

The surveys used rapid marine assessment techniques that have been developed, improved and applied by CSIRO for reef resource and habitat surveys in several areas of Australia, PNG and the Seychelles. Field work was undertaken by a small team of divers operating from a dinghy and locating sample sites using hand-held GPS. On the reef-top, divers swam along a 40 m (sandfish surveys) or 40-100 m (east Torres Strait survey) transect and recorded resource and habitat information 1 m (sandfish surveys) or 2 m (east Torres Strait surveys) either side of the transect line. Sea cucumbers and other benthic fauna of commercial or ecological interest were counted, and where possible, returned to the dinghy and measured, usually as total length but additionally as live wet weight, and then returned to the water. This information was used to produce size-frequency distributions for each species.

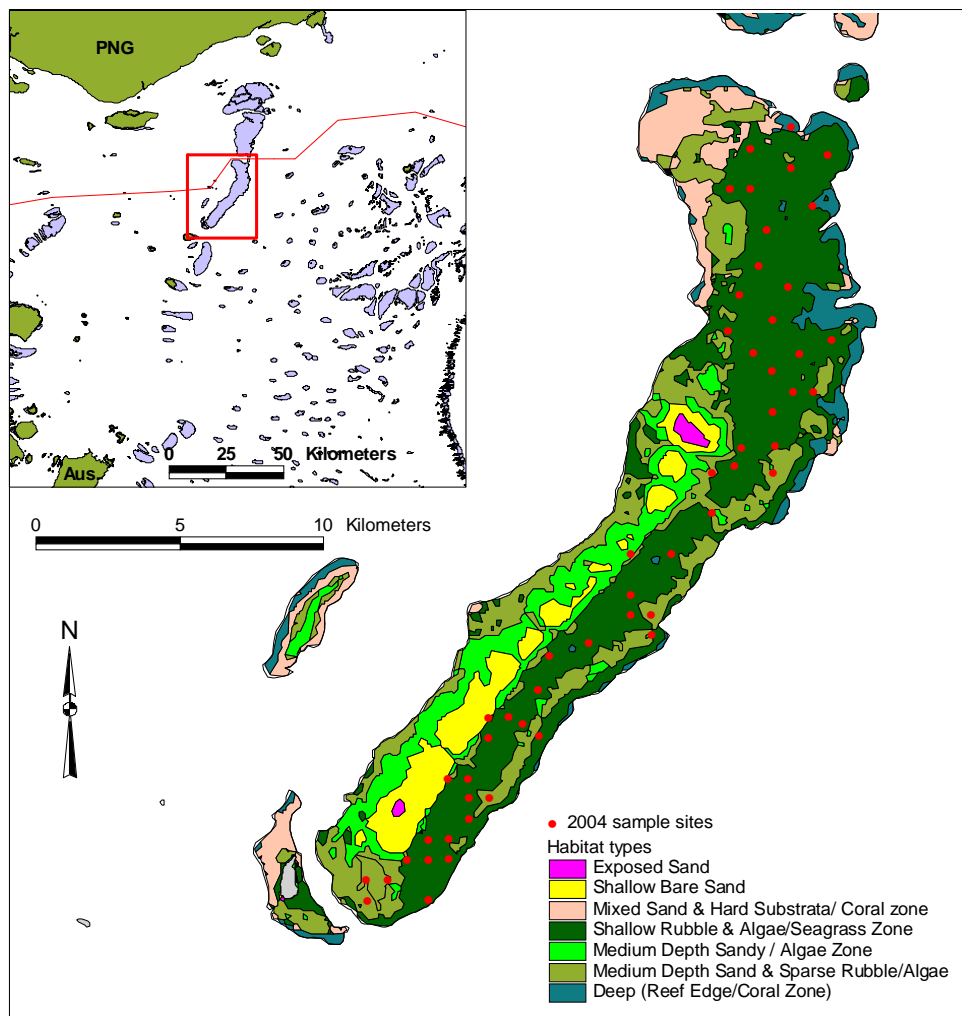
At each site, substrate was described in terms of the percentage of sand, rubble, consolidated rubble, pavement and live coral. The growth forms and dominant taxa of the live coral component and the percentage cover of all other conspicuous biota such as seagrass and algae were also recorded. On the reef-edge, a diver swam along a measured length transect between 1 m and 15 m water depth and recorded resource and habitat variables similar to those recorded on the reef-top.

The data was entered into a database and estimates of the change in population density and distribution of each species of sea cucumber were calculated.

### 2.1. Warrior Reef sandfish

Warrior Reef was surveyed over a 6 day period from the 5/1/04 to 10/1/04. Counts of sandfish and habitat information were collected at 56 repeated sites throughout the main sandfish habitat on Warrior Reef (Figure 2-1). These are the same repeated sites that have been surveyed in 1995/6, 1998, 2000 and 2002. Trends in sandfish density were investigated by analysis of sites counts using a repeated measures analysis.

Sandfish were collected and measured for size-frequency analysis. In most years, the population on Warrior Reef shows a (at least) bimodal size frequency. The mid-point between the two modes is usually about 14 cm total length (TL). This is very close to the estimated size at maturity for sandfish on Warrior Reef of 15 cm TL (Skewes *et al.*, 2000). We, therefore, used this as a cut-off point to analyse the survey counts for juvenile (<14 cm TL) and adult (>14 cm TL) sandfish separately.



**Figure 2-1.** Warrior Reef habitat types from survey data and satellite image analysis. Also shown are the sample sites from the January 2004 survey.

## 2.2. East Torres Strait survey

The east Torres Strait fishery was surveyed over a 9 day period from the 26 January to the 3 February 2005, following the beche-de-mer sustainability workshops (CRC-TS Project Task Number: T1.13 – Section 7). Sampling was done onboard the Royal Australian Naval support vessel, Malu Baizam. Fortunately, we were able to almost double the original planned number of sites, from 75 to 122 sites, due to the assistance of the Malu Baizam. The east Torres Strait survey was designed to assess the status of all commercial sea cucumber species, but with particular interest in the two currently closed species, black teatfish and surf redfish.

As during the 2002 full scale survey, the reefs of the study area were divided into three habitat strata; the reef edge, the reef top and reef top buffer stratum, the latter being a 200 m wide buffer around the inside of the reef margin. During previous surveys the reef top buffer was identified as an area likely to contain higher quantities of targeted species, especially surf redfish and black teatfish (Skewes *et al.*, 2004a).

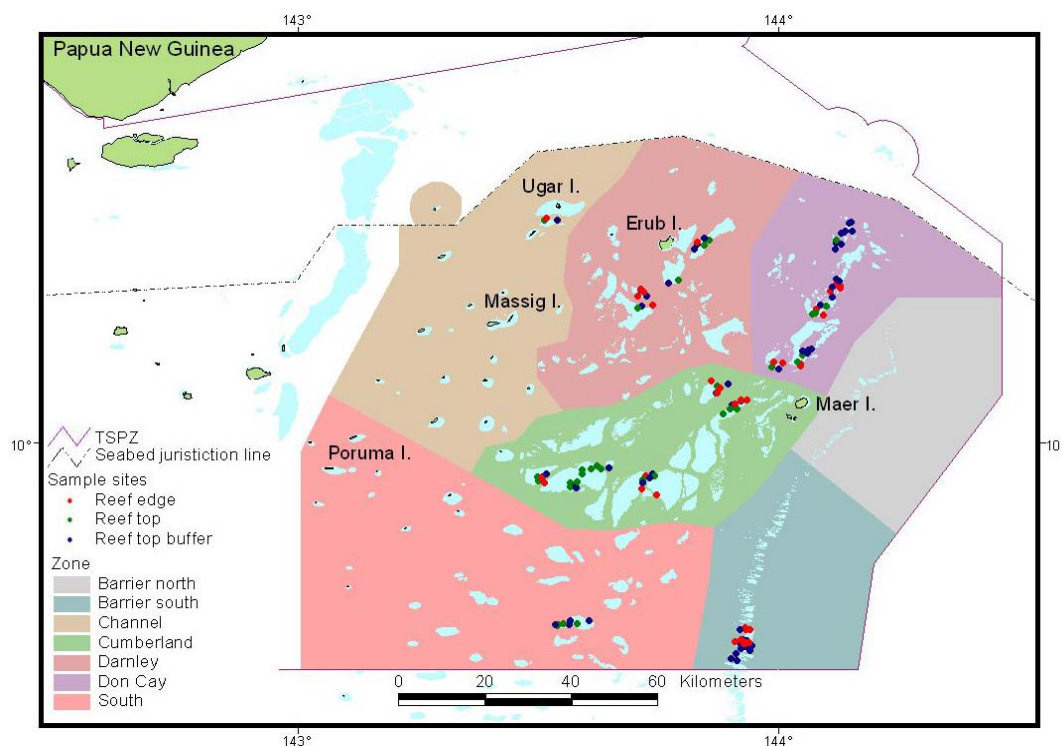
The selection of sample sites for the 2005 survey was based on three considerations: 1) logistic constraints with respect to the amount of sampling that could be done in one day from the support vessel; 2) exclusion of sites with unsuitable habitat (sites >80% sand were not included as they were unlikely to contain high value species); and 3) optimal allocation of sampling effort to the habitat strata based on the density of closed species and other high value species such as white teatfish and prickly redfish (Table 2-1).

**Table 2-1.** Sampling effort allocation based on the density of closed and high value sea cucumbers, and the weighting of the various strata and zones. (E:T:B is the ratio of sites allocated to edge, reeftop and top-buffer zones respectively).

ZONE	Area (ha)	Density (2002)	N (2002)	Prop. of sampling (%)	Ratio E:T:B
Barrier_north	1957.9	64.10	125500	9.9	1:0:14
Barrier_south	7920.9	24.47	193798	15.2	1:0:1
Channel	13074.1	7.98	104357	8.2	1:0:3
Cumberland	50946.4	5.71	290936	22.8	1:6:1
Darnley	28835.5	2.06	59270	4.7	1:0:1
Don Cay	15199.9	29.85	453737	35.6	1:3:4
South	23795.0	1.92	45759	3.6	1:0:1
TOTAL			1273357		2:3:5

As a result of the sample design criteria and logistic constraints, we surveyed 123 sites during the survey, which exceeded the original objective of 75 repeated sites (Figure 2-2). Unfortunately, due to timing constraints, we were not able to sample in the Barrier north stratum. However, this stratum had the smallest reef area (1.4%) and population of sea cucumbers (0.63%) during the 2002 stock survey (Skewes *et al.*, 2004a).

One site near Ugar (Stephens) Island (site 2337) was excluded from the analysis as we had serious doubts about the accuracy of the re-location fix on this site. The re-sampled site had a different depth (3.8m c.f. 1.3m) and had a different substrate type (hard substrate went from 15% to 80% and coral from 15% to <1%) between the two surveys. This indicated that the site was not a repeated site and that the 2002 sample was on the reef-edge and the 2005 sample on the reef-top.



**Figure 2-2.** Map of east Torres Strait showing the extent of study area, zones for stratified sampling and the locations of sites sampled during January 2005.

### 3. RESULTS

#### 3.1. Warrior Reef sandfish

The overall density of sandfish at the repeated sites in 2004 was 40% lower than in 2002, and had dropped to a level similar to the previous record low density recorded in 1998 (Table 3-1, Figure 3-1). The reduction in density occurred for both juvenile (<14 cm TL) and adult (>14 cm TL) sandfish (Figure 3-2), although the reduction was greater for juveniles, with very few observed during the survey (Figure 3-5).

This was a disappointing result as we had expected to see an increase in the density of smaller recruiting sandfish, based on the increased density of adult sandfish in 2002 (Figure 3-2, Figure 3-5). Nevertheless, the density of the adult cohort was again relatively strong, and was still significantly higher than the low densities observed in 1998 and 2000 ( $P<0.001$ ).

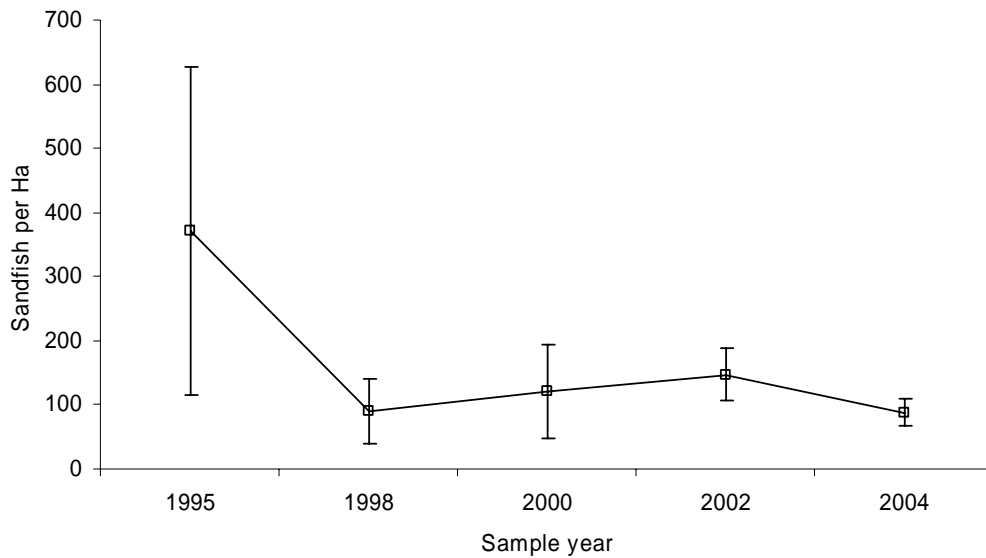
While we saw sandfish at more sites in 2004 than any time previously, which is encouraging (Table 3-2, Figure 3-4), sandfish density declined sharply in the southern section of Warrior Reef since the previous survey, an area that had shown a strong increase in the last survey in 2002 ( $P<0.01$ , Table 3-1, Figure 3-3, Figure 3-4). Once again, the density of sandfish was very low in the northern section, although it had increased slightly (though not statistically significant) since 2002.

**Table 3-1.** Average density (per ha) of sandfish (*H. scabra*) sampled at 56 repeated sites in the seagrass habitat during five abundance surveys in 1995/96, January 1998, January 2000, October 2002 and January 2004 for the whole study area, for adult (>14 cm TL) and juvenile (<14 cm TL) sandfish, and for the northern and southern sections (split at 9°42'). Standard error (s.e.) of estimate is also shown in brackets.

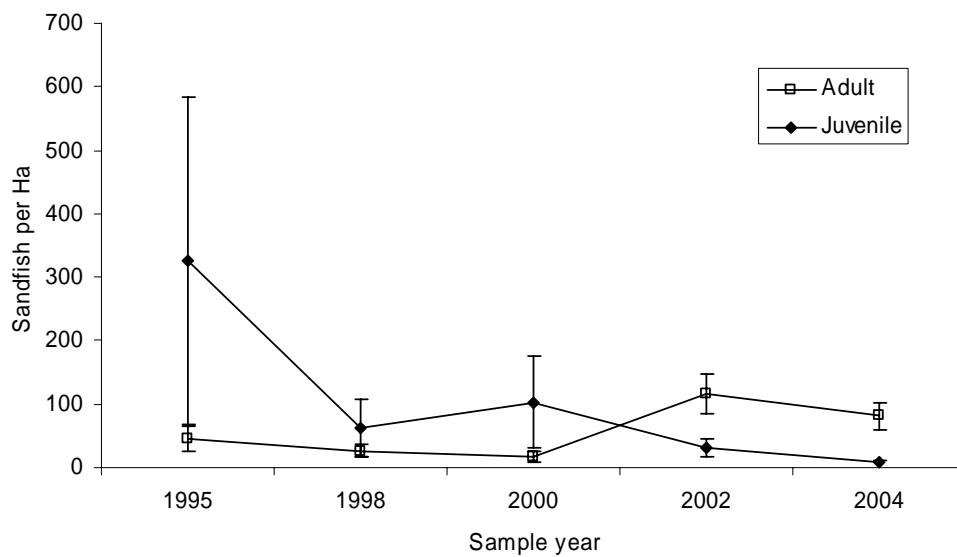
Year	Sandfish ( <i>H. scabra</i> ) per Ha				
	Total area (n=56)	Adults (>14 cm) (n=56)	Juveniles (<14 cm) (n=56)	Northern section (n=28)	Southern section (n=28)
1995/96	370.54 (256.57)	44.64 (20.25)	325.89 (256.80)	669.64 (371.04)	71.43 (22.62)
1998	89.29 (14.16)	26.79 (9.78)	62.50 (10.96)	142.86 (72.05)	35.71 (12.24)
2000	120.54 (72.35)	17.86 (8.68)	102.68 (72.01)	178.57 (103.59)	62.50 (20.10)
2002	147.32 (41.67)	116.07 (31.83)	31.25 (14.33)	35.71 (15.40)	258.93 (54.88)
2004	88.41 (21.39)	80.81 (19.98)	7.60 (4.40)	64.55 (22.17)	112.28 (21.70)

**Table 3-2.** Number of sites where *H. scabra* was observed out of 56 sites on Warrior Reef during repeated measures surveys.

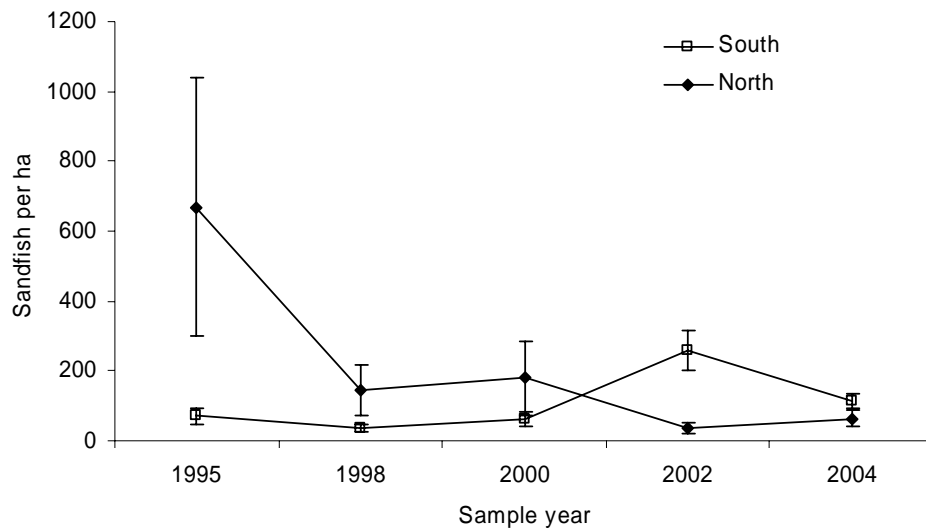
Year	1995	1998	2000	2002	2004
No. sites	11	7	9	15	17



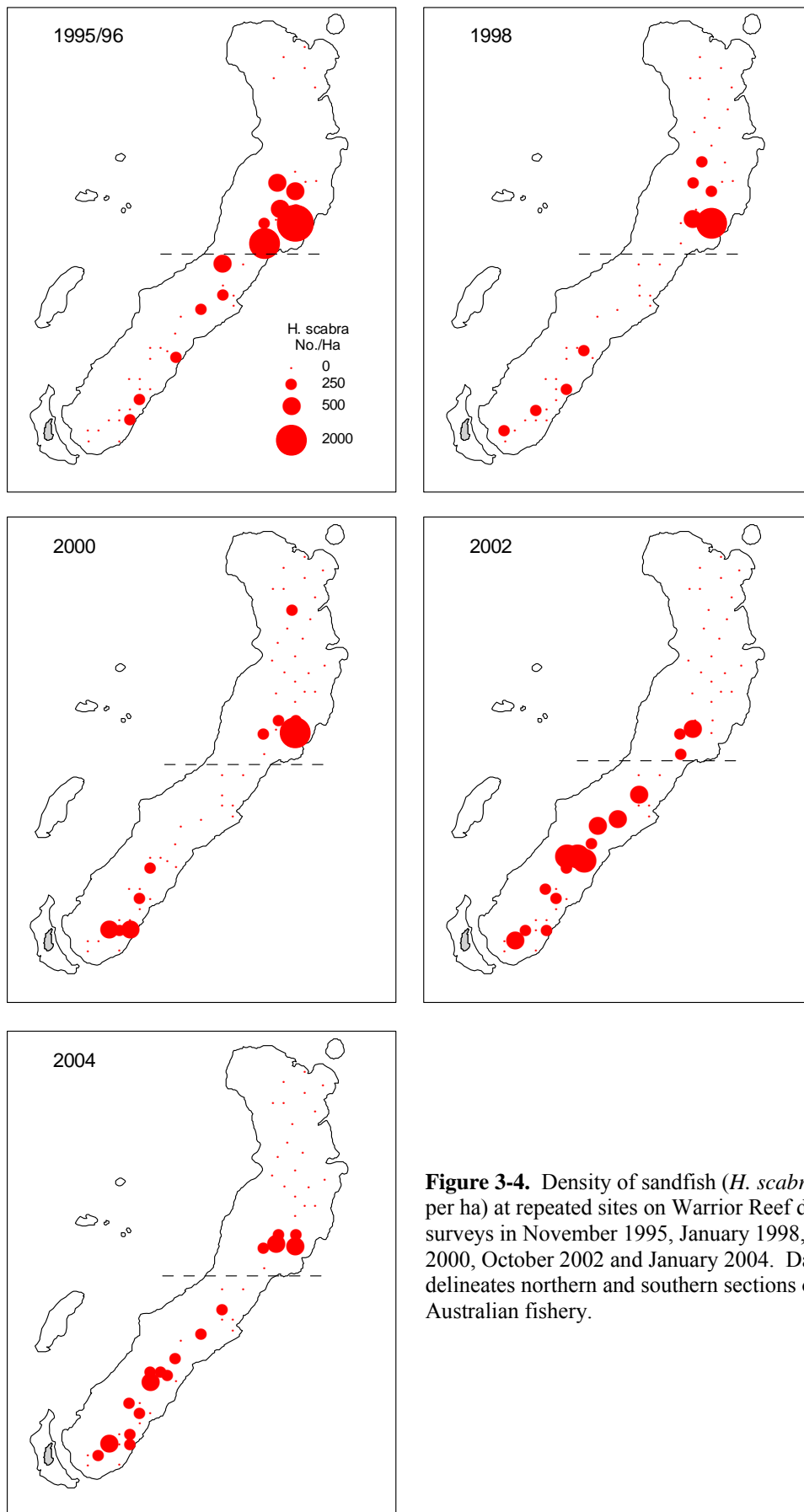
**Figure 3-1.** Graph showing average number of sandfish (*H. scabra*) per ha for repeated sites on Warrior Reef for the five sample years. (Error bars are 1 s.e.)



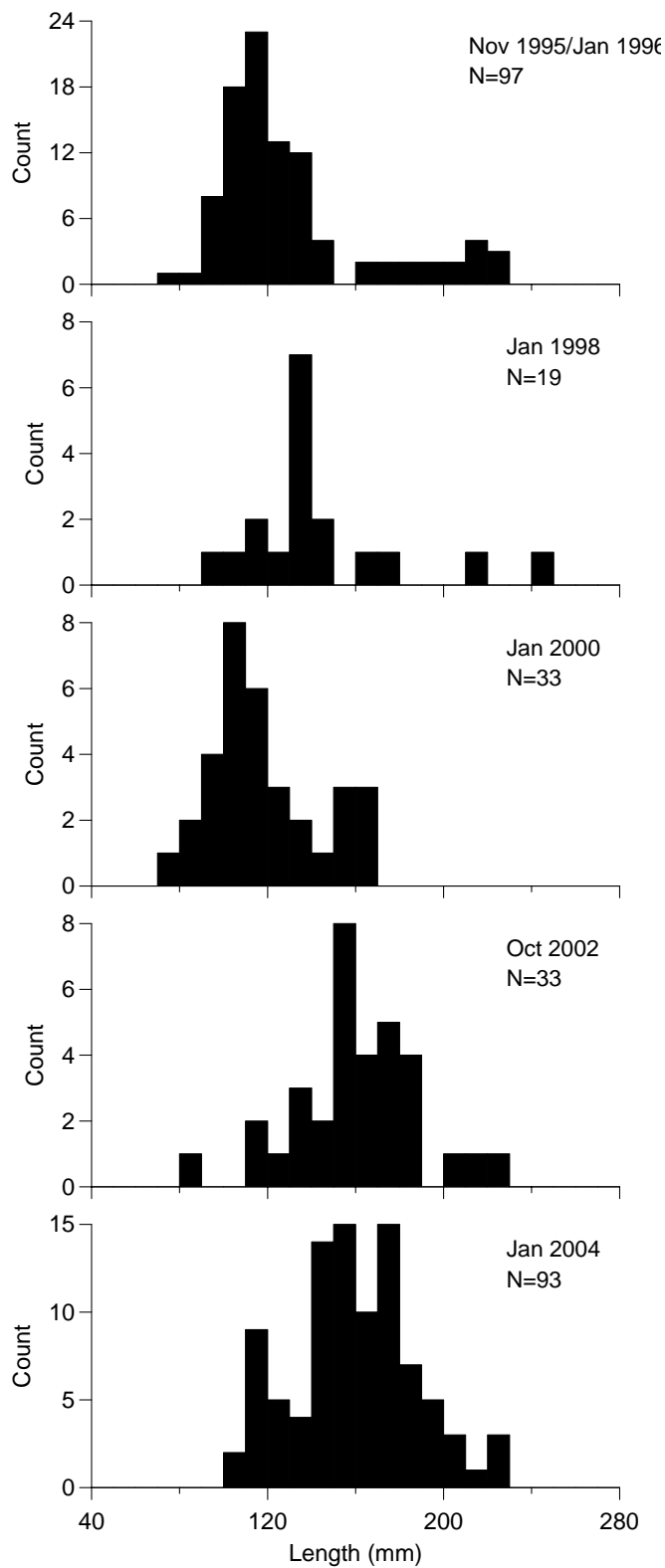
**Figure 3-2.** Graph showing average number of juvenile (<14 cm TL), and adult (>14 cm TL) sandfish (*H. scabra*) per ha for repeated measures sites on Warrior Reef for the five sample years. (Error bars are 1 s.e.)



**Figure 3-3.** Graph showing average number of sandfish (*H. scabra*) per ha for repeated measures sites split into northern (diamonds) and southern (squares) sections of Warrior Reef for the five sample years. Section split at 9°42'. (Error bars are 1 s.e.)



**Figure 3-4.** Density of sandfish (*H. scabra*), (No. per ha) at repeated sites on Warrior Reef during five surveys in November 1995, January 1998, January 2000, October 2002 and January 2004. Dashed line delineates northern and southern sections of the Australian fishery.



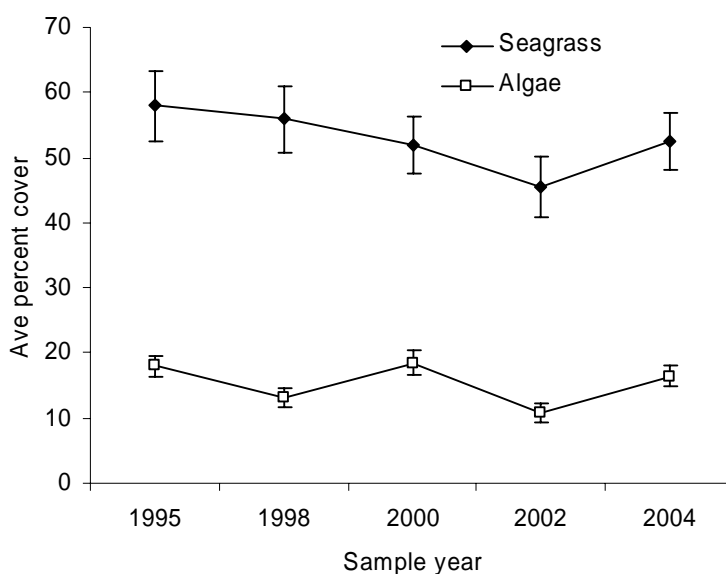
**Figure 3-5.** Length frequencies of sandfish (*H. scabra*) collected during population surveys on Warrior Reef in 1995/96, January 1998, January 2000, October 2002 and January 2004.

### 3.1.1. Environmental data

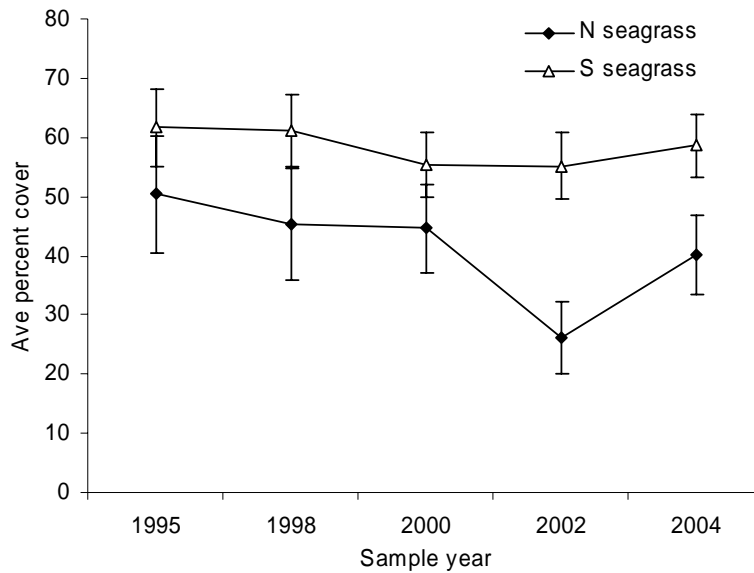
The average cover of seagrass at the 56 repeated sites during the 2004 survey was 52.5%, which was an increase from the low level observed in 2002 ( $P=0.034$ , Figure 3-6), and close to the long-term average sea grass cover (52.7%). This increase was particularly evident in the northern section of Warrior Reef (Figure 3-7). Species composition of the seagrass beds remained essentially unchanged, with the dominant seagrass being *Thalassia hemprichii*, with *Enhalus acoroides* and *Cymdocea* spp. (*C. serulata* and *C. rotundata*) commonly found in association (Figure 3-9).

Algae cover, at 16.4%, also increased in 2004 relative to the previous survey in 2002 ( $P<0.001$ , Figure 3-6) and was also very close to the long-term average for algae cover (15.4%). Algae cover increased similarly in both northern and southern section of Warrior Reef (Figure 3-8). Algae species composition showed some variance with previous years (Figure 3-10) reflecting the dynamic nature of algae communities observed during previous surveys. *Laurencia* spp. and *Sargassum* spp. were again prevalent; however, there was greater cover of filamentous green algae than in previous years.

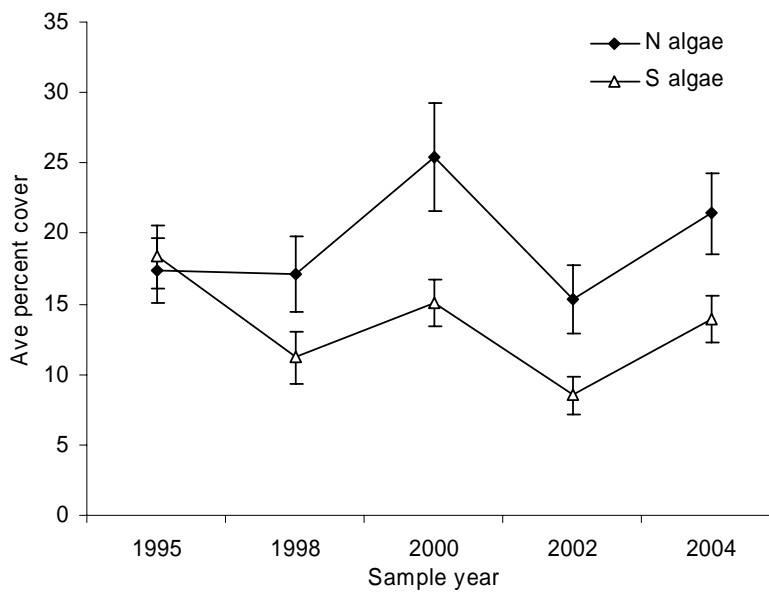
Average cover of live coral in 2004 was low (0.42%) and was similar to the long-term average live coral cover (0.43%) (Figure 3-11).



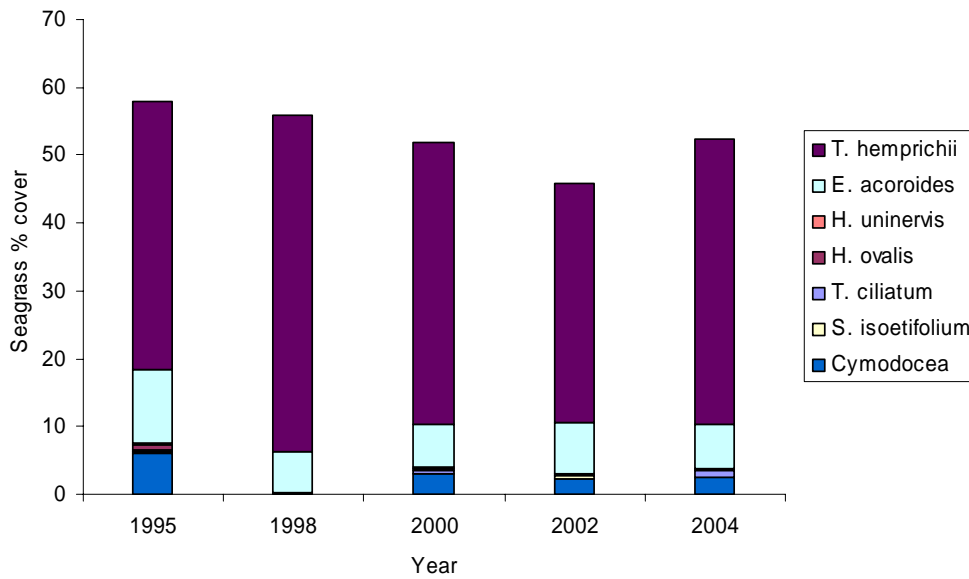
**Figure 3-6.** Average percent cover of seagrass and algae at repeated measures sample sites on Warrior Reef between 1995 and 2004. (Error bars are 1 s.e.)



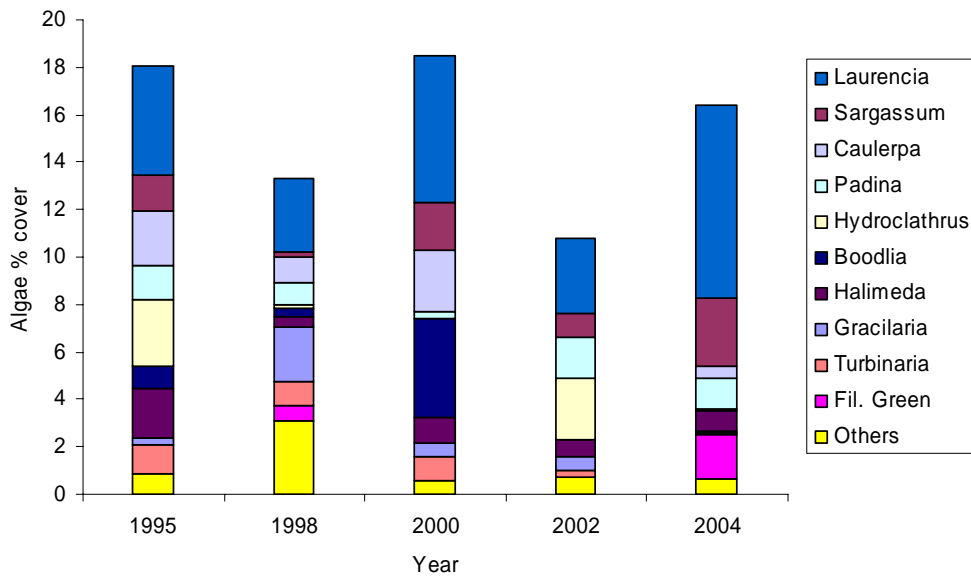
**Figure 3-7.** Graph showing average percent cover of seagrass for repeated measures sites split into northern (diamonds) and southern (triangles) sections of Warrior Reef for the four sample years. Section split at 9°42'. (Error bars are 1 s.e.)



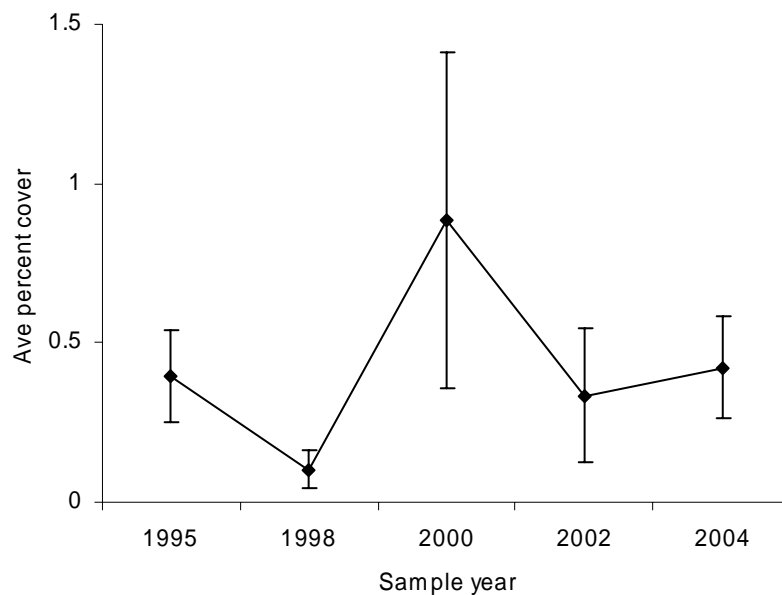
**Figure 3-8.** Graph showing average percent cover of algae for repeated measures sites split into northern (diamonds) and southern (triangles) sections of Warrior Reef for the four sample years. Section split at 9°42'. (Error bars are 1 s.e.)



**Figure 3-9.** Average cover of seagrass species at repeated measures sites on Warrior Reef during the 5 sample years 1995 to 2004.



**Figure 3-10.** Average cover of algae species at repeated measures sites on Warrior Reef during the 5 sample years 1995 to 2004.



**Figure 3-11.** Average percent cover of live coral at repeated measures sample sites on Warrior Reef between 1995 and 2004. (Error bars are 1 s.e.)

### 3.2. East Torres Strait survey

The species composition and overall density of sea cucumbers seen at the repeated sites in 2005 were remarkably similar to the previous survey in 2002 (Table 3-3, Figure 3-12). The overall change in density of all holothurians was just +1.6%, with a 90% CI of +22% to -19%, indicating a reasonable power for detecting change in overall sea cucumber density.

The two closed species, black teatfish (*Holothuria whitmaei*) and surf redfish (*Actinopyga mauritiana*) actually showed a reduction in density between the two surveys (Table 3-3, Figure 3-13). The average density of black teatfish at the repeated sites during the 2005 survey was 22.8% less than we observed in 2002, although the change was not significant at the 0.05 probability level (paired t-test; d.f. = 122;  $P \approx 0.60$ ). The 90% confidence interval of the ratio change was  $\pm 71.4\%$ , which was larger than we expected and due to the highly patchy distribution of black teatfish in the study area. We can also present the results of the repeated site ratio change, and its associated uncertainty, through a probability curve (Figure 3-14). In this way, we can assess the probability of different values of true population change. For example, the probability that the true density in 2005 was higher than 2002 (i.e. greater than 0% change) is 30%; and the probability that the true density in 2005 was greater than 20% higher than in 2002 is only 16%. Conversely, we can be 70% certain that the true density in 2005 is lower than in 2002, and 84% certain that it was lower than 20% greater in 2005 than 2002. In any case, black teatfish were relatively rare in terms of population composition making up only 2% of sea cucumber numbers, despite targeted sampling in the black teatfish preferred habitat, the reef top buffer zone.

We did not observe surf redfish during the 2005 survey (Table 3-3), indicating that it is quite rare and/or has a very narrow habitat distribution. It also calls into question the identification of this species in previous surveys. This group (the genus *Actinopyga*) is poorly described and requires more research to identify which species occur in Torres Strait. This is further supported by the fact that, while the individual species density changes are very variable, the combined *Actinopyga* species density estimate is very similar between surveys (Table 3-3).

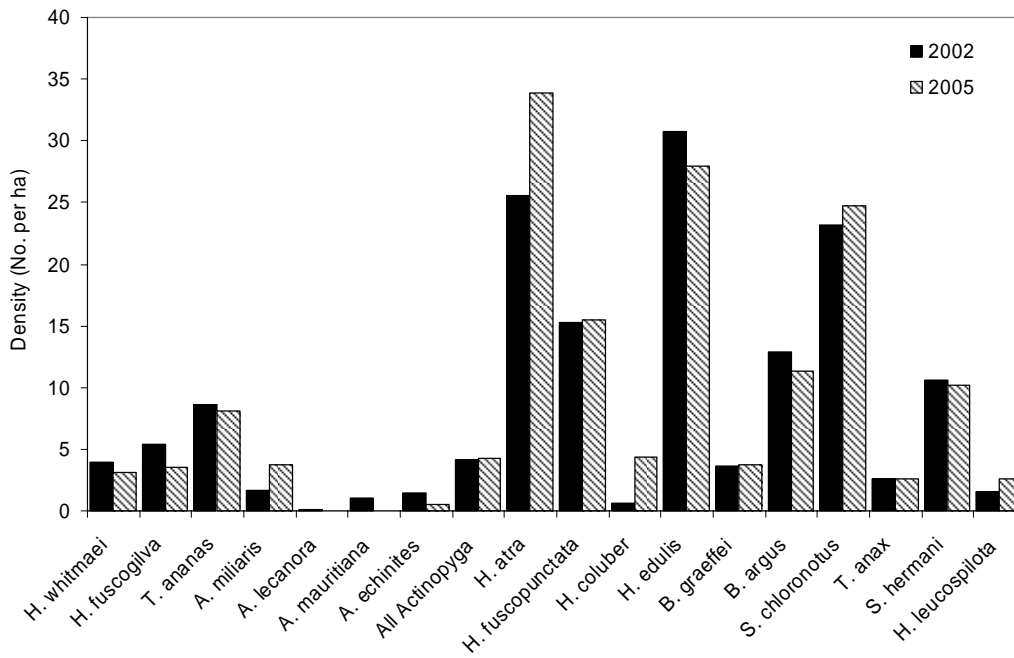
The densities of the two species preferentially targeted since the 2002 survey, white teatfish (*H. fuscogilva*) and prickly redfish (*Thelenota ananas*), also declined between surveys (Table 3-3, Figure 3-12). While there appears to have been low levels of fishing since the previous survey in 2002 (see section 3.2.2), the data available indicates that prickly redfish has had the highest take, with more than 5 t (wet gutted weight) estimated to have been caught in 2005. However, the density estimate for this species was only slightly less in 2005 (-6.0%; Table 3-3, Figure 3-13). The other recently targeted species, white teatfish, showed a larger relative decrease in relative density (-34.4%, Table 3-3.), although the change was not statistically significant (paired t-test; d.f. = 122;  $P \approx 0.35$ ).

Most of the remaining unexploited species showed very little change in density (Figure 3-13). The species with the highest density change was *Holothuria coluber*, which increased from quite low densities to be about 2.9% of the sea cucumber population. This species is quite cryptic normally, being usually found on the shallow reef tops under boulders. However, during the 2005 survey many of the *H. coluber* observed were in the spawning stance, with the posterior end attached to the substrate and the anterior end raised into the water column. Many of these were found on the reef edge, not the usual reef top habitats and this could account for the increased density observed during the 2005 survey.

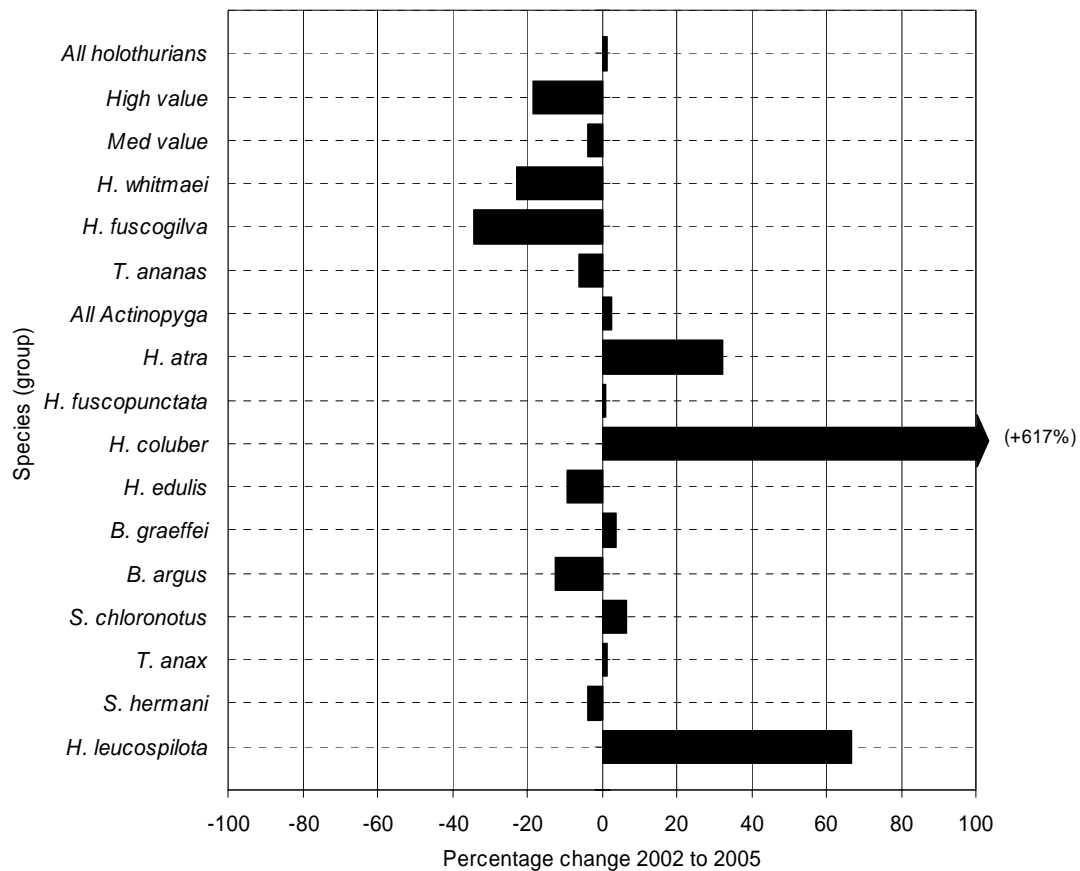
The other species that showed significant density changes were *H. leucospilota* and *H. atra*. *H. leucospilota* has an extremely patchy distribution and is found in very high density patches on the shallow reef top (Skewes *et al.*, 2002); therefore, it is likely that this difference could simply be due to the random chance of encountering one of these high density patches. As for *H. atra*, this species had the highest overall density during 2005, and is one of the three most common species along with *H. edulis* and *S. chloronotus*. Its density had increased by about a third during the 2005 survey. This could be the result of natural population changes for this species.

**Table 3-3.** Average density (per ha) of sea cucumbers sampled at 122 repeated sample sites in eastern Torres Strait during the 2002 and 2005 abundance surveys. The percent change in density between the two surveys is also shown.

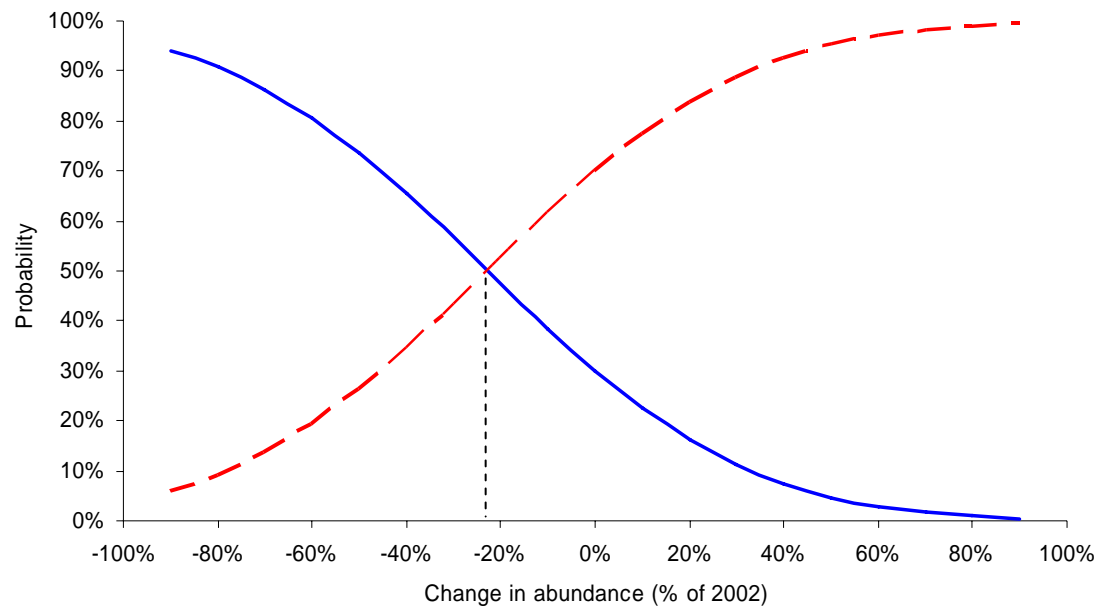
Species	Common name	Average density (per ha)		% change
		2002	2005	
All sea cucumber		150.94	153.28	1.6
High value		18.03	14.74	-18.3
Med value		55.99	53.93	-3.7
<i>H. whitmaei</i>	Black teatfish	4.00	3.08	-22.8
<i>H. fuscogilva</i>	White teatfish	5.43	3.57	-34.1
<i>T. ananas</i>	Prickly redfish	8.61	8.09	-6.0
<i>A. miliaris</i>	Blackfish	1.64	3.79	131.3
<i>A. lecanora</i>	Stonefish	0.10	0.00	-100.0
<i>A. mauritiana</i>	Surf redfish	1.02	0.00	-100.0
<i>A. echinites</i>	Deep water redfish	1.43	0.51	-64.3
All Actinopyga		4.20	4.30	2.4
<i>H. atra</i>	Lollyfish	25.60	33.91	32.5
<i>H. fuscopunctata</i>	Elephant trunkfish	15.30	15.43	0.9
<i>H. coluber</i>	Snakefish	0.61	4.41	616.7
<i>H. edulis</i>	Pinkfish	30.79	27.97	-9.2
<i>B. graeffei</i>	Flowerfish	3.59	3.72	3.8
<i>B. argus</i>	Leopardfish	12.91	11.32	-12.3
<i>S. chloronotus</i>	Greenfish	23.16	24.71	6.7
<i>T. anax</i>	Amberfish	2.56	2.59	1.3
<i>S. hermani</i>	Curryfish	10.60	10.18	-4.0
<i>H. leucospilota</i>		1.54	2.56	66.7



**Figure 3-12.** Comparison of average density (per ha) of sea cucumbers sampled at 122 repeated sample sites in eastern Torres Strait during the 2002 and 2005 abundance surveys.



**Figure 3-13.** Graph showing percent change in density of sea cucumber species between the two repeated measures surveys at 122 sites in 2002 and 2005.



**Figure 3-14.** Change in density of black teatfish, *Holothuria whitmaei*, population in east Torres Strait against the probability that the true change in density is larger or smaller than the change value. Probability curves are based on the repeated measures sampling at 122 sites. The red line is the probability that the true change in density is lower than the corresponding change value, and the blue line is the probability that the true change in density is larger than the corresponding change value. Dashed line represents survey change estimate (-22.8%).

### 3.2.1. Comparisons of the size frequency data

The length frequencies (scaled to reflect the actual density for each size class) of several species are shown in Figure 3-15 to Figure 3-21, and the average size (length and weight) for the two surveys in 2002 and 2005 is shown in Table 3-4. Most of the size frequencies and average size statistics for each species were very similar between the two years.

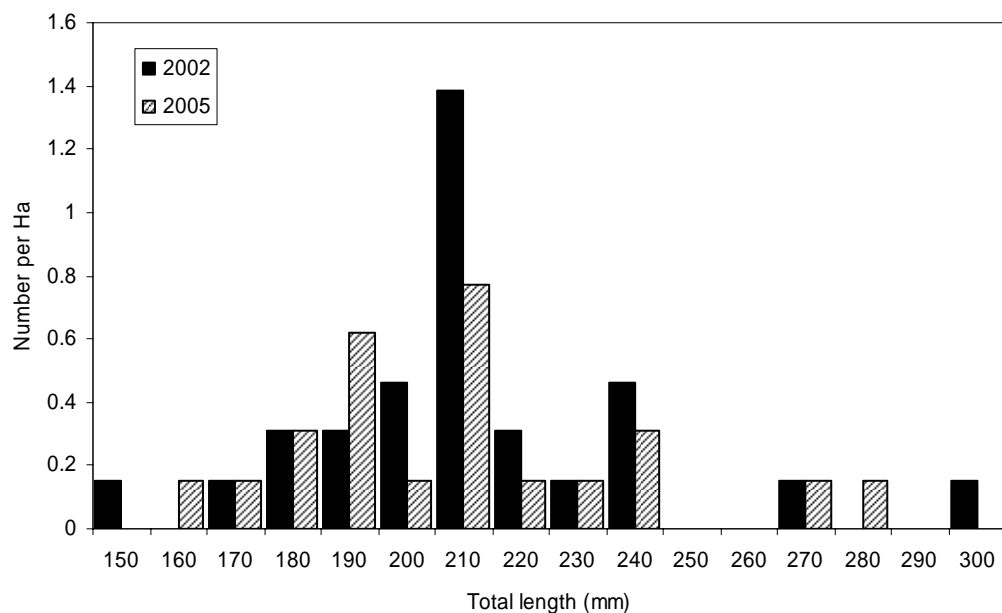
However, the two recently targeted species, prickly redfish and white teatfish both showed a reduction in the average size and weight. Prickly redfish showed the largest reduction in size at 7% by length and 19% by weight (Table 3-4). While we did find some larger prickly redfish during the 2005 survey, they were generally less abundant in the 300 mm to 350 mm size range (Figure 3-16). We did, however, observe higher numbers of small prickly redfish during 2005, which may indicate a significant recruitment to the fishery.

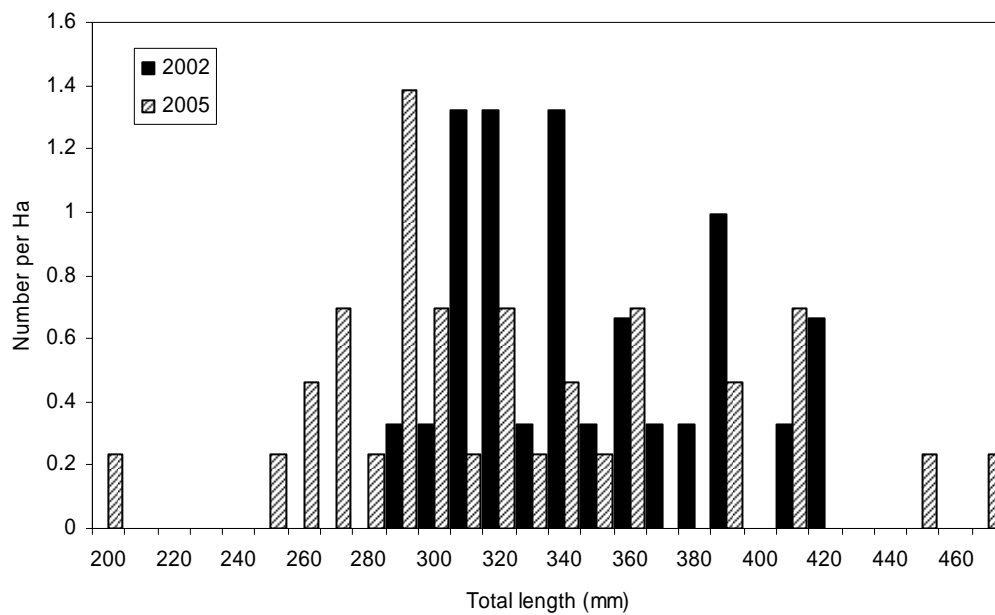
The reduction in the average weight of white teatfish was 12.7% (Table 3-4); however this difference was not statistically significant. There did not appear to be an obvious decrease in the number of large white teatfish in the size frequency data (Figure 3-17).

Curryfish (*Stichopus hermanni*) weight was the only other size factor that proved to have a statistically significant difference between the two surveys, with the average weight being significantly larger during the 2005 survey (+12.1%,  $P=0.028$ )

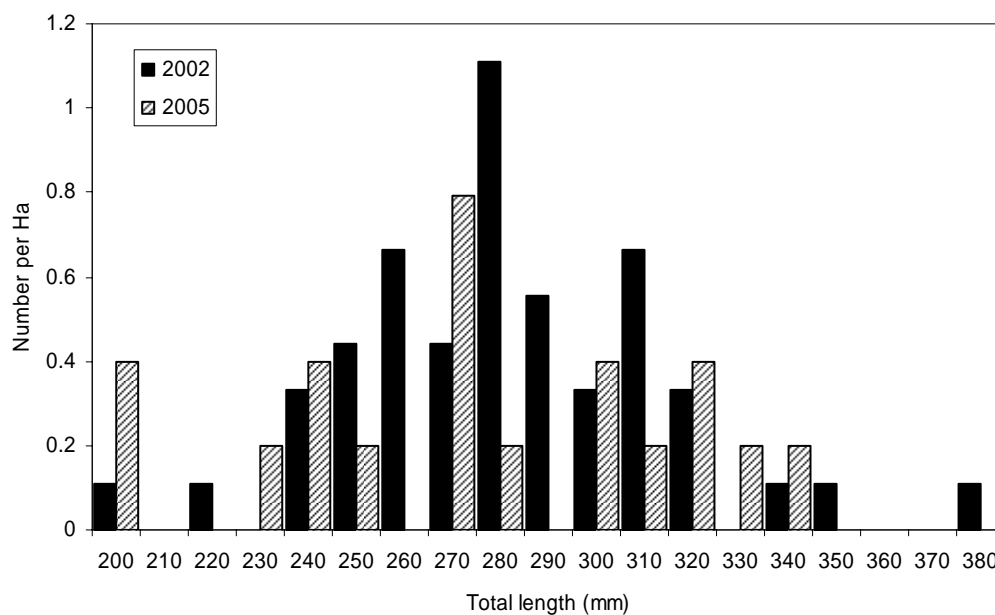
**Table 3-4.** Average size for selected sea cucumber species collected in east Torres Strait during population surveys in 2002 and 2005 (standard deviations in brackets) (\*,  $P < 0.05$ ; \*\*,  $P < 0.001$ ).

Species	Length (mm)		Weight (g)	
	2002	2005	2002	2005
Black teatfish ( <i>Holothuria whitmaei</i> )	213.3 (29.9)	210.0 (31.4)	1658.7 (451.4)	1704.3 (251.8)
Prickly redfish ( <i>Thelenota ananus</i> )	349.4 (38.6)	324.8* (60.0)	2652.4 (902.5)	2147.1** (666.1)
White teatfish ( <i>Holothuria fuscogilva</i> )	284.3 (32.1)	276.1 (42.1)	2681.7 (640.9)	2341.3 (930.1)
Elephant trunkfish ( <i>Holothuria fuscopunctata</i> )	312.6 (55.6)	315.5 (58.6)	1798.2 (701.5)	1831.9 (796.4)
Lollyfish ( <i>Holothuria atra</i> )	167.9 (80.3)	182.9 (77.9)	392.6 (511.8)	407.0 (449.7)
Pinkfish ( <i>Holothuria edulis</i> )	149.9 (36.9)	157.3 (36.3)	156.9 (70.2)	164.8 (87.1)
Curryfish ( <i>Stichopus hermanni</i> )	332.9 (52.3)	338.2 (52.4)	1753.1 (678.2)	1965.9* (637.2)

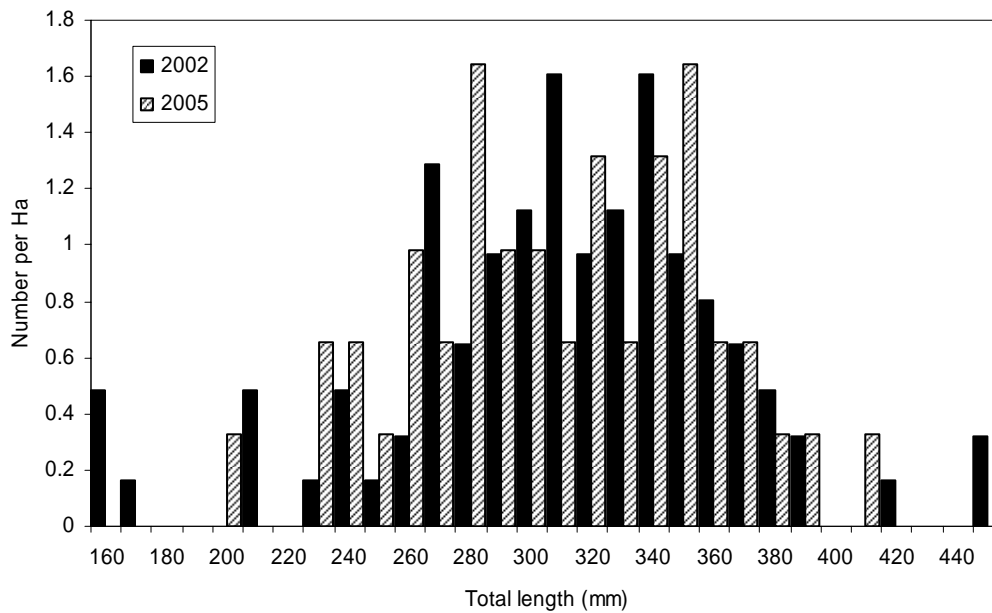
**Figure 3-15.** Length frequencies for black teatfish, *Holothuria whitmaei*, collected during population surveys in east Torres Strait in 2002 and 2005.



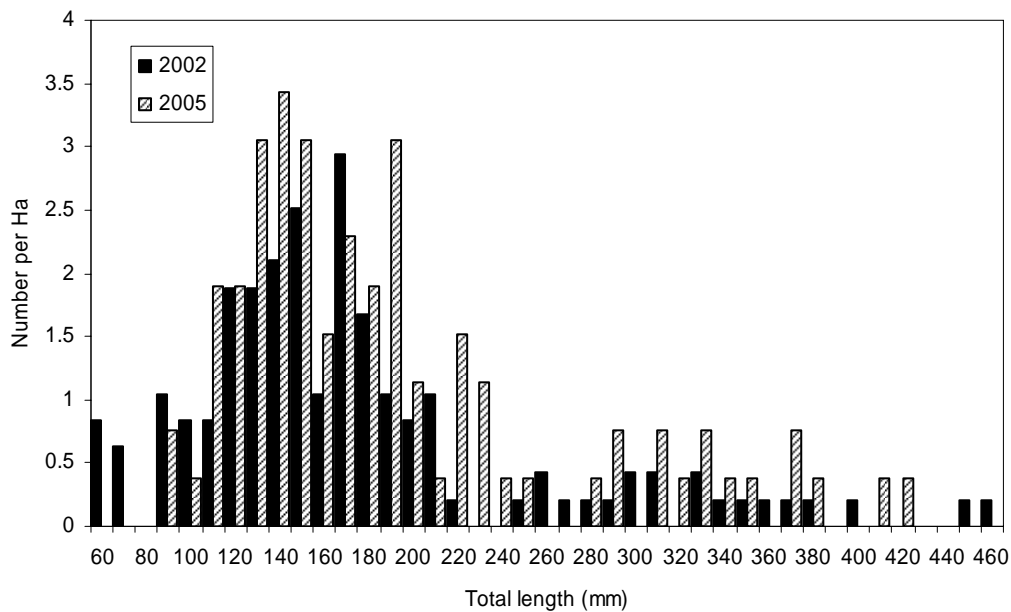
**Figure 3-16.** Length frequencies for prickly redfish, *Thelenota ananas*, collected during population surveys in east Torres Strait in 2002 and 2005.



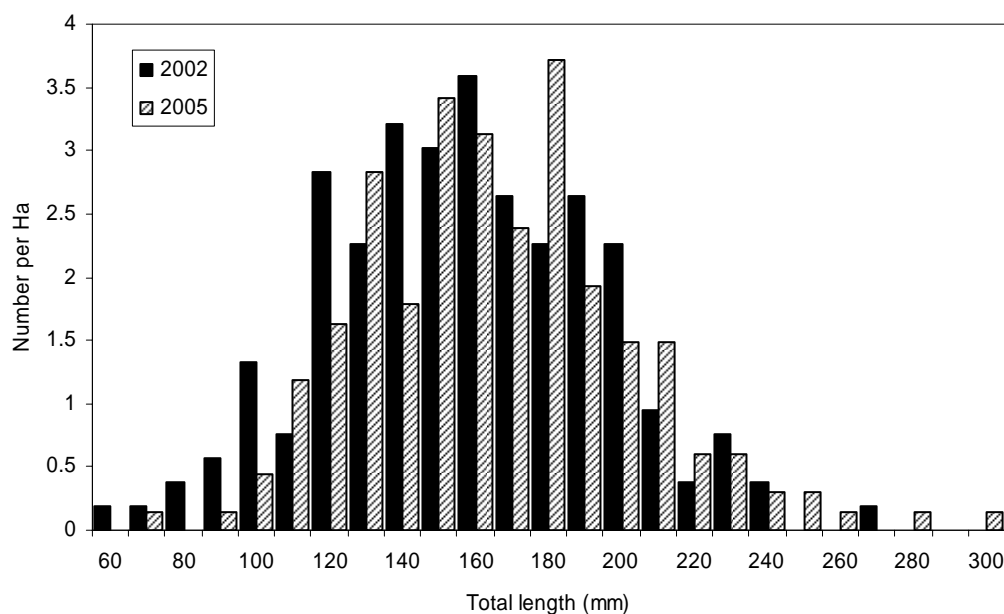
**Figure 3-17.** Length frequencies for white teatfish, *Holothuria fuscogilva*, collected during population surveys in east Torres Strait in 2002 and 2005.



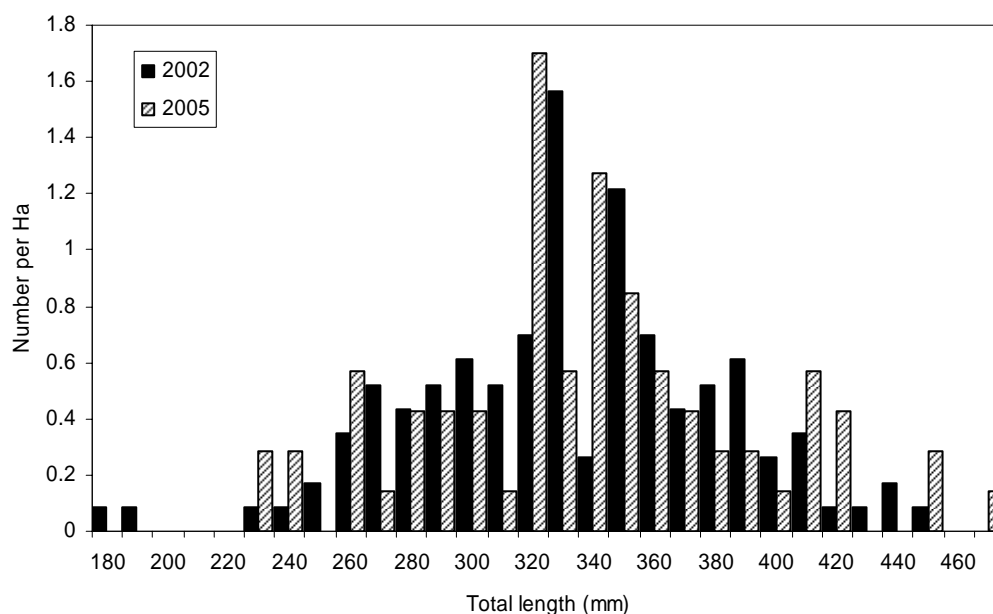
**Figure 3-18.** Length frequencies for elephant trunkfish, *Holothuria fuscopunctata*, collected during population surveys in east Torres Strait in 2002 and 2005.



**Figure 3-19.** Length frequencies for lollyfish, *Holothuria atra*, collected during population surveys in east Torres Strait in 2002 and 2005.



**Figure 3-20.** Length frequencies for pinkfish, *Holothuria edulis*, collected during population surveys in east Torres Strait in 2002 and 2005.



**Figure 3-21.** Length frequencies for curryfish, *Stichopus hermanni*, collected during population surveys in east Torres Strait in 2002 and 2005.

### 3.2.2. Comparison with catch data

Catches from the Torres Strait sea cucumber fishery have been recorded from logbooks (QDPI, 1996 to 2002; Kung, 2002) and the Torres Strait docket book program (AFMA, 2004 to 2005) (Table 3-5). However, the catch records are acknowledged as being sparse and incomplete (e.g. no data for 2003), and catches prior to 1996 have not been officially recorded. Estimates of catches prior to 1996 include 1200 to 1400 t of sandfish caught on Warrior Reef in 1995 (QDPI), and up to 30 t of black teatfish caught around Murray Island in 1993 (R. Torelli, *pers comm.*).

The estimates of the catch for 2004 and 2005 are very low, and indicate that there was probably little fishing occurring in the fishery during this period. This low activity was probably caused by the

closure of several high value species and a lack of external buyers. The abeyance of fishing was confirmed during the Beche-de-mer Workshops (Torres Strait CRC Project 1.13 – Section 7) that were held in early 2005 (Chapter 7), where fishers on some islands indicated that they were under the impression that the entire fishery was closed. Buyers/processors in other islands were reluctant to buy/process species other than black teatfish and/or surf redfish because they were unfamiliar with the other species.

While there has been little apparent fishing in recent years, the data available indicated that prickly redfish have been preferentially targeted (Table 3-5), with more than 5 t estimated to have been caught in 2005.

**Table 3-5.** Estimates of the catch of the (Australian) Torres Strait sea cucumber fishery (in kg, gutted weight) from logbooks (QDPI, 1996 to 2002) and Torres Strait docket book program (AFMA, 2004 to 2005).

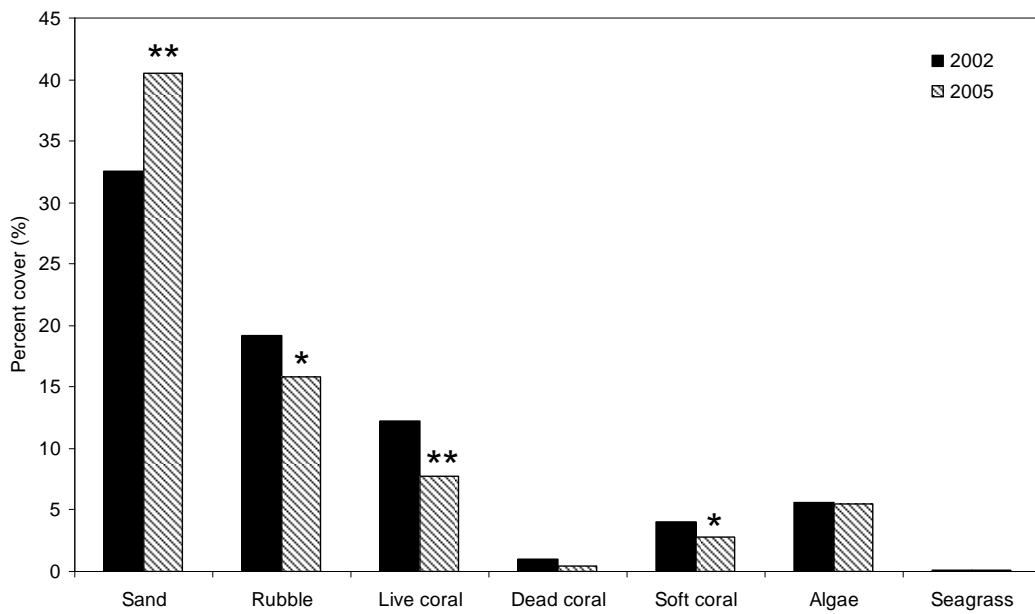
Year	Catch (kg)							Total (year)
	Black fish	Black teat fish	Prickly red fish	Sand fish	Surf red fish	White teat fish	Other	
1996		52777	7	10717	34990			98491
1997	65	40190	41	29955	51658	123	12	122043
1998	1211	18462	620	48	60289	855	440	81925
1999	1675	9196	3332	39	1497	1064	291	17093
2000			347			1207	412	1966
2001	28502	11820	160		59655	3023	1536	104696
2002	10663	3392	10451		6487	147	14575	45715
2003	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2004			1188			25		1213
2005	186		5576			367		6129
Total	42301	135836	21721	40759	214576	6811	17266	479270

### 3.2.3. Environmental data

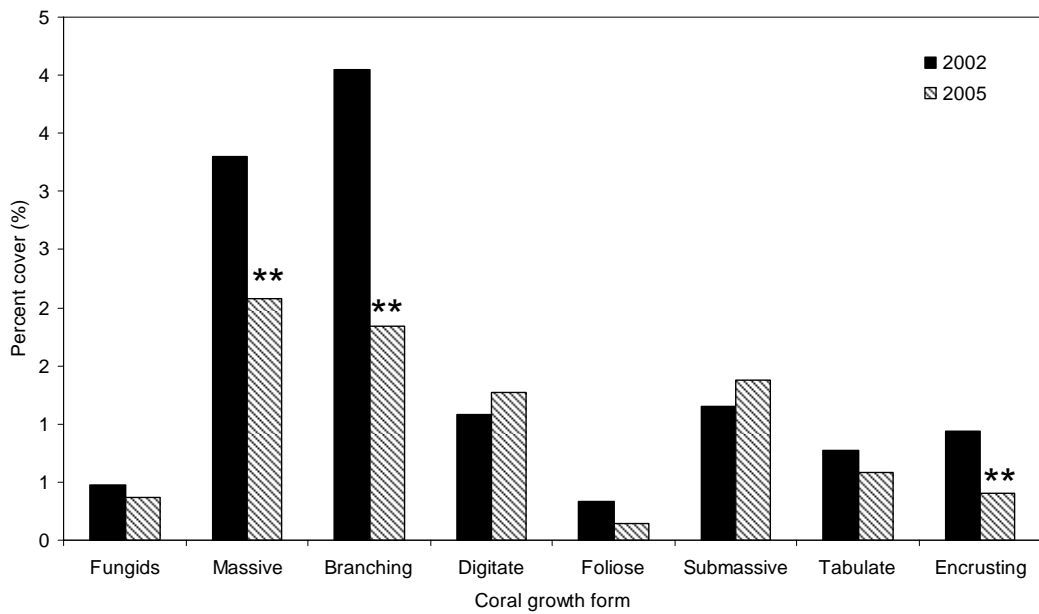
There were some differences in the average cover of habitat components at the repeated sites in the east Torres Strait fishery (Figure 3-22). Sand cover was higher and rubble was lower in 2005 compared to 2002. Live coral cover 37% lower in 2005 compared to 2002, and soft coral cover was 31% lower. Most of the change in live coral cover was in massive and branching corals (Figure 3-23) with reductions of 37% and 55% respectively.

One area we revisited in particular did show signs of degradation compared to previous surveys. This was on a reef 20 km the west-north-west of Murray Island at the northeast head of the Hibernia passage (Popo Reef). During the previous survey in 2002, we had noticed that this reef had a very high cover of branching and tabulate coral, and also a high density of giant clams (*Tridacna gigas*). Upon visiting this site in 2005, a high proportion of the tabulate coral was found to be dead, and there were high densities of crown-of-thorns starfish (*Acanthaster planci*) on the reef. The reef had been severely degraded. However, this appeared to be an isolated degradation. The density of crown of thorns starfish was only slightly higher overall in 2005 compared to 2002 (2.03/ha in 2005 compared to 1.41 per ha in 2002) and the change was not significantly different ( $P = 0.64$ ).

The density of giant clams (*Tridacna gigas*) was similar between the two surveys (6.74/ha in 2002 compared to 6.07/ha in 2005) as was the density of the burrowing clam *T. crocea* (203.32/ha in 2002 c.f. 207.60/ha in 2005) and the free living shallow reef species *Hippopus hippopus* (0.61/ha in 2002 c.f. 0.71/ha in 2005).



**Figure 3-22.** Average cover of habitat types sampled at 122 repeated sample sites in eastern Torres Strait during the 2002 and 2005 abundance surveys (\*,  $P < 0.05$ ; \*\*,  $P < 0.001$ ).



**Figure 3-23.** Average cover of coral growth forms sampled at 122 repeated sample sites in eastern Torres Strait during the 2002 and 2005 abundance surveys (\*,  $P < 0.05$ ; \*\*,  $P < 0.001$ ).

## 4. DISCUSSION

### 4.1. Warrior Reef sandfish

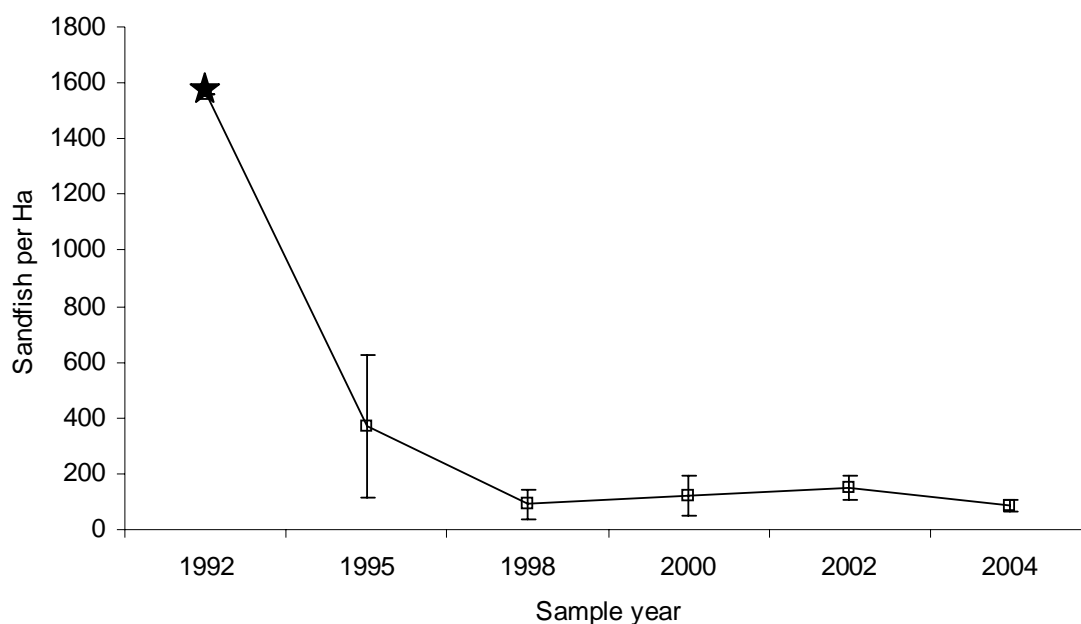
The overall population density of sandfish (*Holothuria scabra*) at the repeated sites on Warrior Reef in 2004 was the lowest observed. However, this result was mostly due to a very low density of juvenile (<14 cm) sandfish – adult (>14 cm) sandfish were also lower than the last survey in 2002 but still greater than 1998 levels. While it is true that burrowing, particularly for smaller individuals, will confound survey results, the fact that larger animals that do not burrow as often had decreased in density is a cause for concern. Also, we visited several sites where small individuals have been seen in high densities in previous surveys on several tides and times of the day, and the lower densities were confirmed each time.

The cause of the lower density observed during the 2004 survey could be attributed to one or more of the following factors:

- 1) Variable burrowing rates of sandfish between the surveys. Sandfish are known to have variable burrowing rates in response to diurnal (time of day), seasonal and tidal cycles, and also in relation to seagrass cover. However, we deliberately carry out the population surveys at the same time of year, the same moon phase and similar time of day to endeavour to nullify these factors, and the repeated measures sample design should nullify the variable environmental factors. Also, previous research has shown the burrowing response to these factors is consistent over time. Therefore, we can have some confidence that the density comparisons between years were mainly due to real changes in density, not burrowing rates. The influence of environmental factors on burrowing rates continues to be the focus of research during our surveys — we collected additional data during the 2004 survey, especially for small sandfish to assist to answer this critical question. Also CSIRO Marine and Atmospheric Research is currently hosting a PhD student at Cleveland, and a section of her thesis deals with burrowing rates for sandfish and the factors that affect it.
- 2) Natural variability in recruitment. As sandfish numbers are still at a low density compared with virgin biomass levels, there is still the possibility that low recruitments will occur due to the dilution (or allee) effect, where the breeding adults are dispersed to an extent that fertilization success in the water column is variable and potentially depressed.
- 3) Illegal fishing by Australian and/or PNG fishers.
- 4) Possible over-fishing of the sandfish population on the PNG side of the border. The sandfish populations that support the fisheries on both sides of the border are most likely part of the same stock. The PNG fishery reopened in 2002 after a two year closure, and recent catches reported indicate that the fishery has been catching between 6.5 and 23.5 t (dry wt), equivalent to between 69 and 250 t (gutted wt) or 135 to 490 t whole live weight per year (PNG NFA, P. Polon). This catch is likely to be from a depleted population, and perhaps even from the Australian side of the border. This represents a significant catch from the fishery when looked at as a whole.

While we are not currently in a position to determine which of these factors is, or are the cause of the low estimated density in 2004, we can be reasonably certain that the population is still in a depleted state, and that it would be very difficult to recommend a reopening of the fishery at this stage.

The current state of the population can be illustrated more clearly by comparing the current density estimates with an estimate of the density of sandfish that would have been on the Warrior Reef to support the 1200 t estimated to have been taken in 1995 (Figure 4-1). We took a conservative approach to calculating this estimate: we used the lowest estimate of the catch range, assumed that there were no sandfish left at the end of the year and that the size frequency of the catch included only those sandfish above the legal minimum size at the time. While there will be some reduction in the density estimates for later estimates due to burying, the comparisons are still quite stark.



**Figure 4-1.** Density of sandfish (*H. scabra*) on Warrior Reef with estimated pre-fishery density (star) based on estimates of the catch in 1995 and habitat area.

## 4.2. East Torres Strait

The species composition and overall density of sea cucumbers seen at the repeated sites in 2002 and 2005 was remarkably similar (Figure 3-12) suggesting that the 122 repeated sites were adequate to allow a legitimate comparison of population changes between the two years.

Both closed species in the east Torres Strait fishery, black teatfish (*Holothuria whitmaei*) and surf redfish (*Actinopyga mauritiana*), had decreased in density since the previous survey in 2002 when they were considered as overexploited (Skewes *et al.*, 2004a). Even though the repeated surveys had less precision than expected and problems with species identification may have confounded the surf redfish result, we can be reasonably certain that the populations of these two species have not recovered to densities that we can recommend that they be reopened to fishing. Allowing a take of these closed populations would result in even lower densities and probably result in a longer period to full recovery.

Although both species were subject to a year of fishing after the January 2002 survey (i.e. during the remainder of 2002), the reported catch for that period was small (Table 3-5). Based on the 2002 population biomass estimate for black teatfish (376.8 t), the average decline observed in 2005 would equate to about 86 t — it is unlikely that even illegal fishing would account for this decline in average density. It is more likely that the survey result reflects the slow recovery for depleted sea cucumber populations, as has also been observed for the east coast black teatfish population (Uthicke *et al.*, 2004).

Although the recent catch data is somewhat sparse, the two species most heavily targeted species since the last survey appear to be prickly redfish (*Thelenota ananas*) and white teatfish (*Holothuria fuscogilva*). While prickly redfish density was only slightly lower in 2005 compared to 2002 (-6.0%), the average size of individuals seen during the survey was significantly lower in 2005 compared to 2002, and the size frequency showed that a significant proportion of the observed individuals in 2005 were smaller (<300 mm TL) individuals. In fact, the density of legal sized prickly redfish (>300 mm TL) declined from 8.3 per ha to 4.9 per ha. While it is unlikely that the modest catches since the last survey in 2002 would have had such a significant impact on the population given the stock estimate from the large scale surveys in 2002 (approximately 400 t), this species (similarly with many targeted species) may be susceptible to localised depletion.

White teatfish did show a large decrease in relative density (-34.4%) however, it was not statistically significant due to the very patch distribution of this species in the study area. There was a small decrease in average weight but the length frequency did not show any obvious decline in larger individuals. Again, given the likelihood of very low catches since the 2002 survey, we do not propose any changes to the recommended TACs for these species (20 t and 15 t for prickly redfish and white teatfish respectively) at this stage. The TACs were quite conservative in any case based on the large scale survey carried out in 2002. However, these targeted species do require close monitoring by the collection of spatial fishery data and regular population surveys.

A problem with the monitoring of species such as surf redfish is the difficulty in identification of this species and its relatives, especially the deepwater redfish. It is unlikely that all of the “surf redfish” caught by the fishery in the past are actually surf redfish (*Actinopyga mauritiana*). In this case, it is difficult to advise on a sustainable catch of any of the *Actinopyga* species.

The population trends for the closed species in Torres Strait are similar to the patterns of recovery for depleted populations in the South Pacific and world-wide. A key finding has been that depleted populations do not recover quickly. The reasons for this are still not known, however, there is likely to be some compensatory mechanisms acting on recruitment, such as dilution (or Allee) effects decreasing the fertilization success of the gametes in the water column. It is also possible that the recruitment patterns for sea cucumber populations are characterised by infrequent large recruitments. More research on this aspect of sea cucumber population biology is required to develop sustainable harvest strategies. The growing awareness among sea cucumber scientists and managers is that sea cucumber fisheries should be generally small and tightly controlled to be sustainable.

The habitat data collected during the two surveys showed that important ecosystem components such as seagrass on Warrior Reef were stable in comparison with historical data. However, there was a reduction in the cover of live coral in east Torres Strait, and some evidence of localised crown-of-thorns starfish outbreaks. These should be monitored in the future to determine longer term trends.

## 5. RECOMMENDATIONS

1. Maintain closures for the currently closed species (sandfish, black teatfish and surf redfish).
2. Implement and monitor individual TACs for at least the higher value and/or targeted species.
3. Integrate research and management for the Warrior Reef sandfish fishery with PNG.
4. Produce a comprehensive identification guide for Torres Strait sea cucumbers.

## 6. FUTURE RESEARCH

1. Monitor the recovery of closed species, and status of targeted species. The continued tracking of the density and dynamics of depleted populations of sandfish and black teatfish in particular, will lead to an understanding of the recovery dynamics of sea cucumber populations, and help determine recovery targets for renewed fishing of depleted species. Fished species also require monitoring to gain a better understanding of the dynamics of fished populations and for the development of sustainable harvest strategies. Ideally, monitoring surveys would occur annually, however this is impractical given the high costs for such a small fishery. It would probably be useful to monitor the sandfish population regularly (2-3 years) but only if it could be established that illegal fishing was not adversely affecting the population. The timing of the next east Torres Strait survey would depend to some extent on the levels of fishing — if the fishery becomes active then surveys should be planned as often as practical.
2. Species ID and taxonomy esp. *Actinopyga* spp. A problem with the monitoring of redfishes and blackfishes is the difficulty in identification of these species. It is unlikely that all (if any) of the “surf redfish” caught by the fishery in the past are actually surf redfish. We have seen very few true surf redfish (*Actinopyga mauritiana*) during our surveys, however, there are other shallow water red *Actinopyga* species that require identification. Also, there are at least 2 and potentially 4

species of “black” *Actinopygas* that could potentially be fished in Torres Strait. In this case, it is difficult to advise on a sustainable catch of any of the *Actinopyga* species.

3. Beche-de-mer conversion ratios. Catch and survey data for sea cucumbers fisheries are recorded in several different processed stages, from whole live to dry (fully processed beche-de-mer). Accurate conversion ratios are, therefore, essential to allow interpretation of catch data that is recorded at different stages of the process train, to determine total catches in a standard unit to relate to set TACs and to assist in monitoring and enforcement in the field. This information will also assist in the design of an appropriate logbook for recording accurate and useful catch data. The relationship between the various processed stages in relation to total length is also very important when trying to manage fisheries using minimum legal sizes (MLS).

The recently completed project, Conversion Ratios for Commercial Beche-de-mer Species in Torres Strait (AFMA Project Number: R02/1195, Skewes *et al.*, 2004b) produced conversion ratios for seven important commercial species, including sandfish (*Holothuria scabra*), prickly redfish (*Thelenota ananas*), blackfish (*Actinopyga miliaris*), surf redfish (*A. mauritiana*), black teatfish (*H. whitmaei*), white teatfish (*H. fuscogilva*) and elephant trunkfish (*H. fuscopunctata*). However, processed (dry) weight data for black and white teatfish were lost due to a misunderstanding in the processing plant. These species are among the most important commercial species so this represents a serious information gap.

4. Socio-economic considerations, community based management (CBM), and appropriate business models for community based fishing operations in Torres Strait. The sea cucumber fishery in Torres Strait has been characterised by boom and bust cycles driven mainly by buyer demand. The size and structure of a future Torres Strait sea cucumber fishery will be limited by the small TACs for high value species especially. Implementing management strategies to limit effort peaks and promote lower level sustainable development through island-based buyers requires research on the socio-economic considerations with respect to this level of enterprise.

## **7. TORRES STRAIT BECHE-DE-MER (SEA CUCUMBER) SUSTAINABILITY WORKSHOP 2005 - A COLLABORATIVE APPROACH (CRC-TS PROJECT TASK NUMBER: T1.13)**

*Task Leader: Sascha Taylor*

In a major education and awareness initiative, Sascha Taylor from AFMA Torres Strait Fisheries and Tim Skewes from CSIRO Division of Marine Research recently conducted a series of two-day sustainability workshops in three communities in eastern Torres Strait. These included Masig (Yorke), Erub (Darnley) and Mer (Murray) Islands.

The workshop, funded by the Torres Strait Cooperative Research Centre (CRC), took place prior to the next scheduled bêche-de-mer survey in these waters. A range of stakeholders including Torres Strait Islander traditional and commercial fishers, seafood buyers/processors and council members attended the workshops. The main objectives were to -:

1. outline the current management arrangements in the fishery;
2. explain the principles of sustainable exploitation and illustrate sea cucumbers' susceptibility to overharvesting using examples from the Torres Strait sandfish and Queensland East coast black teatfish fisheries; and
3. explain and demonstrate the processes/methodologies (sample design, field sampling and calculating Total Allowable Catches - TACs) used to survey bêche-de-mer stocks and assess the status of the stocks.

Importantly, for each of the above themes, feedback sessions provided the opportunity where traditional inhabitants could input into the current knowledge, research methodologies and future management strategies for the fishery. A range of stakeholder interests including Australian

traditional inhabitant commercial and traditional fishers, non-traditional inhabitant commercial fishers and buyers/processors attended the workshops. Conclusions from evaluation forms completed at the end of the workshops by participants (APPENDIX 3: Evaluation forms for Torres Strait Bêche-de-mer (sea cucumber) Sustainability Workshop 2005), suggest that the workshop was a huge success (Table 7-1). This initiative alone improved the understanding by key stakeholders of the nature of research on sea cucumbers and the reasons for management advice that is offered to AFMA based on that research which in turn improve support for future management decisions in the fishery.

**Table 7-1.** Summary of responses from evaluation forms completed at the end of the workshops by participants.

QUESTION	RESPONSE
1.	All found the workshops informative, mostly very informative.
2.	Most found that there was too much information, with a small group (5) wanting more. Six respondents felt neutral.
3.	All found the information easy or fairly easy to understand. No-one recorded difficulty in understanding the information presented at the workshops.
4.	Half indicated they had an excellent knowledge of the research undertaken in the fishery and all but one had good/moderate knowledge. One had poor knowledge.
5.	All found the workshop helpful in understanding the research and reasons for management.
6.	All but one felt that research had assisted the fishery.
7.	All believe that research should incorporate traditional knowledge.
8.	All respondents felt that the workshop allowed for them to provide comments.
<i>Comments</i>	Very good workshop More research needs to be done on (all) marine produce caught commercially Need another workshop

Subsequently, as a follow up, AFMA and CSIRO produced an information brochure outlining the recent outcomes of research, including the results of the 2004 east Torres Strait survey (Anon., 2005).

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## 9. ABBREVIATIONS & GLOSSARY

AFMA	Australian Fisheries Management Authority
CMAR	CSIRO Marine and Atmospheric Research
PZJA	Protected Zone Joint Authority
PNG NFA	Papua New Guinea National Fisheries Authority

## 10. APPENDIX 1: INTELLECTUAL PROPERTY

Data collected during two scientific surveys; Warrior Reef in 2004 and east Torres Strait in 2005 includes sea cucumber density and macroscopic seabed abiotic and biotic components and environmental variables for about 200 sites. The data are currently stored at the CSIRO Marine Laboratories, Cleveland.

## 11. APPENDIX 2: STAFF

T.D. Skewes (CMAR)	Stock assessment / fieldwork / GIS / analysis.
S. Taylor (AFMA)	Sample design / fieldwork / communication.
D.M. Dennis (CMAR)	Sample design / fieldwork / analysis.
M.D.E. Haywood (CMAR)	Advanced Diving / fieldwork.
A.G. Donovan (CMAR)	Database management.



## 12. APPENDIX 3: Evaluation forms for Torres Strait Bêche-de-mer (sea cucumber) Sustainability Workshop 2005



Torres Strait Bêche-de-mer (sea cucumber) Sustainability Workshop 2005  
A Collaborative Approach

EVALUATION FORM (Please tick appropriate box )

**I found the workshop:**       
Very informative Uninteresting

**The amount of information presented at the workshop was:**

Too much Not enough

**Did you find the information provided to be relevant to your needs?**

Yes  No

**The workshop was presented so it was:**

Easy to understand Difficult to understand

**My knowledge of the research undertaken in this fishery was:**

Poor Excellent

**This workshop did assist me to understand the nature of research undertaken and the reasons for management advice that is offered for this fishery:**  Yes  No

**Do you think research has assisted in this fishery?**    
Yes No

**Should research incorporate traditional knowledge?**    
Yes No

**The workshop did allow for me to provide comments:**  Yes  No

**What is your gender?**  Female  Male

**What is your age in years?** ..... years

**Please state the work you are mostly involved in:**

.....

**Other comments?** .....



Torres Strait Bêche-de-mer (sea cucumber) Sustainability Workshop 2005  
*A Collaborative Approach*

**EVALUATION FORM** (Please tick appropriate box )

**I found the workshop:**       
 Very informative Uninteresting

**The amount of information presented at the workshop was:**

Too much Not enough

**Did you find the information provided to be relevant to your needs?**

Yes  No

**The workshop was presented so it was:**

Easy to understand Difficult to understand

**My knowledge of the research undertaken in this fishery was:**

Poor Excellent

**This workshop did assist me to understand the nature of research undertaken and the reasons for management advice that is offered for this fishery:**  Yes  No

**Do you think research has assisted in this fishery?**    
Yes No

**Should research incorporate traditional knowledge?**    
Yes No

**The workshop did allow for me to provide comments:**  Yes  No

**What is your gender?**  Female  Male

**What is your age in years?** ..... years

**Please state the work you are mostly involved in:**

.....

**Other comments?** .....