www.csiro.au

Towards regional and community-scale reporting of marine ecosystem health in the Torres Strait

Lavenie Tawake, James Butler, Tim Skewes (CSIRO)
Alifereti Tawake (James Cook University)
Vic McGrath, Fiona Morseu (Torres Strait Regional Authority)

Final report for MTSRF Project 1.3.5, *Reporting Ecosystem Health in the Torres Strait*

June 2010

Enquiries should be addressed to:

Dr. James Butler

CSIRO Ecosystem Sciences

Tel.: +61 7 3214 2257

james.butler@csiro.au

Copyright and Disclaimer

Important Disclaimer

Suggested citation: Tawake, L., Butler, J.R.A., Skewes, T., Tawake, A., McGrath, V. & Morseu, F. 2010. Towards regional and community-scale reporting of ecosystem health in the Torres Strait. Final report to the Australian Government's Marine and Tropical Science Research Facility. CSIRO Ecosystem Sciences, St. Lucia, Queensland, Australia. 84 pp.

Cover photo: Nicole Murphy, CSIRO

Contents

List of Figures

List of Tables

List of ACRONYMS

AFMA	Australian Fisheries Management Authority
AIMS	Australian Institute of Marine Science
BRS	Bureau of Rural Sciences
CSIRO	Commonwealth Science and Industrial Research Organization
DEWHA	Department of Environment and Water Heritage and the Arts
EHMP	Ecosystem Health Monitoring Program
GBRMPA	Great Barrier Reef Marine Park Area
JCU	James Cook University
MEH	Marine Ecosystem Health
NAILSMA	North Australian Indigenous Land and Sea Management Alliance
RRRC	Reef and Rainforest Research Centre
TSRA	Torres Strait Regional Authority
QEPA	Queensland Environmental Protection Agency
QF	Queensland Fisheries
PZJA	Protected Zone Joint Authority

EXECUTIVE SUMMARY

Currently there is no formal marine ecosystem health (MEH) monitoring or reporting system in the Torres Strait. While some commercial fisheries are assessed and monitored in detail, much of this information is transmitted to regional management agencies such as the Protected Zone Joint Authority, the Australian Fisheries Management Authority and the Torres Strait Regional Authority (TSRA). However, there is increasing awareness of the need to involve Torres Strait Islander communities in the dissemination and collection of ecosystem management and research information, and to establish an integrated system of MEH reporting which is of relevance to agencies and communities. This report presents the findings of Marine and Tropical Science Research Facility project 1.3.5, *Reporting Ecosystem Health in the Torres Strait*. The project was established in 2006 with the following objectives:

- To identify potential marine ecosystem health (MEH) indicators for the Torres Strait that are relevant to regional and community-level stakeholders, and to collate available data for those indicators;

- To develop potential monitoring and reporting frameworks and media for MEH.

Following expert workshops in 2007 and 2008 a list of 21 potential indicators of MEH (12 for condition, 9 for threats/pressures) was established. This project reviewed the data available for each indicator, finding that only four had established biological thresholds of concern (tropical rock lobster, tiger and endeavour prawns and sandfish), and there was high data confidence and scientific and management knowledge for only 27% of marine fishery species. We derived a standardised method of classifying the condition of indicators as ‘healthy’, ‘unhealthy’ and ‘vulnerable’ based on trends where known thresholds of concern did not exist. For indicators of threats/pressures to ecosystem health we did not apply these classifications. Data utility was complicated by the inconsistent temporal and spatial nature of its availability.

Examples of regional-scale report card formats are given, utilising heat maps for trends and spider diagrams for current status. A prototype MEH Index was developed, which showed that for 9 indicators with available data MEH was ‘moderate’ in 2009. Through consultations with communities on Warraber and Darnley Islands in 2010 single species fact sheets were trialled. Communities responded that their favoured media for receiving information was fact sheets and DVDs or videos. Communities also expressed their desire to be involved in MEH monitoring and reporting, but only if the schemes were of direct benefit to them, for example through fisheries co-management schemes. Communities also listed indicators of MEH which would be relevant to their livelihoods, most of which were also identified in the original list of 21.

This report suggests a nested framework for linked community and regional monitoring and reporting of MEH, to be coordinated by the TSRA Land and Sea Management Unit. This would integrate scientific knowledge with local and traditional ecological knowledge. However, a clearer definition of MEH is required which incorporates ecological, cultural and economic perspectives. The process for defining this, and selecting suitable and relevant indicators and thresholds of concern from the list in this report should be undertaken in a participatory manner which includes all relevant stakeholders.

ACKNOWLEDGEMENTS

The project was funded by the Australian Government's Marine and Tropical Sciences Research Facility. We thank the following people for their invaluable assistance in sharing and discussing their management and research data for this project:

Torres Strait Regional Authority (TSRA) – Damian Miley, Frank Loban, Rebecca Clear

CSIRO – Tim Skewes, Darren Dennis, Eva Piaganyi-Lloyd, Nicole Murphy

Bureau of Rural Sciences (BRS) – Gavin Begg, Neil Bensley

Australian Fisheries Management Authority (AFMA) – Patrick Spinney, Glen Salmon, Annabel Jones, Shane Fava, Erik Raudzens

Queensland Environment Protection Agency – Colin Limpus

James Cook University (JCU) – Ashley Williams, Helene Marsh, Mark Hamann, Alifereti Tawake

Department of Environment Water Heritage and the Arts (DEWHA) - Donna Kwan, Jillian Grayson

Queensland Fisheries (QF) - Jane Mellors, Clive Turnbull

Reef and Rainforest Research Center (RRRC) – Mellissa Jess, Shannon Hogan, Suzanne Long

We also thank the communities of Darnley and Warraber Islands, who contributed to the scoping of relevant indicators and appropriate communication materials.

1. INTRODUCTION

Currently marine ecosystem health (MEH) in the Torres Strait is largely determined by the individual condition reports for significant commercial fisheries which have comprehensive monitoring and management strategies established over a long period of time. These include the tropical rock lobster, prawn and reef line fisheries. There have also been research reports on the status and trends of other fisheries such as beche-de-mer, trochus, turtle and dugong. Reporting to the Protected Zone Joint Authority (PZJA) has been carried out through annual reports, technical reports, research articles and factsheets by various organizations such as the Bureau of Rural Science (BRS), Queensland Fisheries (QF), Commonwealth Scientific and Industrial Research Organization (CSIRO), James Cook University (JCU), Australian Fisheries Management Authority (AFMA) and Queensland Environment Protection Agency (QEPA).

However, a method for determining and reporting the overall health of the marine ecosystem by integrating such varied sources of data has never been established. While the PZJA reports annually on the conditions of individual fisheries and their current management regulations, and the Torres Strait Regional Authority (TSRA) has developed a Land and Sea Management Strategy (TSRA, 2005), neither has developed a regional-scale reporting framework for all marine resources.

Equally, comparatively little reporting occurs to Torres Strait Island communities who depend and interact with these marine fisheries daily. Furthermore, the role that communities could play in monitoring and reporting their own resources at a local scale has not been fully explored. Since the 1990s regional management agencies have recognised the need to improve communication tools to engage Torres Strait islanders in research and monitoring (Jones et. al. 2008).

1.1 Objectives

This Marine and Tropical Science Research Facility project 1.3.5 *Reporting Ecosystem Health in the Torres Strait* was established in 2006 with the following objectives:

- To identify potential marine ecosystem health (MEH) indicators for the Torres Strait that are relevant to regional and community-level stakeholders, and to collate available data for those indicators;

- To develop potential monitoring and reporting frameworks and media for MEH in the Torres Strait.

1.2 Approaches to marine ecosystem health reporting

Ecosystem health has been described by Sherman (2000) (cited in Wells, 2005) as 'a concept of wide interest for which a single precise scientific definition is problematical.' Epstein (1999) provides the following definition: 'to be healthy and sustainable, an ecosystem must maintain its metabolic activity level, its internal structure and organization, and must be resistant to stress over a wide range of temporal and spatial scales.'

There are many valid approaches to developing ecosystem health reporting. For example, the Ecosystem Health Monitoring Program (EHMP) for Southeast Queensland, Australia, identified suitable indicators by evaluating a range of variables against a known disturbance gradient. Potential indicators were first identified based on the expertise of the monitoring team. This list was then refined based on conceptual models that showed how the proposed indicators responded to disturbances. A major field survey of disturbed and undisturbed sites was then undertaken to validate the indicators (Bunn and Smith 2002).

To select multiple indicators of marine species or ecosystem conditions to be monitored regularly, Clua *et al.* (2005) developed an indicator 'dashboard' to determine multidisciplinary indicators tailored for specific situations and management objectives. They used this approach to assess and monitor coral reef fisheries from three perspectives: ecology, exploitation and socio-economics. The indicator dashboard was determined through a participatory approach involving all stakeholders, and collective updating and indicator scoring.

A similar approach is practiced by the Locally Managed Marine Area (LMMA) Network in the Pacific. The LMMA Network uses a Learning Framework (Govan *et al.* 2008) as an adaptive tool to determine conditions under which a locally managed marine area strategy has succeeded. Each project analyses and communicates information on their site to a network coordination team which decides whether changes need to be made to project design to improve results. In this way each project learns about successful actions they are taking, and indicators of conditions which determine an effective LMMA are derived from conceptual models of targets and threats for each project. These are measured for each project site and shared through the Learning Framework.

A review by the Reef and Rainforest Research Centre (Browne *et al.* 2008) of report card approaches from national and international examples highlights several fundamental steps. First, the scope of the reporting objectives must be decided, followed by understanding the system, establishing a measurement framework and finally establishing an integration and reporting framework. Other common challenges for developing a report card are governance, goals and scope, conceptual framework and models, indicator selection and organisation, regionalisation, indicator integration and reporting and presentation (Browne *et al.* 2008). We followed these basic steps in this sudy, which are presented below.

1.3 Current marine ecosystem health reporting for the Torres Strait

Currently there is no framework for reporting MEH in the Torres Strait. However, existing information can be collated and applied to identify and develop potential indicators, and a prototype framework for reporting.

Stock status has been studied intensively for certain commercially important Torres Strait marine species (lobster, prawn, beche-de-mer, Spanish mackerel and some finfish). Also, fisheries which have had long term monitoring and data collection have developed biological targets or thresholds of concern and management strategies to assist governing bodies in managing these resources. Reporting of these fisheries is carried out through scientific assessment reports which are published regularly. However, most of this fisheries information is transmitted to the PZJA (Figure 1-0). There is some feedback via community fishers' representatives on PZJA working groups to island communities, and also from AFMA and TSRA, and some fishermen are involved in catch reporting to AFMA and TSRA, but these channels are relatively weak.

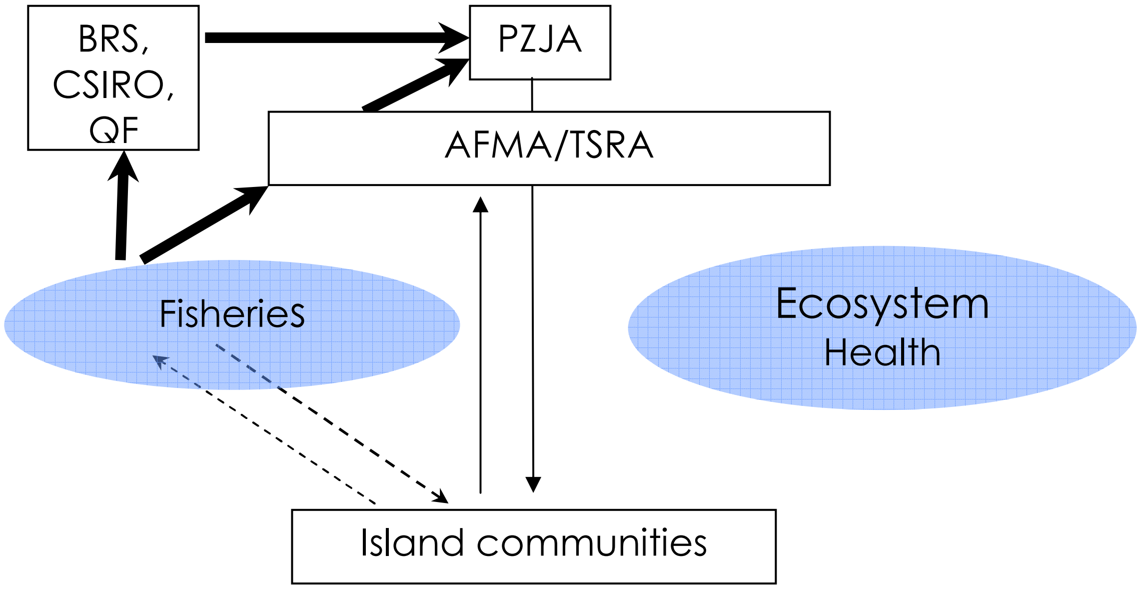


Figure 1-0 Current reporting channels in the Torres Strait. Arrow directions and widths denote the flow and relative volume of information

BRS conducts its own independent annual assessments on commercial fish stocks from scientific data that are managed by government around Australia (Larcombe & McLoughlin, 2006). The most recent fisheries status report was for 2008 (Wilson *et al.* 2009). Stock abundance is described briefly for each year and classified into four categories depending on their current biomass, fishing mortality or exploitation rate. A traffic light approach is used where green represents 'not overfished/not overfishing', amber is 'uncertain', red is 'overfishing and overfished' and there is a category for no data. The annual BRS report for Torres Strait provides an extensive fisheries status assessment for tropical rock lobster and prawns, and a brief report for beche-de-mer, Spanish mackerel, crab, pearl shell, trochus and the reef line fishery. Lobster and prawn status are determined from model outputs of catch and survey data, whereas the status for other fisheries is determined from catch trends.

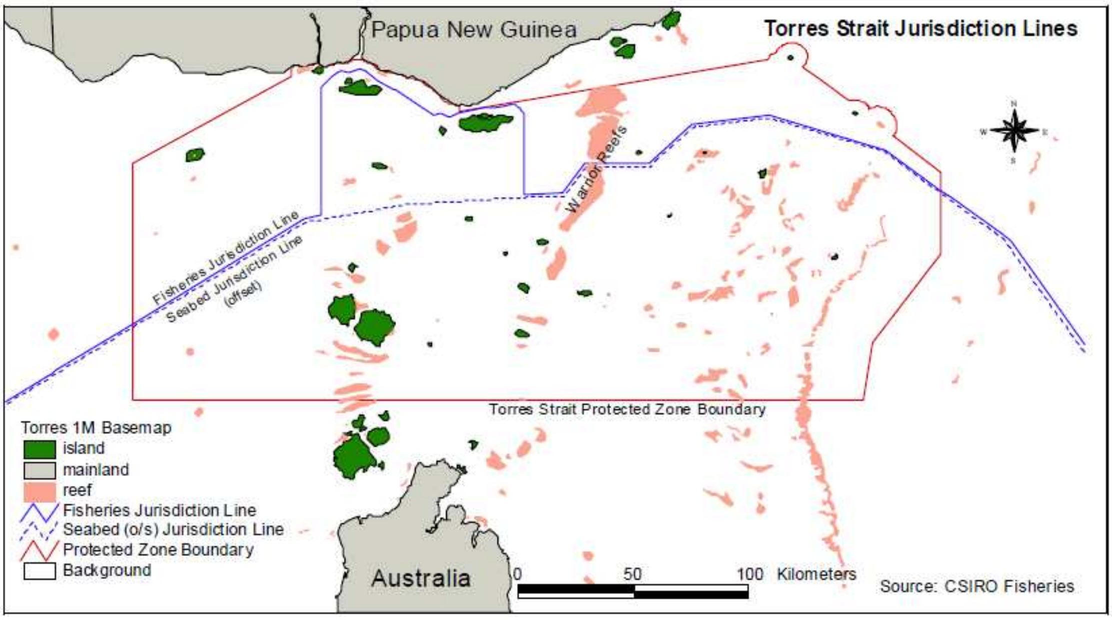


Figure 2-0 The Torres Strait.

The PZJA is responsible for the management of commercial and traditional fishing in the Australian area of the Torres Strait Protected Zone (TSPZ; Figure 2-0) and also reports the condition of each fishery within the TSPZ in their annual report. AFMA also reports stock health for single species but in the form of a scientific technical report for researchers. They work closely with scientists from organizations such as CSIRO and JCU to produce stock assessments for some fisheries. Their assessment reports focus on the scientific description of the fishery and an environmental assessment according to terms of reference set by government. Each fishery is described based on catch and stock surveys and a review of management mechanisms. Fisheries such as lobsters and prawns have been extensively researched since the 1980s, while others such as trochus and crabs have not had any stock assessment.

Other information relating to ecosystem health has been published by the Torres Strait CRC, TSRA and NAILSMA newsletters and websites. The last CRC publications in 2006 reported on the highlights of each fishery, a description of the CRC research that was undertaken for that fishery and their general findings. Emphasis was placed on the description of the management arrangements present in the Torres Strait and ways to improve the link between communities and researchers. A TSRA and NAILSMA newsletter has been produced specifically for turtle and dugong projects, and reports biannually on community aspirations and initiatives and their future plans and activities.

2. MARINE ECOSYSTEM HEALTH INDICATORS FOR THE TORRES STRAIT

A MEH assessment for the Torres Strait has been identified as a priority issue within the TSRA's Land and Sea Management Strategy (LSMS) (Figure 2-1). This is linked to priority assets and threats listed under the Sea asset: social and cultural heritage, shipping, water quality and marine biodiversity.

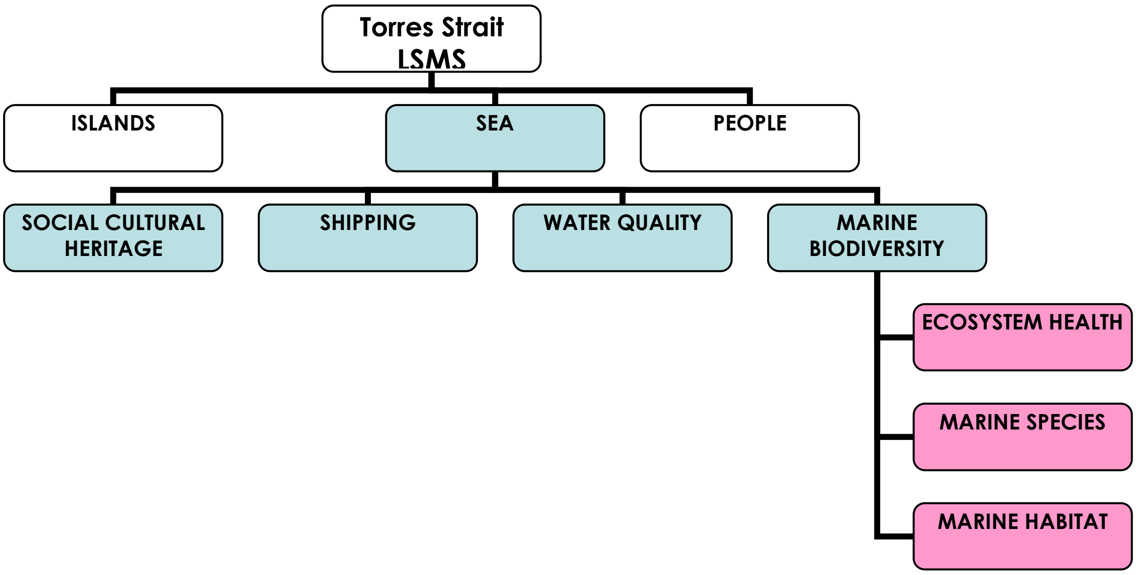


Figure 2-1 TSRA Land and Sea Management Strategy assets and issues framework

Two expert workshops were held in March 2007 and April 2008 to identify potential indicators of MEH and associated datasets. From the workshops a table of indicators and metadata was compiled, including assessments of their potential relevance for different stakeholders (see Appendix A).

2.1 Confidence levels for marine species datasets

The workshops identified many marine-related data sets for the Torres Strait which are collected and held by various agencies and organizations for different purposes, and vary in temporal and spatial scales. For example the prawn and lobster fisheries have 20-year data sets including extensive research and modelling to develop biological reference points, which together enable a high degree of confidence in stock assessments. Other commercial fisheries have extensive catch data (e.g. Spanish mackerel), but no biological reference points, reducing the confidence in stock assessments. Traditional fisheries have even less data and hence confidence.

Consequently we attempted to standardise the levels of science and management knowledge of fisheries species, and hence the level of confidence in their utility as potential indicators of MEH. These were partly based on BRS's assessments of data confidence presented for each fishery in their annual status reports, as follows:

High – BRS states high data confidence and the fishery has undergone a formal stock assessment in the past 5 years using both biomass and catch or catch per unit effort (CPUE), or just biomass.

Medium – BRS states uncertain data confidence and the fishery has undergone a stock assessment using catch or CPUE data only in the past 5 years.

Low – BRS states uncertain data confidence, but some catch data has been collected in the past 5 years.

None – No catch or survey data has been collected within the past 5 years

Appendix B lists existing datasets for different marine fishery species and their respective confidence levels according to these criteria. The table shows that there is high science and management knowledge and data confidence for only 27% of the species. These include tropical rock lobster, the 17 species of beche-de-mer and blue endeavour and brown tiger prawns.

2.2 Potential indicators for marine ecosystem health reporting in the Torres Strait

The list of 21 potential MEH indicators is summarised in Table 2-0, showing the host organisation for data sets, length of data sets, units of measure and the presence of biological reference points or 'thresholds of concern'. Twelve of the indicators are representative of marine assets' condition, while 9 are indicators of threats or pressures to these assets. As explained above, only four of these indicators have established thresholds of concern. However, it may be possible to apply thresholds for sea surface temperatures related to coral bleaching, and crown of thorns starfish densities recognised in the Great Barrier Reef (see Section 2.3).

Table 2-0 Potential indicators of MEH. Highlighted indicators have known thresholds of concern

Indicators Condition (C) or Threat/pressure (T/P)	**Data custodian**	**Data time series**	**Unit of measure**	**Threshold of concern**
Tropical rock lobster (C)	CSIRO	1989 - 2009	Biomass (tonnes)	Biomass target and limit levels
Sandfish and other sea cucumber species (C)	CSIRO	1992 - 2004	Numbers per ha	Biomass target and limit levels
Trochus (C)	CSIRO	1988 - 2006	Estimated total catch	Unknown
Green turtle (C)	QEPA	1976 - 2005	Carapace length of females, annual census	Unknown
Hawksbill turtle (C)	QEPA	1984 - 2004	Annual census	Unknown
Dugong (C)	JCU	1987, 1991, 1996, 2001,2006	Estimated number	Unknown
Spanish mackerel (C)	QF	1985 - 2005	Standard CPUE	Unknown
Blue endeavour prawn (C)	QF	1989 - 2007	Proportion of virgin biomass	Biomass target and limit levels
Brown tiger prawn (C)	QF	1989 - 2007	Proportion of virgin biomass	Biomass target and limit levels
Seagrass (C)	CSIRO Seagrass Watch	1989 – 2004 2004 - 2006	Mean % cover	Unknown Unknown
Coral cover (C)	CSIRO	1994 - 2009	Mean % cover	Unknown
Gold-lipped pearl (C)	CSIRO	1989 - 2009	Mean number	Unknown
Algae (T/P)	CSIRO	1994 - 2009	Mean % cover	Unknown
Sea surface temperatures (SST) (T/P)	CSIRO, AIMS	1990 - 2006	Daily SST, Yearly SST at Thursday Is.	Coral bleaching threshold >30^{0}C SST
Wind speeds (T/P)	CSIRO	1986 - 2006	Annual averages	Storm speeds
Heavy metal pollution (T/P)	GBRMPA, JCU	2002	Level of trace metals	Toxic levels
Traditional fisheries catch (T/P)	CSIRO	1976 - 2005	Estimated dugong and turtle catch per yr	Unknown
Shipping traffic(T/P)	AMA	1997 - 2009	Number of annual voyages (Prince of Wales passage)	Unknown
Illegal fishing(T/P)	AFMA Torres Strait	1989 - 2008	Number of apprehensions in TSPZ	Unknown
Crown of thorns starfish (T/P)	CSIRO	2002, 2005, 2009	Number per ha in Eastern Torres Strait	>30 adults per ha
Fishing effort (T/P)	AFMA Torres Strait	2001 - 2009	Number of licenses	Unknown

2.3 MEH indicators, status and trends

The following sections describe the indicators and collated data on their status and trends. For fisheries with thresholds of concern, the reference or limit values of biomass are described. The target biomass (Btarg) is the desired biomass of a particular fishery. When the levels of biomass exceed Btarg the fishery is considered 'healthy'. The limit biomass (Blim) is the value below which biomass should not fall. If this occurs the fishery is considered 'unhealthy'. When biomass levels are between Btarg and Blim the fishery is considered 'vulnerable'. The virgin biomass (Bo) is considered to be the pristine biomass prior to fishery exploitation. The first biomass value measured is usually assumed to be the Bo value.

Where thresholds are unknown, the overall trend of the data set was used to describe the indicator's status. However, this was only applied to indicators of marine asset condition rather than threats and pressures. An overall increase in measurements of over 20% per year during the time series denoted a 'healthy' status, while an overall decrease of greater than 20% per year denoted an 'unhealthy' status. An overall trend that had either increased or decreased by less than 20% per year was denoted 'vulnerable'.

2.3.1 **Tropical rock lobster** (Source: Darren Dennis, Eva Plaganyi-Lloyd, CSIRO)

Figure 2-2 Tropical rock lobster.

CSIRO researchers have conducted lobster surveys in the Torres Strait annually since 1989 to estimate distribution, abundance and size. There are two survey methods used. The first is a mid-year survey which measures the abundance of both the recruiting and fished age classes, and the second is a pre-season survey, which was initiated in November 2005 to measure the recruiting age class to calculate Total Allowable Catch.

Threshold values for tropical rock lobster stocks are as follows;

- Btarg is 83% of Bo
- Blim is 20% of Bo

Stock assessment models used by CSIRO on survey data produce population trends of spawning biomass. The spawning biomass of lobsters is used here as an indicator for the stock status with a 95% confidence level (Figure 2-3).

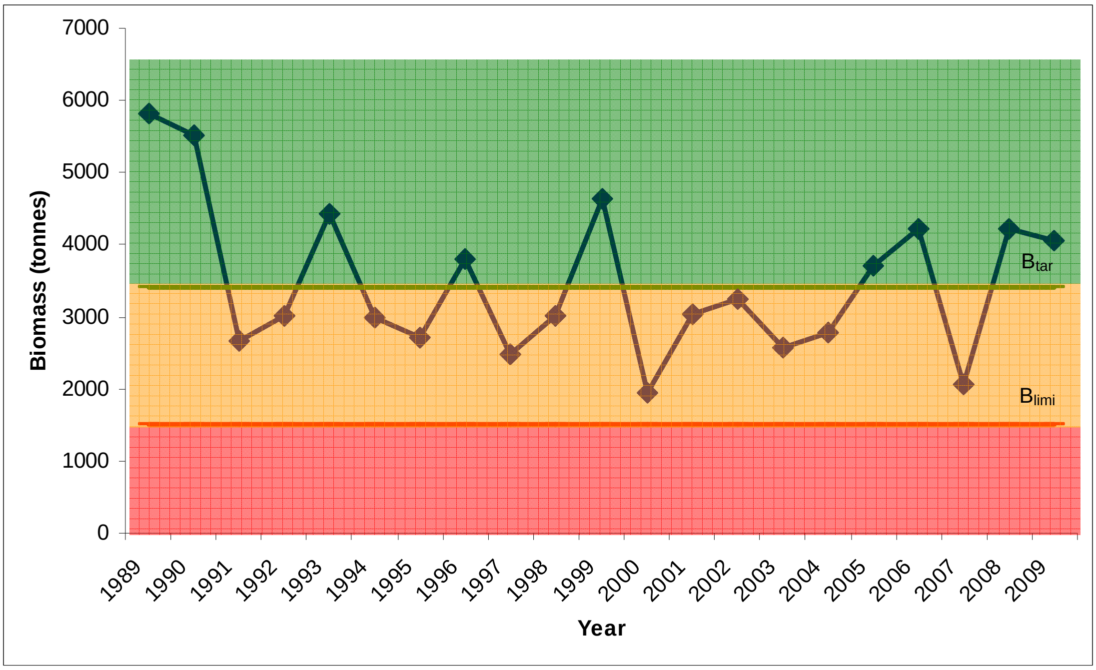


Figure 2-3 Tropical rock lobster spawning biomass in the Western Torres Strait, 1989-2009. (Source: Eva Plaganyi-Lloyd, CSIRO)

Healthy levels of spawning biomass are represented in Figure 2-3 by the green area where survey results exceed the Btarg of 3600 tonnes. Unhealthy levels are represented by the red area where biomass is less than the Blim of 1518 tonnes. A vulnerable health status is represented by the amber area between the Btarg and Blim. Our conclusion that the current stock status is 'healthy' corresponds with the 2008 BRS assessment that the fishery is currently 'not overfished'.

Tropical rock lobsters are scarce in the Eastern Torres Strait, and are therefore not intentionally surveyed. However, counts have been made opportunistically during beche-de-mer surveys by CSIRO in 2002 and 2005. These show a decline in densities (Figure 2-4), but the results are difficult to interpret with only two survey years.

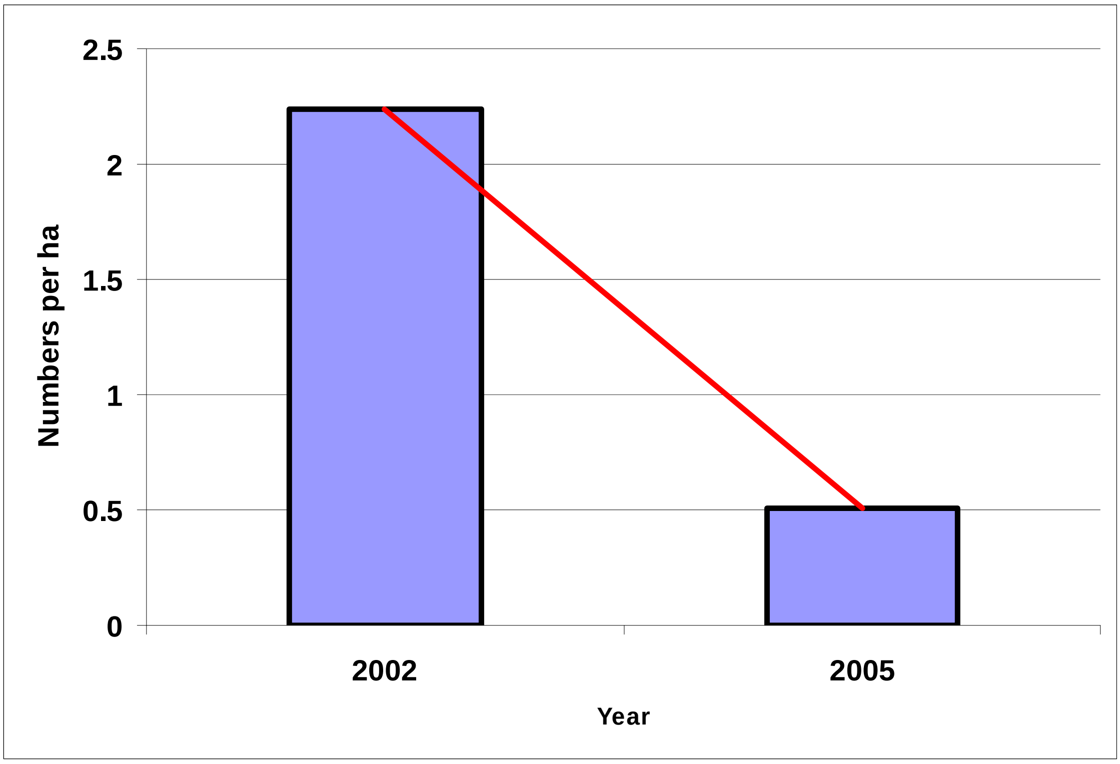


Figure 2-4 Lobster abundance in the Eastern Torres Strait, 2002-2005. (Source: Darren Dennis, CSIRO)

2.3.2 Sandfish (Source: Tim Skewes, CSIRO)

Figure 2-5 Sandfish

The most valuable species of beche-de-mer is the sandfish (*Holothuria scabra*). The fishery is concentrated on Warrior Reef in the Eastern Torres Strait. The first fishery-independent survey was carried out in late 1995 and a second followed in January 1998, and then 2000, 2002 and 2004.

Thresholds are as follows:

- Btarg is 70% of Bo
- Blim is 50% of Bo

Healthy levels of sandfish are represented by the green area of densities which exceed the Btarg of 1092 per ha (Figure 2-6). Unhealthy levels are represented by the red area of densities less than the Blim of 780 per ha. A vulnerable health status is represented by the amber area between Btarg and Blim.

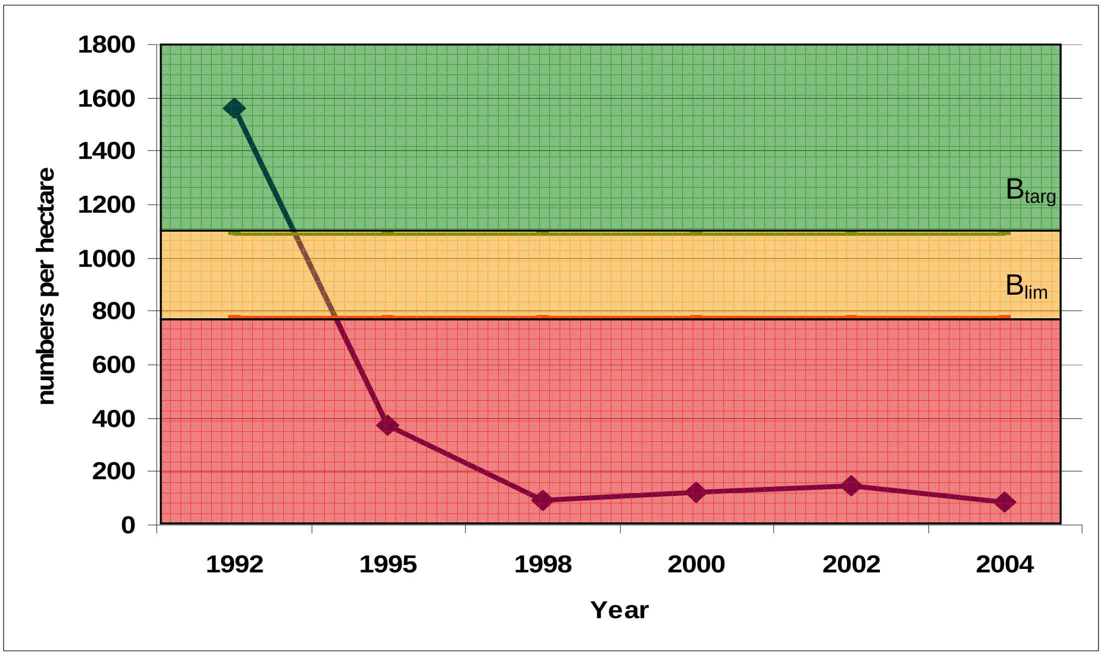


Figure 2-6 Sandfish stock status at Warrior Reef, 1992-2004 (Source: Tim Skewes, CSIRO)

The sandfish fishery was closed in 1993 after survey results in 1992 raised concerns about overfishing. The closure was enforced until October 1995, when the fishery operated under a management plan which included a Total Allowable Catch of 40 tonnes (dry weight per year), a closed season and restricted minimum sizes. However, the 1998 survey resulted in another closure of the fishery, which remains today. Our current assessment of 'unhealthy' (Figure 2-6) is based on the 2004 survey, and corresponds with the 2008 BRS classification of 'overfished'.

2.3.3 Other beche-de-mer species (Source: Tim Skewes, CSIRO)

Density surveys for all other species of beche-de-mer have been carried out by CSIRO in the Eastern Torres Strait reefs in 1995/96, 2002 and 2005. There are no known thresholds values for these species because there is insufficient data. Hence the current health status can only be inferred from changes in abundance from 2002 to 2005. The majority (8 out of 13) of species have a healthy trend, four have an unhealthy trend and one a vulnerable trend (Figure 2-7).

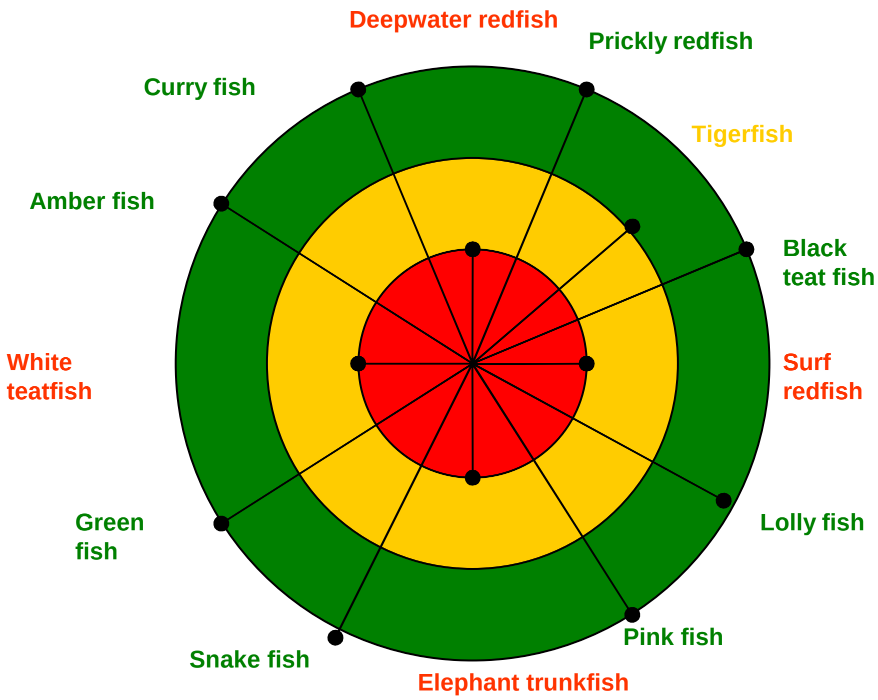


Figure 2-7 Trends of 13 beche-de-mer species' status in the Eastern Torres Strait, 2002-2005 (Source: Tim Skewes, CSIRO)

Our results for surf redfish ('unhealthy') match those of the 2008 BRS assessment of 'overfished'. However, our assessment of blackteatfish as having a 'healthy' trend contrasts with BRS's assessment of 'overfished'. However, it should eb noted that our estimates are based on trend data rather than thresholds.


Surf redfish


Black teatfish


White teatfish


Tigerfish


Deepwater redfish


Lolly fish


Elephant trunkfish


Curry fish


Green fish


Snake fish


Pink fish


Amber fish


Prickly redfish

Figure 2-8 Beche-de-mer species surveyed in Eastern Torres Strait. (Source: WorldFish Center and the Secretariat of the Pacific Community's Fisheries Information Section and Reef Fisheries Observatory. Conceived and prepared by Steve Purcell (WorldFish Center), Emmanuel Tardy (SPC), Aymeric Desurmont (SPC) and Kim Friedman (SPC)).

Although densities of beche-de-mer species in the Western Torres Strait are less than in the Eastern region, lobster surveys have opportunistically counted numbers of all species found at sites in 1989 to 2009. Results show an increase of greater than 20% per year from 1989 to 2009, suggesting an overall healthy trend (Figure 2-9).

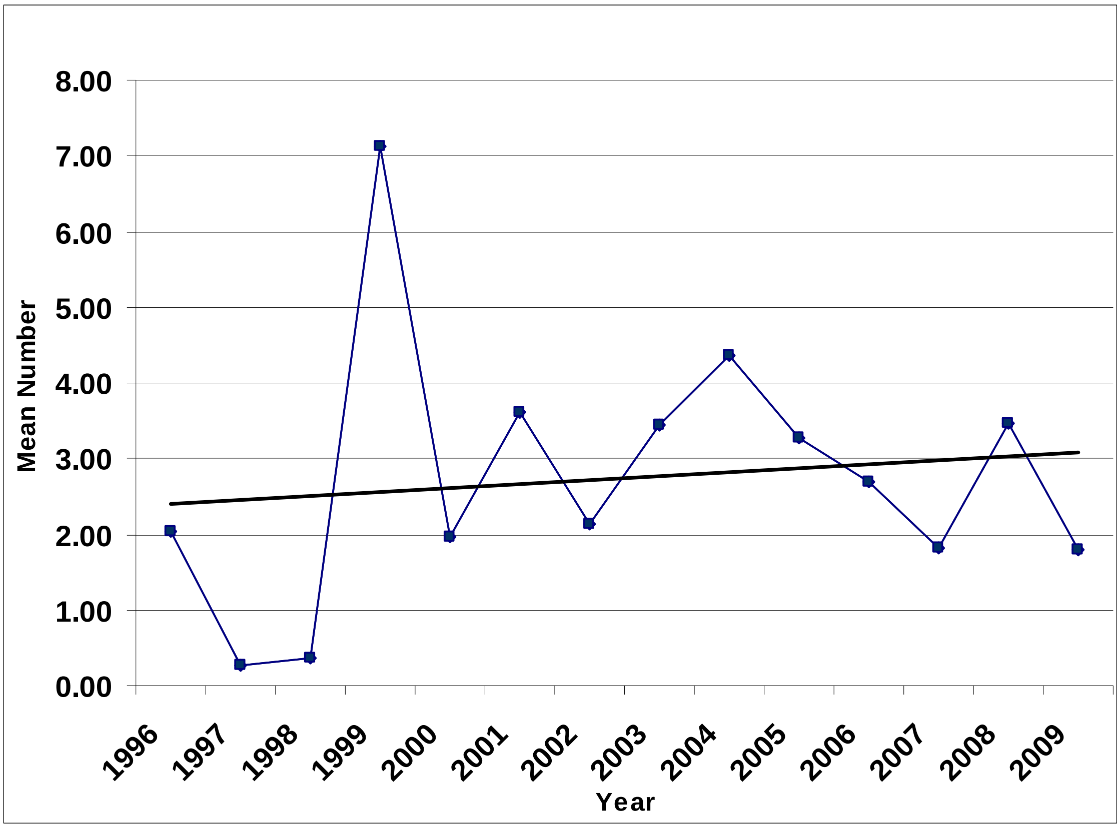


Figure 2-9 Mean numbers of all beche-de-mer species counted at lobster survey sites in the Western Torres Strait, 1989 to 2009 (Source: Darren Dennis, CSIRO)

2.3.4 **Dugong** (Source: Helene Marsh. James Cook University)

The dugong (*Dugong dugon*) *is* distributed throughout northern Australian waters, from Morten Bay, Queensland to Shark Bay, Western Australia. IUCN lists the species as vulnerable to extinction, and it is also listed in Appendix II of CITES. Commercial hunting of dugong is prohibited in both Australia and PNG, although traditional inhabitants of both countries may hunt for non-commercial purposes.

Population estimates are carried out by aerial surveys using a standardised methodology. Surveys have been completed in 1987, 1991, 1996, 2001 and 2006 and results suggest that the dugong population was stable from 1991-1996, and then decreased by nearly 80% from 1996 to 2001 (Figure 2-10).

Thresholds for dugong have not been calculated in the Torres Strait, and therefore the health of the population can only be described by trends in census data.

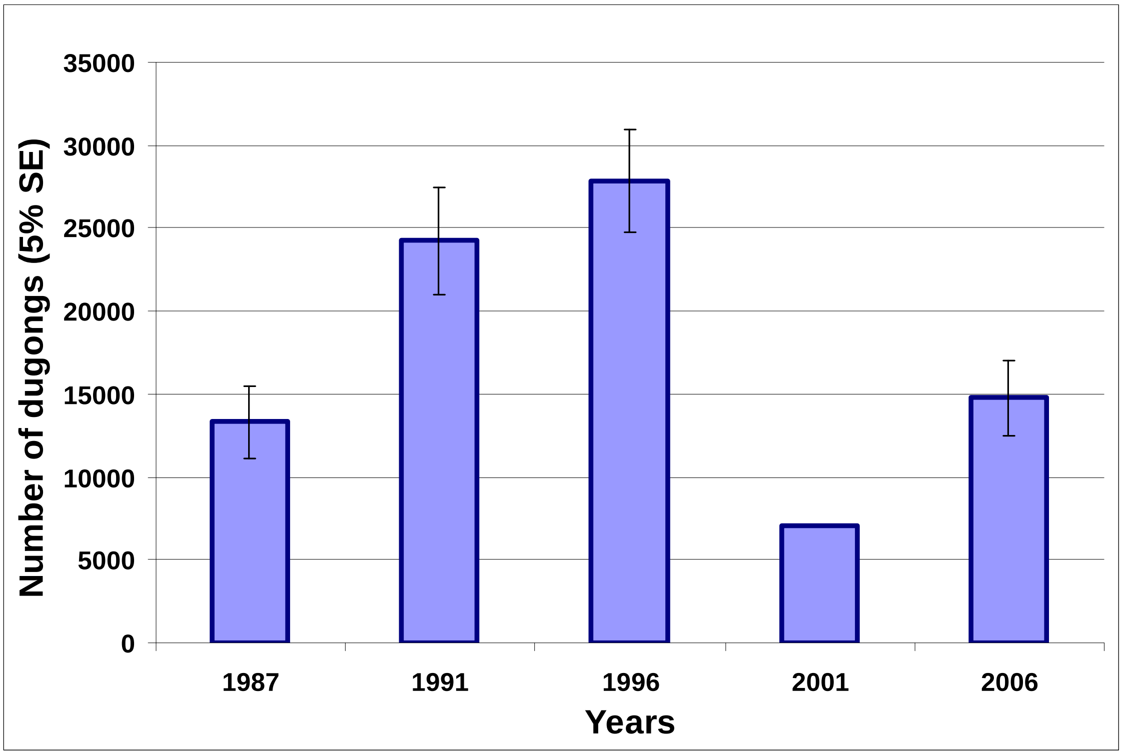


Figure 2-10 Dugong population estimates in the Torres Strait, 1987-2006 (Source: http://www.pzja.gov.au/fisheries/dugong_turtle.htm)

However, it has been reported that dugong population growth is likely to increase at <5% per year, and hence the variability in surveyed numbers may be the result of animals moving in and out of the Torres Strait, perhaps driven by the changes in the availability of food (seagrass). The most recent measurement or current status shows an overall increase in numbers of over 20% per year from 2001 to 2006, denoting a 'healthy' trend. However, the estimated annual traditional catch has ranged from 240 to 800 tonnes since 1976, which is believed to exceed sustainable harvest levels. Therefore the health status of the population is difficult to define with any certainty.

2.3.5 **Spanish mackerel** (Source: Gavin Begg, Queensland Fisheries/BRS)

Figure 2-11 Spanish mackerel

The Torres Strait Spanish mackerel fishery operates predominantly in the Eastern Torres Strait, targeting the narrow-barred Spanish mackerel (*Scomberomorus commerson*). An unknown but relatively small quantity is also taken for subsistence. Standardised CPUE levels are used as an indicator of stock health, and have been monitored regularly by the Queensland Department of Primary Industries and Fisheries (Queensland Fisheries) since 1989 (Figure 2-12).

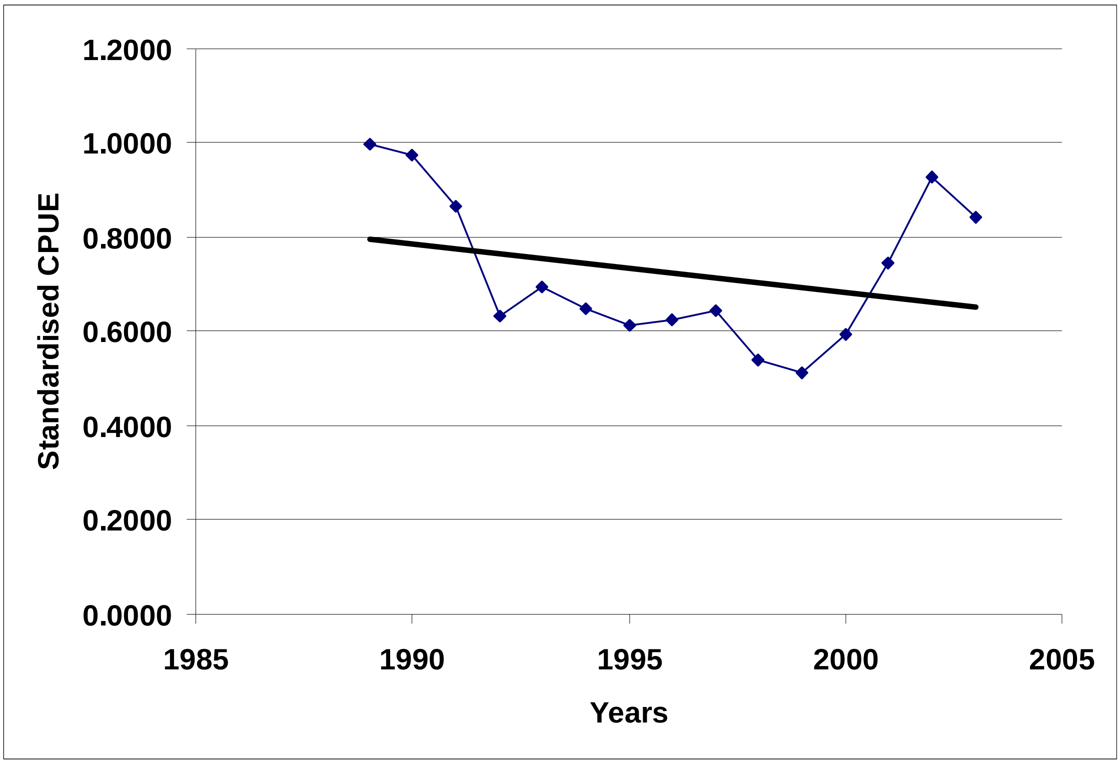


Figure 2-12 Tends of Spanish mackerel stocks derived from standardised CPUE, 1989-2003 (Source: Begg et al. 2006)

Threshold levels have not been developed, and data accuracy is limited to the consistency of fishers' log book entries. Figure 2-12 suggests that since 1989 there has been an overall decreasing trend of less than 20% per year, denoting a 'vulnerable' status. The BRS's 2008 assessment reports that the fishery is 'not overfished' based on estimates of maximum sustainable yield in 2006.

2.3.6 **Green turtle** (Source: Colin Limpus, Queensland Department of Natural Resources and Water/Environment Protection Agency)

Figure 2-13 Green turtles

Green turtles found in the Torres Strait are part of the northern Great Barrier Reef stock which nests on Raine Island, Moulter Cay and No. 7 and No. 8 sandbanks in the Torres Strait. Following expert advice the annual census data from Raine Island has been used as an indicator of stock health in the Torres Strait. Raine Island has been a significant rookery for green turtles for more than 1,100 years, and monitoring is undertaken using annual tagging since the 1974 breeding season.

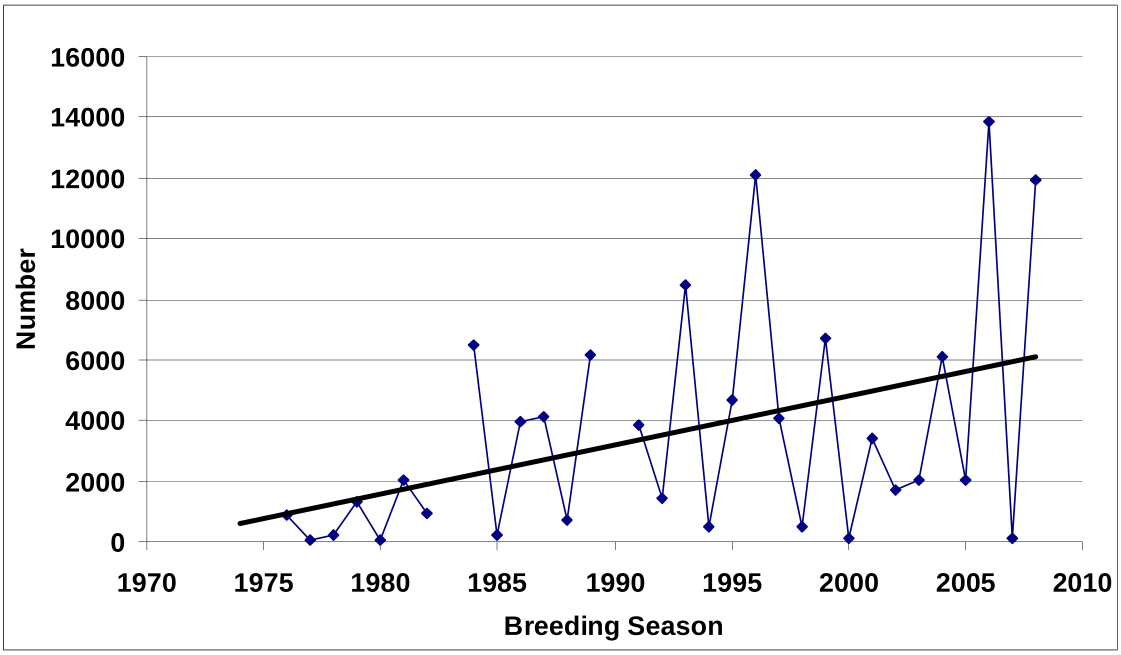


Figure 2-14 Annual census data for nesting green turtle at Raine Island representing the northern Great Barrier Reef stock from 1976-2008 (Source: Colin Limpus, QEPA)

No thresholds have been established for nesting green turtle numbers on Raine Island due to the high degree of variability in the data, so trend data is used here instead to describe stock health. Although there is an overall increasing trend from 1976-2008, there is considerable inter-year variability (Figure 2-14). Overall there has been an increase of less than 20% per year, denoting a 'vulnerable' state. However, expert opinion considers that there is evidence of a decreasing number of larger green turtles, as demonstrated by the declining mean curved carapace length of surveyed females (Figure 2-15). This is concerning because it may be indicative of declining egg deposition and hence population recruitment rates.

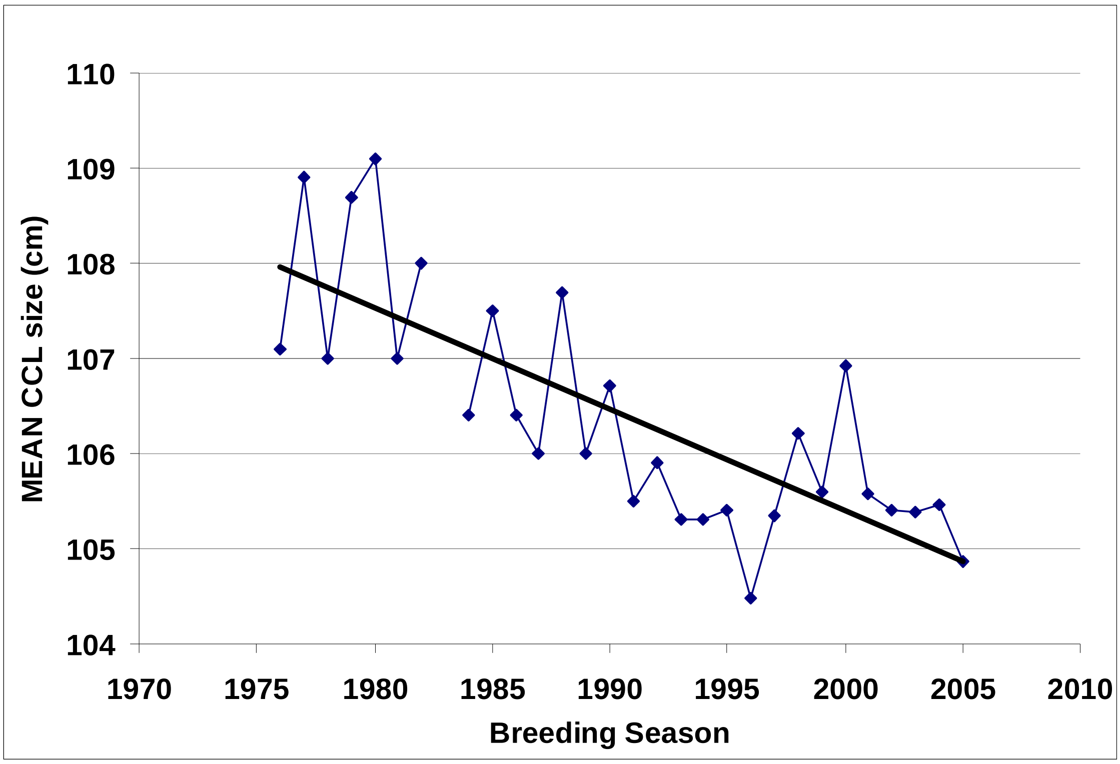


Figure 2-15 Annual variation in curved carapace length of nesting female green turtles at Raine Island from 1976 to 2005 (Source: Colin Limpus, QEPA).

Other indications of declining populations are;

- Reduced numbers of first time breeders relative to remigrants
- Increasing intervals between breeding visits for remigrants
- Very low annual adult recruitment
- <5% of females successfully lay per night

2.3.7 **Hawksbill turtle** (Source: Colin Limpus, Queensland Department of Natural Resources and Water/Environment Protection Agency)


Figure 2-16 Hawksbill turtles

Milman island has been selected as the primary index nesting beach for monitoring the hawksbill turtle (*E. imbricata*) population. This is known to be a substock of the northern Great Barrier Reef population, and has been monitored using nightly tagging from mid-January to mid-February in 1976 to 2000. This index nesting population has been declining by 3-4% per year for at least a decade (Limpus 2008). Updated monitoring since 2000 is currently being published by a PhD research project.

Thresholds have not been developed for hawksbill turtle stocks in the Torres Strait, and therefore health status is described by the trend. Figure 2-17 shows an overall decline of more than 20% per year, denoting an 'unhealthy' status.

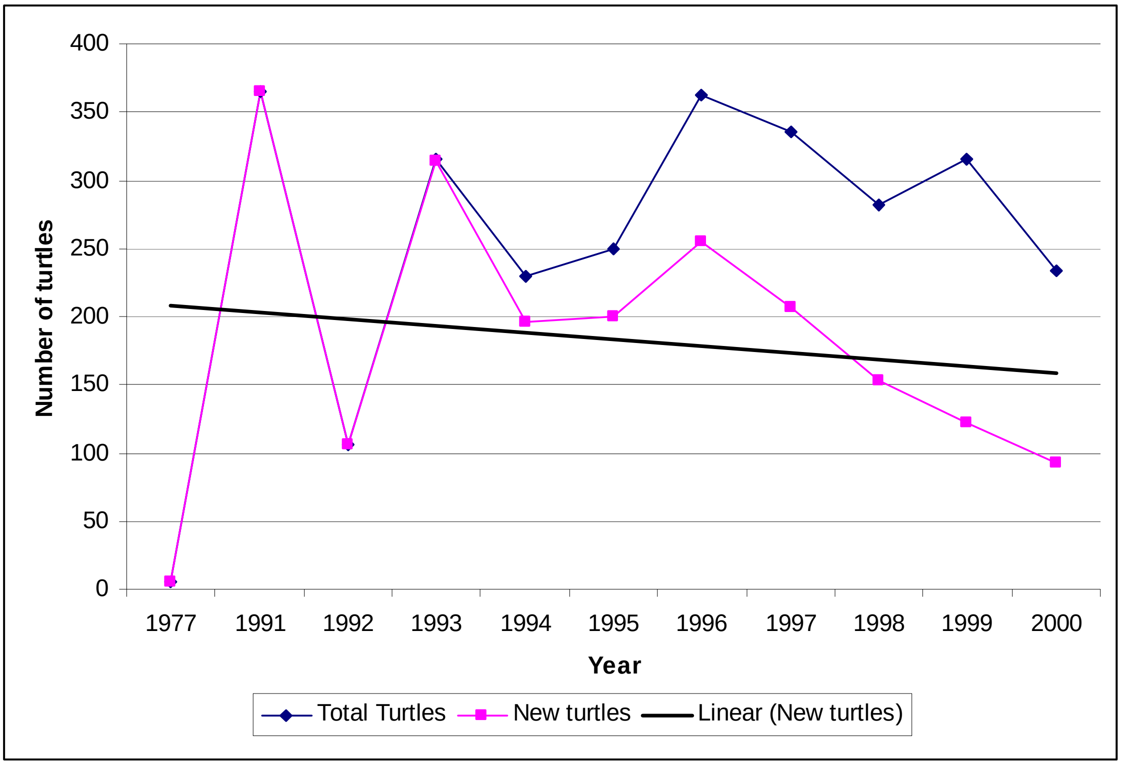


Figure 2-17 Summary of tagging related data from nesting hawksbill turtles on Milman Island in the Torres Strait, 1976-2000. (Source: Limpus 2008).

If the current rate of decline continues then the stock can be expected to decline by >90% by 2020 (Limpus 2009).

2.3.8 **Brown tiger prawn** (Source: Clive Turnbull, Queensland Fisheries)

Figure 2-18 Tiger prawns

The Torres Strait prawn fishery is a multi-species fishery for brown tiger (*Penaeus esculentus*), blue endeavour (*Metapenaeus endeavouri*) and red spot king prawns (*Penaeus longistylus*), and operates in the Eastern Torres Strait. It is one of the most economically valuable fisheries in the region, producing 907 tonnes in 2008 with a value of $10 million. Threshold levels have been developed for tiger prawns from extensive stock assessments undertaken since 1989:

- Btarg biomass ratio 0.41
- Blim biomass ratio 0.205

Figure 2-19 shows a healthy status for the tiger prawn stock, with levels remaining above the Btarg ratio since 2002. This matches the BRS assessment for 2008, which considers tiger prawns as 'not overfished'.

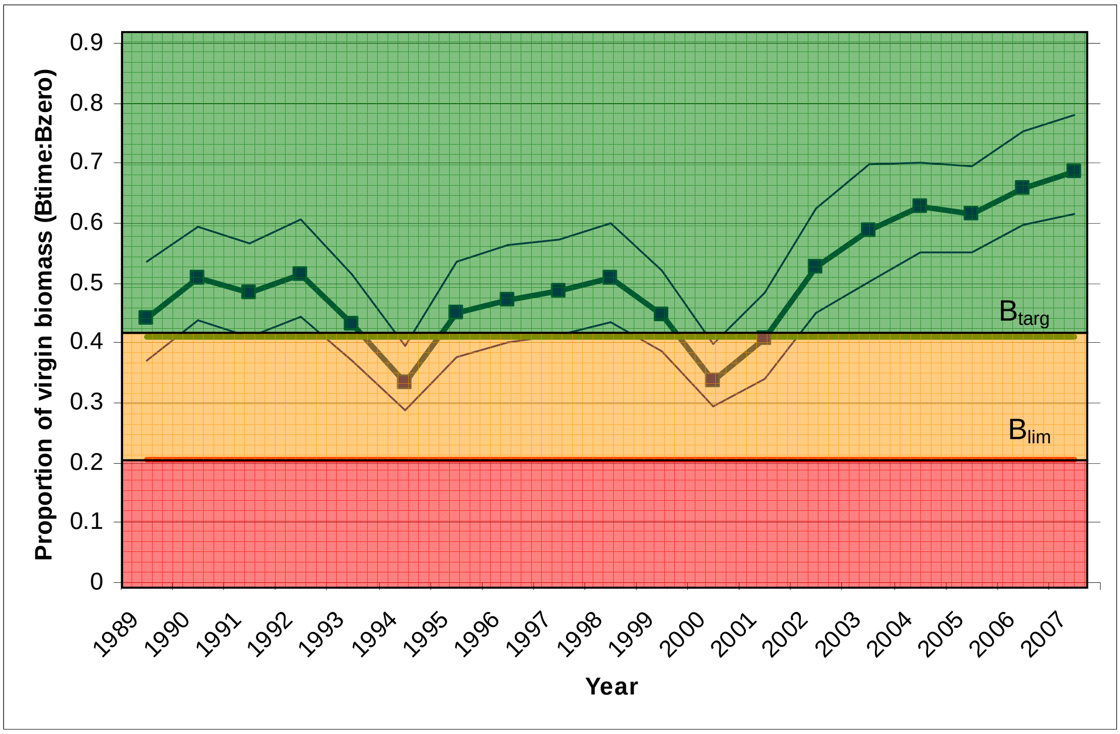


Figure 2-19 Trends of biomass ratios (95% CI) for tiger prawn from 1989-2007 in the Torres Strait. (Source: Clive Turnbull, QF).

2.3.9 **Blue endeavour prawn** (Source: Clive Turnbull, Queensland Fisheries)


Figure 2-20 Blue endeavour prawns

Similar assessments applied to tiger prawns have also been used for endeavour prawns (*M. endeavouri*). Calculated threshold levels are as follows:

- Btarg biomass ratio 0.22
- Blim biomass ratio 0.11

Figure 2-21 shows a very healthy stock status, with levels exceeding the Btarg biomass ratio since surveys began. BRS also concluded in 2008 that the fishery was 'not overfished'.

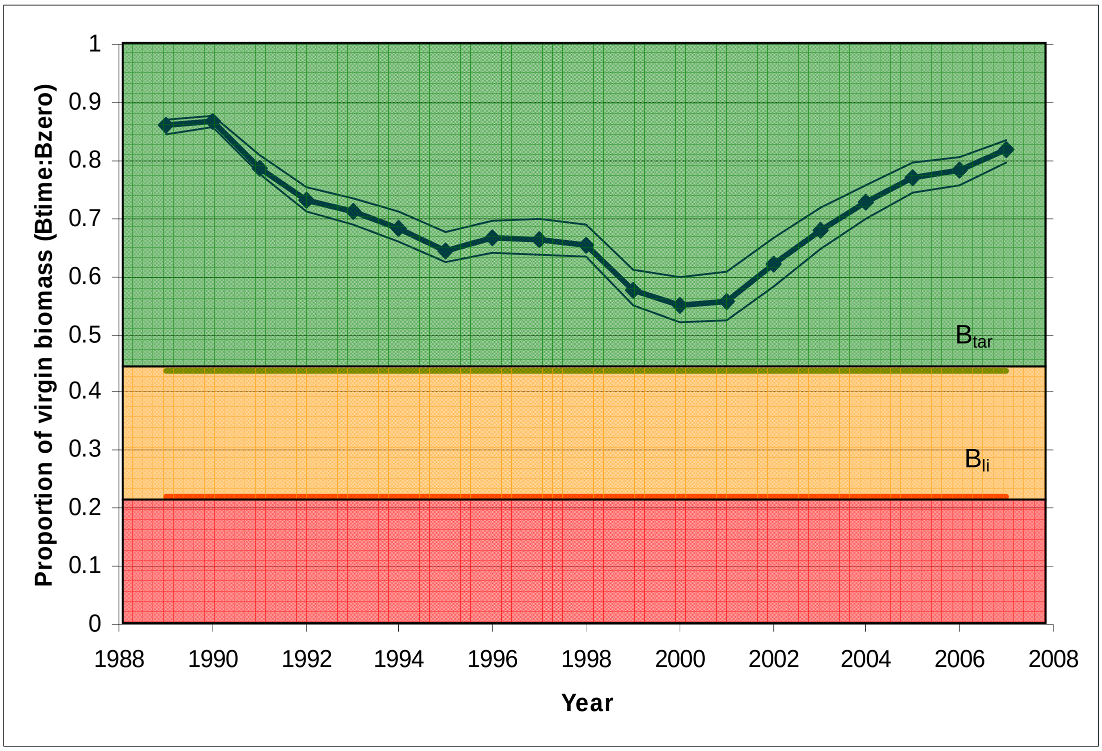


Figure 2-21 Trends of biomass ratios for blue endeavour prawns from 1989-2007 in the Torres Strait (Source: Clive Turnbull, QF).

2.3.10 Trochus (Source: Erik Raudzens, AFMA)

Figure 2-22 Trochus shell

The Torres Strait trochus (*Trochus niloticus*) fishery is a small, single-species commercial and subsistence fishery. It was historically an important source of income for the region between 1920 and 1950 and in the 1980s. The fishery was also an important activity for women and children. The recent level of participation in the fishery has declined largely due to a shrinking of the overseas market for shells in button manufacture. Trochus are susceptible to overfishing because they are sessile with a limited dispersal range.

There are no known population thresholds because there is very limited survey data available. Trends for trochus catches have also been too inconsistent to use as indicators of stock health (Figure 2-23). Consequently BRS classified trochus stock status in 2008 as 'uncertain'.

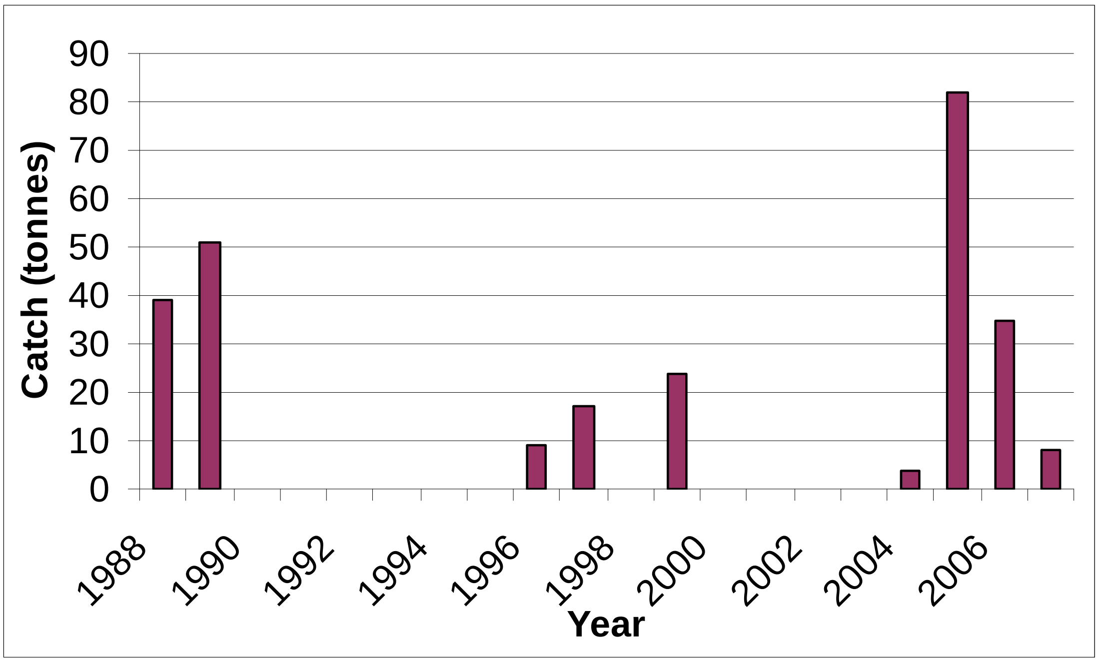


Figure 2-23 Annual catch of trochus from 1988-2008 (Source: Erik Raudzens, AFMA)

Initiatives to increase the level of participation and the livelihood benefits of trochus in the island communities have begun in recent years, with Darnley and Warraber Islanders participating in a trial co-management project for trochus and beche-de-mer.

2.3.11 **Gold-lipped pearl shell** (Source: Darren Dennis, CSIRO)

The PZJA is responsible for management of pearl shell collection in the Torres Strait. Farming of pearl shell is managed by the Queensland Government. The gold-lipped pearl shell (*Pinctada maxima*) and to a lesser extent the black-lipped pearl shell (*Pinctada margaritifera*) are the main species targeted, although five other species occur.

Surveys of the gold-lipped pearl have been undertaken in the Western Torres Strait opportunistically during lobster surveys since 1989. There are no known thresholds because there has been insufficient research conducted. Survey results show an overall increase in the number of gold-lipped pearls of less than 20% per year, which denotes a 'vulnerable' health status (Figure 2-24).

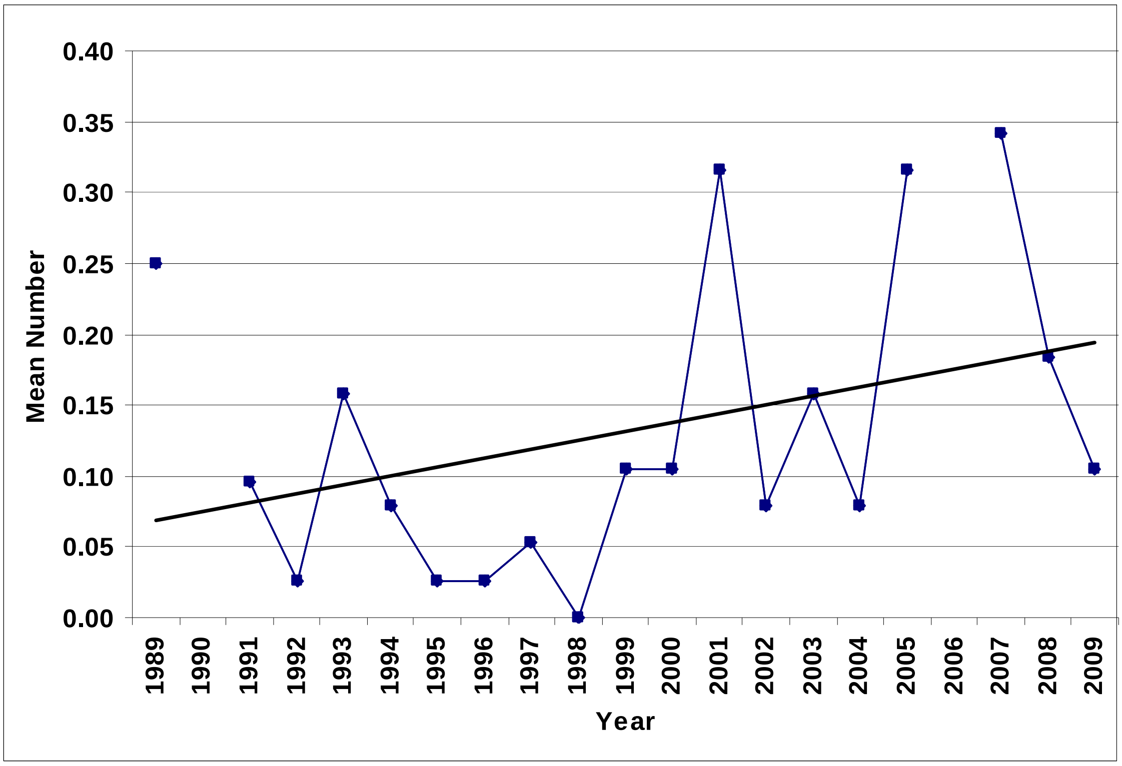


Figure 2-24 Mean numbers of gold-lipped pearl shell per site at 38 lobster survey sites in the Western Torres Strait from 1989-2009 (Source: Darren Dennis, CSIRO).

2.3.12 **Reef line fishery** (Source: Gavin Begg, Queensland Fisheries)

Figure 2-15 Finfish fishing in the Torres Strait

The Torres Strait reef line fishery is a multi-species fishery with a range of reef fish targeted. The fishery focuses on primarily on the highly-valued coral trout (*Plectropomus* spp.), and mixed reef fish (*Lutjanus* and *Lethrinus* spp.), and numerous species of rock cods (*Epinephelus* spp.). A barramundi (*Lates calcarifer*) fishery also exists within the Torres Strait but is limited to the territorial waters adjacent to the six Australian islands in the north west of Torres Strait near the Papua New Guinea coast.

Finfish are generally taken with hand lines. The level of Islander catch in this fishery is expected to increase in future due to the high value of the target species, and the fact that this fishery provides an important economic development opportunity for Islanders in the Eastern Torres Strait.

There are no survey results of these finfish stocks in the Torres Strait. However, there are commercial catch records collected by QF. The data are raw catch data and not standardised, and therefore not suitable for stock assessments and stock health descriptions. However, BRS's 2008 assessment is that the reef line fishery is 'not overfished', based on a management strategy evaluation (Williams *et al*. 2007).

2.3.13 **Mud crab** (Source: PZJA)

Figure 2-26 Mud crab

The Torres Strait crab fishery primarily targets mud crab (*Scylla* spp.), although a small quantity of blue swimmer crab (*Portunus pelagicus*) is occasionally taken. Mud crabs are generally captured by hand or using scoop nets. The level of participation in the commercial fishery is low due to other fisheries being relatively more profitable (PZJA 2007)

There is commercial catch recording carried out by QF. The data collected is raw catch data and not standardised, and therefore not suitable for stock assessments and stock health descriptions. Most fishing effort occurs around the north-western area of the TSPZ, namely Saibai Island, Boigu Island and Dauan Island, as well as further south around the Cape York Peninsula (PZJA 2007). In the absence of any stock assessment it is not possible to assess the health of crab stocks.

2.3.14 **Seagrass** (Source: Jane Mellors, Queensland Fisheries/Seagrass Watch)

Mixed species of seagrass are found in the Torres Strait reef flats, mostly belonging to the genera *Halodule, Thalassia, Thalassodendron and Cymodocea.* The large expanses of open substrate are covered with either *Halophilla* or mixed species (*Halodule, Thalassia and Syringodium)* communities. Lush *Halophila ovalis and Halophila spinulosa* communities are also found in the deep waters (>30m) of the south-western Torres Strait.

Seagrass Watch monitoring has been established around Thursday, Horn and Hammond Islands. Threshold levels for seagrass have not been developed.

Survey results (Figure 2-27) show that Thursday Island seagrass cover has been increasing in the Front and Back Beach sites, but at Hammond Island it has been fluctuating at one site and decreasing in another. The overall area changes of seagrass in the Torres Strait are not known. However, monitoring in northern Queensland by Seagrass Watch has seen the abundance of seagrass increase in the last 10 years, countering the global trend.

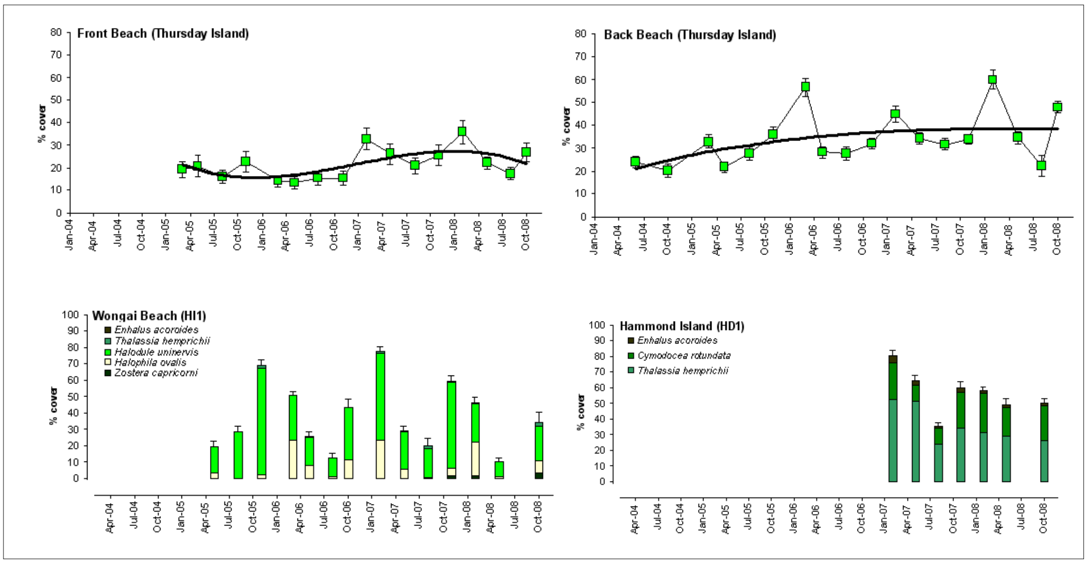


Figure 2-27 Seagrass Watch monitoring results in the Torres Strait (Source: Seagrass Watch)

2.3.15 **Seagrass in the Western and Eastern Torres Strait** (Source: Darren Dennis, Tim Skewes, CSIRO)

Seagrass surveys have also been conducted opportunistically during surveys of lobster and beche-de-mer in the Western and Eastern Torres Strait, respectively. However, there are no known thresholds for these areas.

Figure 2-28 indicates an overall increase in seagrass cover in the Western Torres Strait, but of less than 20% per year, denoting a 'vulnerable' state. However, seagrass cover in the Eastern Torres Strait shows an increase of over 20% per year, denoting a 'healthy' state, although these data are limited to years' sampling (Figure 2-29).

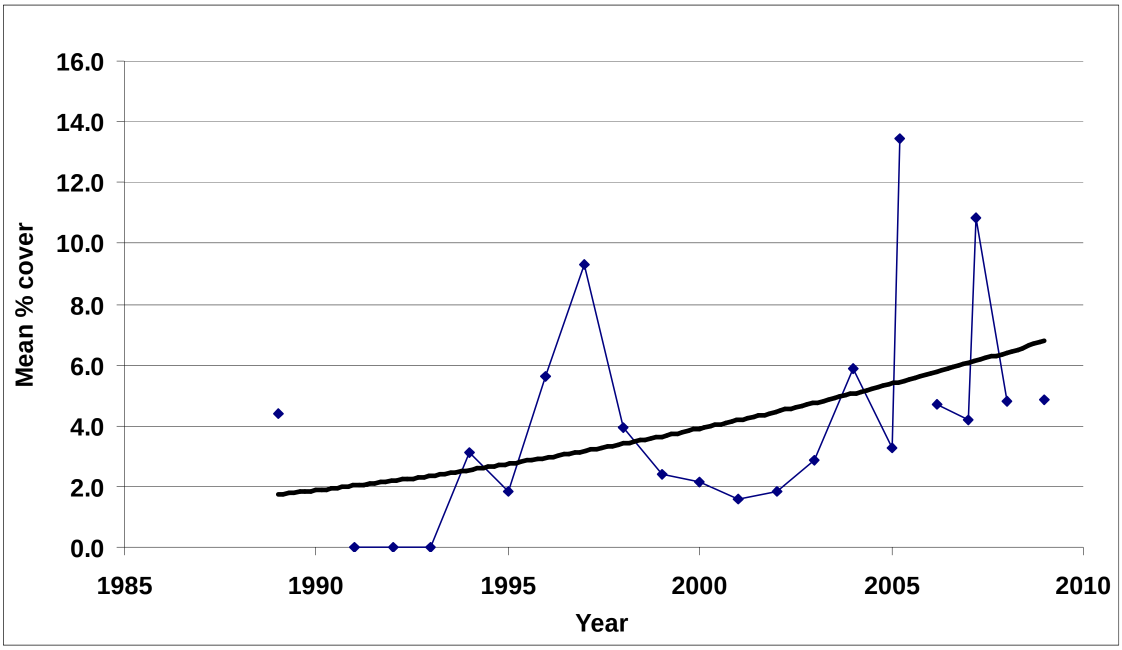


Figure 2-28 Mean percentage cover of seagrass (independent of transect size) per site at 38 lobster survey sites in the Western Torres Strait from 1989-2009 (Source: Darren Dennis, CSIRO)

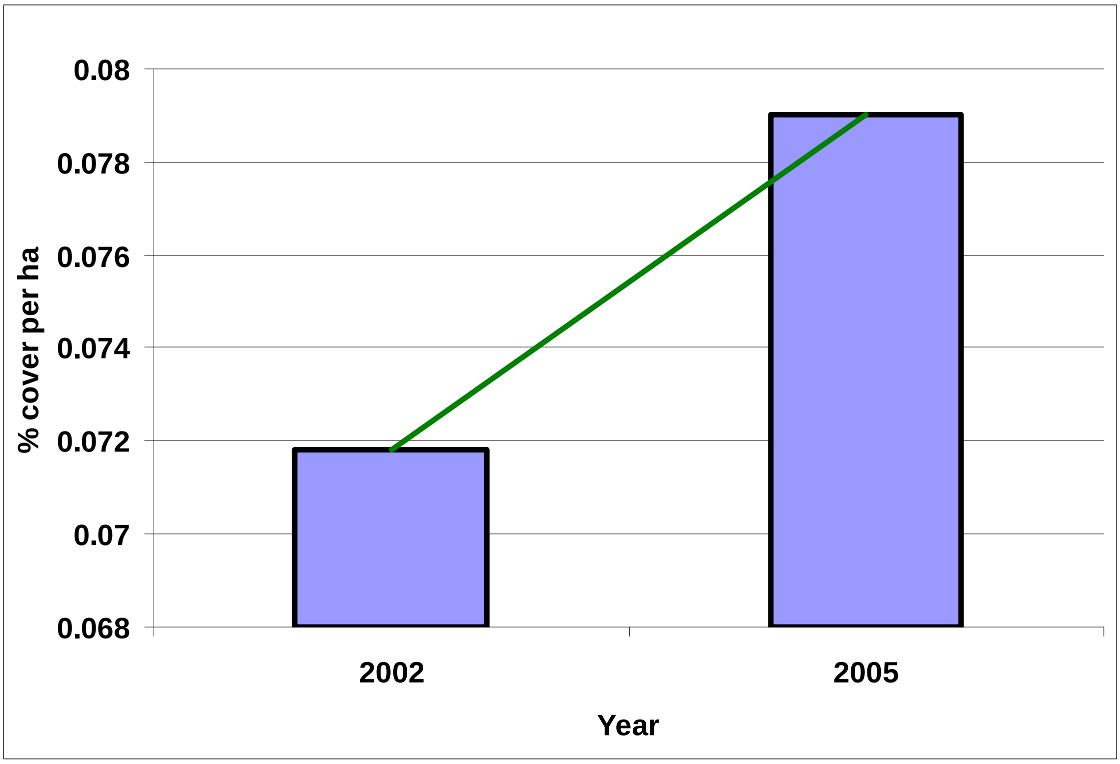


Figure 2-29 Percentage seagrass cover at beche-de-mer survey sites in Eastern Torres Strait, 2002-2005 (Source: Tim Skewes, CSIRO)

2.3.16 **Coral cover** (Source: Darren Dennis, Tim Skewes, CSIRO)

Coral cover surveys have also been conducted opportunistically during lobster and beche-de-mer surveys of the Western and Eastern Torres Strait, respectively. However, there are no known thresholds.

Survey results indicate an overall increase of less than 20% per year in the Western Torres Strait in 1994-2009, denoting a 'vulnerable' state (Figure 2-30). In the Eastern Torres Strait there is an 'unhealthy' decline of over 20% per year in 2002 and 2005, although this is limited to two years of data (Figure 2-31).

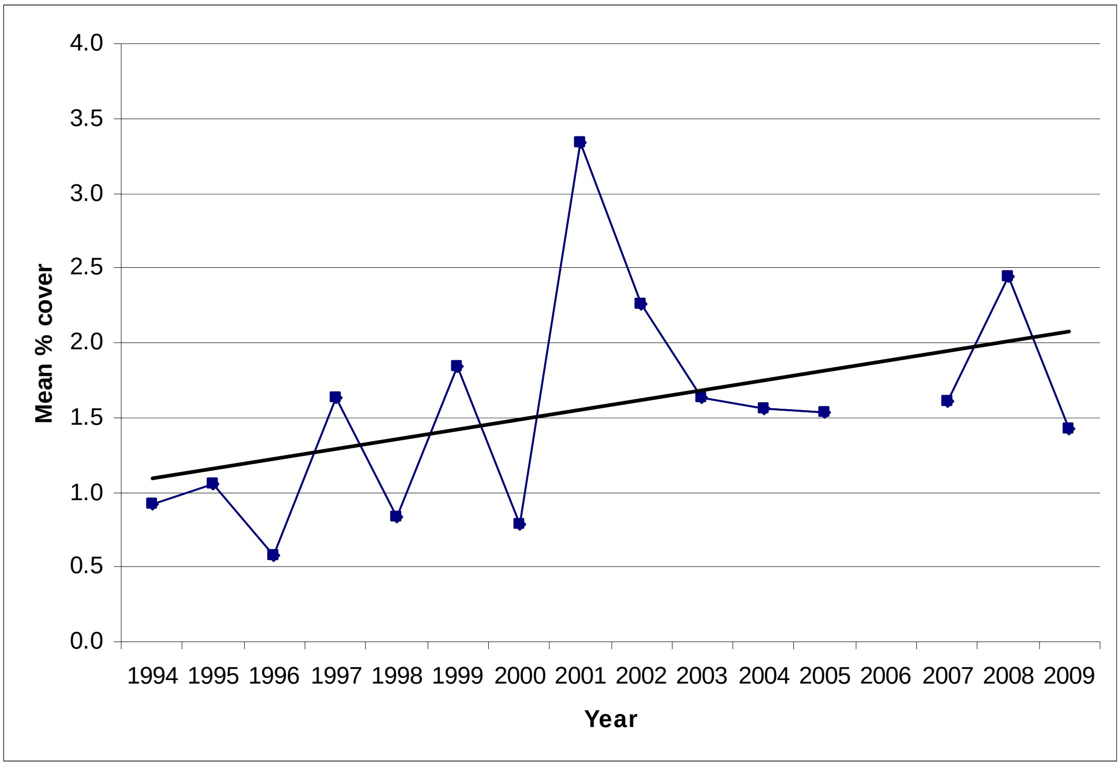


Figure 2-30 Mean percentage cover of live coral per site at 38 lobster survey sites in the Western Torres Strait, 1994-2009 (Source: Darren Dennis, CSIRO).

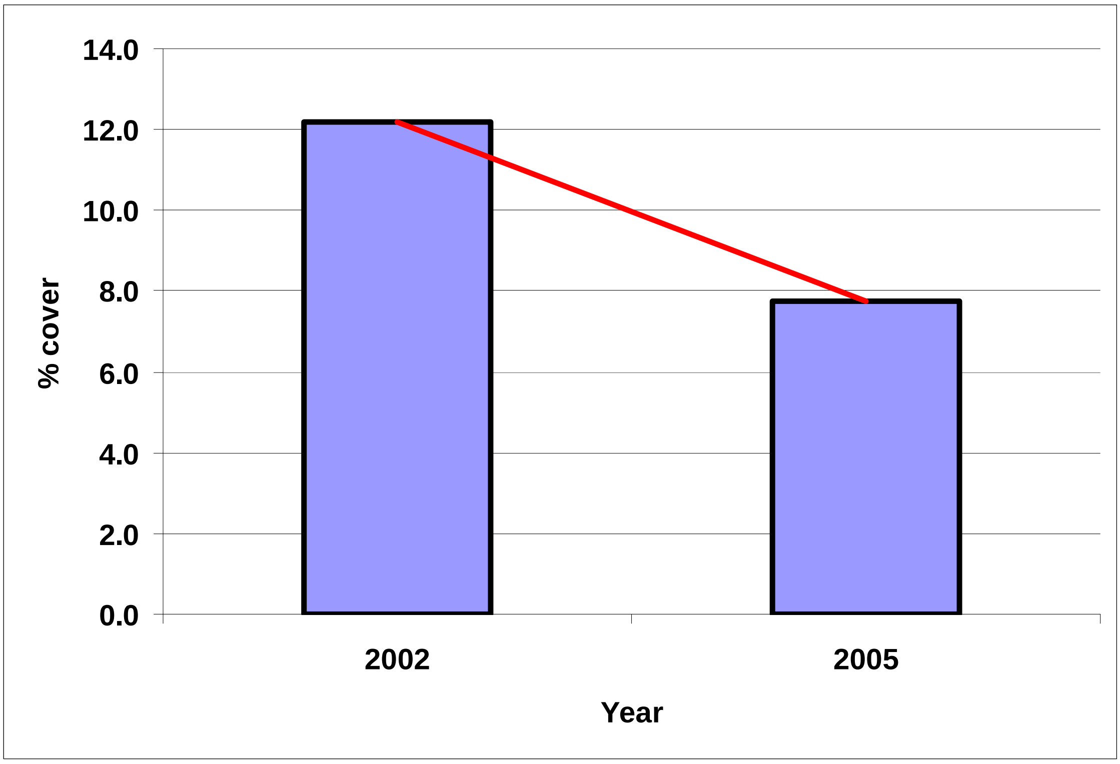


Figure 2-31 Percentage live coral cover at beche-de-mer survey sites in the Eastern Torres Strait, 2002-2005 (Source: Tim Skewes, CSIRO).

2.3.17 **Algae** (Source: Darren Dennis, Tim Skewes, CSIRO)

Algal cover has also been opportunistically surveyed during lobster and beche-de-mer surveys in the Western and Eastern Torres Strait, respectively. There are no known thresholds for algae in the Torres Strait.

The results of the survey carried out in Western Torres Strait show an overall decrease of greater than 20% in 1994-2009 (Figure 2-32). Results for the Eastern Torres Strait (Figure 2-33) also show a decrease of greater than 20% in 2002-2005. However, since algae may be an indicator of coral reef decline it is difficult to assign ‘healthy’ or ‘vulnerable’ definitions in the same way as for ecosystem assets such as fisheries species or habitats. Hence for this indicator and the following 8 we have avoided categorising their health status.

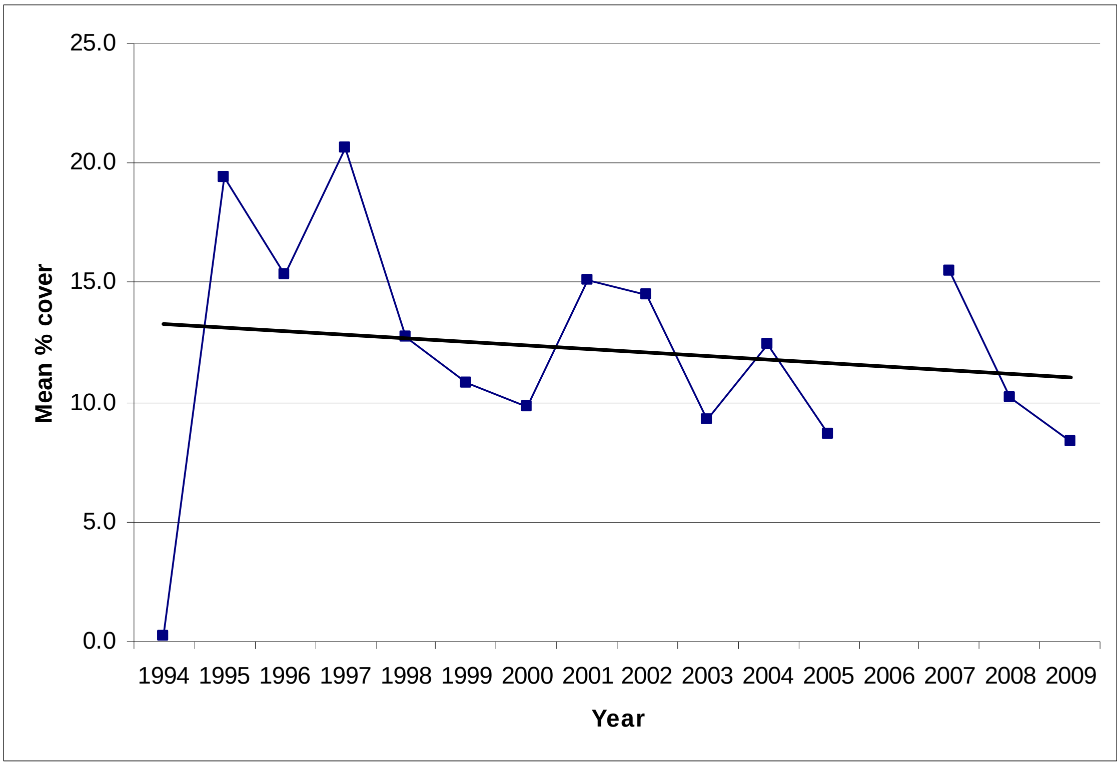


Figure 2-22 Mean percentage cover of algae at 38 lobster survey sites in the Western Torres Strait from 1994-2009 (Source: Darren Dennis, CSIRO)

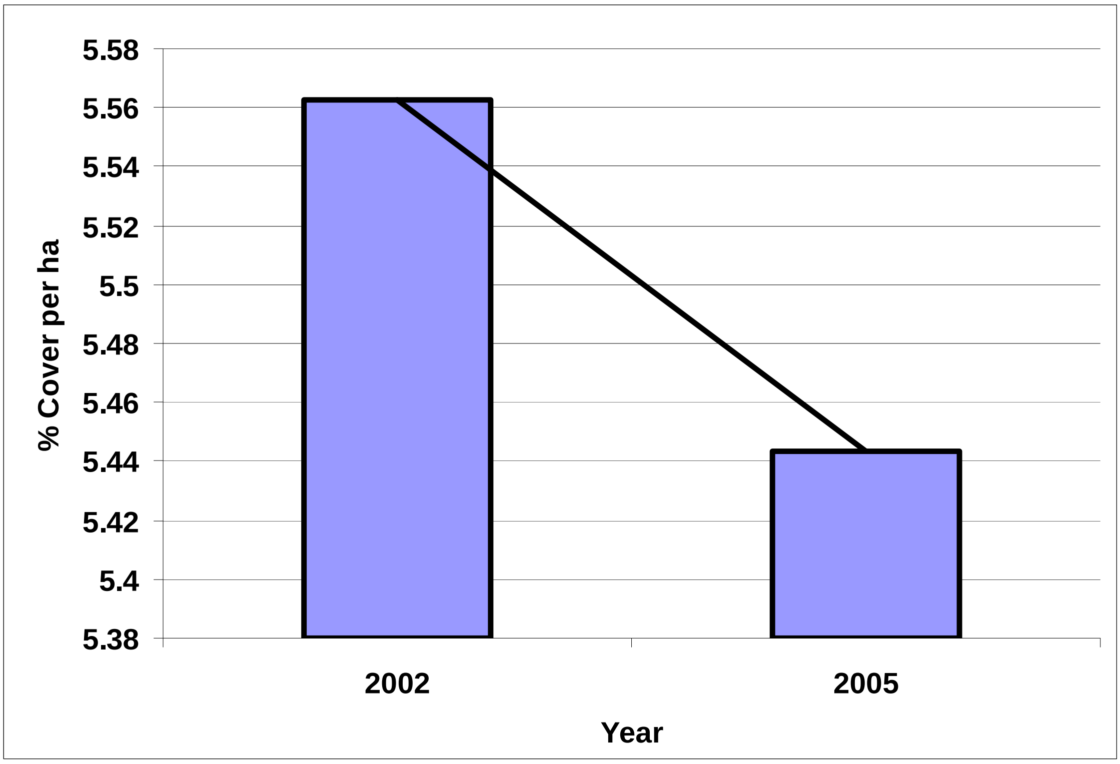


Figure 2-33 Algae cover at beche-de-mer survey sites in the Eastern Torres Strait, 2002-2005 (Source: Tim Skewes, CSIRO)

2.3.18 Sea surface temperature

Sea surface temperatures (SST) have been monitored by CSIRO and AIMS with the use of data loggers and satellite. Combining these data, a daily SST trend is shown in Figure 2-34, which indicates a relatively stable pattern over the 12 year period from 1993 to 2005.

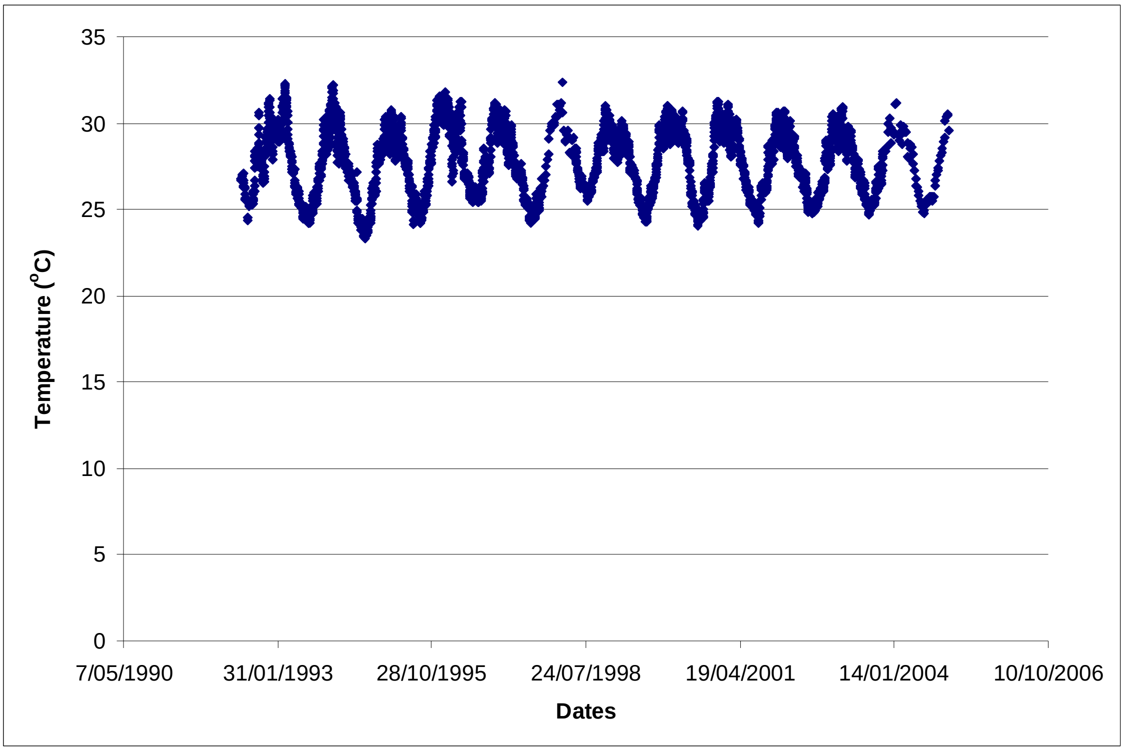


Figure 2-34 Daily sea surface temperatures (combined CSIRO/AIMS data) for the Torres Strait, 1990-2005 (Source: Tim Skewes, CSIRO)

There are no formal ecological thresholds for SST in the Torres Strait; however, detection of early signs of coral bleaching can be determined by forecasts of hot and calm conditions and high water temperatures above 33^{0}C in the Great Barrier Reef (GBRMPA 2009). If this is applied to the Torres Strait, then SST have not exceeded this level in 1993-2005, and this is borne out by no reports of widespread bleaching in the Torres Strait during this period.

2.3.19 Wind speeds

Wind speeds may be an indicator of climate change, and impact upon windows of opportunity for fishing. Records have also been kept for 1988-2005 with the SST monitoring mentioned above. Annual averages show a decline during this period (Figure 2-35), although it is not clear how this should be interpreted in terms of ecosystem health.

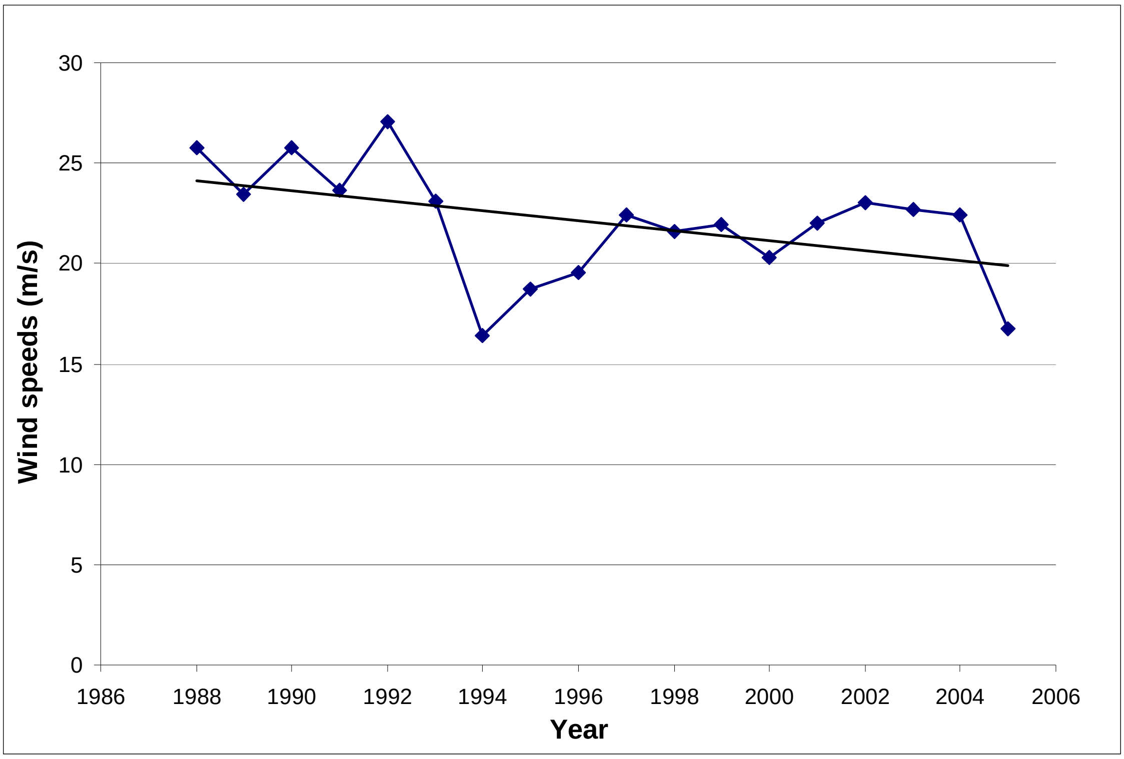


Figure 2-35 Annual average wind speeds in the Torres Strait, 1988-2005 (Source: Tim Skewes, CSIRO)

2.3.20 Pollution – heavy metals

There have been several studies of heavy metal pollution in the Torres Strait. Survey results for the presence of trace metals in sediments around the Torres Strait were published by Haynes & Kwan (2002), who compared concentrations in relation to standard benchmarks. Results of their study showed that concentrations of most metals were higher in sediments collected from the Gulf of Papua and/or northern Torres Strait than in sediments collected from more southern sites in central and southern Torres Strait. Other studies have been carried out by Apte & Day (1998), Baker & Harris (2006), Gladstone & Dight (1994), and Rayment & Barry (2000), showing similar conclusions of higher metal concentration near the Fly River. However, these were all stand-alone studies and there is no continual monitoring information from which to assess long term marine pollution trends.

2.3.21 Traditional fisheries catch

Monitoring traditional fisheries catches of turtle and dugong is difficult because of its cultural significance, and controversial nature relative to government conservation objectives. However, there have been various surveys in the past from 1976 to 2001 indicating that the estimated catch of dugong has been above the sustainable harvest of 92 tonnes per year (Marsh *et al.* 2004). However, collecting accurate data to compare with this threshold is problematic, not least because harvesting by PNG communities is difficult to monitor. Results from available data (Figure 2-36) show that over this period dugong catch has increased and exceeded the sustainable level, while turtle catches have declined (Marsh *et al.* 2004).

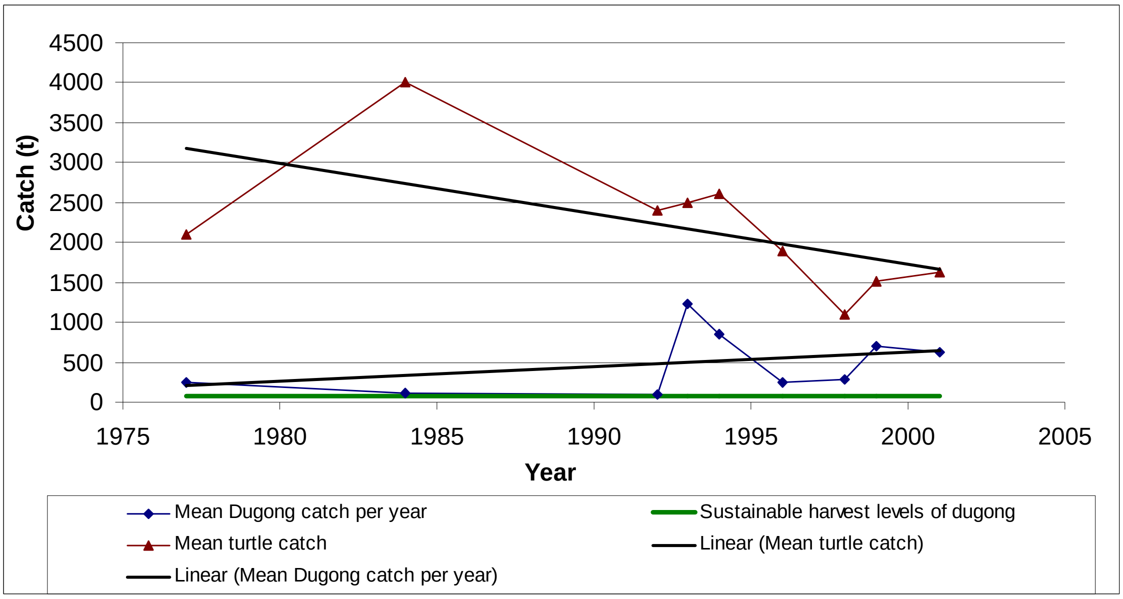


Figure 2-36 Estimated traditional turtle and dugong catch per year from 1976-2001 (Source: Marsh et al. 2004)

2.3.22 Shipping traffic (Source: Australian Maritime Authority)

The Prince of Wales and Great North East Channel has been identified as a high risk area for oil spills due to the concentration of shipping traffic. The channel has also been considered a grounding and collision area (http://www.amsa.gov.au/Shipping_Safety/Great_Barrier_Reef_and_Torres_Strait/). A study by the Australian Navy found that for the Torres Strait, the risk of powered grounding is the dominant contributor to the risk profile for the whole Great Barrier Reef on a per nautical mile basis, with a predicted frequency rate of 1-2 per year (http://www.navy.gov.au/Publication:Semaphore_-_Issue_7,_2007. The number of ships that pass through the Prince of Wales Channel in the Torres Strait has increased over the years since the impact study in 2001; consequently the risk of grounding, collision and oil spills has probably increased.

The total annual numbers of ships and voyages through the channel are recorded by the Australian Maritime Authority, and are shown in Figure 2-37 below. Both indicators have increased steadily from 1997-2009.

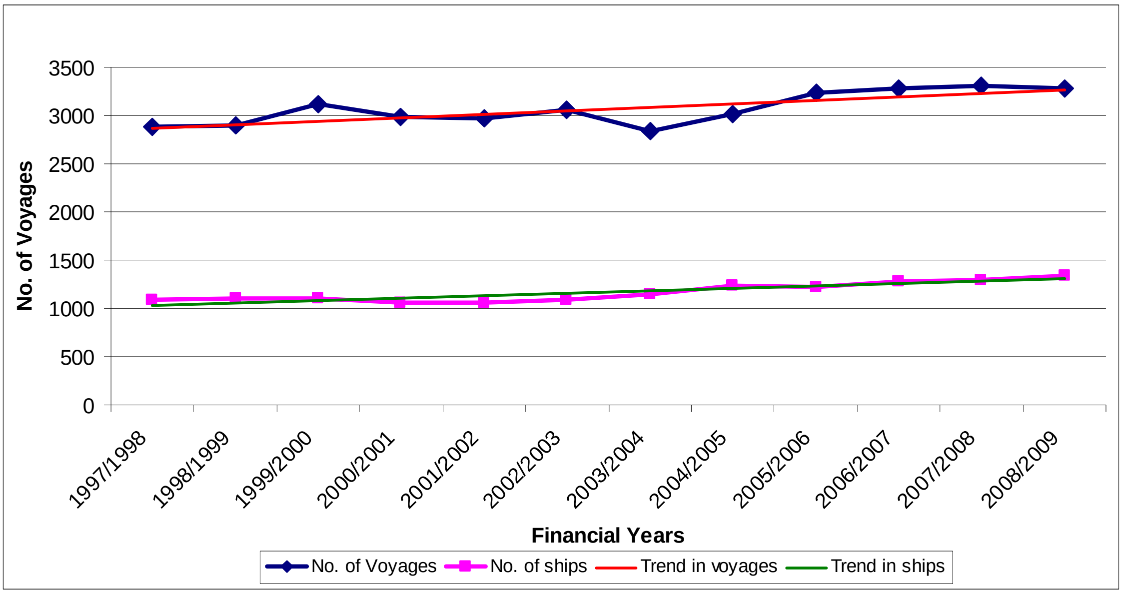


Figure 2-37 shipping activity in the Prince of Wales Passage in the Torres Strait, 1997-2009 (Source: Australian Maritime Authority).

2.3.23 Invasive species

There have been no invasive marine species detected in the Torres Strait up to the compilation of this report. However, there is a risk of marine pest introduction, particularly for species such as *Perna viridis* or the Asian green mussel (Stafford & William 2007). No target pest species were observed during a field survey conducted within Port Kennedy in the Torres Strait in 2008 (Neil *et al*. 2008).

2.3.24 Illegal fishing (Source: Shane Fava, AFMA)

Queensland Fisheries and the Queensland Boating and Fisheries Patrol utilises a private charter to conduct patrols in the TSPZ. They are also assisted by the Thursday Island Police, Australian Navy and other private commercial vessels when the need arises. PNG banana boats operating on Warrior Reef are a concern and difficult to apprehend because of their close proximity to the fisheries jurisdiction line, and their ability to retreat into PNG waters upon detection. However, 99% of apprehensions are recorded on Warrior Reef in relation to the beche-de-mer fishery.

Results show an increasing trend in apprehensions during 1989-2008, possibly indicating an increase in illegal fishing in the Torres Strait (Figure 2-38). The majority of apprehensions were of illegal Indonesian vessels. However, the data have not been corrected for surveillance or patrol effort.

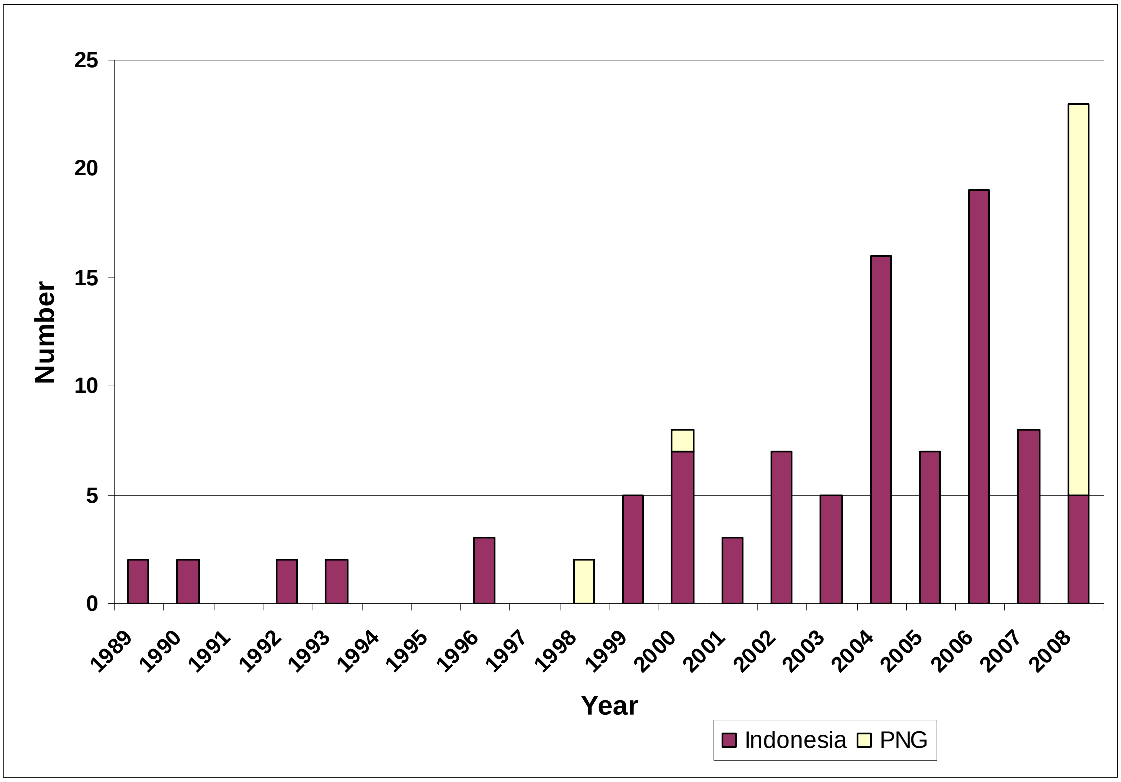


Figure 2-38 Total apprehensions in the Torres Strait Protected Zone from 1989-2008 (Source: AFMA)

2.3.25 **Crown of thorns starfish** (Source: Nicole Murphy, Tim Skewes, CSIRO)

Figure 2-39 Crown of thorns starfish

The crown of thorns starfish (COTS) is a predator of coral polyps. Large outbreaks of these starfish can devastate reefs. In 2000, an outbreak contributed to a loss of 66% of live coral cover on sampled reefs in the Great Barrier Reef. Outbreaks are believed to occur in natural cycles, exacerbated by poor water quality and overfishing of the starfish's predators.

COTS are concentrated in the Eastern Torres Strait, and surveys have been carried out opportunistically in this region during beche-de-mer surveys in 2002, 2005 and 2009. There are no known thresholds for the Torres Strait. However, a density exceeding 30 adults per hectare is dangerous and considered an active outbreak in the Great Barrier Reef (CRC website 2009)

Results for the Eastern Torres Strait survey show that although densities have increased from 2002 to 2009, numbers are still well below the threshold levels for an active outbreak (Figure 2-40 below)

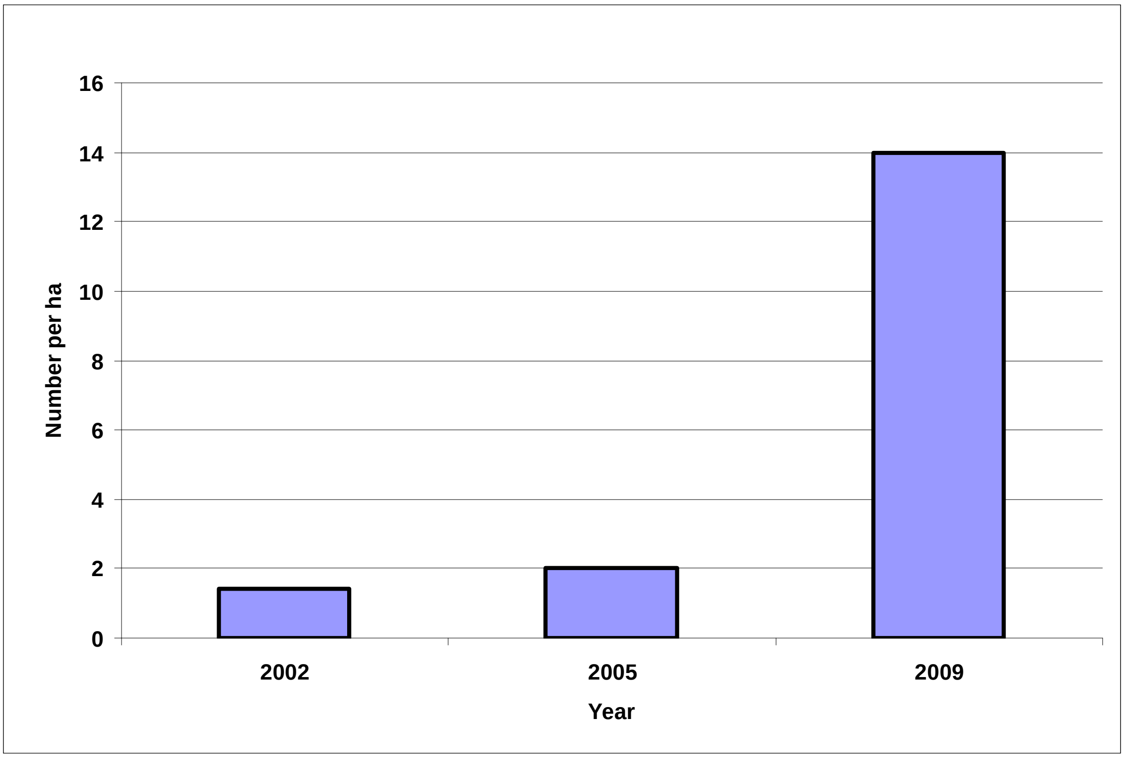


Figure 2-40 Number of crown of thorns starfish per hectare surveyed at beche-de-mer survey sites in the Eastern Torres Strait, 2002-2009 (Source: Tim Skewes, CSIRO).

2.3.26 Fishing effort (Source: AFMA)

A common indicator of fishing pressure is the number of licences issued. AFMA records the number of commercial fishing licenses issued to indigenous communities as TIB (Traditional Inhabitant Licenses) and TVH (Traditional Vessel Holder) licenses. The total number of licenses issued has declined slightly over the last 6 years (Figure 2-41). However, it is difficult to verify the extent that this signifies decreased fishing pressure, since it is not known if all of these licenses are utilised on a regular basis.

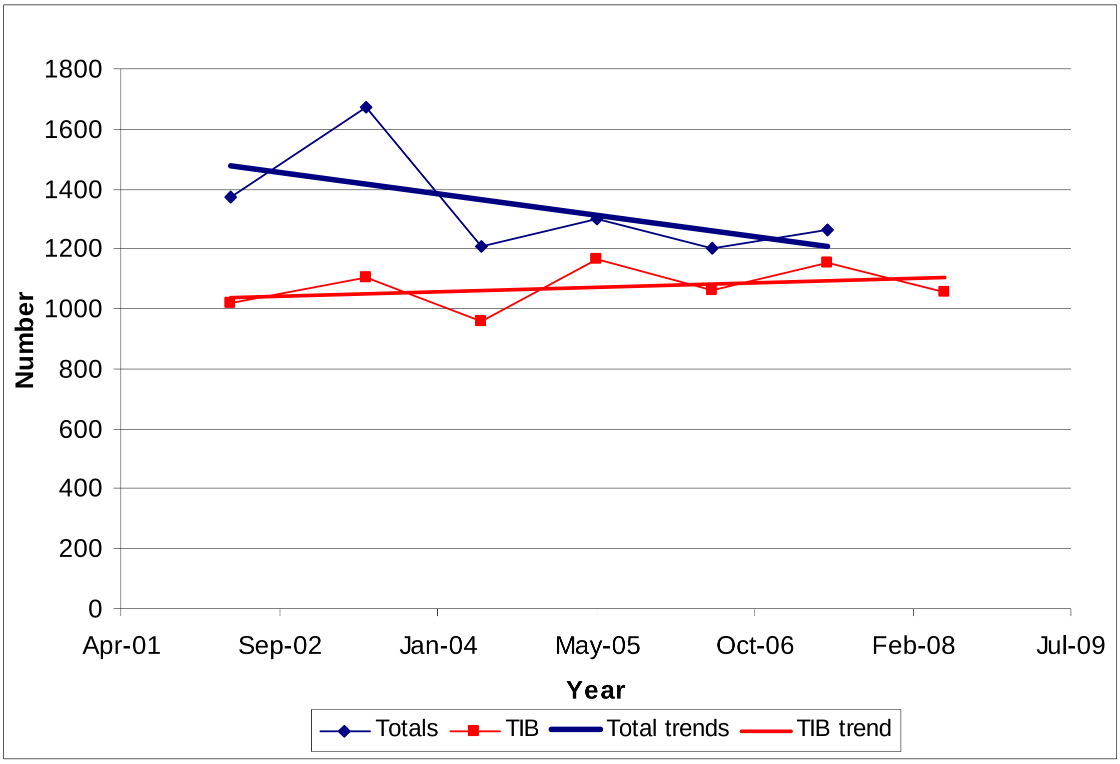


Figure 2-41 Number of fishing licenses issued in the Torres Strait per year, 2001-2008 (Source: AFMA).

3. REPORTING MARINE ECOSYSTEM HEALTH IN TORRES STRAIT

Currently there is no formal MEH reporting in the Torres Strait, either at the regional or community scale. While this study has reviewed potential MEH indicators suggested by expert opinion, and their underlying data, there is no framework to operationalise the information. In this section we explore possible frameworks and media for reporting such data.

3.1 Presentation of data for regional reporting

Regional reporting in the Torres Strait should be tailored for the PZJA and TSRA because of their roles in the regional management of marine resources and the coordination of research and management activities. A report card system has been a common approach taken elsewhere to report on MEH, and could be useful for the Torres Strait at both the regional and community scale.

An annual report card system that combines a heat map and 'spider' diagrams showing current MEH could be a suitable approach for regional level reporting. Heat maps allow the visualisation of collective indicators and their relative historic trends. Spider diagrams enable a composite MEH index from the current status of indicators to be presented. However, for community-scale reporting it was decided that fact sheets describing individual indicators of community priority should be tested.

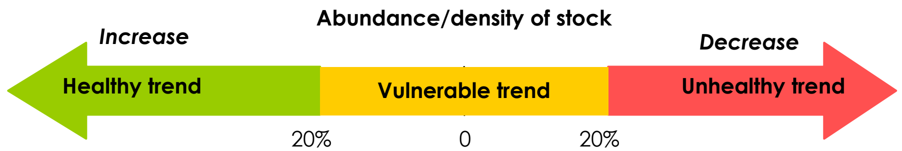
3.1.2 Heat maps

A heat map is a table showing the conditions and trends of a parallel list of indicators chosen to describe the MEH over time. The condition of each indicator is shown using the traffic light approach, where green is healthy, amber is vulnerable and red is unhealthy. Figure 3-1 illustrates a heat map showing the condition of each indicator (tropical rock lobster, sandfish, endeavour and tiger prawn) from 1989 to 2009. The uncoloured cells represent the years where no data was collected.

Figure 3-2 shows a heat map for the conditions of stocks determined by trends in the data where thresholds do not exist. Instead, the increase or decrease of a data point relative to its previous measurement is used to describe the condition of the indicator. Again, the traffic light approach is used to describe the trend where an increase of stock abundance by greater than 20% is described as a healthy trend and shown in light green, and a decrease of greater than 20% is described as an unhealthy trend and shown in light red. A vulnerable trend is denoted when either an increase or a decrease less than 20% occurs, and is shown in amber.

Indicators	Pre-1989	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Tropical rock lobster																						
Sandfish																						
Tiger prawns																						
Endeavour prawns																						

Figure 3-1 Heat map showing condition of indicators with thresholds of concern.



Indicators	Pre 1989	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dugong				inc					inc					dec					Inc			
Spanish mackerel			dec	dec	Dec	inc	dec	dec	inc	inc	dec	dec	inc	inc	inc	dec						
Green turtle	dec	inc		dec	Dec	inc	dec	inc	inc	dec	dec	inc	dec	inc	dec	inc	inc	dec	Inc	dec	inc	
Hawksbill turtle				inc	Dec	inc	dec	inc	inc	dec	dec	inc	dec									
Trochus	inc								dec	inc		inc					dec	inc	dec			
Pearl shell				dec	Dec	inc	dec	dec	nil	inc	dec		nil	inc	dec	inc	dec	inc		inc	inc	
Seagrass Western TS				dec				dec	inc	inc	dec	dec	nil	dec	inc	inc	inc	dec		dec	dec	nil
Seagrass Eastern TS																		inc				
Live coral Western TS				dec				Nil	dec	inc	dec	inc	dec	inc	dec	dec	nil	nil		inc	inc	dec
Live coral Eastern TS																		dec				

Figure 3-2 A heat map of marine resource condition indicators that do not have thresholds of concern, but have trends. (Green represents an annual increase of 20% or more in densities or abundances, red represents an annual decrease of 20% or more and amber represents an increase or decrease of less than 20%.

3.1.3 Marine Ecosystem Health Index

Unlike the heat map, a MEH Index gives a snap shot of the current MEH condition in a year. Classes of MEH are therefore needed to determine the MEH Index. This can be done by averaging the score of the indicators chosen, either with or without weightings. Table 3-1 gives an example of the score given to the range of data values for each indicator. The range of data values can be determined from known thresholds, literature or expert opinion. This set of classes should be developed and agreed by the relevant researchers and experts for each indicator selected.

Table 3-1 Example of classes for scoring indicators. Values only represent possible examples.

MEH INDICATORS	**1 Very Unhealthy**	**2 Unhealthy**	**3 Vulnerable**	**4 Healthy**	**5 Very Healthy**	**Source**
Tropical rock lobster: Spawning biomass	< 1512.8 t	1512-2146	2147-2780	2781-3415.5	> 3415.5 t	Calculated thresholds (CSIRO)
Sandfish: Density on Warrior Reef	<780t	780-857.4	857.4-934.7	934.7-1012	>1012t	Calculated thresholds (CSIRO)
Seagrass: % cover in Western and Eastern Torres Strait	<10%	10-15%	15-20%	20-25%	>25%	Expert opinion
Coral cover: % cover in Western and Eastern Torres Strait	<10%	10-15%	15-20%	20-25%	>25%	Expert opinion
Shipping traffic: Average number of ships per day	5	4	3	2	1	Expert opinion
Illegal fishing: Total apprehensions per year	16-20	12 - 15	8 - 11	4 – 7	0 – 3	Expert opinion
Crown of thorns starfish: Number of adults per ha	> 30	24-30	16-23	8-15	0-7	Literature (GBRMPA)
Sea surface temperatures: Annual average	> 36 °C	34 - 36°C	33-34 °C	31-32 °C	18 - 30 °C	Literature (GBRMPA)
Wind speeds: Annual average	> 28m/s	25 – 28m/s	20 – 24m/s	15 – 19m/s	< 15m/s	Expert opinion

Table 3-2 below shows an example of the scores given to each of the above indicators for 2009. Each score is represented by the current condition of that indicator. The scores are then averaged to give a MEH Index. An example of the classification for the overall MEH Index is shown in Table 3-3, which can also be presented within a spider diagram as shown in Figure 3-3. Based on these complete but limited datasets, overall MEH in the Torres Strait appears to be 'moderate' in 2009.

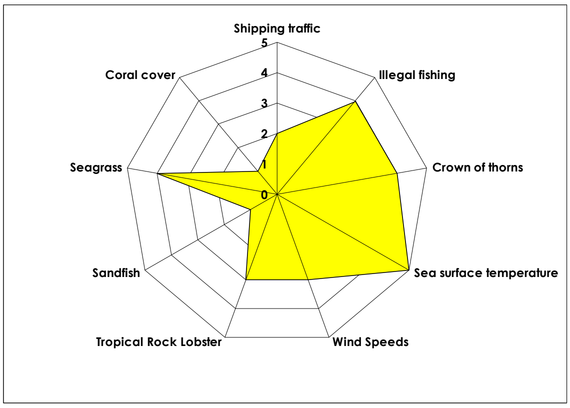
Table 3-2 Example of indicator scores for 2009

MEH INDICATORS	2009 DATA	2009 SCORES
Shipping traffic: Average number of ships per day	3.6/day	2
Illegal fishing: Total apprehensions per year	5	4
Crown of thorns starfish: Number of adults per ha	14/ha	4
Sea surface temperatures: Annual average	28°C	5
Wind speeds: Annual average	22m/s	3
Tropical rock lobster: Spawning biomass	2740t	3
Sandfish: Density on Warrior Reef	540t	1
Seagrass: % cover in Western and Eastern Torres Strait	20%	4
Coral cover: % cover in Western and Eastern Torres Strait	8%/ha	1
Overall score/MEH Index		**3**

Table 3-3 Example of overall classification for an MEH Index

MEH Index	MEH CONDITION
1	VERY BAD
2	BAD
3	MODERATE
4	GOOD
5	VERY GOOD

Figure 3-3 Example of spider diagram showing the MEH Index for 2009, which is moderate.



3.2 Presentation of data for community reporting

There has been limited reporting of fisheries health to Torres Strait Islander communities, and no reporting of marine ecosystem health. The dissemination of information has been a weakness in past fisheries management (Busilacchi 2008). Currently scientific research and information of community relevance is supposed to be transferred to communities through community fisher representatives from various PZJA working groups. However, consultations as part of this project with the communities of Warraber and Darnley Islands suggest that reporting of fisheries health has in fact been negligible there.

Two community consultations were conducted in March and June 2010 on Warraber and Darnley Islands. The first was carried out to identify indicators that were relevant to communities' livelihoods and to field test fact sheets for reporting scientific monitoring results back to communities. The second identified the most suitable media for communicating scientific results to communities, and investigated the extent of community interest in becoming involved in local-scale MEH monitoring and reporting.

3.2.1 Islander community indicators for sea country health

MEH indicators of relevance to communities' livelihoods in Darnley and Warraber included the catch sizes and abundances of some commercial species (tropical rock lobster, mackerel and coral trout, beche-de-mer and trochus) and some environmental indicators (climate, coral health and water quality). The number of commercial fishing boats in their sea country was also identified as a significant indicator to the health of their sea country (Table 3-4). Many of these indicators are the same or similar to those identified by the expert workshops.

Table 3-4 Community indicators for sea country health from Warraber and Darnley Islands

Warraber Island	Darnley Island
Climate: good weather reflects good fisheries	**Size of catch:** larger catches mean healthy sea country
Coral health: some fishermen have noticed coral bleaching and this might be an indicator for deteriorating sea country	**Bait catch:** when bait fish are plentiful it is an indicator of healthy sea country
Number of commercial fishing boats: when there are more commercial fishing boats seen during the year, this indicates that sea country will be fished out	**Weather patterns:** good weather reflects good fishing
Catch rates: e.g. 4 bags of trochus per day is a good sign	**Turtles:** male and female turtles seen together during the day is a good sign
Size of catch: larger catches indicate healthy sea country	**Coral health:** bleaching might be an indicator for deteriorating sea country

Unusual observations: unusual occurrences such as whale sightings mean something different may be happening to their sea country	**Colour of water:** clear water means healthier sea country
	Colour of reef: the reefs were more colourful in the past

3.2.2 Communicating scientific research results to communities

Discussions with TSRA in October 2009 led to the development of fact sheets to report MEH to island communities. A trial fact sheet for the condition of the lobster fishery (Appendix C) was developed and field tested with the communities of Warraber and Darnley Islands. Results of community consultations were used to refine the fact sheet, and to improve their usefulness and suitability for the communities (see Appendix D)

A survey was undertaken during community visits in June 2010 to determine the most favoured media for communicating scientific research and information to communities. A list of four media approaches was provided for the audience to choose and rank. Fact sheets and DVDs or videos scored the highest rankings (Table 3-5).

Table 3-5 Ranking of reporting media by Warraber and Darnley Island communities (1 = high, 5 = low).

Media type	Warraber	Darnley	Comments
Posters	4	4	Cannot take information home
Fact sheets	1	3	Reading may not be suitable for some
DVDs or videos	3	1	Visual images and verbal explanation easiest to understand
Face to face meetings	2	2	Opportunity to communicate with researchers and clarify information

3.2.3 Potential for community-based monitoring and reporting of MEH

One of the recommendations by Stevens (2008) on his review of the PZJA administration was the importance of Traditional Inhabitants involvement with other stakeholders to research, monitor and manage marine resources, ultimately for the benefit of traditional Inhabitants, whether for traditional fishing or economic development. Busilacchi (2008) outlined in her PhD research the need for community-based management to ensure broad-based understanding of sustainability issues. Butler *et al.* (in review) identified fishery species for which science and management knowledge was poor and traditional ecological knowledge (TEK) is likely to be high (Figure 3-4). This analysis identified many traditional fisheries (e.g. turtle, dugong, squid, octopus, gastropods) where TEK could potentially contribute greatly to formal management in partnership with science. However, Butler et al. emphasise that such knowledge integration needs to be trialled at the local community scale.

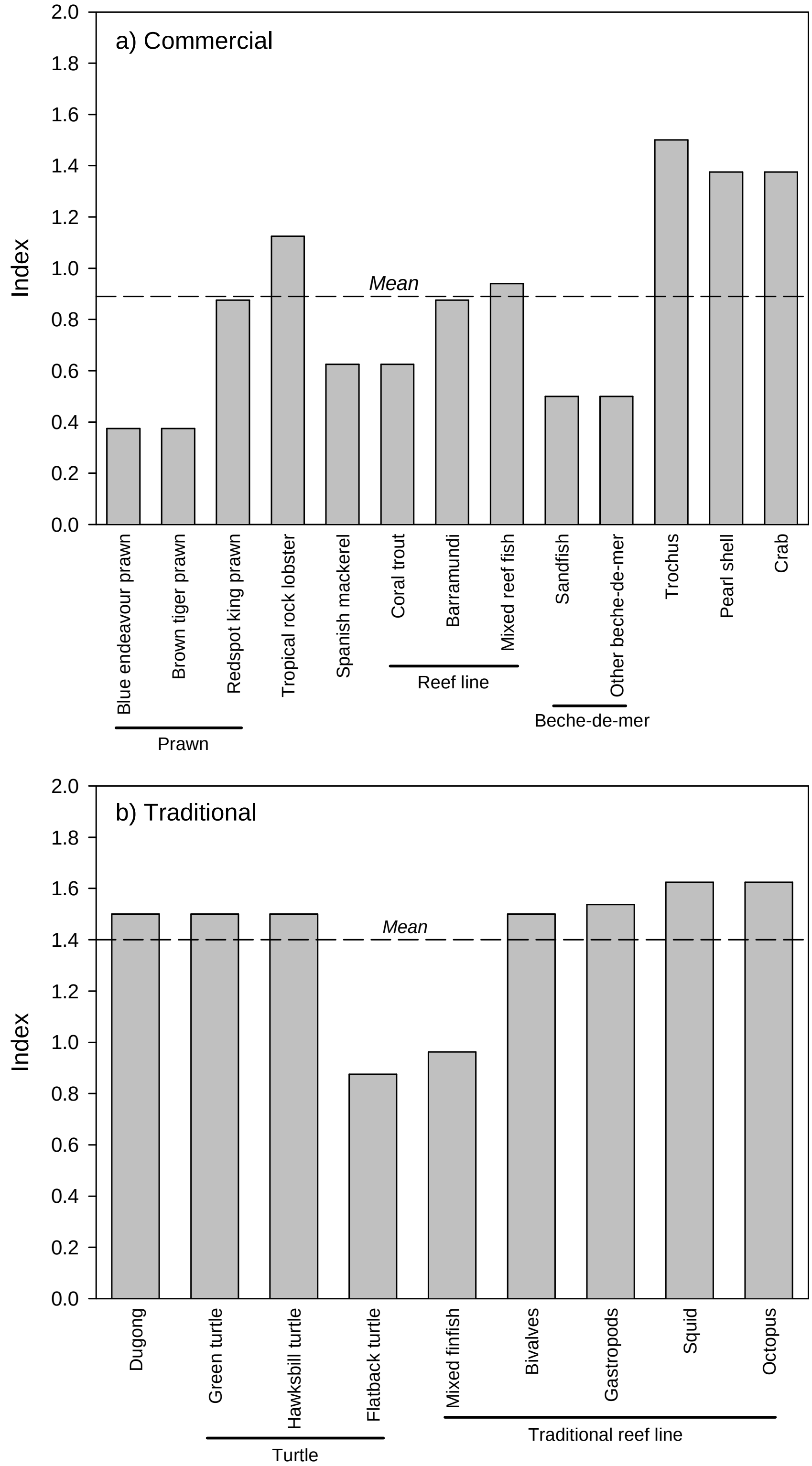


Figure 3-4 Indices of the potential contribution of TEK to fisheries management for a) commercial and b) traditional fishery species. The maximum index is 2, indicating that TEK is very high and science knowledge very low. Dashed lines represent the average index for each sector. See Butler *et al*. (in review) for details.

Community-based monitoring of marine ecosystem indicators is an opportunity that can be developed at an island-base scale to complement and further the regional MEH reporting. However, as with the LMMA projects in Pacific island countries, community-based monitoring has to have a direct benefit to communities in order to become practical and successful. Hence the current co-management fishery projects for trochus and beche-de-mer currently being implemented in Warraber and Darnley islands provide a suitable platform for community-based monitoring. Fishermen involved in these projects were asked whether they were willing to share or report on data or information collected by them for regional MEH reporting. All of the fishermen interviewed agreed that data or information collected from their community-based programs could be shared with regional and scientific communities, especially if it supported community-based management actions.

4. RECOMMENDATIONS

This report explores potential indicators for MEH monitoring and reporting at both the regional and community scales. However, development of an integrated MEH Index appropriate for the Torres Strait is outside the scope of this project. A monitoring program for MEH would have to be co-ordinated in a systematic manner to ensure there are no gaps in data, that thresholds of concern are developed where they do not exist, and that information is relevant and shared by both regional agencies and islander communities. An integrated approach to monitoring and reporting MEH is needed for the Torres Strait. Further, a clear understanding of how MEH should be defined is still required, from both an ecological, cultural and economic point of view.

4.1 Potential MEH monitoring and reporting framework for the Torres Strait

Community-based monitoring of key marine ecosystem health indicators can help communities compare and confirm local and traditional knowledge they already have of their marine resources with scientific research. They will also be able to keep track of their sea country conditions and manage its use more effectively. Community-based projects such as the trochus and beche-de-mer co-management for Warraber and Darnley Islands can provide information on catch and habitat health related to these species. The Turtle and Dugong Management Plans also have the potential to provide data for MEH reporting.

Figure 4-0 describes a potential nested framework for the reporting of MEH in the Torres Strait that involves Torres Strait islanders working with regional and scientific communities to develop a MEH Index for the whole of the Torres Strait. Monitoring data (in yellow) from the community-based projects is used to describe the condition of the relevant indicators (in blue) within their sea country. This can be used to describe the MEH condition for each island (in pink). Conditions for regional indicators described in this report can then be combined with island-based MEH conditions to derive a MEH Index for the region (in green and orange).

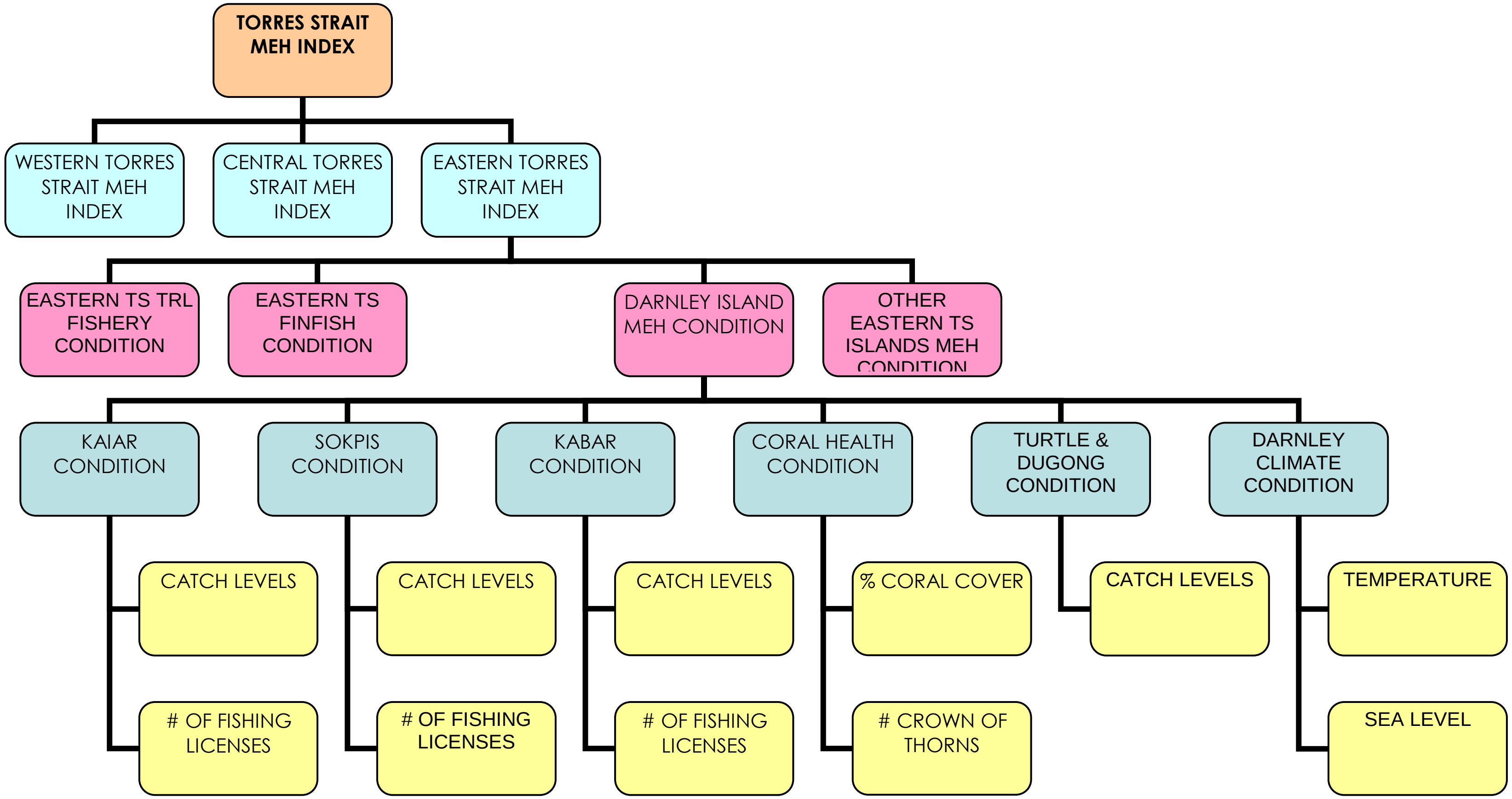


Figure 4-0 A suggested nested MEH reporting Framework for the Torres Strait

This framework incorporates the co-management of community relevant fisheries which provide community-based monitoring programs. Reed *et al.* (2006) suggests that the inclusion of both bottom-up and top-down stages in this process is important to achieve the hybrid local, traditional and scientific knowledge required to provide broader understanding of environmental, social and economic system interactions.

4.2 MEH data integration and dissemination

Currently a centralised data integration hub does not exist in the Torres Strait. The TSRA Land and Sea Management Unit would be the most appropriate agency for this role. Figure 4-1 describes the major stakeholders in MEH reporting in the Torres Strait (boxed/circled in red) and existing or potential mediums of reporting between the stakeholders (in blue). The TSRA Land and Sea Management Unit has been collating and coordinating related MEH information in the past and because of its role in establishing the Land and Sea Ranger program is an ideal hub for MEH information. An annual MEH report card could be developed by TSRA for regional scale dissemination between government, researchers and the PZJA. Report cards could be produced for Torres Strait as a whole, or for island groups depending on the indicators selected by the different communities. Technical reports of scientific research results would be communicated to island communities through videos and fact sheets. Island-based MEH conditions could be monitored and reported by rangers through community posters or fact sheets, co-developed by TSRA and the island communities.

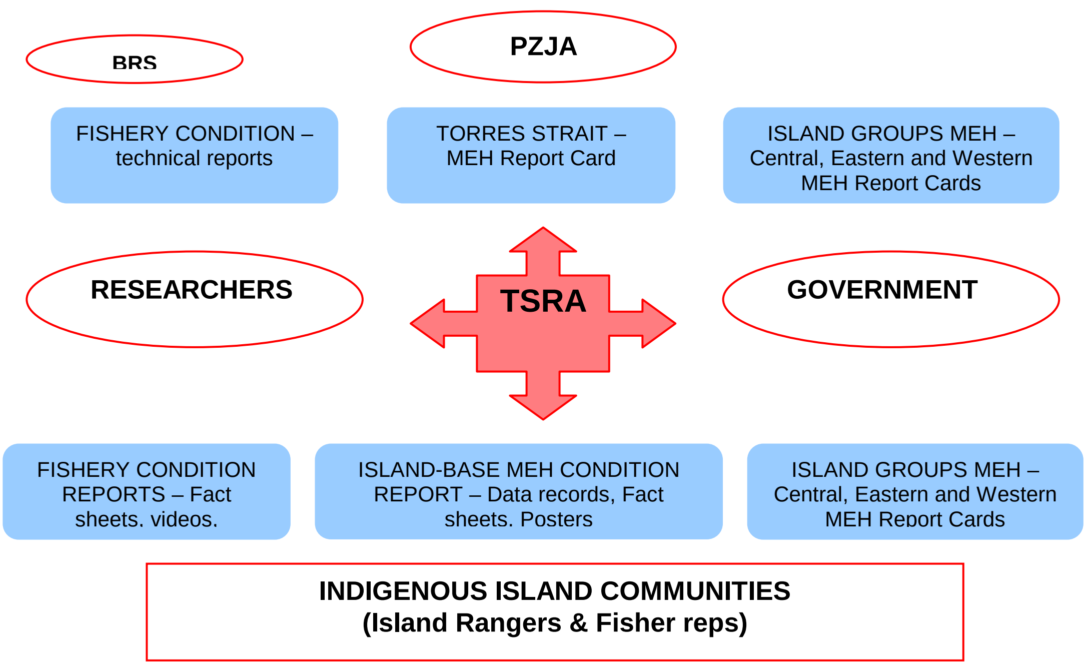


Figure 4-1 Suggested role for TSRA in MEH reporting for the Torres Strait

5. REFERENCES

Apte, S.C. & Day, G.M. 1998. Dissolved metal concentrations in the Torres Strait and Gulf of Papua. *Marine Pollution Bulletin* 36: 298-304.

Baker, E.K. & Harris, P.T. 2006. Copper, lead and zinc distribution in the sediments of the Fly River Delta and Torres Strait. *Marine Pollution Bulletin* 22: 614-618.

Begg, G.A., Chen, C.C.M., O'Neill, M.F. & Rose, D.B. 2006. Stock assessment of the Torres Strait Spanish mackerel fishery. CRC Reef Research Centre Technical Report No. 66, CRC Reef Research Centre, Townsville.

Browne, M., Kuhnert, P., Peterson, E., Bartley, R., Steven, A. & Harch, B. 2008. *Review of existing approaches used to develop integrated report card frameworks (IRCF) and their relevance to catchment draining to the Great Barrier Reef*. Final Draft Report to the Marine and Tropical Sciences Research Facility. Reef and Rainforest Research Centre Limited, Cairns.

Bunn, S. & Smith, M.J. 2002. Design and implementation of ecosystem health monitoring program for streams and rivers in Southeast Queensland, Australia: an overview. In: Bulletin in North American Benthological Society. http://www98.griffith.edu.au/dspace/handle/10072/9103.

Busilacchi, S. 2008. *The subsistence coral reef fish fishery in the Torres Strait: monitoring protocols and assessment*. PhD thesis, James Cook University, Townsville, Australia.

Butler, J.R.A., Tawake, L., Skewes, T.D., Tawake, A. & McGrath, V. *in review.* Cultural edges in the Torres Strait, Australia: determinants of the current and future application of traditional ecological knowledge in adaptive fisheries management. *Ecology and Society*.

Clua, E., Beliaeff, B., Chauvet, C., Davids, G., Ferraris, J., Kronen, M., Kulbicki, M., Labrosse, P., Letourneur, Y., Pelletier, D., Thebauds, O., & Leopold, M. 2005. Towards multidisciplinary indicator dashboards for coral reef fisheries management. *Aquatic Living Resources* 18: 199-213.

CRC Reef 2009. *Managing Crown of thorns starfish outbreaks.* CRC Reef Research Centre. http://www.reef.crc.org.au/discover/plantsanimals/cots/cotsmanage.html

Epstein, P.R. 1999. Large marine ecosystem health and human health. *In: The Gulf of Mexico Large Marine Ecosystem: Assessment, Sustainability and Management.* H. Kumpf, K. Steidinger and K. Sherman (eds). pp 177-186. Academic Press, London.

Gladstone, W. & Dight, I.J. 1994. Torres Strait baseline study. *Marine Pollution Bulletin* 29: 121-125.

Govan, H., Aalbersberg, W., Tawake, A. & Parks, J. 2008. *Locally Managed Marine Areas: A Guide for Practitioners.* The Locally Managed Marine Area Network.

Great Barrier Reef Marine Authority, 2009. Coral Bleaching Response Plan 2009-2010.

Haynes, D & Kwan, D. 2002. Trace metals in sediments from Torres Strait and the Gulf of Papua: concentrations, distribution and water circulation patterns. *Marine Pollution Bulletin* 44: 1296-1313.

Jones, A., Barnett, B., Williams, A.J., Grayson, J., Busilacchi, S., Duckworth, A., Evans-Illidge, E., Begg, G.A. & Murchie, C.D. 2008. Effective communication tools to engage Torres Strait Islanders in scientific research. *Continental Shelf Research* 28: 2350-2356.

Larcombe, J. & McLoughlin, K. 2006 (eds) 2009, *Fishery status reports 2008: status of fish stocks and fisheries managed by the Australian Government*, Bureau of Rural Sciences & Australian Bureau of Agricultural and Resource Economics, Canberra.

Limpus, C. 2008. *A Biological Review of Australian marine turtle species.2. Green Turtle. Chelonia mydas. (Linnaeus)*. State of Queensland Environment Protection Agency

Limpus, C. 2009. *A Biological Review of Australian marine turtle species.3. Hawksbill Turtle. Eretmochelys imbricata. (Linnaeus)*. State of Queensland Environment Protection Agency

Marsh, H., I. Lawler, D. Kwan, S. Delean, K. Pollock & M. Alldredge. 2004. Aerial surveys and the potential biological removal technique indicate that the Torres Strait dugong fishery is unsustainable. *Animal Conservation* 7: 435–443.

Neil, K.M, Hilliard, R, Russell, B. & Clark, P. 2008. Introduced marine species: management arrangements of consideration for Torres Strait. *Continental Shelf Research* 28: 2317-2323.

Rayment, G.E. & Barry, G.A. 2000. Indicator tissues for heavy metal monitoring - additional attributes. *Marine Pollution Bulletin* 41: 353-358.

Reed, M. S, Fraser, E. D. G. & Dougill, A. J. 2006. An adaptive learning process for developing and applying sustainable indicators with local communities. Ecological *Economics* 59: 406-418

Sherman, B. J. 2000. Marine ecosystem health as an expression of morbidity, mortality and disease events. *Marine Pollution Bulletin* 41: 232-254.

Stafford, H. & William, R.C. 2007. *Is it a Pest? Introduction and naturalised marine animal species of Torres Strait Northen Australia.* Queensland Department of Primary Industries and Fisheries, Cairns.

Stevens, R. 2008. Review of Torres Strait Protected Zone Joint Authority Fisheries Administration Arrangements. AFMA/QDPI&F/TSRA Discussion Paper.

Torres Strait Protected Zone Joint Authority Annual Report 2006-2007. Australian Fisheries Management Authority, Canberra.

Wells, P.G. 2005. Assessing marine ecosystem health: concepts and indicators with reference tot he Bay of Fundy and Gulf of Maine, Northwest Atlantic. *In: Handbook of ecological indicators for assessment of ecosystem health.* Jorgensen. S.E, Costanza, R and Liu Xu. F (eds). CRC Press, Florida.

Williams, A.J., Begg, G.A., Little, L.R., Currey, L.M, Ballagh, A.C. & Murchie, C.D. 2007. Evaluation of the Eastern Torres Strait reef line fishery. Technical Report no.1, Fishing and Fisheries Research Centre, James Cook University. Townsvillie, QLD.

Wilson. D., Curtotti. R, Begg. G., & Phillips. K. (eds) 2009. *Fishery status reports 2008: status of fish stocks and fisheries managed by the Australian Government.* Bureau of Rural Sciences & Australian Bureau of Agriculture and Resource Economics, Canberra.

APPENDIX A – POTENTIAL INDICATORS FOR THE TORRES STRAIT USING AVAILABLE DATA SETS.

Data set type	Type of data	Models	Indicators from data set	Risk of using the indicator	Thresholds of concern	Risks for the resource	Community relevance	Government relevance	Fisher relevance
TS Lobster	Mid-season fishery-independent population surveys of recruiting (1+) and fished (2+) lobsters since 1989. 542 sites surveyed in 1989 and a sub-set of these sites surveyed in the following years. Fisheries catch and some effort data available from indigenous and non-indigenous sectors. Semi-quantitative seabed habitat surveys undertaken concurrently Three fishery-independent pre-season population surveys of recently settled (0+) and recruiting (1+) lobsters since 2005.	Stock-recruitment model based on population size of recruiting (+1) lobsters in year (X+2) and fished (+2) lobsters in year X. Age-structured fishery model used to determine MSY. Annual fishing mortality rates are estimated. Use of Commonwealth Harvest Strategy to set the target reference point (S_{MSY}).	1. Stock size (B) at a particular year 2. Size and age distributions 3. Abundance of +1 and +2 lobsters 4. Spatial trends of the lobster abundance 5. Fishing mortality 6. Spawning stock and recruit stock size 7. Number of TIB licences endorsed for different fisheries	1. The estimates of abundance from the fishery-independent population surveys have associated errors. The stock recruitment relationship is variable but is only used in the long range TAC forecast and fine tuned by the pre-season population estimate. 7. There is high latent effort in the TIB sector, and one person could have multiple licences, so it won't necessarily indicate effort in the indigenous sector	If S falls below S_{MSY} (Spawning stock size at Maximum Sustainable Yield) there are signs of overfishing. If B falls below Blim (20% of the virgin biomass) stock is seriously overfished, drastic measures should apply Change in the mean lobster size Increase take of undersized lobsters for subsistence (no data available on traditional take) Levels of fishing too far below MSY may indicate under-utilisation	Commercial fishery harvest Seabed habitat deterioration Climate change impacts PNG over-fishing	If the stock size (B or S) is kept above the target reference point, traditional fishing should be unimpacted, if B falls below Btarg, traditional fishing will be the first to be affected Localised depletion on home reefs Economic development if MSY is not achieved	If the stock size (B) is below Btarg, management measures should be put in place to avoid over-fishing	If the stock size (B) is kept above Btarg, fishing should be reasonably good in the following years.

Data set type	Type of data	Models	Indicators from data set	Risk of using the indicator	Thresholds of concern	Risks for the resource	Community relevance	Government relevance	Fisher relevance
			8. Illegal take (number of sightings) 9. Market price	8. Number of sightings may not indicate illegal fishing of lobster					
TS Prawn	Fishery dependent data; logbook data - Catch composition and catch rates Observer data on by-catch. - composition of by-catch, interactions with SOCI species, TRL etc Fishery independent data (Feb 1998-08) 19 sites, most of these are in the west and east of Warrior Reef closure areas. The focus is on an annul recruitment index. DAFF data (07-08) May, July, Sept, Nov, 114 sites surveyed in TS. Species composition and catch categories, sex and spawning condition, size and fishery independent CPUE. VMS data	Catch rates and Spatial harvest strategies models by species, location and depth. Endeavour prawn stock assessment, Multi-species spatial stock model (in development)	1. Catch rates by species 2. Spatial commercial harvest (VMS) trawling areas 3. By-catch composition 4. Catch and effort data 5. CPUE of tiger and endeavour prawns 6. The standardised Catch rates will give indication of the stock. 7. Tiger prawn stock biomass	4. Could be market driven and not because of a decrease in the stock 5. Again it could be market driven, fishery dependent data could be biased 6. fishery dependent data could be biased – need to adjust for changes in fishing power.	Fishing above MSY When stock goes below 20% of virgin biomass Increase in by-catch of protected species	Commercial fisheries Habitat loss Climate change	Bycatch of protected species (Turtle) and of lobster. Trawling area near their communities and home reefs Anchorages Perception issues.	Bycatch of protected species (Turtle) and of lobster. Anchorages Perception issues. Stock falling below 20% of virgin biomass	Stock falling below 20% of virgin biomass Perception issues.

Data set type	Type of data	Models	Indicators from data set	Risk of using the indicator	Thresholds of concern	Risks for the resource	Community relevance	Government relevance	Fisher relevance
Beche-de-mer	Research surveys from 1995-2005 Environmental data. Fisheries by area (eastern and Warrior). 7 surveys, 4 for sandfish. And other species, 1519 sites survey through TS Some fishery data Distribution ranges	Harvest strategies Blim =50%B0 TAC= 10% of estimated biomass B re-open +70% of B0 Stock assessment	1. Stock size 2. Breedin g population over large area (meta population) 3. Spatial trends by species 4. Density changes by species 5. Number of TIB licences endorse for different fisheries 6. Localize d depletion 7. Serial depletion 8. Illegal take (number of sightings)	1 Funding for surveys not very likely 2. Funding for surveys not very likely 3. Funding for surveys not very likely 4. Funding for surveys not very likely 5. There is high latent effort in the TIB sector, and one person could have multiple licences, so it won't necessarily indicate effort in the indigenous sector 6. Taxonomic uncertainties and lack of data 8. Number of sightings may not indicate illegal fishing of beche-de-	When population falls below 50% over a broad area Adult distributions are far apart (risk with fail reproduction).	Multispecies fishery and effort shift in species PNG overfishing Environmental variables.	Species distribution for their fishing (small fisheries). Important indigenous fishery Community base management proposal	Sustainability of the fishery	Important indigenous commercial fishery

Data set type	Type of data	Models	Indicators from data set	Risk of using the indicator	Thresholds of concern	Risks for the resource	Community relevance	Government relevance	Fisher relevance
			9. Market price	mer					
East TS Finfish	Fisheries data Research from JCU on the TIB catch and docket book data. By product data? Observer surveys for by-catch, effort measure, species composition and survival of by-catch Length frequency distribution , age of recruitment, sex maturity Information from the lobster and beche de mer surveys included some finfish	Spanish mackerel stock assessment (rudimentary) Assessment of biological parameters	1. Number of active TIB licences 2. Total catch data 3. Change in length frequency distribution 4. Change in species composition for reef line 5. Catch rates 6. Total catch 7. Localise d depletion	1. There is high latent effort in the TIB sector, and one person could have multiple licences, so it won't necessarily indicate effort in the indigenous sector 2. may be due to effort reduction 4. Inaccurate reporting of species caught 5. Risks with reporting through docket books 6. Risks with reporting through docket books 7. Risks with reporting through	Exceeding mackerel TAC CPUE stability Exceeding by-catch thresholds Declining Coral trout numbers near communities TIB CPUE increase	No ongoing fisheries independent survey Commercial fisheries Habitat loss Climate change	Catch rates Localised depletion near their community Line fishing	Sustainability of the fishery Optimising the use of the resources	Healthy stocks for commercial exploitation

Data set type	Type of data	Models	Indicators from data set	Risk of using the indicator	Thresholds of concern	Risks for the resource	Community relevance	Government relevance	Fisher relevance
			8. Market price	docket books					
Other fisheries	Fisheries information trochus, pearl from independent surveys of beche de mer and lobster	TAC set for trochus	1. Catch rates 2. Densities 3. Market price	1. catch is market driven for several species such as trochus and pearl	Localise depletion of trochus Exceeding trochus TAC	Commercial fisheries Habitat loss Climate change	Localise depletion	Sustainability	Important indigenous commercial fishery
Dugong	Independent aerial surveys every 5 years estimating population size (1987. 1991, 1996, 2001 & 2006) Biological data (diet, natural mortality rates, reproductive biology including size & sex at maturity, fecundity) Harvest estimates Seagrass surveys	Spatial model for dugong (Marsh & Grech, 2008) Dugong Population Simulator (AFMA, 2008) Population Viability Analysis (Heinsohn et al, 2004) Potential Biological Removal (Marsh et al, 2004) population	1. Changes in dugong distribution, density & abundance 2. Harvest 3. Loss of seagrass	1. Potential lack of ongoing survey money 2. Lack of reliable catch data, inconsistency across region and uncertainty of PNG harvest 3. Dugong populations are highly variable anyway due to migratory nature so may not be a good indicator of abundance	If population is below MSY Total catch exceeds estimates of maximum sustainable yield (Marsh et al, 2004 & Heinsohn et al, 2004)	Over harvesting (TS, PNG & NPA) Illegal foreign harvest Habitat loss Climate change	Community management plans Traditional fishing High cultural value	Sustainability Australia & PNG bilateral arrangement s TEP obligations Broader Australian community perception	Sustainability Culture
Turtle	Independent population surveys (feeding & nesting populations) Population genetics information Catch data (outdated	Population models (not very detailed resolution due to lack of info in the foraging turtles. However information on	1. Changes in abundance by species 2.Harvest	1. No information on foraging turtles, only on nesting 2. Lack of reliable catch data,	If population is below MSY (populations thresholds are unknown) Cultural related thresholds/indi	Over harvesting (TS, PNG, NPA, Indonesian and South Pacific) Illegal foreign harvest Habitat loss	High cultural value Traditional fishing Community management	Sustainability Australia & PNG bilateral arrangement s TEP	Sustainability

Data set type	Type of data	Models	Indicators from data set	Risk of using the indicator	Thresholds of concern	Risks for the resource	Community relevance	Government relevance	Fisher relevance
	and unreliable – only covers areas of the PZ) Daru market data (not current) QPWS tagging and migratory data JCU and Hammond island tagging data TSRA harvest data (recent but sporadic & inconsistent across communities) Aerial surveys (JCU data) Applied ecology data	nesting turtles (green and hawksbill) is very detailed)	3.Changes in nesting turtle populations (nesting & hatching success) 4.Habitat condition (feeding & nesting habitat) 5.Temperature and climate (general & feeding/nesting habitat) 6.Natural mortality rates 7.Effort and cost of hunting 8. Sea level rise	inconsistency across region and uncertainty of PNG harvest 3. Not all populations will be monitored – only key sites 4. No data available on erosion and inundation of nesting areas 6. No information on foraging turtles 7. No data available	cators (hunting) unknown Sand temp below 24 or above 34 the eggs die	and/or change from climate change (feeding & nesting habitats)		obligations Broader Australian community perception	
Traditional fisheries	CSIRO 1991 – 2001 yearly survey of several communities (mostly focus on turtle and dugong), with landing information and interviews Environmental effects on hunting	Stratified analysis to estimate catches by island Subsistence versus commercial per region and seasonal	1. Level of subsistence catch 2. Spatial catch	1. Lack of information. Some traditional food leaves the Strait to family in Mainland 2. Unreliable data Some of	Abundance decline below sustainable levels (populations thresholds are unknown) Cultural related thresholds/indi	Over harvesting Habitat loss Climate change PNG harvest unknown	Subsistence fishing	Community health Sustainability	Interactions with commercial fishing

Data set type	Type of data	Models	Indicators from data set	Risk of using the indicator	Thresholds of concern	Risks for the resource	Community relevance	Government relevance	Fisher relevance
	Some catch data (although concerns are that they are underestimated) Baseline information Catch and effort data on finfish traditional catch in Eastern TS (PhD project)	difference	3. Level of sale of other protein products (shops) 4. Species composition of traditional catch	the existing data may be underestimated 3. A change in the level of intake of other protein product may not be an indication of a change in traditional harvest levels 4. May be reflecting an interaction with commercial fisheries rather than the state of the stock harvest traditionally	cators unknown				
Seabed habitat	Maps of abundances and distribution of sea bed habitats and biodiversity Various environmental variables to develop the physical habitats in TS Distribution maps by species Seabed fish and other by-catch (fishery data) Acoustic data, towed video, sediments, benthic invertebrates Observer program in the	Model: Regression trees and predicted distributions and composition Combine above with the distribution and trawl effort and their overlaps Species assemblages from trawls (regression trees, predicted	1. Intensity of trawl effort 2. Trawl overlaps with important habitat areas 3. Heavily trawl areas and composition of by-catch 4.Assemblages exposed to trawling and the intensity 5. Important species distributions	5.Based on one survey	High risk levels for important species due to trawling Significant decline of some garden bottom species By-catch species level greater than target species catch level By-catch species level greater than	International shipping Based on one survey Mining moratorium re-establish	Assessment of sustainability of trawl fishery	Sustainability By-catch (EPBC)	Interaction with other fisheries (lobster)

Data set type	Type of data	Models	Indicators from data set	Risk of using the indicator	Thresholds of concern	Risks for the resource	Community relevance	Government relevance	Fisher relevance
	TS trawlers Biological habitat facies composition Composition and biomass of sled invertebrates Composition and biomass of trawl by-catch	distribution and composition) Model of historical effort of trawling and the decrease of some species.	compare to trawling areas 6. Trawl exposure of different species 7. Changes in the species composition of trawling 8. Level of depletion of garden bottom reefs	7 & 8 Based on one survey a and potential lack of ongoing survey money	the limit reference point				
Seagrass	Mapping component, distribution, abundance, ecosystem services, spatial surveys at Port Kennedy. Type of seagrass Baseline survey in 2002 with fine scale monitoring seasonally 4 sites monitored. Monitoring associated fauna. Algae cover monitoring from 2002, 2004 2006, 2008 on March each year Seagrass productivity Monitoring where seagrass is falling and which species are the affected one in a spatial scale. Deepest in	Changes in abundance and spatial distribution Seasonal response of different communities of seagrass and abundance. Exposure to air and Temp. (climate change) and their response. Seagrass productivity by species and what influences the productivity. (photosyntheti c activity)	1. Abundance and distribution changes. 2. Type of communities and how they relate to each other. 3. Seagrass health 4.Productivity of seagrass by species and their distribution Areas where seagrass has disappear?? (anecdotal) Dieback events increased	1. requires regular ongoing monitoring 2. dependent on seagrass species and habitat type	1. 20% change from seagrass cover 95th percentile for season compared to past year or average of all previous 2. >30% change in distribution/ extent 3. Dominant species has changed composition >20% as modifier	Seagrass dieback Climate change Reduced water quality	Related to dugong and turtle populations Fisheries productivity Marine health around their communities.	Sustainability Climate change DEWHA and AFMA for connection to fisheries Indicator of marine health	Marine health indicator

Data set type	Type of data	Models	Indicators from data set	Risk of using the indicator	Thresholds of concern	Risks for the resource	Community relevance	Government relevance	Fisher relevance
	15 m approx.	Turnover time for seagrass species, carbon sequestration.							
Reef Habitat	Reef habitat data, started from the 1995 survey Many samples, species composition of many animal groups (including finfish) Type of species (such as habitat forming species) Temporal data Data on algae, seagrass and reefs JCU data for core samples of coral adults in TS Complementary data from lobster surveys Counts of conspicuous organisms from 1994	Analysis on habitat forming species in a quantitative basis. Gradients of different species like coral and seagrass in the TS Cluster analysis based on number of species Environmental correlation with the species and covariates with the different specie Map of distribution of substrates Live coral counts and pearl counts %coverage. Includes seagrass	1. Changes in number and type of species 2. Change in the habitat forming species 3. Temporal and spatial changes of the habitat and composition 4. Reef types and exposure to fishing 5. Reef type and distance from communities 6. Reef type and biodiversity 7. Reef type and important fishery species 8. Extent of coral bleaching 9. Reef coverage and species	No ongoing monitoring	Level of coral cover decline (sand covering reef) Coral bleaching increase Algae cover increase Crown of thorns increase (check with reef check website)	Climate change Coral bleaching	Identify important reef habitats for biodiversity and traditional fishery Cultural value of home reefs	Sustainability and other fisheries	Marine health Impact on commercial fisheries
Invasive species	Localized information on marine pests in TI and Horn Island	Vector analysis risk, hotspots, potential	1. Number of vessels and type of vessels that go		High amount of cargo ships and foreign	No ongoing monitoring of invasive	Health concerns and other	Foreign Compliance Economy,	

Data set type	Type of data	Models	Indicators from data set	Risk of using the indicator	Thresholds of concern	Risks for the resource	Community relevance	Government relevance	Fisher relevance
	Vessel movements (international and domestic) Shipping movements Foreign fishing vessels sightings Risk species information Feral fauna and weeds data	management arrangements	through TI and TS 2. Foreign fishing sightings 3. Ghost net sighting 4. Foreign fishing vessel sinking 5. abundance of feral fauna an weeds	2. Not very robust data 3. No data on invasive species in ghost nets 4. No data on invasive species in sunk vessels 5. Poor data	fishing vessels going through TI and TS	No information on potential invasive species from across international boarder (PNG) Uncertainty with legislative responsibility of government agencies	concerns	markets Environment Biosecurity issues	
Island data	Poor information Add hoc surveys (mammals, vegetations) no regional approach in the past Surface water information (capacity, use) Ground water Sea water levels Satellite imagery of TS Wildlife, geology, vegetation, water, infrastructure, soil acidity, bushfire for 6 communities and will extend to 9 Health and education data Census data on	Sea water level models to be developed soon Vegetation data to be develop (80 new regional ecosystems). Land use planning Costal modelling in some of the islands (sand movement, dynamics, sea level and consequences of putting infrastructure).	1. Health indicators 2. Level of education indicators 3. Level of feral and weed by region 4. Changes in flora and fauna 5. Level of land clearing 6. Surface and ground water levels 7.Population levels 8. Changes in seawater level	3. Poor data 4. Poor data 6. Poor data on ground water 8. Poor data	To be developed	Population pressure	Land use planning	Land use planning	N/A

Data set type	Type of data	Models	Indicators from data set	Risk of using the indicator	Thresholds of concern	Risks for the resource	Community relevance	Government relevance	Fisher relevance
	population Vessel survey (number of dinghies) may be needed for future, there is in the past and could be compared. Ghost net data is starting to develop								
Shipping traffic (carrier boats)	AMSA data on shipping traffic		1. No. of vessels in risk category 2. Number of grounded vessels 3. Level of shipping traffic				Marine pests introduction Oil spill risks Grounded vessels and damage to habitats Marine pollution	Environment Biosecurity risks	Damage to environment and risk for fisheries
Weather and Climate Sea surface temperature , primary productivity	NASA and BOM environmental data Satellite imagery AIMS environmental data from TI Historical data (traditional knowledge, need to be collected)		1. Air and water temperature levels 2. Sea level 3. Storm frequency 4. Rainfall levels 5. Foraminifera as indicators for coral health, indicator species. Ageing adults of coral and coral forams	Data is not throughout the Torres Strait Lack of knowledge to make a connection between changes in climate parameters and environmental consequences	Sea level reaches concerning levels Frequency of storms rises Mayor changes in the foram composition	Climate change	Weather pattern changes will have an effect to the marine environment and the fisheries and their lifestyle	Climate change Environment	Climate change affecting fisheries
Pollution	Torres Strait baseline study from heavy metals		Heavy metal concentration in		High levels of heavy metal				

Data set type	Type of data	Models	Indicators from data set	Risk of using the indicator	Thresholds of concern	Risks for the resource	Community relevance	Government relevance	Fisher relevance
	and sediments from the Fly River		sediments across Torres Strait		concentrations				

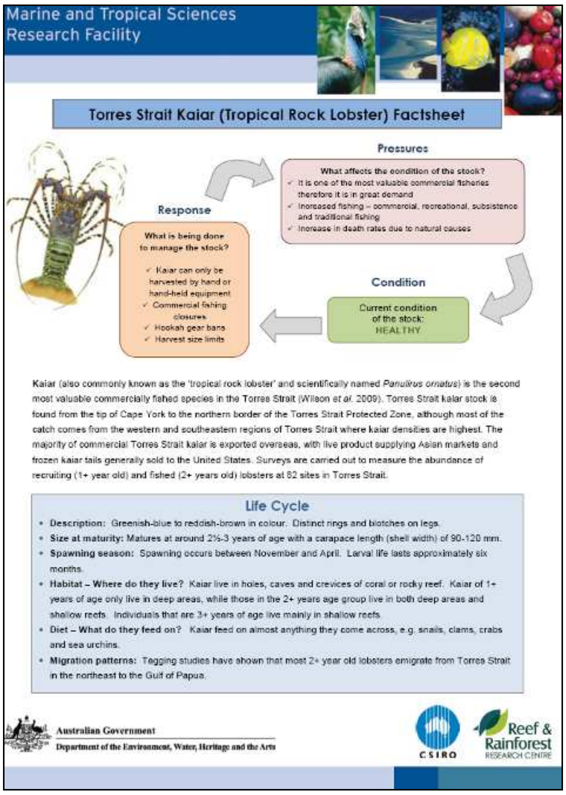
APPENDIX B CONFIDFENCE LEVELS FOR AVAILABLE DATA SETS

Species' scientific names	Common names	Catch surveys / CPUE	Stock surveys / Biomass	Stock assessment	Confidence level (BRS 2008 or expert opinion)	Science and management knowledge
Tropical Rock Lobster Wilson D, Curtotti R, Begg G & Phillips K (eds) 2009						
Panulirus ornatus	Tropical rock lobster		✓	✓	Uncertain	**High**
Beche-de-mer Wilson D, Curtotti R, Begg G & Phillips K (eds) 2009 Skewes et al. 2006						
Holothuria scabra	Sandfish		✓	✓	Uncertain	**High**
Holothuria whitmaei	Black teatfish – high value		✓	✓	Uncertain	**High**
Holothuria fuscogilva	White teatfish – high value		✓	✓	Uncertain	**High**
Thelenota ananus	Prickly redfish – high value		✓	✓	Uncertain	**High**
Actinopyga miliaris	Blackfish – medium value		✓	✓	Uncertain	**High**
Actinopyga mauritiana	Surf redfish – medium value		✓	✓	Uncertain	**High**
Actinopyga echinites	Deepwater redfish – medium value		✓	✓	Uncertain	**High**
Bohadschia argus	Tigerfish – medium value		✓	✓	Uncertain	**High**
Stichopus chloronotus	Greenfish – medium value		✓	✓	Uncertain	**High**
Stichopus variegatus	Curryfish – medium value		✓	✓	Uncertain	**High**
Holothuria atra	Lollyfish – low value		✓	✓	Uncertain	**High**
Holothuria fuscpunctata	Elephant truck fish – low value		✓	✓	Uncertain	**High**
Holothuria coluber	Snakefish – low value		✓	✓	Uncertain	**High**
Holothuria edulis	Pinkfish – low value		✓	✓	Uncertain	**High**
Bohadschia graeffei	Blackspot seacucumber – low value		✓	✓	Uncertain	**High**
Thelenota anax	Amberfish – low value		✓	✓	Uncertain	**High**
Bohadschia marmorata	Brown sandfish – low value		✓	✓	Uncertain	**High**
Trochus Wilson D, Curtotti R, Begg G & Phillips K (eds) 2009						
Trochus niloticus	trochus' nacreous (mother of pearl) shell	✓			Uncertain	**Low**
Turtle Limpus, C. J., Miller, J. D., Oarmenter, C. J., and Limpus, D. J. 2003.						
Chelonia mydas	Green turtle	✓	✓		Uncertain	**Medium**
Eretmochelys imbricata	Hawksbill	✓	✓		Uncertain	**Medium**
	Flatback	✓	✓		Uncertain	**Low**

Dugong Marsh, H. D., Hodgson, A., Lawler, I., Grech, A. and Delean, S. (2007)						
Dugong dugong	Dugong	✓	✓		Uncertain	**Medium**
Crabs Wilson D, Curtotti R, Begg G & Phillips K (eds) 2009						
Scylla spp.	Mud crab	✓			Uncertain	**Low**
Portunus pelagicus	Blue swimming crab	✓			Uncertain	**Low**
Spanish Mackerel Wilson D, Curtotti R, Begg G & Phillips K (eds) 2009						
(*Scomberomorus commerson*)	Narrow-barred Spanish mackerel	✓		✓	Uncertain	**Medium**
(*Scomberomorus queenslandicus*)	School mackerel	✓			Uncertain	**Low**
(*Scomberomorus semifasciatus*)	Grey mackerel	✓			Uncertain	**Low**
(*Scomberomorus munroi*	Spotted mackerel	✓			Uncertain	**Low**
(*Grammatorcyn us bicarinatus*).	Shark mackerel	✓			Uncertain	**Low**
Prawns Wilson D, Curtotti R, Begg G & Phillips K (eds) 2009						
Metapenaeus endeavouri	Blue Endeavour Prawns	✓		✓	High	**High**
Penaeus esculentus	Brown Tiger Prawn	✓		✓	High	**High**
Penaeus longistylus	Red Spot King	✓			Uncertain	**Low**
Reef Line Fishery Wilson D, Curtotti R, Begg G & Phillips K (eds) 2009						
(*Plectropomus* spp.)	Coral trout species	✓		✓	Uncertain	**Medium**
L. calcarifer	Barramundi	✓			Uncertain	**Low**
(*Cromileptes altivells*)	Barramundi cod	✓			Uncertain	**Low**
(*Plectropomus* spp.)	Coral trout species	✓			Uncertain	**Low**
(*Lutjanus* spp. and *Lethrinus* spp.)	Mixed reef fish	✓			Uncertain	**Low**
(*Epinephelus* spp.)	Rock cods	✓			Uncertain	**Low**
Pearls Wilson D, Curtotti R, Begg G & Phillips K (eds) 2009						
Pinctada maxima	Gold-lipped pearl	✓			Uncertain	**Low**
Pinctada margaritifera	Black-lipped pearl	✓			Uncertain	**Low**
Traditional Fisheries Harris. A., Deew, G., Polner, I. and Kerr, J. 1994.						
Anadara sp.	Akul	✓			Uncertain	**None**
	Bivalves	✓			Uncertain	**None**
Pinctada maxima	Pearl oysters	✓			Uncertain	**None**
Cardium Spp.	Cockles	✓			Uncertain	**None**
P.margaretifera	Black lip oysters	✓			Uncertain	**None**
	Clams	✓			Uncertain	**None**
Panulirus ornatus	Cray	✓			Uncertain	**None**
P.versicolor	Barrier cray	✓			Uncertain	**None**
Portunus spp	Sand crab	✓			Uncertain	**None**
	Reef crabs	✓			Uncertain	**None**
Ocypode spp.	Ghost crabs	✓			Uncertain	**None**
	Spider shell	✓			Uncertain	**None**
	Bailer shell	✓			Uncertain	**None**

	Octopus	✓			Uncertain	**None**
	Squid	✓			Uncertain	**None**
	Rabbitfish	✓			Uncertain	**Low**
Valamugil buchanani	Mullet	✓			Uncertain	**Low**
Lethrinus laticaudis	Emperor	✓			Uncertain	**Low**
Gnathanodon speciosus	Whitefish	✓			Uncertain	**Low**
Choerodon cyanodus	Tuskfish	✓			Uncertain	**Low**
Carangoides gymnostethus	Trevally	✓			Uncertain	**Low**
Caranx papuensis	Whitefish	✓			Uncertain	**Low**
Herklotsichthys quadrimaculatus	Sardine	✓			Uncertain	**Low**
Mugil spp.	Mullet	✓			Uncertain	**Low**
Scomberoides commersonnian us	Queenfish	✓			Uncertain	**Low**
Lutjanus carponotatus	Stripey	✓			Uncertain	**Low**
Carangoides fulvoguttatus	Whitefish	✓			Uncertain	**Low**
Choerodon schoeleinii	Bluefish	✓			Uncertain	**Low**
Sphyraena jello	Barracuda	✓			Uncertain	**Low**
Sphyraena barracuda	Barracuda	✓			Uncertain	**Low**
Liza vaigiensis	Mullet	✓			Uncertain	**Low**
C.cephalotes Choerodon	Tuskfish	✓			Uncertain	**Low**
Psammoperca waigiensis	Nightfish	✓			Uncertain	**Low**

APPENDIX C TROPICAL ROCK LOBSTER FACT SHEET



Marine and Tropical Sciences Research Facility

Torres Strait Kaiar (Tropical Rock Lobster) Factsheet

Pressures

What affects the condition of the stock?
- ✓ It is one of the most valuable commercial fisheries therefore it is in great demand
- ✓ Increased fishing – commercial, recreational, subsistence and traditional fishing
- ✓ Increase in death rates due to natural causes

Response

What is being done to manage the stock?
- ✓ Kaiar can only be harvested by hand or hand-held equipment
- ✓ Commercial fishing closures
- ✓ Hookah gear bans
- ✓ Harvest size limits

Condition

Current condition of the stock: HEALTHY

Kaiar (also commonly known as the 'tropical rock lobster' and scientifically named *Panulirus ornatus*) is the second most valuable commercially fished species in the Torres Strait (Wilson *et al.* 2009). Torres Strait kaiar stock is found from the tip of Cape York to the northern border of the Torres Strait Protected Zone, although most of the catch comes from the western and southeastern regions of Torres Strait where kaiar densities are highest. The majority of commercial Torres Strait kaiar is exported overseas, with live product supplying Asian markets and frozen kaiar tails generally sold to the United States. Surveys are carried out to measure the abundance of recruiting (1+ year old) and fished (2+ years old) lobsters at 82 sites in Torres Strait.

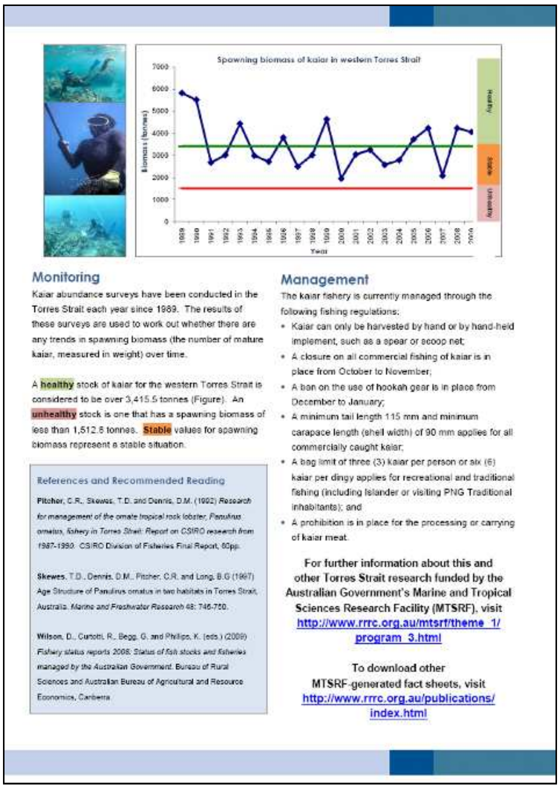
Life Cycle

- **Description:** Greenish-blue to reddish-brown in colour. Distinct rings and blotches on legs.
- **Size at maturity:** Matures at around 2½-3 years of age with a carapace length (shell width) of 90-120 mm.
- **Spawning season:** Spawning occurs between November and April. Larval life lasts approximately six months.
- **Habitat – Where do they live?** Kaiar live in holes, caves and crevices of coral or rocky reef. Kaiar of 1+ years of age only live in deep areas, while those in the 2+ years age group live in both deep areas and shallow reefs. Individuals that are 3+ years of age live mainly in shallow reefs.
- **Diet – What do they feed on?** Kaiar feed on almost anything they come across, e.g. snails, clams, crabs and sea urchins.
- **Migration patterns:** Tagging studies have shown that most 2+ year old lobsters emigrate from Torres Strait in the northeast to the Gulf of Papua.

Australian Government
Department of the Environment, Water, Heritage and the Arts

CSIRO

Reef & Rainforest Research Centre



Monitoring

Kaiar abundance surveys have been conducted in the Torres Strait each year since 1989. The results of these surveys are used to work out whether there are any trends in spawning biomass (the number of mature kaiar, measured in weight) over time.

A **healthy** stock of kaiar for the western Torres Strait is considered to be over 3,415.5 tonnes (Figure). An **unhealthy** stock is one that has a spawning biomass of less than 1,512.8 tonnes. **Stable** values for spawning biomass represent a stable situation.

References and Recommended Reading

Pitcher, C.R., Skewes, T.D. and Dennis, D.M. (1992) *Research for management of the ornate tropical rock lobster, Panulirus ornatus, fishery in Torres Strait: Report on CSIRO research from 1987-1990.* CSIRO Division of Fisheries Final Report, 60pp.

Skewes, T.D., Dennis, D.M., Pitcher, C.R. and Long, B.G (1997) Age Structure of Panulirus ornatus in two habitats in Torres Strait, Australia. *Marine and Freshwater Research* 48: 745-750.

Wilson, D., Curtotti, R., Begg, G. and Phillips, K. (eds.) (2009) *Fishery status reports 2008: Status of fish stocks and fisheries managed by the Australian Government.* Bureau of Rural Sciences and Australian Bureau of Agricultural and Resource Economics, Canberra.

Management

The kaiar fishery is currently managed through the following fishing regulations:
- Kaiar can only be harvested by hand or by hand-held implement, such as a spear or scoop net;
- A closure on all commercial fishing of kaiar is in place from October to November;
- A ban on the use of hookah gear is in place from December to January;
- A minimum tail length 115 mm and minimum carapace length (shell width) of 90 mm applies for all commercially caught kaiar;
- A bag limit of three (3) kaiar per person or six (6) kaiar per dingy applies for recreational and traditional fishing (including Islander or visiting PNG Traditional inhabitants); and
- A prohibition is in place for the processing or carrying of kaiar meat.

For further information about this and other Torres Strait research funded by the Australian Government's Marine and Tropical Sciences Research Facility (MTSRF), visit http://www.rrrc.org.au/mtsrf/theme_1/program_3.html

To download other MTSRF-generated fact sheets, visit http://www.rrrc.org.au/publications/index.html

APPENDIX D COMMUNITY MODIFIED FACTSHEETS FOR KABAR, SOKPIS, KAIAR

Marine and Tropical Sciences Research Facility

Australian Government
Department of the Environment, Water, Heritage and the Arts

Fact Sheet – May 2010

Torres Strait Kaiar (Tropical Rock Lobster)

Life Cycle

Size at mature age

- Tropical rock lobsters (Kaiar) mature at around 2½ to 3 years of age with a carapace length (shell width) of 90-120mm.

What are their migration patterns?

- Tagging studies have shown that most 2+ year old lobsters emigrate from Torres Strait to the northeast into the Gulf of Papua to breed. They then seem to disappear.

When is the spawning season?

- Spawning occurs between November and April.
- Larval life lasts approximately six months.

Where do they live?

- Kaiar live in holes, caves and crevasses of coral or rocky reef.
- At around one year of age, they live only in deep areas.
- At 2+ years of age, they live in both deep areas and shallow reefs.
- At 3+ years, male kaiar live mainly in shallow reefs.

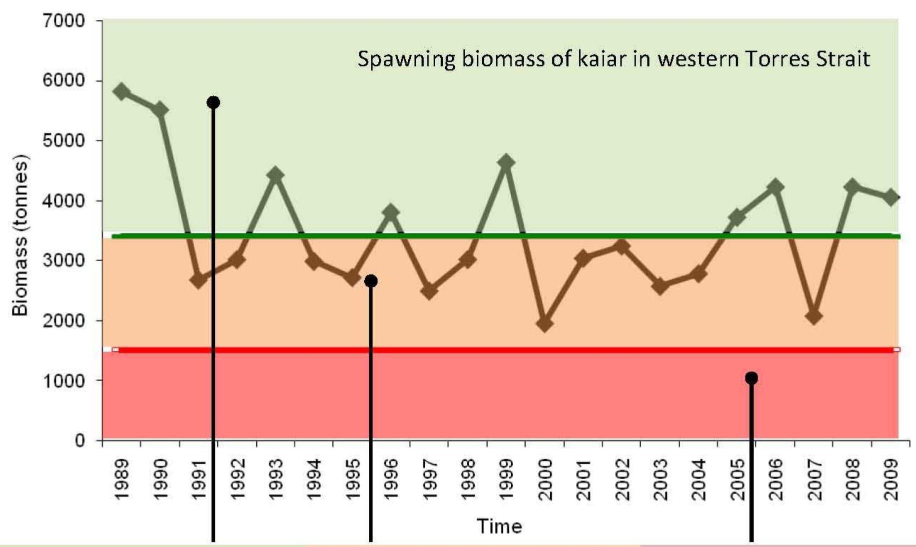
What do they feed on?

Kaiar feed on almost anything they come across. Their diet includes snails, clams and sea urchins.




CSIRO
Reef & Rainforest RESEARCH CENTRE

Kaiar stocks in the Torres Strait are currently at a healthy level



Kaiar stocks are **HEALTHY** (green) when the number of kaiar harvested each year is less than the number of kaiar reaching a mature age to spawn each year.	Kaiar stocks are **STABLE** (amber) when the number of kaiar harvested each year is equal to the number of kaiar reaching a mature age to spawn each year.	Kaiar stocks are **UNHEALTHY** (red) when the number of kaiar harvested each year is much greater than the number of kaiar reaching a mature age to spawn each year.

Healthy stocks of Kaiar can be maintained by:

☑	☑	☑	☑	☑	☑
Harvesting only by hand or with hand-held equipment, such as a spear or scoop net.	An October to November closure on all commercial fishing of kaiar.	A December to January ban on the use of hookah gear.	Only taking kaiar of tail length greater than 115 mm and carapace length (width) greater than 90 mm to be sold.	Taking no more than three (3) bags of kaiar per person, or six (6) kaiar per dingy.	A prohibition on the processing or carrying of kaiar meat.

This fact sheet was produced by researchers from the CSIRO funded by the
Australian Government's Marine and Tropical Sciences Research Facility (MTSRF)
Program 3 'Torres Strait: Status, Use and Trends'.

Further information about Program 3, including overviews of each of the Torres Strait projects, visit
http://www.rrrc.org.au/mtsrf/theme_1/program_3.html

To download this and other MTSRF fact sheets, visit
http://www.rrrc.org.au/publications/tnq_factsheets.html

Marine and Tropical Sciences
Research Facility

Australian Government
Department of the Environment, Water, Heritage and the Arts

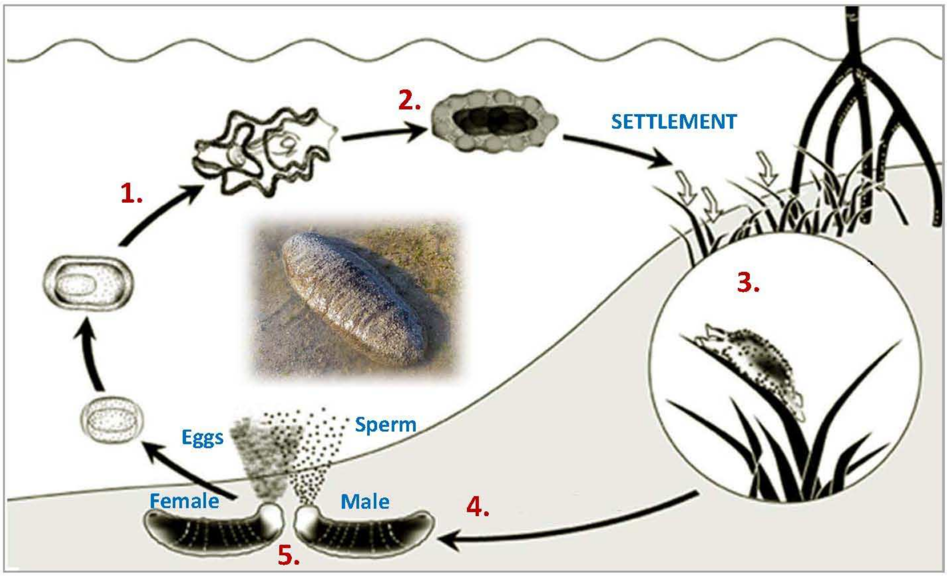
Fact Sheet – May 2010

Torres Strait Sokpis (Warrior Reef Sandfish)

Life Cycle of the Sandfish (Sea cucumber)

1. Tiny fertilised eggs develop into very small larvae

2. Larval stages drift in the water for more than a week before settling on the sea floor as juvenile sea cucumbers



3. Sea cucumbers settle at a size of about one millimeter (1 mm) and grow into juveniles

4. Sea cucumbers need to grow for more than 2-3 years before they reach a large enough size to produce eggs and sperm

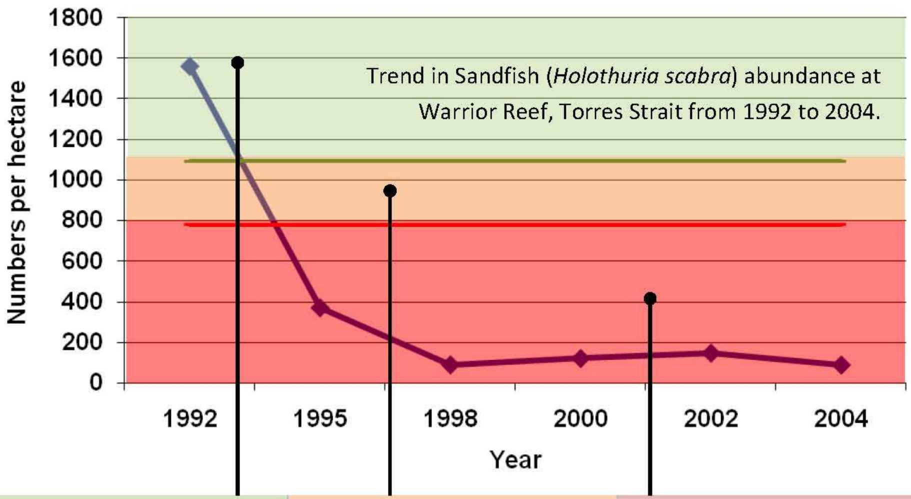
5. Males and females need to be close enough (within 2-10 metres) to each other to allow sperm to fertilise eggs successfully

Graphic adapted from Friedman, K., Purcell, S., Bell, J. and Hair, C. (2008) Sea cucumber fisheries: A managers toolbox. ACIAR, Australia (Available for download at: http://aciar.gov.au/system/files/node/10097/MN135.pdf)

CSIRO

Reef & Rainforest
RESEARCH CENTRE

Sandfish stocks in the Torres Strait are currently at an unhealthy level



Sandfish stocks are **HEALTHY** (green) when the number of sandfish harvested each year is less than the number of sandfish reaching a mature age to spawn each year.	Sandfish stocks are **STABLE** (amber) when the number of sandfish harvested each year is equal to the number of sandfish reaching a mature age to spawn each year.	Sandfish stocks are **UNHEALTHY** (red) when the number of sandfish harvested each year is much greater than the number of sandfish reaching a mature age to spawn each year.

Healthy Sandfish stocks can be rebuilt by:

☑	☑	☑	☑	☑	☑
Prohibiting the commercial harvest of sandfish (TAC = 0 t)	Having a minimum size limit of 180 mm when harvesting	Harvesting only by hand or with a hand-held non-mechanical implement	Having a ban on the use of hookah or SCUBA gear during harvest	Having a bag limit of three (3) sandfish per person or six (6) sandfish per dinghy during traditional fishing in the area of the fishery	Researching new harvest strategies and community-based management

This fact sheet was produced by researchers from the CSIRO funded by the
Australian Government's Marine and Tropical Sciences Research Facility (MTSRF)
Program 3 'Torres Strait: Status, Use and Trends'.

Further information about Program 3, including overviews of each of the Torres Strait projects, visit
http://www.rrrc.org.au/mtsrf/theme_1/program_3.html

To download this and other MTSRF fact sheets, visit
http://www.rrrc.org.au/publications/tnq_factsheets.html

Marine and Tropical Sciences Research Facility

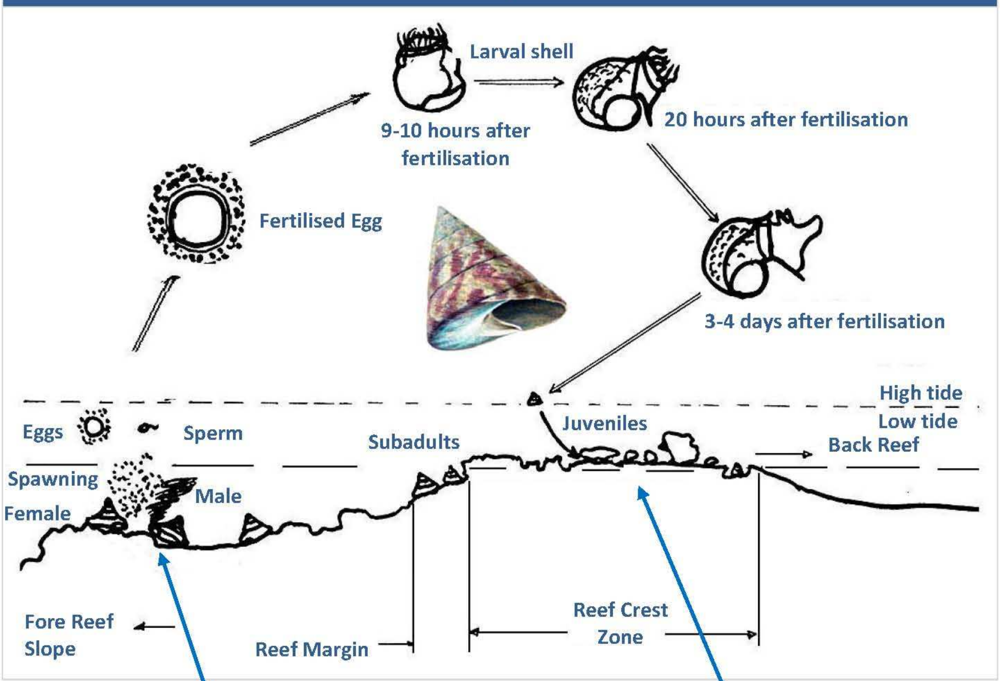
Australian Government

Department of the Environment, Water, Heritage and the Arts

Fact Sheet – May 2010

Torres Strait Kabar (Trochus)

Life Cycle



Male and female kabar need to be close together (within ten metres) to allow eggs and sperm to fertilise successfully.

Kabar need to grow for more than 3-4 years before they reach a large enough size to produce eggs and sperm.

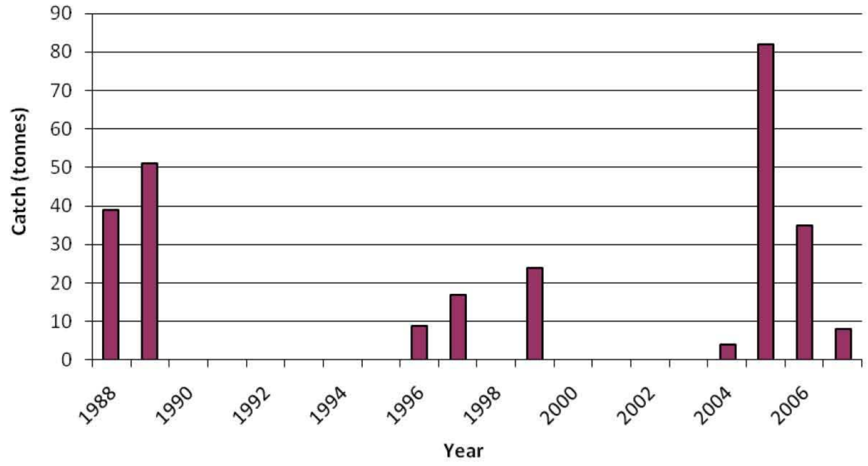
Graphic adapted from Kitutani, K. and Yamakawa, H. (eds.) (1999) Marine snails seed production towards restocking enhancement – Basic Manual. Field Document No. 14, FAO Corporate Document Repository (Available for download at: http://aciar.gov.au/system/files/node/10097/MN135.pdf)

CSIRO

Reef & Rainforest RESEARCH CENTRE

The health of kabar stocks in Torres Strait have been uncertain, and information on catch is limited

Total catch of kabar from 1988 to 2006, Torres Strait



Healthy stocks of kabar can be maintained by:

☑	☑	☑
Limiting the method of harvest to hand collection or with hand-held non-mechanical implement.	Having a minimum harvest size limit of 80 mm and a maximum harvest size limit of 125 mm.	Researching new harvest strategies and community-based management.

This fact sheet was produced by researchers from the CSIRO funded by the **Australian Government's Marine and Tropical Sciences Research Facility (MTSRF) Program 3 'Torres Strait: Status, Use and Trends'.**

Further information about Program 3, including overviews of each of the Torres Strait projects, visit http://www.rrrc.org.au/mtsrf/theme_1/program_3.html

To download this and other MTSRF fact sheets, visit http://www.rrrc.org.au/publications/tnq_factsheets.html

Contact Us

Phone: 1300 363 400
+61 3 9545 2176

Email: enquiries@csiro.au

Web: www.csiro.au

Your CSIRO

Australia is founding its future on science and innovation. Its national science agency, CSIRO, is a powerhouse of ideas, technologies and skills for building prosperity, growth, health and sustainability. It serves governments, industries, business and communities across the nation.